THE MONSTER IS COMING!

Peugeot's bid to defend Dakar crown with aggressive new 3008 DKR

Driving Technology Into Pole Position

INTERNATIONAL

RACE TECH

Motorsport Engineering

NOVEMBER 2016 No. 192 UK £5.95 USA $11.99 www.racetechmag.com

NSX GT3

How Acura transformed the NSX into a racecar

Revealed

The most innovative new products of the year

New Ligier LMP2 car breaks cover

Why Jaguar snubbed WEC for Formula E

9 771356 297055 11

www.racetechmag.com

ACCELERATE INNOVATION

AVL RACING

www.avl.com/racing

SIMULATE ENGINEER MAKE TEST RACE

NSX GT3

How Acura transformed the NSX into a racecar

COVER STORY PAGE 44

RACE TECH INTERNATIONAL
Motorsport Engineering

Volume 23 Issue 12
Published October 2016
The next issue will be published
in early November 2016
ISSN 1356-2975

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

Overseas copies are sent via air mail
Special offer 12 issues for the price of 10
12 issue subscription UK: £45.00
Europe: €97.50, US/Canada: US$127.40
Rest of World: £75.00
All major credit cards accepted. Cheques and money orders only in Pounds Sterling payable to Kimberley Media Group Ltd.

BACK ISSUES AVAILABLE:
8, 9, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126, 127, 128, 129, 130, 131, 132, 133, 134, 135, 136, 137, 138, 139, 140, 141, 142, 143, 144, 145, 146, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 178, 179, 180, 181, 182, 183, 184, 185, 186, 187, 188, 189, 190, 191
Price including post & packing:
UK: £5.50, Europe: £6.50, Rest of World: £7.55
You can pay by cheque or credit card but please note the minimum on Switch & Delta is £14

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

Cover image: Courtesy of Honda Racing

Design & Production:
Maluma Design Associates,

Printed by Warners Midlands plc

The evolution in **FLUID HORSEPOWER™** continues...

NEW FOR 2016... XKS SILICONE OUTER COVER
A gloss black Silicone covering over the XK Aramid braid reinforcement.
For both ProPLUS & ProPLUS Xtreme.
Excellent Braid Protection.
Easy Clean Up.

XRP ProPLUS Race Hose™

SMOOTH INTERNAL TUBE
Superior flow rates, minimum pressure drop AND ease of clean-out, not possible in convoluted hoses.

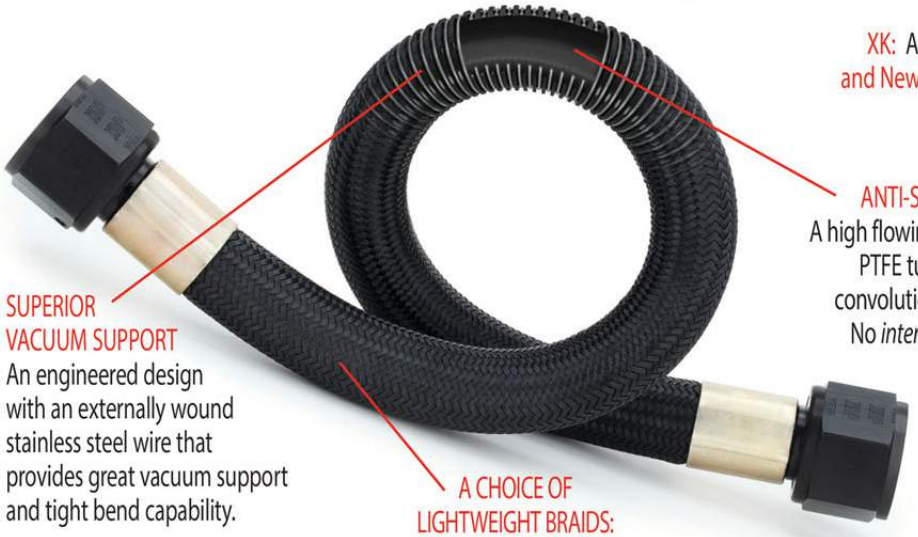
ANTI-STATIC PTFE IS COMPATIBLE WITH ALL AUTOMOTIVE FLUIDS AND FUELS
A highly compressed, non-porous matrix that resists fuel permeation and diffusion.

EXTERNAL CONVOLUTIONS
Promote hoop strength for vacuum resistance and supports tight bend flexibility.

RACE CRIMP HOSE ENDS
Hundreds of styles. Choice of full hex or lightweight turned down swivel nuts. Black is standard, also available in Blue or Super Nickel.

PATENTED MANUFACTURING PROCESS
Creates a full PTFE smooth-bore hose for optimal flow with external convolutions for flexibility.

A CHOICE OF OUTER BRAIDS
XS: Stainless Steel,
XM: Lightweight XtraTemp Monofilament
XK: Aramid Fiber, XT: Tube only for inside fuel cells
and New XKS: Silicone over Aramid.



SUPERIOR VACUUM SUPPORT
An engineered design with an externally wound stainless steel wire that provides great vacuum support and tight bend capability.

ANTI-STATIC PTFE TUBE
A high flowing, smooth bore, PTFE tube with *external* convolutions for flexibility. No *internal* convolutions to restrict flow.

A CHOICE OF LIGHTWEIGHT BRAIDS:
XM - XtraTemp Monofilament, XK - Aramid and
NEW XKS: Gloss black Silicone over Aramid braid.

ProPLUS Xtreme Race Hose™

Highly Kink-Resistant, Quite Possibly The Perfect Dry Sump Vacuum Race Hose

Go to www.xrp.com to learn more about the ProPLUS Race Hose™ product line.

An exceptional achievement in race hose technology...

Follow us on Instagram @XRPracing

Like us on Facebook /XRPinc

UNITED STATES XRP, Inc.
5630 Imperial Hwy., South Gate, CA 90280
sales@xrp.com tel +1 562 861 4765 fax +1 562 861 5503

EUROPE & UK Protec Fuel Systems Ltd.
info@protecfuelpumps.com tel +44 (0) 121 572 6533

XRP®
THE XTREME IN RACECAR PLUMBING

EDITOR
William Kimberley

CONTRIBUTING EDITORS
Andrew Charman

CONSULTANT EDITOR
Mark Skewis

EDITORIAL ASSISTANT
Sebastian Scott
Thiam Loong Ser

PHOTOGRAPHY
LAT

ART EDITOR
Paul Bullock

ADMINISTRATION/ SUBSCRIPTIONS
Vikki Amour

SALES EXECUTIVES
Mike Norman

COMMERCIAL DIRECTOR
Maryam Lamond

MANAGING DIRECTOR
Adrian Goodsell

PUBLISHING DIRECTOR
Soheila Kimberley

RACE TECH
Motorsport Engineering

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

www.kimberleymediagroup.com

KIMBERLEY
MEDIA GROUP LTD

@racetechmag

facebook.com/
RaceTechmagazine

ALL ABOUT THE ALGORITHM

THERE has been quite a bit in the news recently, especially about the new ownership of Formula 1, which is quite momentous, but the thing that has caught my eye, and it's not really motorsport related – yet – is the fact that hackers took over and controlled an autonomous car from 20 kilometres away. The car in question was a Tesla and the alleged perpetrators were Chinese.

As autonomous and interconnected cars become more common, it brings with them a very real threat that should be treated with the greatest respect. As Brian Spector, CEO of MIRACL, an expert in this area, has commented, having very limited encryption, identity management and data protection within such a powerful computer is extremely dangerous and poses a real and serious threat to everyone using the roads today.

As Cesare Garlati, chief security strategist, prpl Foundation has stated, criminals using a little lateral thinking can use one part of the car's anatomy to get to another. This could have dangerous consequences if hackers found their way into more critical functions, such as the brakes as researchers were able to do with the Tesla recently. The lack of subject matter expertise with mechanical and electrical engineers is leaving systems wide open to attack.

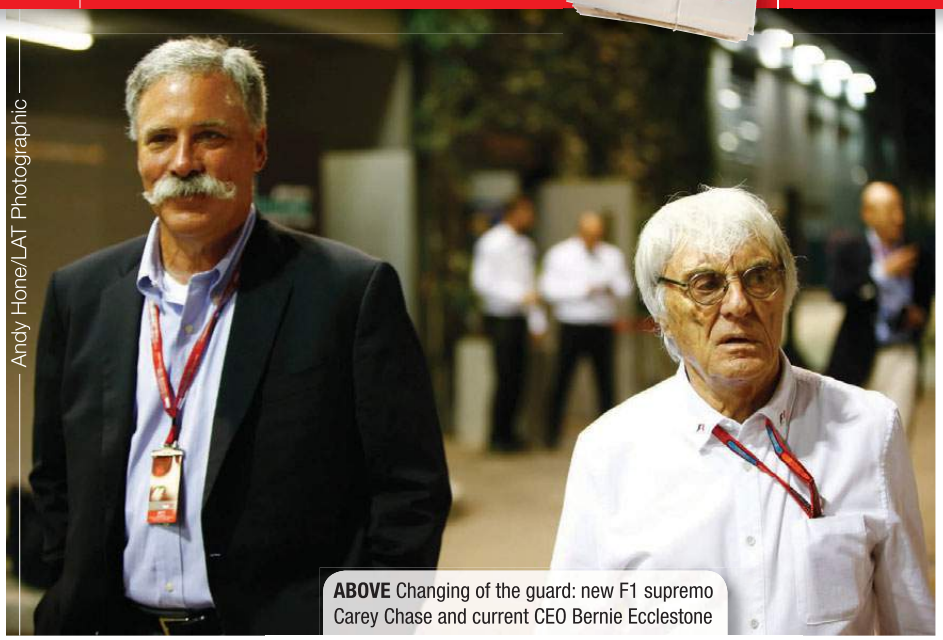
While this undoubtedly puts a bit of a question mark over the future of the autonomous car, something that we are beginning to take for granted – even if we don't like the prospect, I still remember Audi Sport's Ulrich Baretzky's comment to me earlier this year that when travelling at 250 km/h along the autobahn, he would rather share the road with a fully sensored up car that was fully alert to its surroundings than someone who might be on his or her mobile, not paying attention or about to fall asleep.

I am also mindful of the comment made by Nick Rogers, the Jaguar Land Rover Group engineering director to Craig Scarborough in the article in this issue on Jaguar's return to motor racing by coming into the FIA Formula E Championship that it's all about the algorithms and how they are as important in this new virtual world as the mechanical world. While he is referring to developing them for a car's system and subsystems, an important part of this is developing secure networks that are safe from being hacked by rival teams – and this to me is where motorsport can play a relevant if not vital role in helping the automotive world as well as other industries.

You just have to look at a Formula One or World Endurance Championship paddock to see the huge masts waving in the wind from truck rooftops – and more and more have sprouted up over the last few years. The huge amount of data that is being transmitted to and from the trucks to their bases is almost overwhelming and would be invaluable to any other team on the grid if they could get access to it, but as far as we know, they don't. This tells me that there are some very clever people working in all the teams whose job is to ensure their team's cyber security so that their data can be safely transmitted without being hacked. This is the sort of knowledge that can be of huge value to car companies that are developing autonomous vehicles.

To be honest, the algorithm as such doesn't really press my button. I am still much more about the mechanics and even electronics but I do acknowledge that we have to move with the times. I have no doubt that cyber security will become more and more of an issue in the wider world over the next few years and while this isn't a traditional area of motorsport, it typifies what those involved in it are good at and that is developing technologies and processes and pushing boundaries as well as building up a knowledge base that is second to none that can then be used by other industries.

William Kimberley
EDITOR


Andy Hone/LAT Photographic

ABOVE Changing of the guard: new F1 supremo Carey Chase and current CEO Bernie Ecclestone

New broom promises brighter F1 future

William Kimberley

ENGLEWOOD, CO: The new owners of Formula 1 have promised to grow the sport and make it more accessible to fans. The new incoming president Carey Chase has told Formula1.com that his aim is to take Formula 1 to the next level.

Formerly president of 21st Century Fox, Chase has had a long and successful career in the media business, a knowledge he hopes to use in Formula 1. He will be working with current F1 boss Bernie Ecclestone who will remain as CEO for up to 30 months following the complete takeover of the business in the first quarter of 2017. The first phase has already taken place with Liberty Media taking an immediate 18.7% share in Delta Topco, the holding company for the Formula 1 business that is owned by a consortium of partners led by CVC Capital Partners, for $746m in cash. This includes a $75m discount that will be repaid in the second part of the transaction that will require anti-trust approval, Liberty Media shareholder approval and certain third party consents, including FIA approval.

According to figures released by Liberty Media in the takeover, the 19 races in 2013, 2014 and 2015 generated $1,639m, $1,702m and $1,697m respectively while the 21 races in 2016 are expected to generate £1,820m. Approximately $9.3bn of revenue is under long term contracts.

The figures are broken down and show that 30-35% is generated from the race promoters who pay to host a Formula 1 race, the same percentage figures from TV rights, 15% from advertising and sponsorship and 20% from other sources such as the Paddock Club, freight and TV production and post production.

Liberty Media expects to use its expertise in live events and digital monetisation to grow the business further. It is setting out to enhance the distribution of content, especially in the digital domain, establish a broader range of commercial partners, including sponsorship and evolve the race calendar.

It has also identified Formula 1 as a key player in the growing market for live premium sports rights. According to its figures, the average annual value of NFL has grown by 1.6 with its broadcasting deals with CBS, Fox, NBC and ESPN, the British Premier League by 1.7 with its deal with Sky and BT but it is NBA that sets the standard with its 2.8 annual growth rate with its nine year deal with ESPN and Turner.

In an interview with Formula1.com at the Singapore Grand Prix, Chase talks about creating long-term value, rather than short-term profit. He also explains how he expects to grow the business. "Formula One is a great business, a great franchise and we want to build on that and I see that there is opportunity too for stepping up by investing in all sorts of areas – some of the historic areas in making the racing great, making tracks more exciting than ever; investing in marketing the sport so that it connects with fans in the right way; investing in new platforms – digital platforms – that really are able to connect to the fans with the information that they really want, taking advantage of everything that the sport has to offer.

"I have been in the media business, so I know content well – and sports are content, sports are entertainment. Sport has been an enormous part in the business we've built at Fox – and not just US sports, but global sports: cricket, soccer, rugby – and Formula One. Formula One has been a big part of Fox Sports.

"The historic pillars are important and we will continue to grow those – make the events bigger from the promotion side of it, and with broadcast probably widen the core television experience to today's needs. I believe that a good digital product makes the television product more rewarding."

Charles Coates/LAT Photographic

ABOVE Broadcasting revolution in the air? "A good digital product makes the television product more rewarding" – Carey Chase

Steve Etherington/LAT Photographic

ABOVE Mercedes team engineering director foresees problems ahead in finding suitable technical directors in the future

Mercedes developing future technical directors

Sebastian Scott

BRACKLEY, UK: Aldo Costa, engineering director of Mercedes AMG Petronas F1 team, thinks teams face a problem seeking the next generation of technical directors. With modern race cars becoming ever more technically advanced and engineering departments expanding, well-rounded and knowledgeable engineers are becoming few and far between.

Engineers are becoming incredibly specialised very quickly, preventing the younger generation from having the opportunities to become future technical directors according to Costa.

"We've got this problem, we are looking for the next technical director at Mercedes," said Costa, "we are trying to do a programme for development of these students who are slightly different, trying to let them understand a bit more widely around the car, to hopefully become the next generation of technical directors.

"People like me. I changed in a team many different types of job to try to understand as much as I could everywhere. These days, young guys get employed and they become specialists and they don't go around and they don't grow up with a general knowledge of the car."

The motorsport industry is coming to the realisation that more needs to be done than is currently happening in order to establish the next generation of engineers and technical directors. It is expected more programmes will start emerging in future similar to the Reiter Young Stars which has been extended into 2017. RT

Race car courses for budding engineers

William Kimberley

DONINGTON, UK: The Motorsport Industry Association (MIA) has partnered with MTS Monza to teach the mechanics of race cars and race bikes at Donington with the top five students guaranteed a placement with a professional race team for six months. The hands-on, pit garage practical and classroom courses are taught by successful, current race car and bike mechanics. The courses provide all technical, practical and mechanical knowledge required by a race mechanic, and include organised tours to race teams and a visit to Autosport International in January.

The MIA also organises the School of Race Engineering that is aimed at individuals who wish to further their career in race engineering. Using Base Performance simulators, alongside a classroom environment, delegates will learn from current race engineers, who will share their in-depth knowledge and experience. The school is open to UK and international delegates, engineering students, graduates and technicians who want to further their experience and education to help secure a position within this highly competitive industry. Delegates will receive lunch and refreshments throughout the weekend and dinner on the Saturday evening. For more information contact info@the-mia.com. RT

A single kit future for IndyCar aero

Andrew Charman

INDIANAPOLIS, IN: As previously predicted in *Race Tech*, the Verizon IndyCar Series has confirmed that development of the bespoke aerodynamic body kits used by the Honda and Chevrolet teams in the series are to be frozen, ahead of a single kit being introduced for the 2018 season. The use of a single kit will effectively return IndyCar to the position it was in prior to the 2015 season when all the teams used the single kit developed by chassis manufacturer Dallara.

Hadar Goren/IndyCar

ABOVE Smoothing the path: The return to a single aero kit could make the cars more visually pleasing

The teams will use their existing kits, unchanged, through to the end of the 2017 season, while the new kit, which is said to have the support of all teams in the series, is developed.

IndyCar president of competition Jay Frye told US media that part of the reason for reverting to a standard kit was the sport's goal to attract a third engine manufacturer – the cost of developing an aero kit being a major obstacle to potential new entrants.

Aims in developing the standard kit will include simplifying it with fewer separate components and moving more downforce to the car's underside. Frye also hopes that by effectively adopting a clean-sheet approach, the visual appearance of the IndyCar chassis will be improved.

A manufacturer to develop the new kit will be selected once initial development has taken place. According to reports in the US, Pratt & Millar, which developed the kit that has enabled Chevrolet to take the most recent two of its five successive IndyCar titles, has ruled itself out of the new kit's development, despite wide support across the IndyCar field for it to take on the role. RT

IndyCar cuts its test schedule

Andrew Charman

INDIANAPOLIS, IN: The Verizon IndyCar Series has reduced the amount of in-season testing permitted as part of a programme of cost-cutting measures. During 2017 four two-day open tests will be held by the series, in February, March, May and September. Teams will be allowed one extra test day between 11 April and 17 September. A pre-season test window will open on 3 October and run until 6 April, with teams allowed three test days. The closure of the window occurs between the first two races of the 2017 season at St Petersburg on 12 March and Long Beach on 9 April, allowing teams to test after the season-opener if needed.

By running a rookie driver to the series teams can test for up to an extra four days during the season or a single extra day by running a driver from the supporting Indy Lights Series.

Tyre supplier Firestone can also schedule two-day tests with only two teams taking part in each, but those teams can carry out their own testing on one of the days. Engine suppliers Chevrolet and Honda are also permitted two test days during the pre-season window. If a new team enters the series, it will be permitted up to four additional days of testing. RT

NASCAR hands out stiffer penalties for tech failures

Andrew Charman

DAYTONA BEACH, FL: NASCAR has issued new rules concerning the penalties that will be applied if cars fail technical inspections at the conclusion of races. There have been numerous examples of penalties being issued when cars failed to pass the laser-measuring platforms at the end of races, or were found not to have all the lug nuts in place on their wheels. Penalties have resulted in point deductions in the driver and owner championships and fines and suspensions for the crew chief.

However, just in time for the start of the season-concluding Chase, with its knockout format, NASCAR has tightened the penalty procedure across all three of its leading series, the Sprint Cup, Xfinity Series and Craftsman Truck Series.

Victory in a Chase race automatically advances the driver to the next elimination stage of the 10-race series, but officials will now have the choice of declaring a car 'encumbered' and stripping the driver of the automatic advance.


Jerry Markland/NASCAR via Getty Images

ABOVE Seeing the light: NASCAR developed the laser inspection platform for the 2014 season but in 2016 it has produced many penalties, reputedly as teams 'push the envelope' of legality

Failing the platform will now be deemed at P4 level under NASCAR's penalty system, which will be applied if a vehicle's rear toe measurements exceed the allowed measurements on both sides. As well as being declared encumbered, a Sprint Cup team will lose 35 championship driver and owner points, while the crew chief will be fined $65,000 and be given a three-race suspension.

Xfinity Series teams will suffer the same penalties but with a $20,000 fine for the crew chief. Craftsman Truck entrants are not checked on the LIS platform. Having at least two lug nuts improperly secured or missing will result in a 15-point penalty plus a $20,000 fine and one-race suspension for the crew chief, but they will now only be fined $10,000, and not suspended if only a single nut is at fault. RT

VBOX VIDEO

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

Supplied in a rugged, water resistant case, with two cameras, internal GPS logger, backup battery supply, up to 30s video pre-buffer and real-time graphical overlay, **VBOX VIDEO** represents the ultimate in tough, reliable motorsport video loggers.

VBOX VIDEO when used with **CIRCUIT TOOLS** - intuitive, simple to use data analysis software developed by racing drivers for racing drivers - can quickly help any level of driver go faster.

- Dual Camera HD – 1080p
- Real-time graphical overlay
- Ultra-smooth video
- Class leading driver training software (Windows, macOS & iOS versions)
- 10Hz GPS data logging
- Video record pre-buffer
- Camera preview over WiFi
- CAN interface

VBOX VIDEO HD2 available to order online now

Professional racing drivers share their experience on advanced circuit driving techniques in our FREE eBook: www.vboxmotorsport.co.uk/ebook

www.vboxmotorsport.co.uk

New Dakar Peugeot to uphold honours

Hal Ridge

PARIS, France: Peugeot Sport has unveiled the 3008 DKR, a brand-new car to replace the victorious 2008 DKR to defend its Dakar rally title in January. While its extreme appearance almost harks back to the Group B-derived dune chargers of the past, it is based on a new model although under the skin it is more about perfecting and developing the technologies using knowledge gained with the 2008.

It will remain rear-wheel drive – Stephane Peterhansel's victory in the 2008 last year being the first outright win for a two-wheel drive machine in 15 years. A six-speed sequential gearbox is mounted to the car's mid-rear mounted V6 diesel engine producing in the region of 340 bhp and 800 Nm torque that sits longitudinally in the tubular spaceframe chassis.

The car boasts 460 mm of suspension travel, similar to its predecessor, but the new version features developments to the dampers, of which there are two per corner to deal with the extreme conditions on the world's most famous cross-country event. Further improvements have been made to the overall mechanical integrity, the electronics and engine management.

The 3008 is longer than its predecessor by 213 mm, but the wheelbase is also increased, by 200 mm, meaning the car maintains its short front overhang, and thus the ability to climb seemingly insurmountable inclines.

The carbon fibre clad tubular spaceframed machine will make its competition debut in the hands of Carlos Sainz at the start of October on Morocco's Rally as part of the pre-Dakar development programme. Peugeot drivers won every stage of the Dakar in January and the French carmaker will be hoping for a similar performance in the New Year in a bid to secure its sixth overall win. RT

See Peugeot 3008 DKR page 28

Kia comeback

Hal Ridge

BARCELONA, Spain: Almost 12 months after debuting his unique Kia Rio Supercar in the FIA World Rallycross Championship, former World Rally star Gigi Galli is set to return to World RX.

On the eve of the car's debut in Italy, *Race Tech* magazine interviewed Galli's G Car Sport team for a feature in RT181 (December 2015), but the next day, in its first rallycross practice session, the car suffered engine problems and despite grand plans for a two-car full-time World RX assault this year, all went quiet on the Italian front.

Working behind closed doors, Galli employed the services of established rallycross engine builders Lehmann, based in Liechtenstein, a firm which built engines for Group B Audi Quattros almost three decades ago and currently supplies motors to Mattias Ekstrom's EKS RX Audi S1 team, which currently leads both the drivers' and teams' championship standings in World RX. Like the HKS unit originally used by Galli in his Kia, the 2.0-litre turbocharged engine will fall into the 'custom engine' regulations introduced into World Rallycross in 2015.

Before the inception of the 'custom engine' regulations, a chassis had to be accompanied by an engine block from the same manufacturer. The 'custom engine' regulations allow for any engine components to be used, as long as they fit within strict dimensions and weights, dictated by the regulations.

Based on Lehmann's existing rallycross customers, the assumption can be made that the engine in the Kia shares its origin with the units in EKS's Audis, although Galli won't be drawn on such details.

Other changes to the Kia have included the engine management, with Lehmann traditionally using Bosch for both the ECU and dash display.

Cautious of not wanting to return to competition until he was sure his Kia was on the pace, Galli tested his updated car at the Barcelona rallycross circuit, located in the final sector of the Circuit de Barcelona-Catalunya Formula 1 venue the day after the World RX event in September, to compare times set by World RX contenders the previous day, in similar conditions.

"We ran a few kilometres without any major problems, which was just a confirmation of our feeling," said Galli, whose Kia looked visibly better balanced than on its debut in Italy, at the Spanish test. "I have to say the time is better than we expected. I'm so happy to be working with our engine builder, Lehmann. The engine is working well. Last year we were not really ready at all, but now our partners have given us a good step, with Reiger (suspension) and UNIC (transmission) also. They have good experience, that's what we need. Italy has no experience in rallycross, we are like a pioneer for this in Italy."

The Italian says his car is night and day different to when he drove it last year, and doesn't feel that driving with a longitudinally mounted engine after competing for years in rallying with a transverse setup will affect him. "The car is another story to when I first drove it. We did two tests before this, and now this is the first real test to simulate a race. For sure the car is okay. It's quite different (to what I am used to), in terms of power and so on; everything is different. What I know is that the weight distribution is quite equal (with the longitudinal setup) thanks to the position of the engine."

Following the success of the test, Galli is expected to contest the final two European-based rounds of the World Rallycross Championhip in Latvia and Germany in October. RT

SUPERTECH

CHOOSE YOUR

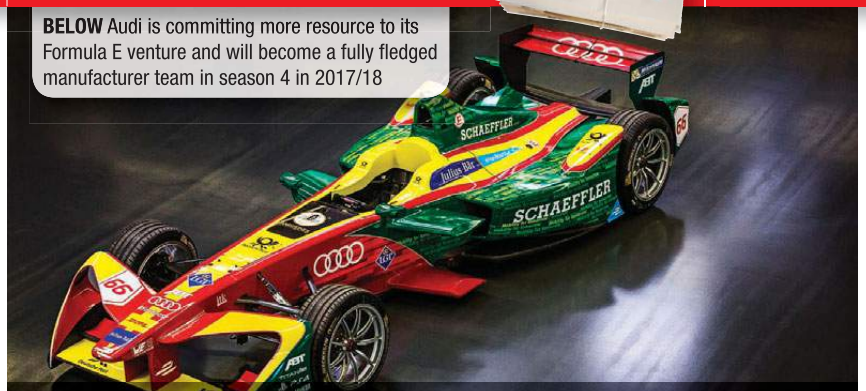
WEAPON

STREET PERFORMANCE / HIGH PERFORMANCE / INCONEL / SODIUM FILLED / TITANIUM VALVE

FUSING PERFORMANCE, DURABILITY, AND SUPERIOR CRAFTSMANSHIP THERE ISN'T A BETTER CHOICE FOR PERFORMANCE VALVE TRAIN COMPONENTS. CHOOSE YOUR WEAPON AND DESTROY THE COMPETITION.

WWW.SUPERTECHPERFORMANCE.COM

SUPERTECH



BELOW Audi is committing more resource to its Formula E venture and will become a fully fledged manufacturer team in season 4 in 2017/18

Audi confirms electric racing future

William Kimberley

INGOLSTADT, Germany: Audi has confirmed that it is becoming more involved in the FIA Formula E Championship. In season 3 that gets under way in October, it will provide more financial and technical support to Team ABT Schaeffler Audi Sport but in the 2017/18 season 4 it will develop into a fully fledged factory commitment.

Audi Sport has been giving its name to the team ever since the inaugural 2014/2015 Formula E season and in the Brazilian Lucas di Grassi making one of its factory drivers available in the course of this co-operation. In addition, the team has been able to use Audi Sport's infrastructure in Neuburg.

"Electric mobility is one of the key topics in our industry," said Dr Stefan Knirsch, Audi board member for technical development. "We intend to evolve into one of the leading premium car manufacturers in this field. By 2025, every fourth Audi should be an electric vehicle. The first model for this is planned to be an SUV we're going to present in 2018. In the light of these plans, adapting our motorsport programme and taking up a commitment in a fully electric racing series is only a logical move."

"Audi has consistently been using motorsport to test and develop new technologies further for subsequent use in production," said Dr Wolfgang Ullrich, head of Audi Motorsport. "With quattro drive we revolutionised rally racing and subsequently set standards in circuit racing as well. In the 24 Hours of Le Mans, Audi was the first manufacturer to have achieved victories with a TFSI engine, a TDI and a hybrid race car, so writing motorsport history on several occasions. Now we intend to repeat this in fully electric racing. Formula E with its races being held in the hearts of major cities is an ideal stage for this purpose and Team ABT Schaeffler Audi Sport a logical partner for us." RT

Jaguar reveals name and livery

William Kimberley

COVENTRY, UK: Jaguar has revealed the I-TYPE 1 as the car that will be competing in season 3 of the FIA Formula E Championship. It has also outlined its partnership with Panasonic that will become the team's title sponsor. It forms part of the car company's 'Race to Innovate', its mission to change the perception of electric vehicles, to develop new electric technology and to inspire future generations. In addition, Jaguar also announced Lear Corporation as an Official Team Partner.

"Today marks a new chapter in the history of Jaguar Racing," said Gerd Mäuser, chairman of Panasonic Jaguar Racing. "As the first premium car manufacturer in Formula E we are proud to be back in top level motorsport. The future is changing and we're part of that change. We can't wait to begin racing competitively in inner city locations inspiring a whole new generation of fans to join us on this exciting journey. Formula E is the perfect platform to inspire the next generation."

Nick Rogers, executive director, product engineering at Jaguar Land Rover, underlined the important role Formula E will play in developing next generation electric vehicle technology and the importance of electric vehicles in Jaguar Land Rover's future product portfolio. "Over the next five years we will see more changes in the automotive world than in the last three decades," he said. "The championship will enable us to engineer and test our advanced technologies under extreme performance conditions. We will apply this vital knowledge as part of our real world development. At Jaguar Land Rover we employ 9,000 engineers and the team will draw on these engineers to extract data and push the boundaries of electric technology in a race environment." RT

ABOVE The 1-TYPE-1 Jaguar that will be taking the famous name back to motor racing

See The Cat Whirrs page 28

OMP named Electric GT safety supplier

LONDON, UK: The Electric GT Championship, the first ever 100% zero emissions GT championship, has confirmed that OMP will become the series' official safety partner. The championship, which was announced in March, will see 20 identical race-prepared Tesla Model S version P85+ cars running on Pirelli tyres. 10 teams and 20 drivers will compete across seven races during season one.

"Motorsport will always have an element of risk involved, so it was important for us to have a trusted partner with a first-rate track record in safety," said Mark Gemmell, the Electric GT Championship CEO. "OMP has proven itself an industry-leader in this regard over the last 40 years and its unending pursuit of innovation and quality makes it an excellent fit for our ground-breaking new series." RT

Motorsport. Redefined.

Highly Evolved.

Actual Screen Images

The STACK LCD Motorsport Display is the next evolution of driver communcation and data acquisition. Designed specifically for the harshest of environments, the carbon composite housing is IP67 sealed against water and dust intrusion and will easily withstand 20 g of continuous vibration and 50 g of shock. Our 7" LCD panel ensures easy visibility under all circumstances with a retina level pixel densisty, unmatched brightness and an optically bonded lens for extreme glare suppression. The display layout is fully configurable to your individual specifications. The system will accomodate four programmable data bus channels (2 CAN and 2 serial) in conjunction with a nearly limitless amount of discrete analog sensors and its integrated 3 Axis Accelerometer. Data collection can occur at up to 1 kHz and the internal memory allows for practically infinite recording time. User defininable warnings take advantage of super bright, multi-coloured LEDs placed around the perimeter of the chassis to alert the driver to critical onscreen information. Quite simply, everything else suddenly seems a bit dated.

World Class Instrumentation

YouTube™

stackltd.com

STACK STACK STACK

Advanced manufacturing investment

William Kimberley

MODENA, Italy: CRP Group, which is well known in the motorsport, UAV and aerospace industries for its expertise in additive manufacturing and advanced 3D printing, has recently been heavily investing in new machinery including a Ricoh AM S5500p laser sintering system. A multi-material 3D printer with large modelling area of 550 x 550 x 500 mm, it enables the concurrent manufacture of several components, saving time. It ensures fast, flexible and cost-effective production thanks to its highly accurate and repeatable manufacturing capabilities.

"We are the first in Italy to have a multi-material 3D printer with a large modelling area," said Franco Cevolini, CEO of the CRP Group. "It allows us to make the most of the range of the materials available to us, including our Windform family of high-performance composite materials."

CRP has also invested in a new Mikron HPM 800U milling machine that optimises the milling process, which improves the process safety and the quality of the workpiece in unmanned operation and can be used for anything from heavy roughing work to precise finishing work. It has also been built for speed, accuracy and reliability.

The third investment is in an X line 2000R from Concept Laser, the largest laser melting-based 3D printer in the world. Used primarily in the aerospace and automotive industries it increases the build volume of the X line 1000 by 27%, from 126 to 160 litres. The exact measurements are 800 x 400 x 500 mm, which is two to three times larger than that offered by competitors with laser melting metal 3D printing capabilities. At the heart of the new system is the dual laser system, with each ray offering 1000 watts of power. Although it is not the only factor, this contributes to increased build speed, as the build area is exposed simultaneously from two different positions.

"Speed and volume are important requirements for high-quality production," said Cevolini. "The benefits offered by X line 2000R is a decisive competitive advantage when it comes to competing, and it projects CRP Meccanica among world leaders in terms of production capacity."

CRP Technology, a part of the CRP Group, has launched Windform FX Black, a new generation polyamide based composite material with a dark black colour. Its mechanical characteristics make it particularly suited for additive manufacturing applications and it is characterised by exceptional resistance to repeated bending and torsion, and excellent impact resistance even at low temperatures. Its consistency and behaviour are similar to polypropylene and ABS injection moulded parts. No post-production treatments are needed, as the material has an excellent surface finish in its sintered state. Any additional manual finishing improves its polish. RT

Hyundai's first customer car

BELOW Hyundai Motorsport team principal Michel Nandan and Andrea Adamo, who oversees the Customer Racing department, and Luca Murdolo, team manager of the privately run Italian squad that has bought the car

ALZENAU, Germany: A year after its establishment, Hyundai Motorsport's Customer Racing department celebrated a major landmark in mid September when the first New Generation i20 R5 ordered by a private team was rolled out of Hyundai Motorsport headquarters in Alzenau, Germany, and passed to its new owners.

The milestone comes in the middle of a very busy period for the department responsible for the new machine. This began with the most recent tests of the New Generation i20 R5 in late August, ahead of the homologation process for the car. This was carried out alongside the building of the third and fourth New Generation i20 R5 chassis. More importantly, however, these are the first chassis to be built specifically for a customer, as the programme moves from development and testing, into production. RT

Citroën reveals WRC concept car

PARIS, France: Citroën Racing has shown a concept car ahead of the Paris Motor Show that it says is a first look at the C3 WRC car with which it will be competing with in next year's FIA World Rally Championship. According to the press release, the chassis is 55 mm longer than the production version for aero purposes that include a protruding front bumper and a rear bumper fitted with a diffuser. It also features an enlarged rear spoiler that has been moved further back for even greater aerodynamic support. The engine has been slightly uprated to around 380 bhp by enlarging the diameter of the turbo flange to 36 mm. RT

PERSONNEL

Former Ferrari and Haas F1 Team strategist **Ruth Buscombe** has joined the Sauber F1 Team as its new strategy engineer, starting from the Malaysian Grand Prix. She joins Sauber from the Haas F1 Team where she held the position of strategy engineer before leaving in June. She is the most recent recruit of Sauber since the team was taken over by Longbow Finance in July, following the team's founder Peter Sauber selling his shares to the investment group in order to ensure the future of the team. RT

BRAKE LATER

FERODO Racing brake pads give you race winning bite, deceleration and control all the way to the Apex.

FERODO®
RACING

WWW.FERODORACING.COM

Ebrey/BTCC

BELOW Power play: The performance of the Levrog GT has sparked a major row between Team BMR and BTCC organiser TOCA

BMR Subaru stokes BTCC engine row

Andrew Charman

LONDON, UK: The war of words over the British Touring Car Championship's engine equalisation rules has continued this month, with series organiser TOCA describing further comments made by the Silverline Subaru BMR Racing team as "incomprehensible."

Race Tech reported last month how BTCC series director Alan Gow had dubbed comments at Knockhill by BMR driver Jason Plato, criticising the equivalency process, as "bizarre" and "borderline offensive".

Plato had claimed, after setting pole position at the Scottish circuit that his Subaru Levorg should have been half a second faster, and indicated that the equivalency rules were hampering the Subaru team's progress.

In response Gow stated that he was "just astounded by this latest round of moaning by Jason," and revealed that the transformation in performance of the Subarus after the opening two meetings of the championship was due to a waiver given to the team allowing the modification of the cars' inlet manifolds. Gow also speculated as to whether Plato's views were shared by his team.

Before the following meeting at Rockingham, Team BMR issued a statement, understanding the frustrations of their drivers but adding that having seen the data that TOCA uses to determine the engine equivalency, "the maths and processes are in fact a remarkably accurate judgement of the power output of each engine at the test conditions… we support TOCA and the foundation of the processes in place."

Within hours, however, BMR withdrew the statement, and tried without success to persuade websites that had already published it to take it down. A revised version was then issued, adding a paragraph reading: "We believe these test conditions do not translate to actual 'on track' straight-line speed performance and recommend revisions moving forward if we are to achieve the common goal of 'on track' speed equalisation."

The revised statement also suggested that other teams and manufacturers had made "similar proper Homologation Extension applications also in accordance with the regulations."

The revision produced a firm reply from TOCA, which described parts of the statement as "factually incorrect" and "adding to confusion".

The series organisers insisted the waiver given to BMR was a unique occurrence. "No BTCC team has ever before been granted a waiver during the course of the championship to change a major component that will substantially improve their performance," and BMR's stance on straight-line speed was branded "incomprehensible" by TOCA, which stated: "There has never been a common goal of 'on track speed equalisation'.

"As BMR acknowledges and agrees, each engine's power is equalised, but how that then converts to on-track performance is entirely up to each team and subject to a great many variables in each car – such as aerodynamics, weight, engine cooling, differential settings, drivetrain format, gearing, corner exit speeds, rolling resistance and many more variances…

"Therefore like all other major motorsport championships, we have never sought to equalise straight-line speed performance….We do not know of any major championship (particularly one with such a great variety of engine types, drivetrains and body shapes as ours) where this is done.

"To think that all cars should be subject to a 'speed equalisation' is nonsensical, in our view. To attempt to match each and every type of car to achieve identical top speeds is a naïve and virtually impossible goal – particularly with the diversity in our championship."

As *Race Tech* went to press no further comments had been released by Team BMR. RT

Wing angle loses MG a one-two result

Andrew Charman

SILVERSTONE, UK: Just as *Race Tech* went to press the two MG6 entries of Triple Eight Racing were excluded from a one-two finish in round 25 of the British Touring Car Championship at Silverstone.

In post-race scrutineering the rear wing angles of the two MGs were found to be outside of the permitted homologation box. The two cars were sent to the back of the grid for the next race and the victory was awarded to the Speedworks Toyota Avensis of Tom Ingram that had crossed the line in third.

The BTCC's NGTC formula specifies a single rear spoiler for all entries, supplied through series organiser TOCA. Its position on the rear of the car is determined in a wind tunnel test administered by TOCA before the car enters the championship. The height above the rear of the car and position forward of the rearmost part of the rear bumper determined in the test, as part of the series' efforts to equalise the aerodynamic performance of the various different cars in the championship. Five degrees of adjustment angle is built into the wing with a tolerance of +2/-3 degrees, pivoting on the front fixing point of the wing.

Triple Eight later announced its attention to appeal the exclusion of driver Josh Cook from second place, but accepted the penalty to race winner Ashley Sutton.

If the appeal proves successful Cook would take his first win in the BTCC. RT

Ebrey/BTCC

ABOVE Aero angst: The angle of the rear wing on Ashley Sutton's MG (right) handed Silverstone victory to the Toyota of Tom Ingram (left)

Ford back in TCR

SINGAPORE: Hong-Kong based FRD Motorsport debuted its TCR Series specification Ford Focus at the Singapore rounds of the International championship on 17-18 September. The car was based on the Focus built for the first season of the championship in 2015 by UK-based Onyx, but Brian Ma, technical head of FRD Motorsports, admitted that the planned update to the Onyx car had evolved into a more extensive redesign.

TCR

LEFT Fast Ford: FRD Motorsport hope to restore the Ford Focus to competiveness in the TCR International Series

"The original intention was to do an update and improve a few things that prevented (the car) from being competitive," he said. "However, as we delved into the development process further, we realised we could provide a better car to our future customers by starting anew in many areas – I would say the 2016/17 Focus is more a redevelopment than an evolution of the 2015 car."

The changes include a new engine package, a new Xtrac six-speed paddleshift transmission – the original road-based gearbox having been an Achilles heel of the Onyx car – all new electronics and damper and brake systems, and an aerodynamic package already proven on an FRD entry in the Chinese Touring Car Championship. RT

IN BRIEF

THE US looks set to lose another track after agreement was reached to sell Nashville Superspeedway to a real estate operation. The oval was opened in 2001 to an unusual 1.3-mile length to suit both NASCAR and IndyCar races, but struggled to attract attendances and staged its last race in 2011. RT

HONDA is expected to confirm its continuing involvement in the World Touring Car Championship shortly, following the withdrawal of Citroën at the end of this season. The Japanese brand decides its programme on a rolling year basis, but is currently enjoying its most competitive season in the WTCC. Honda officials say nothing is confirmed yet but signs are positive. RT

PROPOSED cost-cutting measures under discussion for the DTM include reducing each manufacturer's entry from seven to six cars, cutting the grid to 18 cars. New technical regulations are also under discussion but a switch from the current V8 engines to 2.0-litre units has been delayed until 2019. RT

NISSAN has confirmed that it will race for at least two more years in the V8 Supercar series, continuing with its current Altima model and V8 engine despite the arrival of new Gen2 rules to the Australian series with a wider choice of car and powertrain options. However, the Japanese brand will also launch a study into a potential different package for the 2019 season onwards. RT

THE Verizon IndyCar Series has confirmed a switch of its brake supplier from Brembo to Performance Friction. In a multi-year agreement, PFC will become the exclusive supplier of the carbon brake package to the series from the 2017 season onwards. The braking performance has been the most consistently criticised element of the Dallara chassis and the change has met with wide support among teams. RT

Tues 29th & Weds 30th November 2016

We are delighted that both Ulrich Baretzky, Head of Engine Technology at Audi Sport, and Formula 1 consultant John Iley have both agreed to be our Chairmen again, chairing what should yet again be a fascinating debate.

Chairmen

John Iley
Formula 1 consultant

Ulrich Baretzky
Head of Engine Technology at Audi Sport

Keynote speaker

Ian Constance
Chief Executive Officer, Advanced Propulsion Centre UK

Cabinet Members

Gilles Simon
Engineering Consultant

Fred Turk
Vice President of Mahle Motorsport

Vincent Beaumesnil
Sports Manager, Automobile Club de l'Ouest

Steve Sapsford
Global Market Sector Director, Ricardo

Pascal Vasselon
Technical Director, Toyota Motorsport GmbH

Dr Peter Schoeggl
Head of Business Field, AVL List

To book tickets now
Visit - www.worldmotorsportsymposium.com
or call +44 (0) 20 8446 2100 #WMS16

AERO TEC LABORATORIES LTD

WMG THE UNIVERSITY OF WARWICK

www.kimberleymediagroup.com

KIMBERLEY MEDIA GROUP LTD

THE NEXT GENERATION

Technology Change and How to Deal with it - a Motorsport Perspective

DRIVING TECHNOLOGY INTO POLE POSITION
RACE TECH INTERNATIONAL
WORLD MOTORSPORT SYMPOSIUM
29 & 30 November 2016

We live in whirlwind times. What was hot and current even just 10 years ago, is now passe and forgotten. Gone are the days when things could be taken for granted, when technology evolved more slowly, when it was easier to plan - everything is now happening at breakneck speed.

The next generation engineer will be challenged by issues that are not yet being flagged up on any radar screens, so what this World Motorsport Symposium sets out to address is what might be just over the horizon. What will racing cars of the future look like?

The theme of the next Symposium is
Technology change and how to deal with It - a motorsport perspective.
Motorsport technology has always pushed boundaries, but those boundaries are rapidly changing in the modern world, and just what are those boundaries anyway and are they relevant to motorsport? So the question is whether motorsport is blazing a trail, playing catch up or does it have anything to offer in the new digital era?

These and many other issues will be covered in what promises to be the most wide ranging discussions the RACE TECH World Motorsport Symposium has ever held.

VENUE:

WMG
THE UNIVERSITY OF WARWICK

International Manufacturing Centre (IMC)
University of Warwick
Coventry, CV4 7AL

AWARDS DINNER

Evening of Tuesday 29th November
Network with Motorsport's elite....

THE AWARDS: **Dino Toso Racecar Aerodynamicist of the year**
Racing Engine Designer of the year
Don Burgoon Most Innovative New Motorsport Product of the year

The RACE TECH World Motorsport Symposium networking awards dinner begins with a champagne drinks reception that has become an evening renowned for gathering the best in the industry and offering a perfect networking environment in a warm and friendly setting. With a table plan that is meticulously planned to allow guests to sit with those they'll benefit from most, they can also guarantee an evening of fine wine and food. The awards ceremony promises to be short and sweet too.

7.15pm - Champagne drinks reception
8.00pm - Dinner
10.00pm - Awards ceremony

To book tickets now
visit - www.worldmotorsportsymposium.com
or call +44 (0) 20 8446 2100 #WMS16

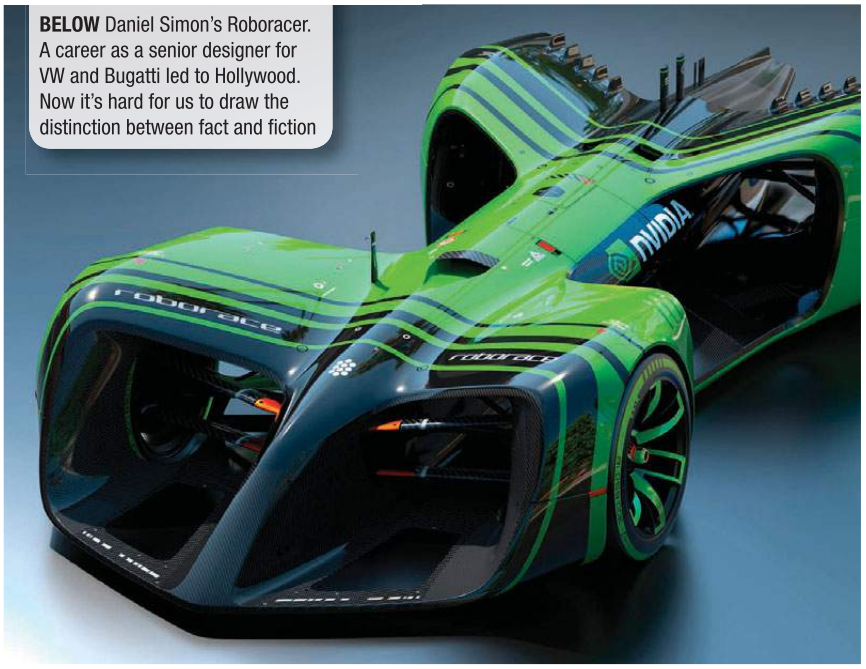
Nailcote Hall
Hotel, Golf & Country Club

A quintessentially English 17th century country house hotel based in Warwickshire, Nailcote Hall will be the venue for the RACE TECH World Motorsport Symposium champagne drinks reception and Networking Awards dinner

Martin Whitmarsh, former McLaren F1 team principal and Adrian Newey

ROBOT RACING: JUST ADD DRIVERS

Chris Ellis embraces the Roborace dream



BELOW Daniel Simon's Roboracer. A career as a senior designer for VW and Bugatti led to Hollywood. Now it's hard for us to draw the distinction between fact and fiction

WHEN I saw Daniel Simon's concept of a 'roboracer' my first reaction was, "I want to drive it!" Which is not quite as silly as it sounds. Let me explain why.

For a moment, forget about the computers and powertrain, and imagine building Daniel's car around an F1 survival cell. Would the central nacelle need to be much wider? No. Would Red Bull's cockpit windscreen look out of place? No. Would a large fin (functionally, an 'advertising hoarding') behind the cockpit spoil the lines of the car? Definitely not; it would look even better. And there it is – the overall design of a 2019 Formula E car!

The proposed Roborace minimum weight limit is 1,000 kg, so will provide scope for a 300+ kW surge power system connected to all four wheels to maximise energy recovery during braking which, together with extra battery capacity, should make feasible both a top speed of close to 300 kph and a race duration of at least 40 minutes, without the current embarrassing need for two cars per driver. The enclosed wheels and double wings all round should help reduce drag, assuming sensible levels of downforce.

Now let's take our prototype 2019 Formula E car and replace the driver with the necessary computer gubbins, cameras, etc. The result will be a much more impressive Roboracer. A total power limit of 500 kW, say, for both formulae would allow direct competition between the two, although perhaps not until at least 2021. Note the synergy and the cost savings, plus the scope for future 'Man vs Machine' spectaculars.

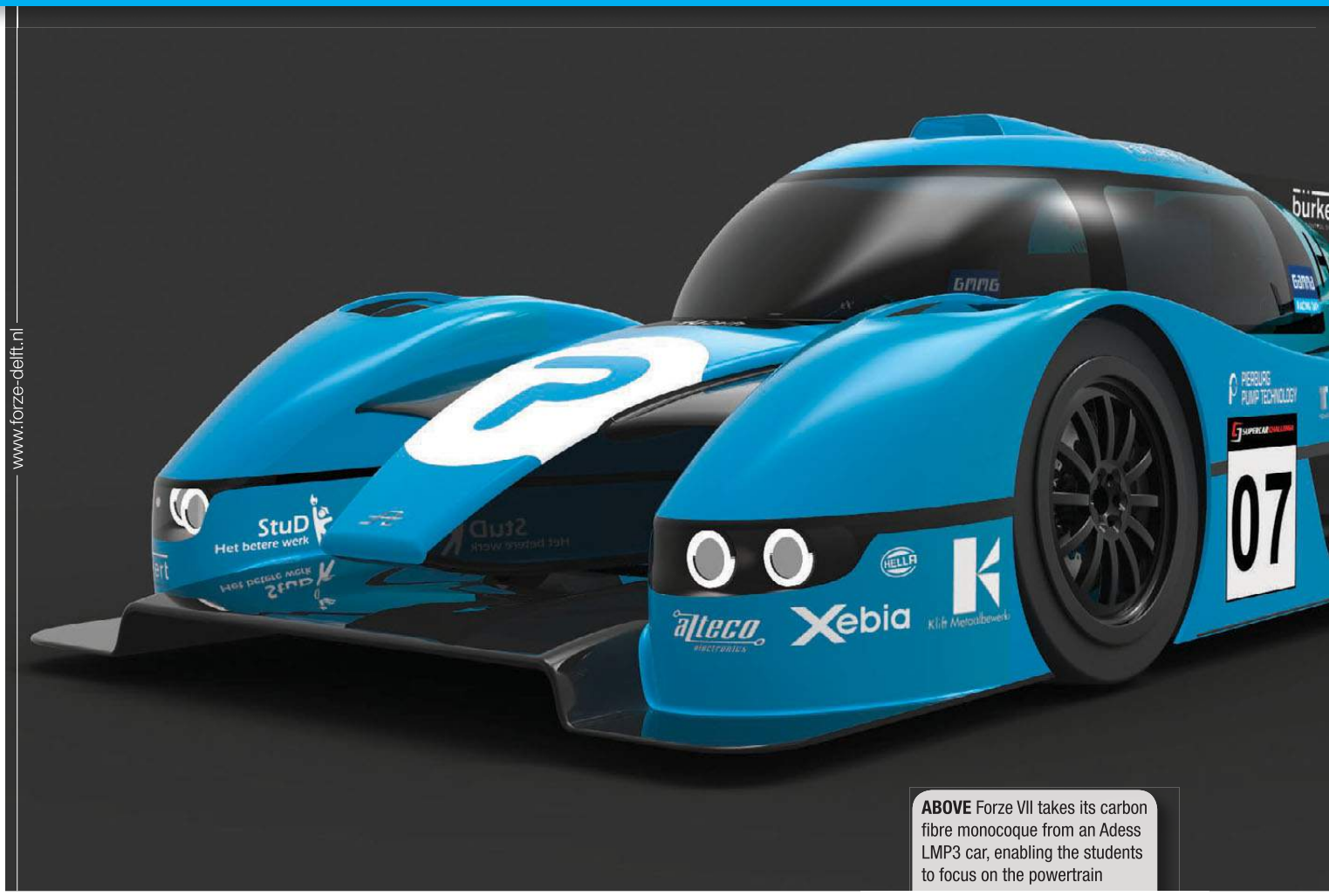
There's a fundamental difference between the software needed to drive road cars and Roboracers. Road driving is essentially cooperative, not competitive, despite the way some of us drive. Driverless cars will be made to obey, precisely, all the rules of the road, including speed limits. Expect even the German government to enforce a blanket 130 kph limit on 'automobiles'. Incidentally, given the use of the term 'autonomous vehicles', perhaps the word 'automobile' ('auto' for short) can become the new, very sensible, global name for driverless cars, now that most Americans are calling cars – 'cars'.

Autos will take cooperation to the next level, because they will be communicating constantly with each other, so that they will not just be aware of what all the vehicles around them are doing, but what the other autos *intend* doing. Think 'collective intelligence'; for example, the sharing of opinions amongst the autos about the level of driving skill of the human drivers: "He seems to be pissed. Steer well clear (precise location supplied)." And the nearest police auto will 'hear' this and surge forward, the autos in front diving out of its way…

We can expect at least one roboracing team to be caught trying to sacrifice their second auto to give their first one victory; but no blood was spilled. The FIA will have fun trying to stop this, and framing the regulations. For example, will racing autos be allowed to consult the 'big brains' in the pits – and the humans back in Maranello, etc? How autonomous is autonomous?

Will Roborace impact Formula 1? I hope so. Take my theoretical 2019 Formula E car, throw out the massive battery pack, upgrade the surge power system to deliver 400 kW, and fit a slim straight six delivering up to a new FIA engine power limit of 600 bhp. BMW has already sold hundreds of road-legal M4 GTSs with 493 bhp available from a 3.0-litre straight six, so it should find it easy to supply a relatively cheap 600 bhp racing version to some of the F1 teams. Ferrari, Honda, Mercedes and Renault will probably hate this idea. So it's probably a good idea – see 'complex monopoly'.

The bottom line is – Daniel Simon's Roboracer concept has already shown Formula E the way forward, even if roboracing inevitably proves boring once the novelty wears off. And it also shows how much better looking the cars of Formula 1 could be if narrow-minded, short-term, interests weren't allowed to dominate decision making. RT



ABOVE Forze VII takes its carbon fibre monocoque from an Adess LMP3 car, enabling the students to focus on the powertrain

A FORZE TO BE RECKONED WITH

A group of students could be about to make history as the first team to compete against conventional cars in a fuel cell vehicle, **Chris Pickering** discovers

WHAT are the chances that we'll see a hydrogen fuel cell racecar from a major manufacturer in the next years? There have been persistent rumours that BMW or Audi could enter a car in the experimental Garage 56 class at Le Mans, possibly as soon as 2018. You can also imagine somewhere like Pikes Peak being a prime candidate for a demonstration drive. But whenever and wherever one of the large carmakers does decide to pitch its hat into the ring, it's highly likely that a group of students from The Netherlands will have beaten them to it.

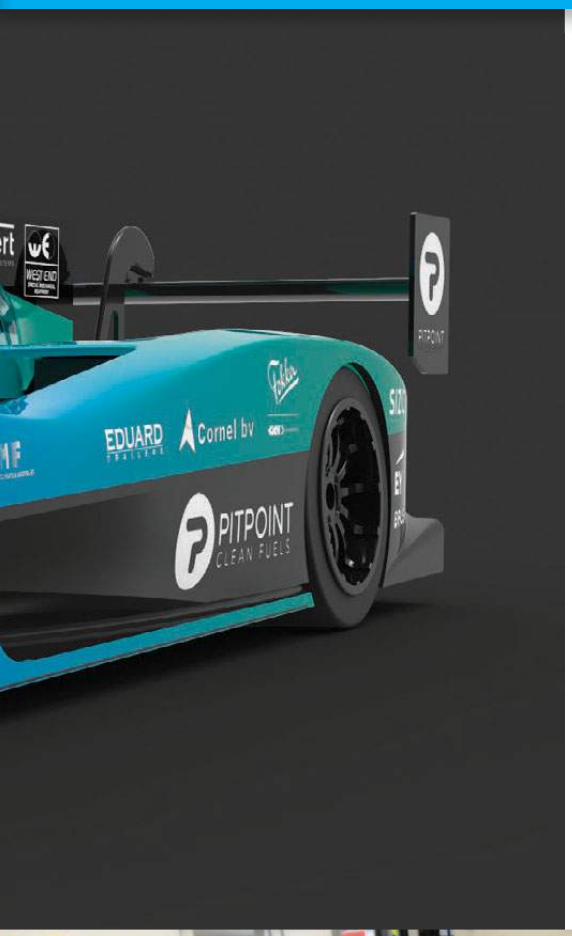
Around the time that this issue of Race Tech goes to press, the Forze Delft team should begin track testing with a new fuel cell-powered car that it plans to enter into the Dutch Supercar Challenge. Comprised of around 70 students, the team is an independent organisation based at Delft University of Technology and open to anyone looking to take part.

Some of you may be rolling your eyes at this point. This isn't the first time we've heard about a fuel cell car waiting in the wings, nor would it technically be the first to compete. But there are a number of reasons why this one deserves to be taken seriously – not least because the Delft team has considerable 'form' in this area.

The Forze project was originally born out of the Formula Zero kart championship. It's often overlooked that fuel cell vehicles were actually competing in these time trial events as far back as 2008.

Having successfully built the first three Forze cars for Formula Zero, Delft took its fuel cell knowhow to Formula Student for numbers four and five. Things got serious in 2013, however, when the team built its first full-size fuel cell car, the Forze VI, based on a heavily modified kit car chassis.

That car captured the electric lap record at Zandvoort in December 2015 with a time of 2m 04.45s, breaking the previous record set by a Tesla roadster at 2m 10.9s. It also holds the unofficial record for a fuel cell vehicle



at the Nürburgring Nordschleife, where it knocked a full minute off the previous time – admittedly set by the rather less sporting Nissan FCV X-Trail concept!

For the latest car – christened the Forze VII – the plan is to race side-by-side with conventional combustion-engined opposition in one of Europe's most hotly-contested sports car championships. We're no longer talking about demonstration drives or record attempts, but full-length competition. Things, it seems, have got distinctly serious.

UNDER THE SKIN

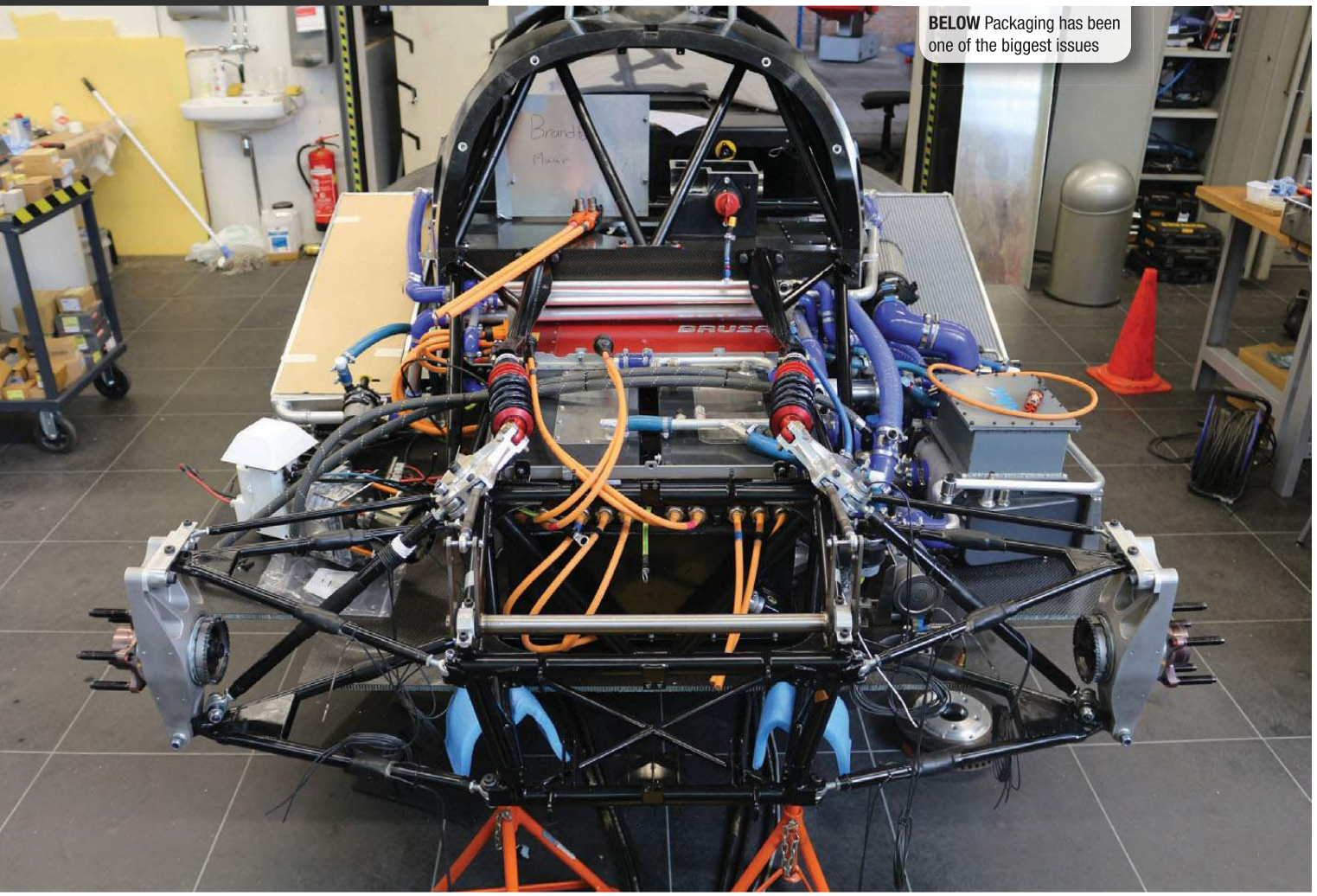
Make no mistake, engineering a fuel cell car is a formidable challenge by any standards, but the students at Delft have simplified things to a degree by using existing components. The Forze VII's carbon fibre monocoque, for instance, is taken from an Adess LMP3 car. From the rear bulkhead back, however, the structure has all been designed in-house, with a tubular steel subframe (expertly welded by WEST END) used to carry the powertrain components and the rear suspension.

"In most LMP cars the engine would be used as a structural component, but you can't do that with our fuel cell, so we've got quite a substantial frame," explains outgoing team manager Rick Everaert. "Using this approach gave us more flexibility, but getting the packaging to work was still really hard. It's so densely packed [around the powertrain] that we even struggled to route the cables."

The Forze VII's suspension is double wishbones with pushrod actuation all-round. As with a lot of sports prototypes it uses coil springs all around, allied to a set of Koni adjustable dampers.

Like most fuel cell vehicles, the Forze VII is effectively a hybrid. The fuel cell stack runs at a fixed output, supplying a capacitor-based energy storage system known as the accumulator. This handles all the transient power demands – reacting almost instantaneously to the driver's throttle inputs while the fuel cell keeps topping it up at a fixed rate in the background.

This energy storage system also gives the car ▶



BELOW Packaging has been one of the biggest issues

ABOVE Hydrogen is stored in a carbon fibre tank mounted on top of the rear frame

a substantial regenerative braking capability. At 1.5 MJ it has more than four times the capacity of the original Formula 1 KERS units. It's also quite a bit larger than the accumulator used on the Forze VI after lap simulations showed that the extra capacity would more than cover the increased weight.

"The accumulator acts as an energy buffer. We have around 184 capacitors that can supply 200 kW to the motors at 700V for 15 seconds. It also has to store all the energy recovered during regenerative braking," comments Evereart.

Again, the team has used a number of off-the-shelf components. The fuel cell is based around a commercially-available 100 kW Ballard FC Velocity MK1100 stack, originally designed for buses. It produces 250V and 400A, which is then stepped up to between 500V and 700V before it's fed to the accumulator.

Two Sevcon Gen4 size 10 controllers are used to manage the twin Yasa P400HL 160 kW axial flux motors. These drive onto a single-speed gearbox, designed in-house by one of the Delft students and weighing just 6 kg (13.23 lbs).

"We knew fairly early on that we were going to use a single speed gearbox," explains Evereart. "Combined, the P400s can produce as much as 320 kW and they provide plenty of torque, so we're limited by traction at one extreme and aerodynamic drag at the other. Using a multi-speed gearbox would only add weight to the design."

LIGHT SIDE OF THE FORZE

Hydrogen may be the lightest element in the universe, but the fuel cell stack, storage tanks, capacitors and associated systems quickly add up in weight. At 90 kg dry (around 100 kg during use) the fuel cell is the single heaviest part of the entire car. You do get a useful economy of scale, though.

Even using off-the-shelf components, the Forze team says its fuel cell powertrain is substantially lighter than a comparable battery-electric design once you start to look at longer distances. Beyond around 30 minutes of racing it starts to get very difficult to eke out the required battery capacity at a sensible weight, whereas with a fuel cell you can – within reason – simply add more hydrogen.

"As you increase the capacity, our system rapidly becomes lighter than a battery solution," comments Evereart. "We've designed it to run for 45 minutes, but we're looking to push that even further next year."

Currently the car is said to weigh around 1,100 kg – 170 kg more than the V8-powered LMP3 car upon which its chassis is based. In zero emissions terms, however, it's something of a lightweight: according to those figures, it's over a quarter of a tonne lighter than the GreenGT H2 that we featured recently (although that, admittedly, was targeting somewhat higher performance levels).

The hydrogen is stored in a carbon fibre tank, mounted on top of the rear frame ▶

The world's fastest fuel cell car

AWAY from the world of circuit racing, fuel cell vehicles can be even faster. In 2009 a group of students from Ohio State University, in collaboration with Monégasque car company Venturi, set a new Land Speed Record for fuel cell vehicles at 303.03 mph (487.67 kph).

Known as the Buckeye Bullet 2, the car used a Ballard PEM fuel cell system related to that found in the Forze VII. Free from any concerns about range or reliability, the students were able to push what had been a standard 250 kW system up to more than 600 kW (805 hp) for an attempt on the flying mile and flying kilometre records.

Having succeeded, the group has now turned its attentions to a lithium ion battery-powered development of the same car, with which it hopes to crack the 400 mph barrier. RT

BELOW Fuel cell in a hurry: Buckeye Bullet 2

Ohio State University

RACE CAR | ROAD CAR | PERFORMANCE | HISTORIC | SPECIAL VEHICLES

CUTTING **EDGE** TECHNOLOGY

PRECISION PERFORMANCE

The PRO 5000 R offers you Radi-CAL™ brake caliper technology in an entry level range.

Forged designs, developed using our vast experience in motorsport, incorporate the latest innovations from our pioneering asymmetric design concept.

The new 2016 range will comprise four 4-piston and three 6-piston options.

Fit AP Racing brakes and clutch systems for race success.

The science of friction

T: +44 (0) 24 7663 9595 E: racetech@apracing.co.uk W: www.apracing.com

AP RACING

(more or less where the airbox would sit on a combustion-engined car). Inside, the gas is pressurised to 700 bar, although Everaert is quick to dispel any safety concerns. "It's a very robust tank," he points out. "During a recent test done by the producers, the tank was projected against a wall at high speed; the wall was blown to pieces, not the tank. It's probably safer than a conventional fossil-fuel tank."

These high pressures are required to compress a meaningful quantity of hydrogen – very good in terms of specific energy by mass, but very poor in energy density by volume – into a manageable storage space. Inside the fuel cell, however, the pressures are far lower, so the students have co-developed a regulator system with German company Bürkert Fluid Control Systems. On the high pressure side, the tubing comes from Goodridge (which are used up to 10 bars), while the connectors are provided by Teesing BV.

The other half of the fuel system is an electric compressor, capable of feeding air from the surrounding atmosphere into the fuel cell at up to 5,000 litres per minute. Broadly speaking, the fuel cell will start to generate electricity from the moment the air and hydrogen supplies are switched on, but the management is quite complex.

A small auxiliary battery – roughly the size of that found in a laptop – provides power to the basic functions during start-up. This begins with powering up the low voltage side of the system and manually isolating the fuel cell for its initialisation procedure. After around 15 seconds the stack is up to full power and the vehicle is ready to drive.

SINGLE BIGGEST CHALLENGE

This is made possible by a network of interconnected control systems, and the single biggest challenge has been integrating them all, Everaert explains: "There are a lot of control challenges, such as managing the fuel cell stack with enough air and hydrogen. We have 72 different control modules, working with 520 sensors and more than 200 actuators, so it's quite tricky to get everything to work together."

Another issue is thermal management, he explains: "Controlling the temperature of the fuel cell was a major design challenge for us. The system generates quite a lot of heat and you have to manage all of that through the radiators. In a combustion-engined car a lot of the waste heat goes out through the exhaust; our fuel cell system is more thermally efficient overall, but it doesn't really have an exhaust, so you have to handle almost all of that heat loss through the radiators."

The Forze VII uses seven different cooling circuits. Two large air inlets on the sides feed the main radiators placed next to the tub; one of which cools the fuel cell, while the other cools the motor controllers and the air compressor. Above and slightly behind them, fed by vents on the rear haunches, sit a pair of slightly smaller heat exchangers, tasked with dissipating heat from the accumulator and the DC-DC converter. Further back, twin oil coolers are used for the gearbox and the electric motors.

A considerable amount of CFD work went into optimising the design of the cooling system. The components themselves are also quite sophisticated – one of the water pumps alone can shift more than 100 litres of water per minute.

As we speak, the Forze VII's powertrain is already up and running, although only on

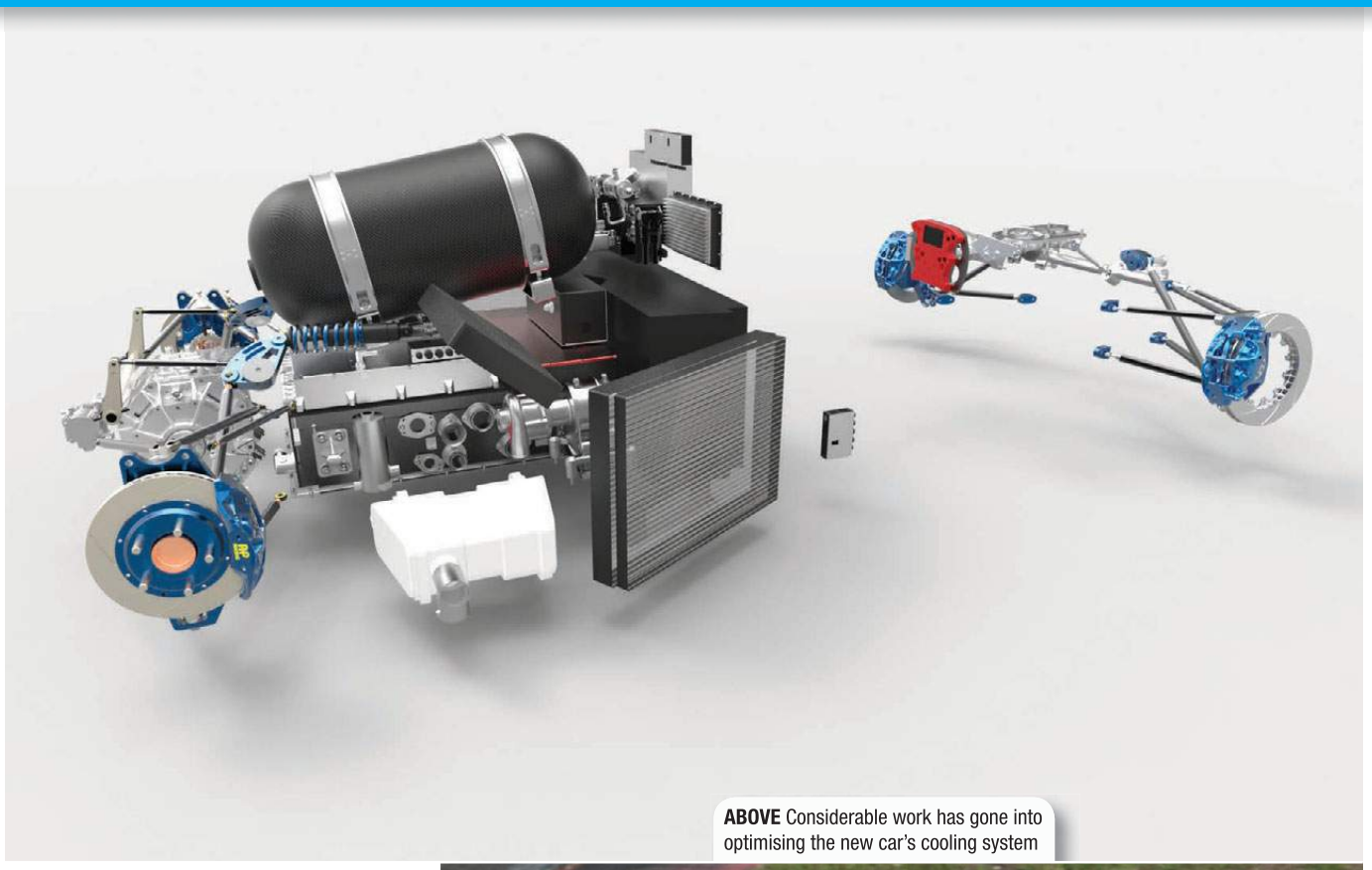
The race to Le Mans

FORZE Delft, along with Swiss outfit GreenGT, can legitimately claim to be the world leaders in hydrogen motorsport, but they may not be alone for long.

Rumours started circulating last year that BMW was considering a Garage 56 entry to showcase the fuel cell technology it was co-developing with potential Le Mans rival Toyota. More recently Audi has also expressed a cautious interest in the idea of running a hydrogen-fuelled car. The company's head of technical development, Dr Stefan Knirsch, confirmed in August that a fuel cell-powered entry "could be possible".

Speaking to *Autocar*, Dr Knirsch commented: "If we wanted to demonstrate our [fuel cell] capabilities [that's one] way we could do it. But the first thing is that we must be certain that it has a production future. We don't like to show things that are not leading to a production reality, and at the moment the lack of infrastructure leaves that uncertain."

ABOVE & BELOW The GreenGT H2 has already completed a full lap of Le Mans, above, so who's next? BMW has already tested this fuel cell sports car, below, on the track…



ABOVE Considerable work has gone into optimising the new car's cooling system

the dynamometer. By the time you read this, however, there's a good chance it will have covered its first outdoor runs.

The team plans to turn the wick up gradually, but simulation work, backed up by past experience with Forze VI, predicts that the new car should be capable of 0-100 kph (0-62 mph) in a little under four seconds and a top speed of around 210 kph (130 mph) once it's operating at full strength. Lap times are projected to be around the 1m 55s mark at Zandvoort. That's a couple of seconds quicker than a Clio Cup racecar, so more than rapid enough to give the DSC's Sport class cars something to worry about on track (with zero tailpipe emissions, don't forget).

The Delft students have no intention of finishing there, though. So does that mean there will be a Forze VIII? "There will definitely be a new car at some stage, but first we want to develop the Forze VII for at least one more year – hopefully while competing in the Dutch Supercar Challenge. Ultimately we dream of competing at Le Mans, but competing as a student team with this technology is just not feasible at the moment," admits Everaert.

Sooner or later someone is bound to do it. The resources required to launch a full Le Mans programme may be beyond a student team – even one as capable and as well funded as Forze Delft – but we'd put money on them being the first outfit to actively race a fuel cell vehicle. And that would truly be a landmark achievement. RT

ABOVE The record-breaking Forze VI blazed the trail for the hydrogen fuel cell-powered LMP project

TALKING THE TORQUE!

Its aggressive looks steal the headlines, but better drivability and air conditioning are key features of Peugeot's new Dakar challenger. **Hal Ridge** reports on a car designed to conquer some of the world's most daunting terrain

THE Peugeot 2008 DKR became the first two-wheel drive car to win the Dakar Rally outright for 15 years in January. But, not content with winning the world's toughest endurance event, and then follow it up with victory on the Moscow to Beijing Silk Way Rally in July, Peugeot Sport will return to the gruelling South American-based Dakar Rally in 2017 to defend the biggest prize in cross-country motorsport, with a new creation.

The new Peugeot 3008 DKR has been conceived by the Velizy-based outfit to coincide with the launch of parent company Peugeot's 3008 SUV, which was unveiled at the Paris Motor Show this autumn. Outwardly the Dakar contender is based on a new model, but under the skin it is more about perfecting and developing existing technologies, using knowledge gained with the 2008 DKR since its inception for the 2015 Dakar.

Like its predecessor, the chassis of the 3008 DKR remains of tubular steel spaceframe construction, not steel monocoque like its road-going cousin, mostly hidden under lightweight carbon fibre bodywork.

"The spaceframe is close to the 2008 because the concept of the car is really the same; it's still two-wheel drive with a turbodiesel engine," explains head of Peugeot Sport, Bruno Famin. "We've just improved areas to make it more reliable and to work also on the geometry of the suspension. We have some fixing points that are a bit different on the frame, but 90% of it is like the previous car." Indeed Famin is refreshingly honest that the existing concepts have been carried over from the 2008, and about the reasoning behind the development process.

"The Dakar project is still quite new (to us) and we still have a lot of margins to improve on the car," he says. "We built the first car, the 2015 car, very quickly. We did it in 10 months. We succeeded in finishing the 2015 Dakar, which was already quite a good result even if the level of performance was not the one we were aiming for, but we had to learn. Then for 2016 we made a quite big evolution of the car, keeping the same concept but making it wider, longer and lighter, but we still had a margin to improve, especially on the suspension side and trying to fight with the weight because we have put in an air conditioning system. We worked also on the aerodynamics and when working on the shape of the car, the idea came to use the shape of the new 3008 SUV that Peugeot is launching right now. Everything matched to switch to the 3008 and give the new car a 3008 look, so that's what we did."

TWO-WHEEL NOT FOUR-WHEEL DRIVE

The philosophy of the project from its inception was for Peugeot Sport to prove that four-wheel drive is not a requirement in standard road-going cars, as part of a marketing synergy with its parent company's consumer products, despite the Dakar challenger appearing drastically different visually. As such, like the 2008 before it, the 3008 DKR is driven only by the rear wheels, with the drive being sent from the mid-rear mounted longitudinal diesel engine via a six-speed Sadev

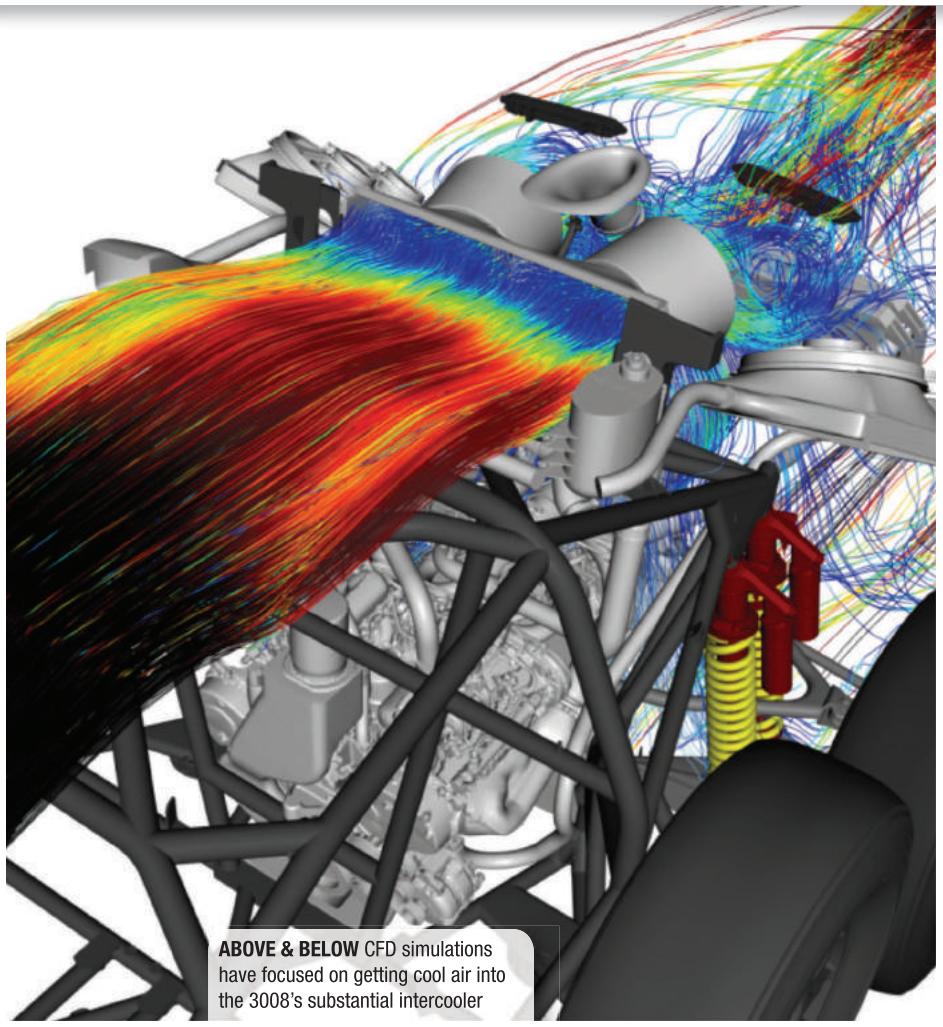
ABOVE Eight months of intensive work have underpinned the launch of the 3008 DKR, with which Peugeot bids to defend its Dakar crown

sequential gearbox and differential.

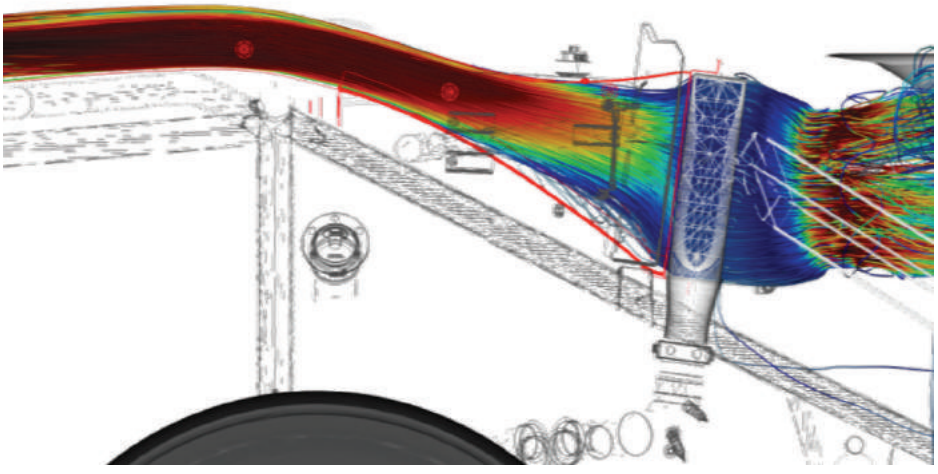
"In the 2008 and now the 3008 standard cars we have what is called the Grip Control System, which balances the torque of the car from one [driven] wheel to another. The DKR car is two-wheel drive of course and it shows that a standard car – a small SUV like the 2008 and 3008 – can go on very bad roads or in very bad conditions that people think they need a four-wheel drive for. That's not the case; it's very good that we can demonstrate that with the cross-country car, that two-wheel drive in competition can go everywhere and win races as difficult as the Dakar or the Silk Way Rally."

While Famin makes a valid point about the ▶

ABOVE The car maintains its predecessor's short front overhang, aiding the ability to climb steep inclines



ABOVE & BELOW CFD simulations have focused on getting cool air into the 3008's substantial intercooler



comparisons to the 3008 DKR's distant road-going relation, the competition machine is rather more radical. The car boasts a staggering 460 mm of suspension travel, similar to its predecessor, but the new version features developments to the ZF Sachs remote reservoir dampers, of which there are two per corner to deal with the extreme conditions on the world's most famous cross-country event.

Being two-wheel drive, the technical regulations look favourably on the machine by compensating for the lack of driven wheels by allowing the car to run lighter than its four-wheel drive rivals, with longer suspension travel (four-wheel drive maximum is 250 mm) and the use of bigger wheels. The two-piece aluminium 17" wheels of the 2008 DKR have been replaced by one-piece magnesium rims on the 3008 DKR, for both strength and weight. Within those wheels, four-pot callipers and 355 mm vented discs are used all round.

For 2017, a brand new route will take the Dakar event that originated in Africa through Argentina, Bolivia and Chile. "In the Dakar we don't have any more big stages of desert, we have much more twisty stages like the final ones in the 2016 event and the traction of the four-wheel drive is a big advantage," says Famin of the terrain. "The advantage of the two-wheel drive given by the federation to balance with the four-wheel drive is that we can be lighter, but the theoretical minimum weight is so light that you cannot make it. We are in the middle between the minimum weight and the four-wheel drive weight.

"We are allowed to have an inflate and deflate system for the tyres while the car is running, so the driver does not need to stop when he arrives on the dunes sections, but, there are almost no dunes sections anymore, so that is not so important. When the road is broken or in bad shape then the two-wheel drive is a bit faster, but when the road is twisty the four-wheel drive is faster."

THE BALANCE CHALLENGE

There are, he suggests, two balances of performance: the technical rules and the road of the race itself, which is determined by the type of terrain that the organisers choose. "It will balance in one way or another," he says, "but it's our challenge [to use two-wheel drive] to be at the finish line first, whatever the type of road you have."

The 3008 is slightly longer than its predecessor, due to the size of the body, but the wheelbase remains the same. The car maintains its short front overhang, and thus the ability to climb seemingly insurmountable inclines.

On the original 2015 car, each double-wishbone corner was universal so that components could be interchanged one side to another. That is no longer the case, as part of the quest for outright performance, with many hours of FEA analysis devoted to finding the best solution. "We have changed the geometry of the suspension, especially on the front axle, working on the anti-diving characteristics of the car," comments Famin. "On the first car we could change from one corner to another, but not now. The wishbones and components are quite strong. Even on the Silk Way Rally, when Stephane Peterhansel had a big crash he was able to fix the car – the wishbones were okay. We had some problems with the dampers, but it is possible to swap them from side-to-side."

With Peugeot Sport entering four cars into the Dakar – which like the WRC and Le Mans, both of which it has conquered, has become as much of a flat-out sprint as a feat ▶

Eibach®

IMPERIAL RANGE

METRIC RANGE

TENDER | HELPER

OFF ROAD

COIL SLEEVE

BUMP STOPS

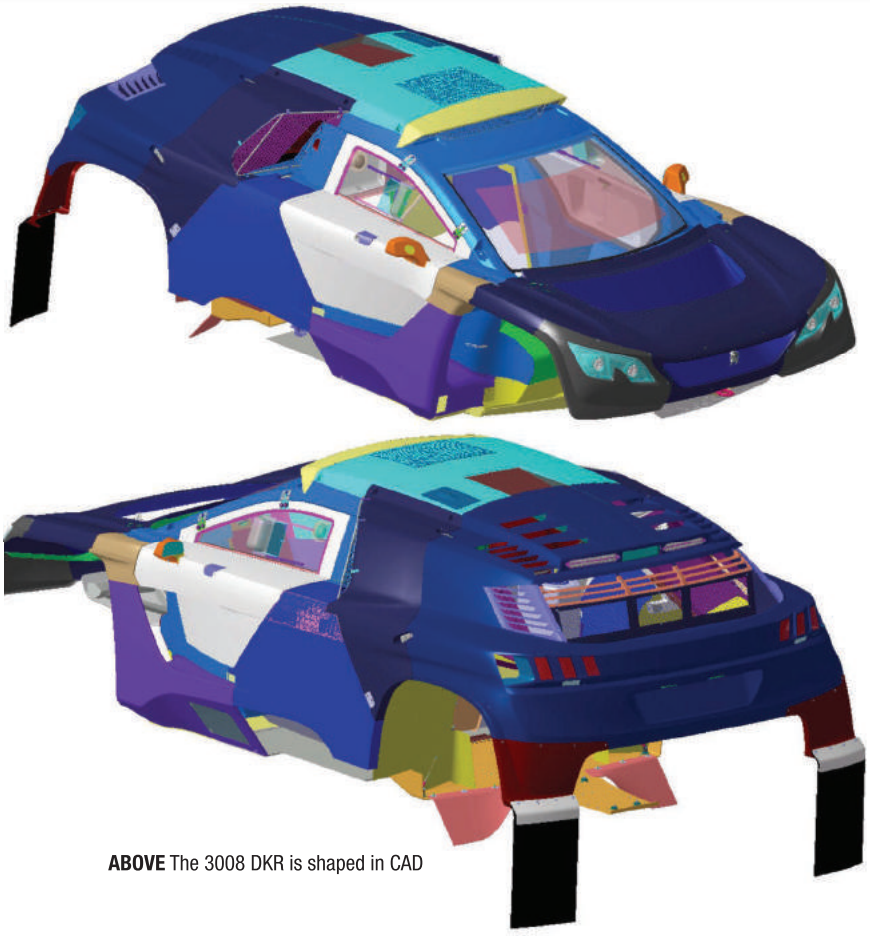
DOMINATE THE TRACK. RULE THE STREET.

ERS | Eibach Race Spring System

- Over 1,300 single components – main and tender springs – metric and imperial, various auxiliary race suspension accessories, ready and in stock on 5 continents
- Comprehensive Program of single components
- Single Main Springs with highest rate-linearity and lowest rate tolerance
- Progressive Characteristics via set-up of different springs serially – double or even triple spring combinations
- Extreme Low Weights achieved through Super Hi-Ten materials and manufacturing technology
- Smallest Solid heights, maximized spring travels and higher maximum loads
- Spring Surface Stabilization through specialized shot peening
- Every ERS Spring preset to block
- Block and Sag Resistant
- Smallest Tolerances and precise plane parallelism of spring ends
- High Dynamic Durability – under Motorsports conditions
- High quality corrosion protection by phosphating and epoxy coating
- Springs Printed with part-number (speaking code = rate and dimensions)
- Individual protective single box packaging

Eibach UK | Phone: 01455 285 851 | e-Mail: sales@eibach.co.uk

eibach.com



ABOVE The 3008 DKR is shaped in CAD

of endurance – Famin raises an interesting solution to any potential issues for its leading cars come January's event. "The cross-country rallies are so hard that if you lose one hour, the fight for victory is over," he insists. "If early in the race one car is a bit behind, for sporting reasons or technical problems, this car becomes the chase car. Then if the leading car has a problem, we have the chase car to be able to give it some parts or some assistance – that's how we see it now. We don't want to make compromises on the design to make the car easier to maintain by the crew, but we can have help between cars."

SMALL POWER LOSS

Regulation changes for the 2017 Dakar event mean that the turbochargers' inlet restrictor has been reduced from 39 mm to 38 mm. That doesn't sound much, but the V6 3.0-litre 24-valve bi-turbo engine, with a 'vee' angle of 60 degrees in the 3008 DKR, suffers from a net power loss of around 20 horsepower from the air loss. The engine, based on the PSA-Ford unit found in the Citroen C6 and Peugeot 607, produces in the region of 340 bhp with 800 Nm torque, and hits the rev-limiter at 5000 pm.

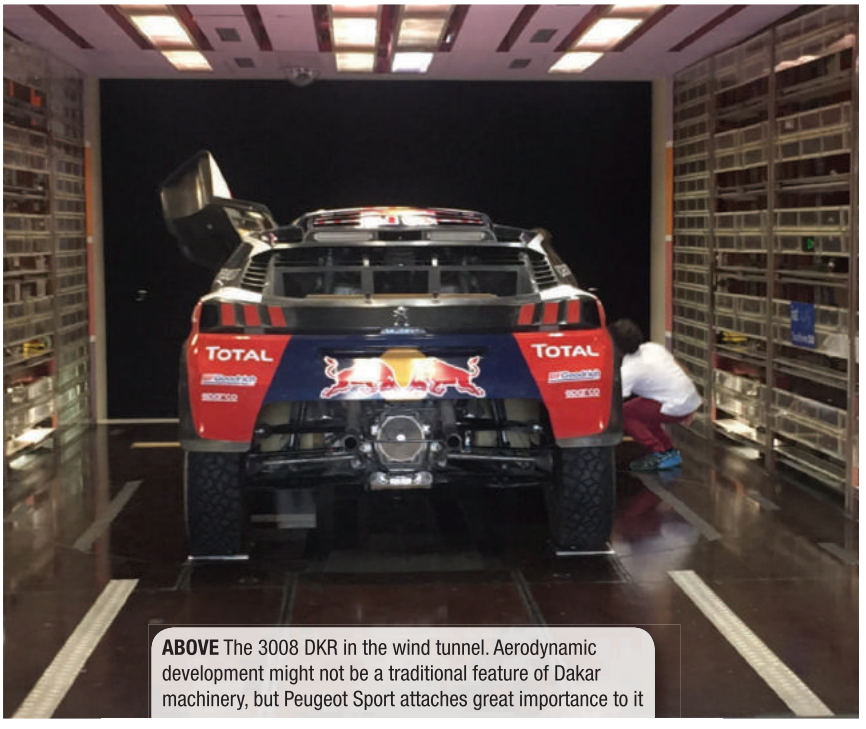
Diesel-powered Dakar machines are allowed to be turbocharged, a benefit in the high altitudes, while petrol rivals must remain naturally aspirated. Peugeot Sport initially used the unconventional cross-country method of powering the 2008 DKR for both economy in the long event, meaning they have to carry less fuel, and for low-down torque.

As per the regulations, the engine's internals remain as standard, but with turbo internals, exhaust, inlet and engine management systems allowed to be modified. With drivability being as critical on the Dakar's punishing terrain as in any motorsport discipline, Peugeot Sport has worked hard on the delivery of the engine's performance, and has the ability to draw on experience from its successful Le Mans programme. "Maximum power is of course important but it's not the main point for this type of car. We've concentrated our efforts and development on the drivability of the engine, that's really the main point," explains Famin.

"The driver needs a very drivable engine, especially in the dunes or when the road is very difficult. They need to have an engine which reacts immediately and smoothly and to be able to control everything. Of course it's always good to have more horsepower, but it's a second order issue in this situation."

Part of the move from the 2008 to the 3008 DKR is for aerodynamic advantages, which not only help the tallest version of the 3008 you will ever see to 'slip' through the air, but also to aid engine cooling in the searing heat of the South American stages. Getting cool air into the 3008's substantial intercooler is critical to performance. Considerable time was therefore invested in CFD simulations to influence how the air would reach the intercooler and radiators.

"I don't think there are many teams working on the aerodynamics on cross-country cars," muses Famin, "but we strongly believe that it's important. For the ▶



ABOVE The 3008 DKR in the wind tunnel. Aerodynamic development might not be a traditional feature of Dakar machinery, but Peugeot Sport attaches great importance to it

NATIONAL MOTORSPORT ACADEMY

APPLY ONLINE
CHOOSE YOUR OWN START DATE

The WORLD'S FIRST ONLINE Motorsport Engineering Degrees

FdSc Motorsport Engineering | BSc (Hons) Motorsport Engineering

NMA Team - Lotus Evora GTE

Accelerate Your Career In Motorsport!

AFFORDABLE - FLEXIBLE - ONLINE

Who should do this course?

Do you...

- Want to improve your career prospects by becoming a highly qualified Motorsport Engineer?
- Work or volunteer in motorsport without a degree?
- Work in the automotive sector and would like a career change into motorsport?
- Want a motorsport degree but can't justify the time/travel & accommodation costs at university?
- Have work or family commitments & need to earn while you learn while studying for your motorsport qualification?

If you answered YES to any of the above, then the NMA Online BSc (Hons) Motorsport Engineering Degree is the course for you!

* Degrees are awarded by our partner Staffordshire University.

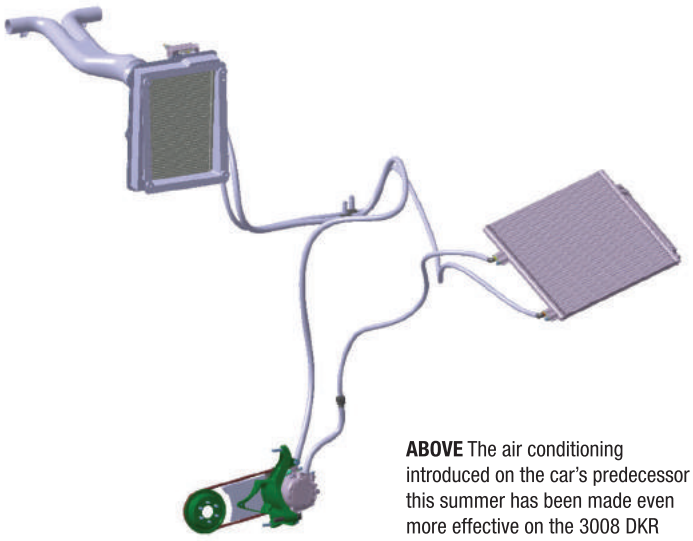
STAFFORDSHIRE UNIVERSITY
IN PARTNERSHIP

Why Study with NMA?

- 40% lower fees than other universities & access to student loans
- Choose your own start date, no term times or semesters, work at your own pace & study from anywhere in the world
- Mature students welcome - No upper age limit
- Earn while you learn
- No travel or accommodation costs
- Study Online & On-track
- Free industry standard CAD software


Race day experience for students

motorsport.nda.ac.uk **+44 (0)1159 123456**



ABOVE The air conditioning introduced on the car's predecessor this summer has been made even more effective on the 3008 DKR

> *"The driver didn't even remember the 15 last kilometres of the stage. That's when we realised we had to have air conditioning"*

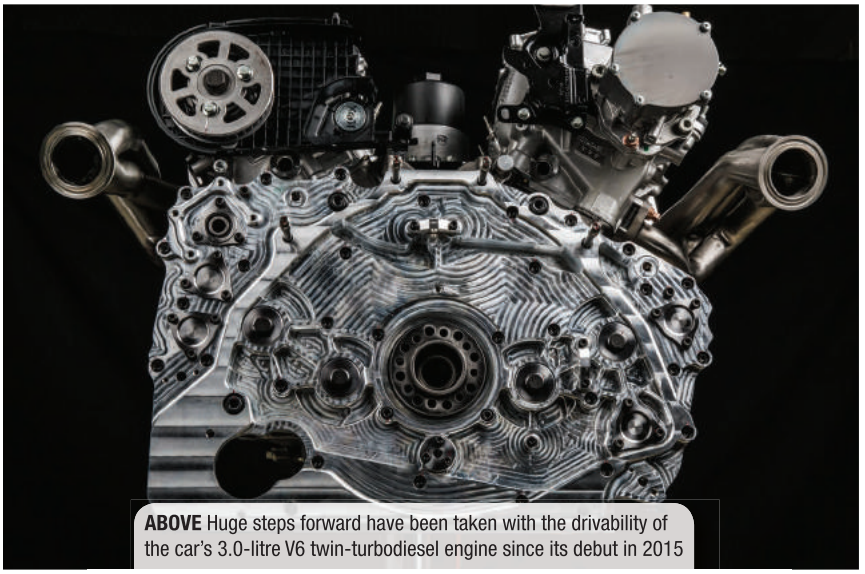
wheels, airflow and the cooling. This kind of car has to race in very difficult temperature conditions. It's also about reliability and the performance, because the cooler your air is entering the engine, the better, so working on the aerodynamics we have to work on the form, the shape of the car."

It's fair to say the use of cool air has been a hot topic in the planning of the latest Dakar assault. For the 2016 event, air conditioning was introduced to the 2008, and has been refined in the new car. Such a luxury may seem obscure in the most extreme of competition vehicles, but in temperatures that can exceed 60 degrees centigrade out on the stages, the initial decision to run without A/C in the 2015 car was quickly rectified. The system used is very similar to that found in a standard car, operated by an engine pulley-driven pump.

"We were not very sure at the beginning of the project, but now we are convinced that it [air conditioning] is very useful," says Famin. "We realised that in such long stages, where the driver and co-driver can be five or six hours with 60 or 70-degree heat outside, it is very important to keep them cool, for the performance and safety.

"The driver needs to always have his brain working properly. I personally realised that on the second stage of the 2015 Dakar. The stage had been very, very hot and very long; Peterhansel finished the stage very slowly and there was no problem on the car, the problem was himself. He lost his performance and he didn't even remember the 15 last kilometres of the stage. Then we decided to go with A/C.

"We have tried to optimise the size of the system for the weight, of course, and we are working on a more advanced system with a new concept. The target use of the A/C is not exactly the same as with a standard car where you need to cool the volume of the car, but in the race car it's just the driver and co-driver. We're not talking about comfort, we're talking about safety and performance."



ABOVE Huge steps forward have been taken with the drivability of the car's 3.0-litre V6 twin-turbodiesel engine since its debut in 2015

STAR DRIVER LINE-UP

The French marque can call on a spectacular array of driver talent. Its line-up features 12-time winner Stephane Peterhansel, two-time World Rally champion and former Dakar winner Carlos Sainz, nine-time WRC champion and World Rallycross driver Sebastien Loeb and five-time Dakar motorcycle winner Cyril Despres.

For all the star names, though, intense

BELOW The benefit of the inflate and deflate system for the tyres is lessened by the fact that the 3008 car will encounter fewer dunes than its predecessor, seen here

preparation has always been a hallmark of Peugeot Sport's success on the Dakar, with initial testing of the 3008 DKR taking place in late September. The car makes its competitive debut in early October, on the Morocco Rally. However, despite all that planning, the route isn't declared until the event starts, making pre-Dakar setup choices difficult.

Just like on any other competition vehicle, the team can adapt the car at each service for the following conditions. "We can change the ride height, the damper characteristics, stiffness of the dampers, springs and so on. The only problem is that the Dakar stages are secret until the day before, so you never know which kind of conditions you will have," concludes Famin.

"You can imagine that a stage will be very good, something like a WRC type, but you don't know if the organisers have put 10 kilometres of very rough section at the end of it, where you could get stuck. It's a question of compromise but we can adapt the setup from one day to another."

Whatever conditions the 2017 event throws at Dakar competitors, Peugeot Sport believes that in the new 3008 DKR it has a strong chance of defending its title. RT

THE CAT WHIRRS!

Craig Scarborough quizzes JLR Group Engineering Director Nick Rogers on the genesis of Jaguar's decision to choose Formula E for its return to racing

WHEN a historic brand decides to start a race team, the choice of category and technology is key. Although nowadays this is largely driven by marketing factors, balancing the publicity, organisation, risk and budget can easily see a project fail. So when Jaguar announced that Formula E would be the arena for its racing comeback in 2016, it illustrated not only the future direction for the Jaguar Land Rover brand but also the step-change currently going on in the automobile industry.

Jaguar Racing will enter Season 3 of the electric-powered FIA Formula E race series, coming in both as a race team and the manufacturer of the powertrain. Williams Advanced Engineering and Panasonic will be its technical partners.

THE CAT IS BACK

A true heritage automotive brand, Jaguar Land Rover is one of the few survivors of the British motor industry and right now one of the UK's great success stories. Of course Jaguar needs no introduction to motorsport fans, with racing success across a range of series, boasting victories at Le Mans and technical innovations such as the introduction of racing disc brakes.

As an evolving modern British brand, the staid image of bygone road car models is now replaced with an exciting range of cars led primarily by performance, rather than comfort and refinement. Thus they are pushing forwards with technology, the level of investment and headcount underlines the place JLR has in the UK at the moment.

"We are the largest investor in R&D in the UK and we are proud of the growth we've seen over the last few years," boasts Nick Rogers, JLR's Group engineering director. "We have 9000 engineers, both here at Gaydon and at Whitley, our propulsion centre," he adds.

Those locations also underline another tie to Jaguar's past in the heart of the UK and its technical philosophy. A Midlander himself, and with JLR for over 33 years, Rogers is proud to say, "We're giving more engineers jobs and making fantastic products here in the Midlands."

Like many automotive manufacturers, Jaguar is now moving towards electrification of its range. Concept cars such as the CX75 and forthcoming variants of the key product range will be electric. Rogers is positive about this change in motive power, sating: "Electrification is taking place across the range; that's extremely exciting. So part of that development activity is to test the vehicles in a real world situation." Which leads to the reasoning behind which category to enter.

WHY FORMULA E?

As a performance saloon car manufacturer, also with a Le Mans racing heritage and even a recent F1 programme, Jaguar's entry back into top level racing could have taken several paths. The WEC has facets of electrification and presents a good image to reflect the JLR brand in, yet the decision

BELOW From D-Type to I-Type: Jaguar's new racecar

Photos: Jaguar/Craig Scarborough

was taken to compete in a developing, all-electric, city centre racing series. So why was this route taken?

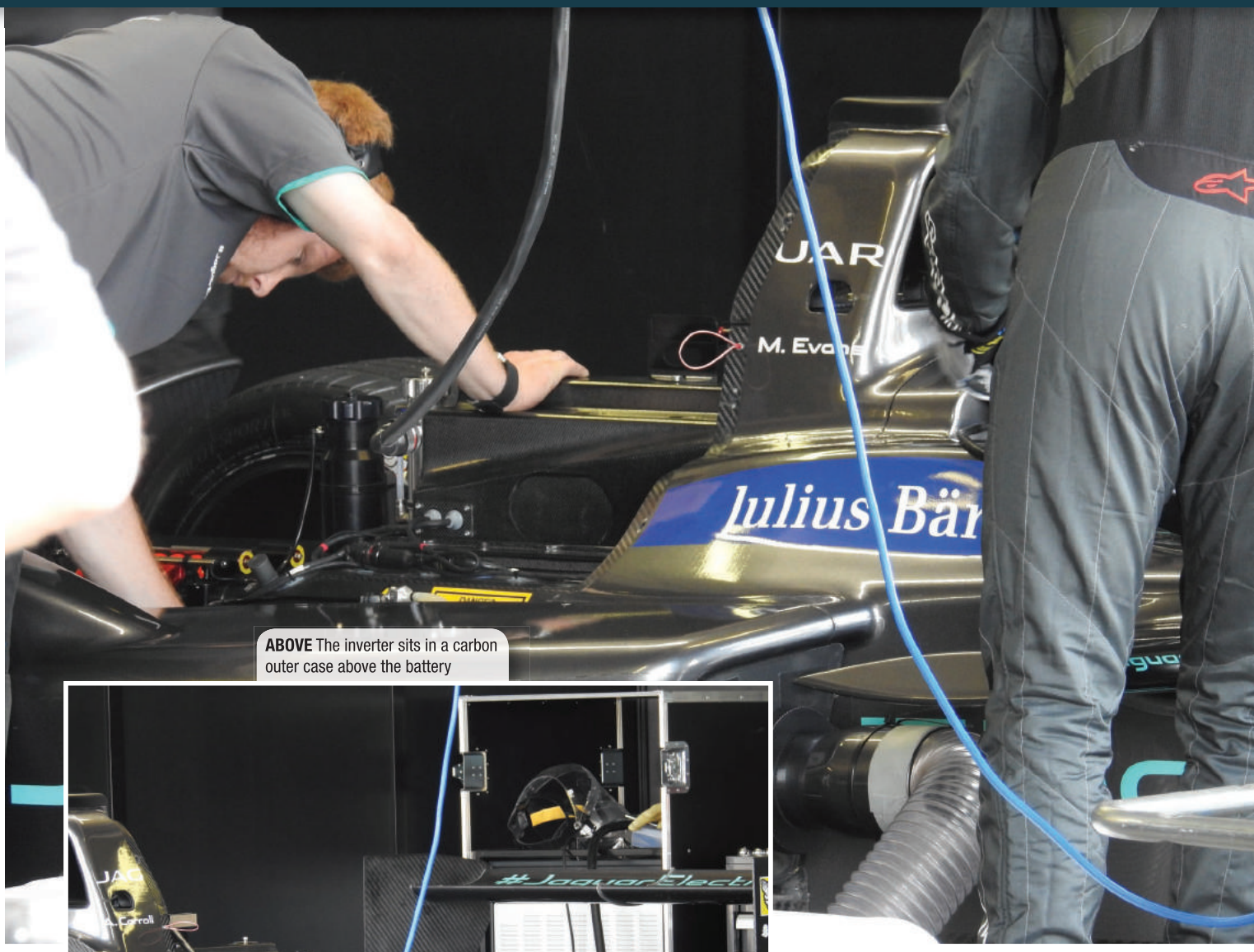
"How the series is structured, from a fan base point of view, in the heart of cities, and clever things such as the cost cap structure, creates a championship we know is focused on performance and innovation in a controlled manner," explains team manager James Barclay.

This could perhaps be seen as a rebuttal to F1, WEC and touring car racing, but Formula E (FE) is gaining major manufacturer support. At the point of the announcement, there wasn't a headline manufacturer team in FE, though Renault and, less overtly, the VW-Audi and DS-Citroen groups had a presence. So the Jaguar entry was significant. Since then Audi, DS and Renault have stepped forward, with BMW already in the wings and brands such as Nissan, Honda, Volvo, Ford and Mercedes rumoured to be looking at investing in the category.

> *"If you need to find a way, you will get inventive"*

From an engineering perspective, FE presents Rogers with a good fit between road and race, with a new technical challenge thrown in for good measure. "This formula fits with the technology we are developing anyway," he says. "It's a good test bed for technologies we are developing for our future vehicles, focusing on zero emissions and pushing technology to the edge.

"It's a perfect fit and we are extremely ▶



ABOVE The inverter sits in a carbon outer case above the battery

ABOVE The orange cable passes from the inverter to eMotor

excited to be working on it. It will be part of a new era of innovation we are driving at JLR. It is an extended part of our R&D process. Obviously we have a huge core R&D process and this is part of pushing the boundaries in an endurance situation."

CRITICAL PATH

With the entry agreed back in December 2015, the critical path to get a powertrain and race operation to the first Season 3 race this month in Hong Kong is daunting and couldn't be adequately tackled by JLR alone. So it has extended the technical partnership with Williams Advanced Engineering (WAE), the offshoot from the F1 team, which partnered with JLR on the CX75 project.

This was a logical partner, given its experience of electrification in both F1 and other automotive projects. But it also brings the benefits of an organisation which knows how to operate a race team at the track.

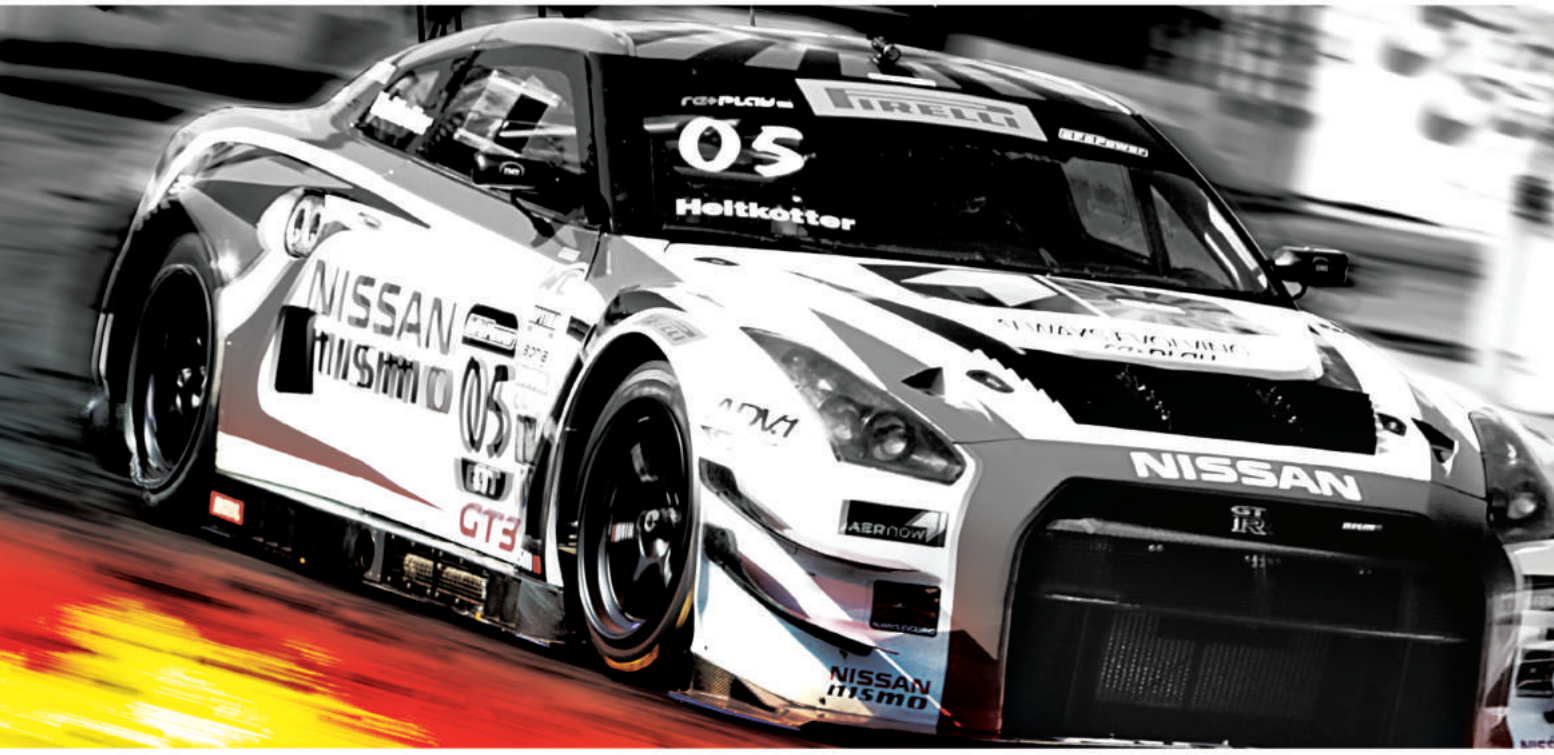
WAE is also a technical partner of the Formula E series itself, producing the traction battery for all the cars. This was seen by some existing teams as a conflict of interest, concerned that perhaps Jaguar Racing might gain from Williams' knowledge of teams and their Season 2 powertrains. However, the need to compartmentalise its operation is key to WAE doing business in many race series; while rivals are wary, the issue hasn't escalated since the announcement.

The fit is a natural one and of course Rogers extols the virtues of the arrangement: "We've had a partnership since CX75, The CX75 had the same technology, the same synchronous motor, the same battery technology, so that's a great partnership working with those guys over there. They've got a great history in racing and there's a great technology flow between us."

A design team of some 12 people was set up, based at JLR, with some activities going on at WAE at Grove. However, the team has a reach into not just WAE, but also the whole JLR engineering group.

This philosophy appears to be an honest and integral part of the project for JLR. "The team will have full access to all the simulation tools in our virtual hub we've got over at Gaydon, and all the test facilities at the test tracks. This is a key part of our ▶

THE 2016 PERFORMANCE RACING INDUSTRY TRADE SHOW



THE BUSINESS OF RACING

STARTS HERE

PRI 2016
Indianapolis
December 8 – 10, 2016

CONNECT WITH MORE THAN 1,200 RACING INDUSTRY SUPPLIERS

Discover new racing products & business opportunities at PRI, the world's largest gathering of motorsports professionals.

TECHNOLOGY IDEAS BUSINESS

RACE ONLY
CREDENTIALS REQUIRED

Learn More at **www.pri2016.com**

product development," explains Rogers. "If you are talking about the structure of the algorithms, they can touch on the electrical work of an organisation of two and half thousand people. So there's access to the wider group."

Key names in the team are race director Craig Wilson and principal vehicle engineer John Russell. Wilson is also MD of WAE, with a background in racing with TWR, Holden and Jaguar. Russell, meanwhile, has a long history in motorsport and was usefully involved in both Williams and Jaguar's past F1 projects.

No doubt some initial analysis work was completed before the December signing of the contract to take the entry freed up by the Trulli race team. Nevertheless, some key dates were soon upon the Jaguar Racing design team: gearbox crash tests in late February; testing in the spring; and the full powertrain homologation deadline at the end of August. Jaguar hit those targets and after private testing had two pairs of cars ready for the two official tests at Donington Park over the summer.

> *"Software development where the future battleground will be"*

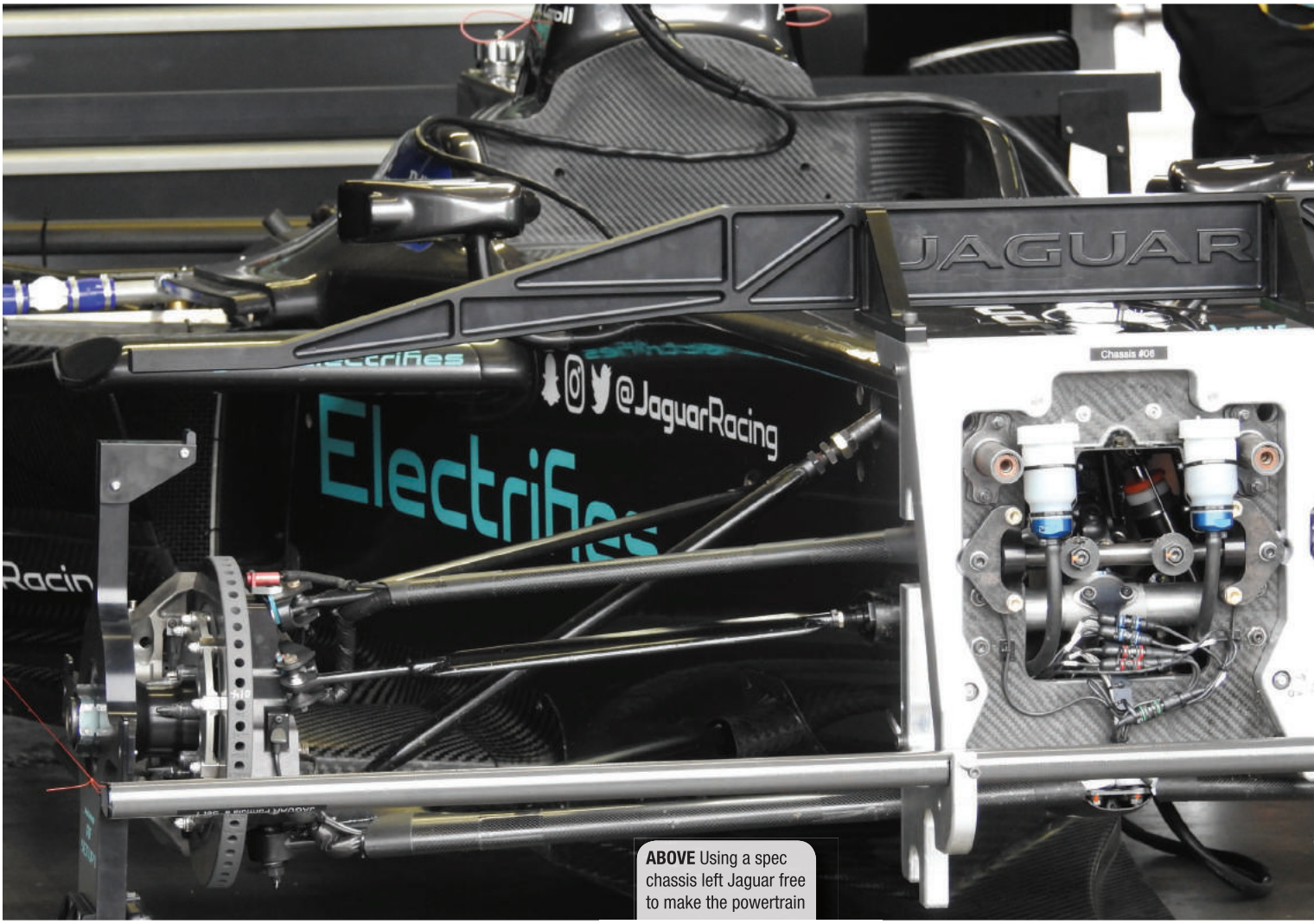
The project to get the Season 3 package ready for these dates was tight, but the challenge was also relished, says Rogers: "Of course we are just starting out, starting to understand how we can embrace that journey. We've had all sorts of conversations about propulsion, gearbox and all sorts of things." Himself an engineer at heart, Rogers adds, "It's all sorts of really good engineering and technical things that our engineers can get excited about."

Faced with a mere two months to get the gearbox ready for crash testing, no doubt compromises had to be made? "Necessity is the mother of invention," Rogers affirms, "and we love that: if you need to find a way, then you will get inventive."

I-TYPE

When the project was officially launched at Gaydon, Jaguar applied the name I-type to the racecar. It marked a refreshing change to prefixing everything electric with the letter E, but of course Jaguar has used that prefix to good effect in the past!

Overall Jaguar Racing's engineering job was to produce an electric powertrain mated to the single-make traction battery. Under the Formula E rules for Season 3, this starts at the battery's rear mounting face, extends back to the rear crash structure and out to the rear uprights (both suspension pick-up point and outer CV joints). Key amongst the hardware required is the eMotor, its inverter, transmission and rear suspension. ▶



ABOVE Using a spec chassis left Jaguar free to make the powertrain

Staley/LAT

ABOVE The first incarnation of the car's powertrain might be viewed as pragmatic, but the involvement of Panasonic suggests a more innovative future

Given the lead times, the team hasn't reinvented the wheel: the powertrain layout is near-identical to the Season 1 set up. This is no doubt down to the tight timescale involved in passing the crash tests and the reduction in simulation and design time which it enforced. While conceptually similar to the McLaren Advanced Engineering/Hewland Season 1 layout, the I-type's hardware is wholly different.

In detail this means that the eMotor sits longitudinally inside a metal casing, driving a gearbox through to the differential. In Jaguar's embodiment of this layout, it differs to the Season 1 package by the gearbox casing appearing to be cast as one piece and not a gearbox/bellhousing bolted together.

Furthermore, the differential mounting into the case is F1-style, split vertically rather than bolted in from the side. This helps the gearbox case manage the loads from the differential's bevel gears wanting to push it out sideways, when either accelerating or recovering kinetic energy under braking.

It's thought that the car has tested with just two gears, which appears to be an optimum figure for the current level of FE technology. Rumour suggests that the gearbox itself was designed as a four-speed and running just two pairs of gears and one selector, this being a compromise forced by the rush to keep the project on track.

Also similar to the Season 1 powertrain, the inverter – to switch power from the DC battery to the AC synchronous eMotor – sits behind the roll hoop and atop the battery. With the longitudinal eMotor/gearbox set up, there's a lack of space to package the volume of the inverter inside the casing, even though it would lower the centre of gravity.

Given the highly specialised nature of the engineering going into the eMotor, inverter and gearbox, many current teams partner with third parties to provide this technology. On this subject Rogers isn't keen to go into detail. Instead he suggests the eMotor is 'Jaguar', adding that Jaguar "is the heart of the car". It's most likely that the hardware is based on WAE know-how, perhaps with a gearbox manufacturer sub-contracted for the gears and castings.

SOFT SELLING

Given the breadth of technical resources at JLR and WAE, perhaps more might have been expected from its first FE powertrain. Maybe a more integrated layout? A transverse motor installation? Carbon fibre casings? Yet the reasoning can be understood, starting a year behind the other teams and confronted with a very tight timescale. Moreover, the effectiveness of the package is as much about the software controlling the hardware to increase the use of the energy available and translate that into a raceable format.

Unlike the hardware, which is homologated and one powertrain per car has to last the full season, software development is free. This is where the future battleground will be in Formula E. As the hardware matures, the knowledge to map the EV control systems will grow. The importance of this isn't lost on Rogers: "That's our core IP. Those algorithms, as ever in this virtual world that we live in, are as important as the mechanical world."

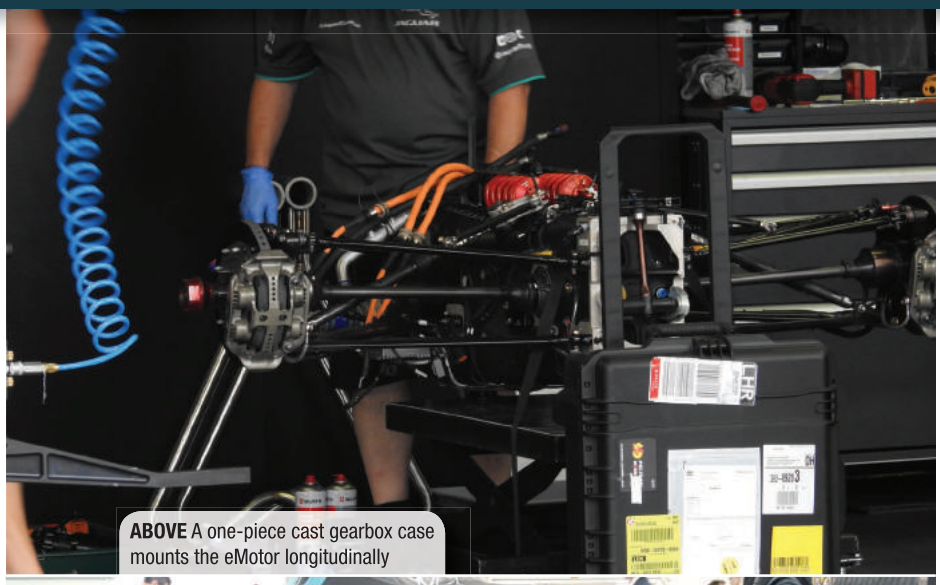
Despite being an old-hand in the automotive industry, this world of coding also excites Rogers and the young team at JLR. "The control systems on a battery electric vehicle are about the maximum efficiency of the control of the motors, both to accelerate and decelerate," he reasons. "It's maximising every watt of energy that's going into powering the car forward as fast as possible and it's also about the smooth transition to regenerative braking, making sure you pull the watts back out and put them back into the battery."

Then, significantly, Rogers mentions the importance of the battery upstream in the control system: "Those algorithms and that logic shows the intelligence in how to look after a battery, how to look after those cells to make sure they don't overheat, to make sure you maximise the energy going back into it."

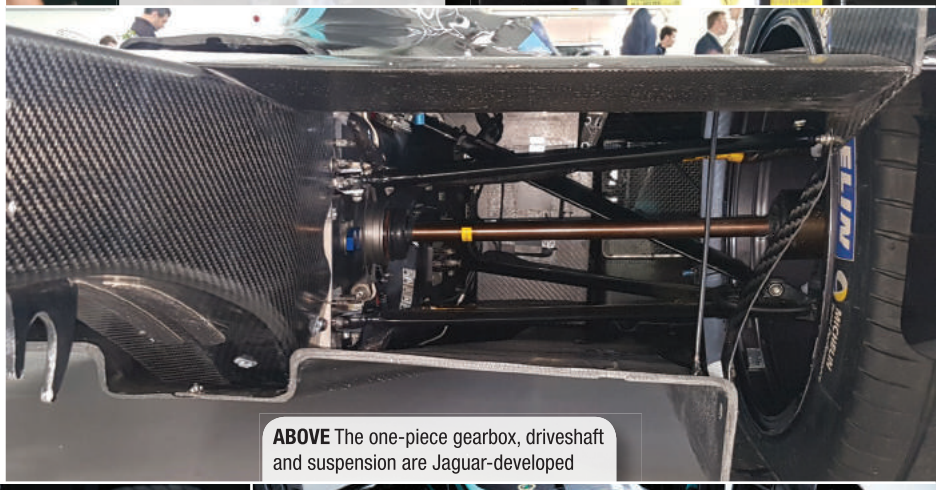
> *"Panasonic is pivotal in the world of electrical cells"*

This is insightful, as Jaguar Racing is partnering not just with WAE, which also makes the battery, but its new title partner is Panasonic. Now, while the Japanese brand develops goods across a wide range of products, it's also pivotal in the world of electrical cells, batteries, which in turn is key in the world of electric vehicles and thus FE.

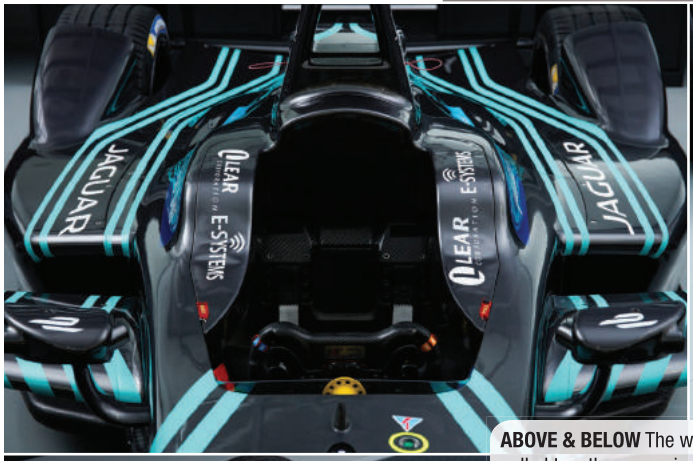
This level of joined-up thinking is telling in JLR's approach to Formula E and perhaps the possibilities this series offers automotive manufacturers and EV technology start-ups. Although this powertrain may be a pragmatic solution to go racing in season 3, it's clear Jaguar Racing is on course for a big future in the series. So far it has shown that the package works, is reliable and performance is in the ballpark. One wonders what success and innovation Jaguar might find to add to its illustrious history. RT



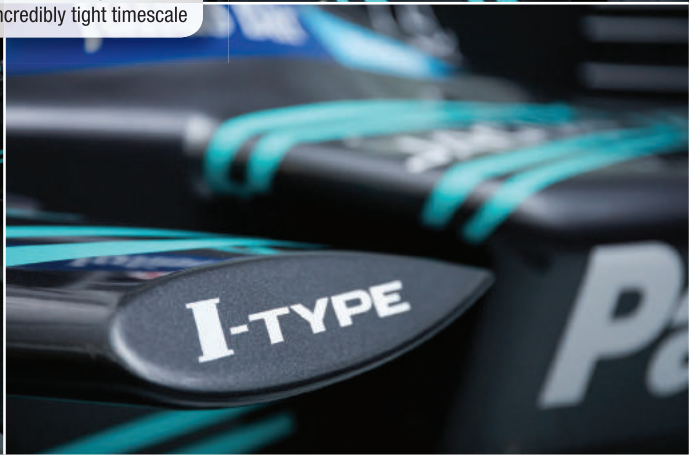
ABOVE A one-piece cast gearbox case mounts the eMotor longitudinally



ABOVE The one-piece gearbox, driveshaft and suspension are Jaguar-developed



ABOVE & BELOW The whole package has been pulled together on an incredibly tight timescale



RETURN OF AN ICON

With the latest Acura NSX poised to go head-to-head with rivals on the racetrack, **Sophie Williamson-Stothert** traces the transformation of the road car into a GT3 contender

THIS is the fully-fledged racing version of the 2017 Honda Acura NSX – the only supercar designed, developed and manufactured in the US.

At a glance, you would be forgiven for assuming that the Acura NSX GT3 race car is identical to its road-going counterpart. But, as with all GT3 racers, there's a lot more to this machine than first meets the eye – not to mention the hundreds of hours dedicated to developing and testing just one car.

The NSX GT3 is the result of collaboration spanning three continents. Initial development, build and shakedown testing was conducted by the company's Japanese race engineering arm in collaboration with JAS, Honda's Italian partner. Additional development, testing and final homologation to FIA GT3 global racing specifications is being undertaken by Honda Performance Development (HPD), its North American race engineering group, in Santa Clarita, California. "It's really exciting to be running a car that has been developed with a global viewpoint," admits Steve Eriksen, vice president and COO of HPD.

> *"More time and effort is put into the analysis, rather than the actual testing"*

If you were to pin a label on the key differences between the Acura NSX road car and the latest GT3 entrant, it would be on the surgical removal of Honda's first-of-its-kind Sport Hybrid Super Handling All-Wheel Drive power unit hybrid powertrain.

The NSX GT3 might be based on the same foundations of the car that rolls off the production line at the Performance Manufacturing Centre in Marysville, Ohio – down to the pistons and the dry sump setup – but the chassis has been stripped back to basics in order to create a blank canvas and shed unnecessary weight.

"The GT3 car is built directly from a new 'white body' to meet FIA GT3 requirements, rather than a conversion of an existing production car which, of course, has three electric motors and is an all-wheel-drive car," says Allen Miller, IndyCar and Sports Car race team leader at HPD.

"As such, it was really a large design task to create new front and rear suspension components – minus the hybrid motors and related equipment – as well as the cockpit roll cage and the many other safety requirements."

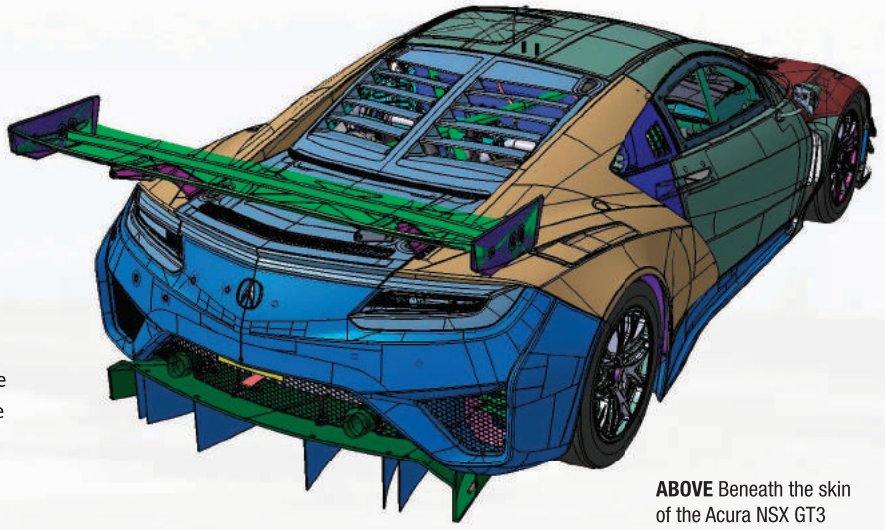
It's no surprise that, following the debut of Honda's second generation NSX – the reincarnation of the esteemed mid-engined supercar of the 1990s developed in conjunction with three-time Formula 1 world champion Ayrton Senna – Acura would want to homologate the model as an FIA-approved GT3 competitor.

However, in order to do this, Acura would first have to completely revise the drivetrain. Powered by a 3.5-litre twin-turbocharged, DOHC 75-degree V6 engine, the production Acura NSX also features three new electric motors and a nine-speed dual-clutch transmission (DCT). Although electric and hybrid powertrains have developed a presence

All photos: Courtesy of Honda Racing

in a number of motor racing paddocks over the past five years, including Formula E and on the Le Mans 24 Hours grid, the GT3 rules prohibit its use.

Acura has stripped the NSX GT3 of Honda's Sport Hybrid Super Handling All-Wheel-Drive (SH-AWD) system but continues to utilize the production 3.5-litre V6 now coupled to a six-speed sequential-shift Xtrac racing gearbox, delivering power to the rear wheels. Other than the dismantling of the hybrid source, the mill uses the same design specifications as the engine in the production car, including the block, heads, valvetrain, crankshaft, pistons and dry sump lubrication system.



ABOVE Beneath the skin of the Acura NSX GT3

HYBRID HURT

But don't be fooled into thinking the elimination of such a complex system consists of loosening a couple of bolts and fixing an additional part in its place. The removal of this particular hybrid powerplant was arguably the most challenging task of the conversion process. In fact, the entire build of a GT3 is a long and complex job.

"The engine installation required some work to eliminate the rear axle hybrid unit," explains Miller. "This involved removing the hybrid motor from the back of the engine then designing a new flywheel, clutch and starter assembly to mate to the new race-spec gearbox. Adding an alternator was also necessary with the removal of the hybrid motor."

The iconic NSX originally went on sale in 1990 with a 270 bhp, 3.0-litre V6 engine behind its seats. This unit was later updated to a 3.2-litre V6, which produced 20 additional horses. It was incredibly fast thanks to its low ▶

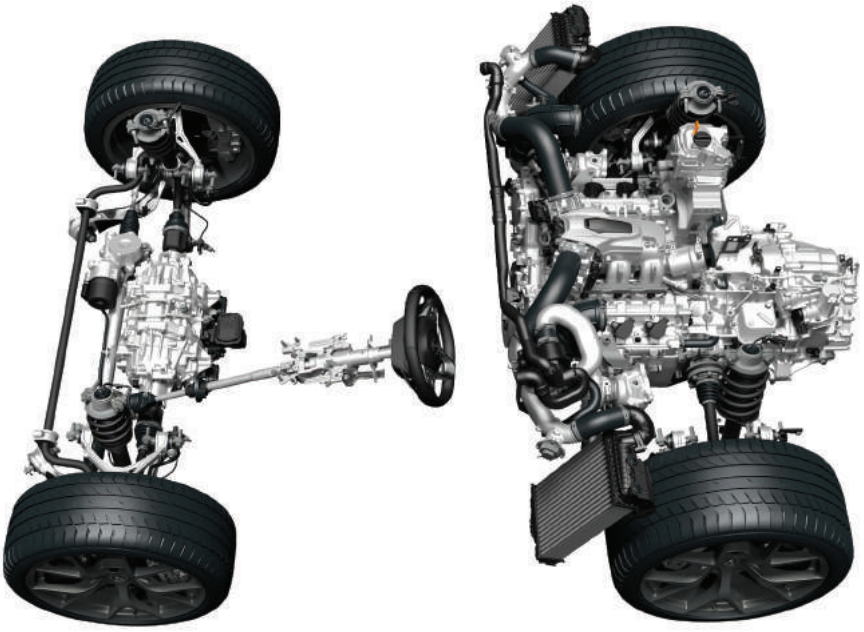
ABOVE The road car is a technological benchmarker. Now the race version, driven here by Peter Kox, is nearly ready to prove its credentials

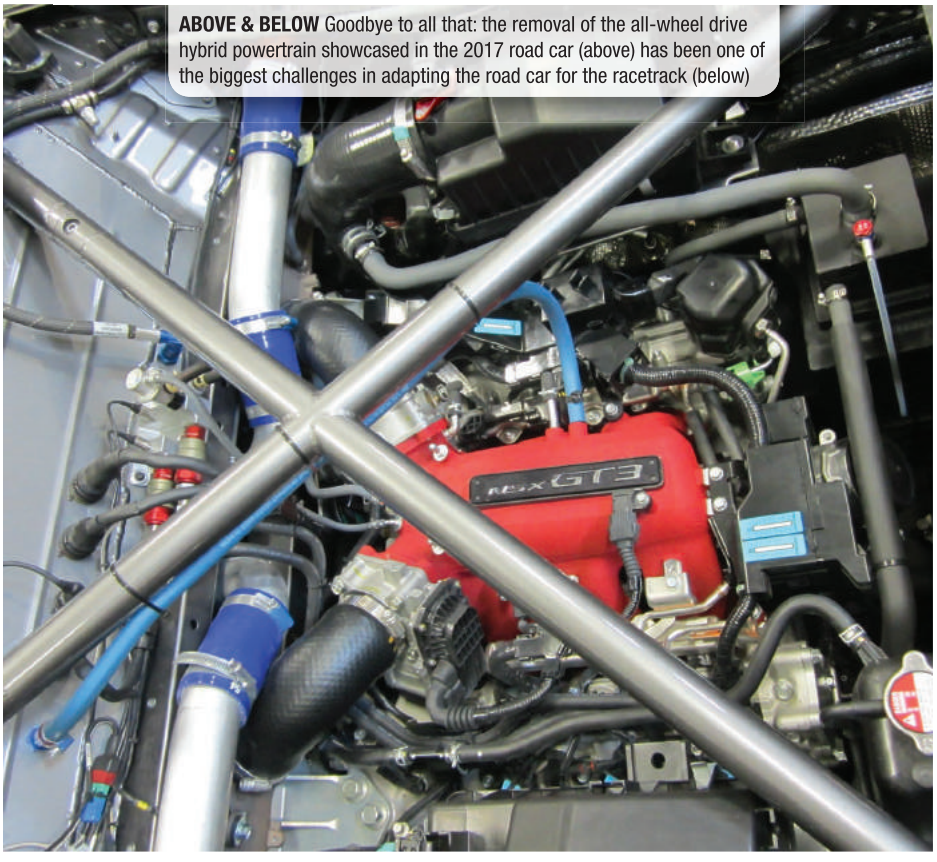
kerb weight – it could sprint from 0 to 60 mph in 5.1 seconds, which later dropped to an impressive 4.5 seconds by the late '90s.

When Honda pulled the production plug on its iconic model in 2005, it announced plans to develop a successor – a project which has taken more than a decade to come to the surface. In fact, it's safe to say we all grew impatient waiting for it, until the 2015 North American International Auto Show, when the new Acura NSX became reality.

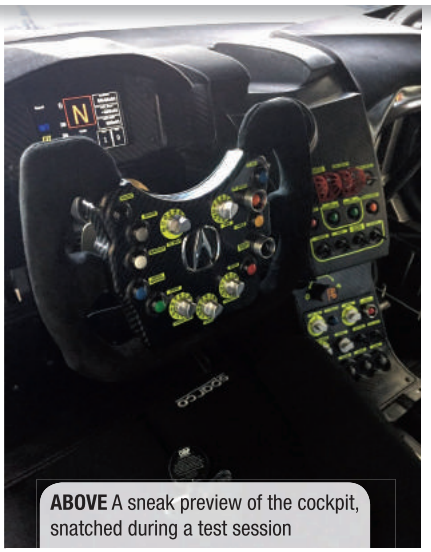
Today, a quarter of a century after the original NSX rolled off the production line, the second generation model couldn't be more different to its predecessor. Well, aside from engine configuration and its number of cylinders.

The point is, much like the first generation car, the 2017 NSX is another technological benchmarker, thanks to a multi-material body structure, advanced aerodynamics and a cockpit that supports performance driving on every level.





ABOVE & BELOW Goodbye to all that: the removal of the all-wheel drive hybrid powertrain showcased in the 2017 road car (above) has been one of the biggest challenges in adapting the road car for the racetrack (below)



ABOVE A sneak preview of the cockpit, snatched during a test session

Keeping to the production-based theme, the NSX GT3 utilises the production car's ultra-rigid and lightweight custom carbon fibre shell and aluminium-intensive spaceframe, which is produced by the production plant in Ohio – the exclusive manufacturing home for the 2017 Acura NSX.

On the surface, the NSX road car and GT3 racer look to be almost inseparable. But if you look a little closer, you'll see that the track-goer features custom GT3 bodywork and aero components, including front canards, splitters, side skirts, smaller wing mirrors, hood vents, a new underbody diffuser, a deck wing spoiler for greater downforce, a new bonnet, a revised front grille and a larger air dam. All of these features are set to increase the performance figures.

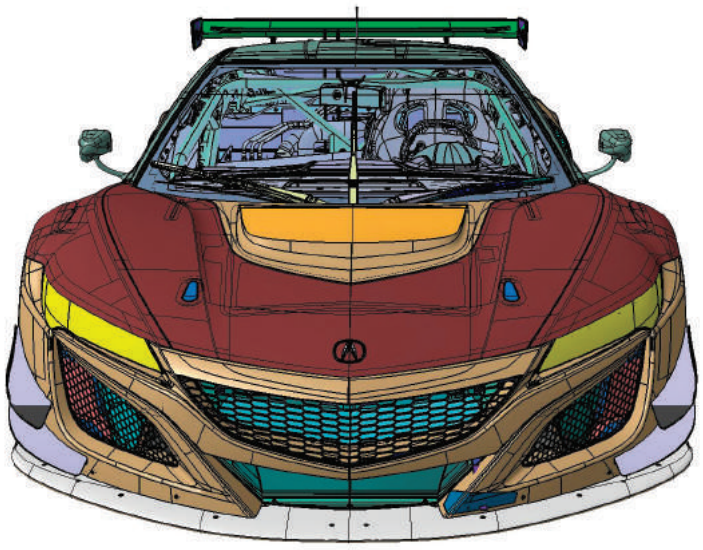
As for the interior, nearly every item that has no racing purpose has been omitted. What remains is a carbon fibre racing bucket seat, a full roll cage – which the team admits was probably the second most labour-intensive job on the list – various switchgear, digital instrument cluster and a racing steering wheel. To sum up, there's acres of bare carbon-fibre to please the eye.

DOUBLE ASSAULT

Acura has confirmed a twin-pronged assault on the racetrack. It will run factory supported programmes for the NSX GT3 in the IMSA WeatherTech SportsCar Championship and Pirelli World Challenge (PWC) with Michael Shank Racing and RealTime Racing.

It already participates in the PWC, albeit the TLX GT model has been running with special dispensation and has therefore been something of a square peg in a round hole. In IMSA, though, where its experience has ▶

ABOVE & BELOW Developing the racing variant ahead of the Balance of Performance tests has been painstaking work, be it in the digital domain or at the test track



been gained in the prototype ranks, Acura is entering fresh territory with the move to GT3.

Although the programme gives Acura a foot in both the sprint and endurance camps, the design's fuel cell capacity remains the same because both series feature a similar duration between pit stops of around an hour. The biggest setup difference will revolve around the engineers' solution to the issues posed by the tyres: Pirelli in sprints; Continental in endurance.

Though the sprint and endurance cars will essentially be supplied in the same spec, the respective championships' Balance of Performance (BoP) machinations will soon take them in different directions.

The Balance of Performance process adjusts limits on horsepower, weight, engine management and aerodynamics to prevent a single manufacturer from becoming dominant in the class. The cars in GT3 are designed to have a weight between 1200 kg and 1300 kg, with horsepower between 500 bhp and 600 bhp. All cars have a very similar power to weight ratio.

BALANCING ACT

'Balance of Performance' is often viewed both as a blessing and a curse. Plenty of the latter are provoked almost instantly in most engineers and designers by the mere mention of the term.

On the one hand, it allows for a wide variety of carmakers to be approved with almost no limit on engine sizes and ▶

Born to race

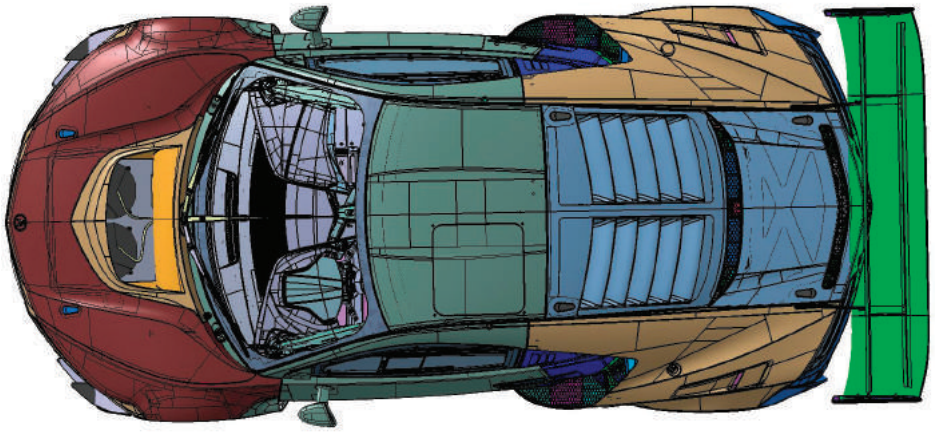
"IN essence, from the beginning, racing was a part of the thought process for this vehicle and that dictated a number of the decisions made on the car," reveals Steve Eriksen, vice president and COO of HPD.

"North America is the NSX's largest market and being able to race a version of the car here is very important to demonstrate the performance aspect of Precision Crafted Performance, which plays a big role in the Acura brand direction going forward," he says.

"The great part about this particular vehicle is that it's a supercar, and it's manufactured right here in the US. As such, we've received great support in this racing endeavour from the associates that have been involved in the design and development, as well as the manufacturing, of the vehicle.

"If I look back at its development, there's been involvement from members that have been involved in Honda's and Acura's racing programmes over the years and these members have directly influenced the design directions for the NSX itself.

"The NSX is a great car and, just like the street car, it's generating a lot of interest as a new GT3 entry." RT



configurations, or chassis construction or layout. The lure of a level playing field means the NSX will join the likes of Ferrari, Porsche, BMW, Lamborghini and Audi in the IMSA WeatherTech SportsCar Championship, and Porsche, McLaren, Cadillac, Bentley and Nissan in the Pirelli World Challenge.

The flip side is that a team can find itself penalised for its technical success. Nevertheless, consensus is that the better the base car can be made, the easier it will be to navigate the BoP minefield. To that end, the NSX GT3 has been the subject of both scale model and full-scale wind tunnel tests, as well as Computational Fluid Dynamics (CFD) simulations.

As Race Tech catches up with Lee Niffenegger, HPD senior programme engineer, he is just driving away from the BoP aero test at Michelin's facility at Ladoux in France.

"The guidelines, set by the FIA, are really just a base line," he explains. "It's not until the cars filter into their own series that they have to hit particular performance and aero windows in order to compete.

"Before you even reach the Balance of Performance process, the aim is to get the car as near to those desired windows as possible. A lot of hours go into this process, but I'd say more time and effort is put into the analysis, rather than the actual testing.

"In order to hit the Balance of Performance requirements, we have to tick the drag, downforce and efficiency boxes, which means we pay particular attention to aerodynamics. You also have to remember we use stock components from the road car, such as the intercoolers, which we have to make sure are working as they should be. Obviously we were constrained by the shape of the NSX as a road car, but that's why we've changed the track and bodywork.

"As long as the results don't show the NSX as too far off the desired Balance of Performance windows, it's ready to go," he concludes. "Once the validation and aero testing has taken place, it's then down to the series and the team."

INCREDIBLE MACHINE

One of those teams tasked with that fine-tuning will be RealTime Racing, which switches from the current pair of Acura TLX GTs fielded in PWC to the NSX GT3 for next season. Team founder Peter Cunningham is enthused about continuing his squad's long-term relationship with Acura, including 14 victories in World Challenge competition with the first-generation NSX and winning the 1997 GT series: "After personally being involved with the initial track testing and racing of the first generation Acura NSX 26 years ago, it is a great honour for my team and I to have this opportunity with the NSX GT3 programme.

"The new generation NSX is an incredible machine, and will be a great platform for Real Time and Acura to contend for the 2017 Pirelli World Challenge title."

"By continuing our long-time partnership with RealTime Racing in the Pirelli World Challenge and extending our association with Michael Shank Racing in the WeatherTech SportsCar Championship, we plan to build on Acura's long tradition of success in North American sports car racing," adds Art St. Cyr, president of HPD.

"The NSX was designed as a pinnacle expression of Acura Precision Crafted Performance, and we're looking forward to proving out its ultimate performance capabilities in GT3 competition. We've been working with the NSX engineering teams in Ohio and Japan to bring our dream of a truly world-class new Acura NSX racecar to fruition."

That dream becomes reality next January in the IMSA GTD class of the Rolex 24 at Daytona.

The arrival of Acura, and the halo effect it brings, has been welcomed in both series. Rivals will nevertheless be casting envious glances in the NSX's direction and Peter Kox, the development driver in both Europe and North America, confirms: "I think it has the potential to be a really good GT3 car, but it's still early days.

"One strength of the NSX, for sure, will be the reliability. It is really well put together and until now, we had some issues but not really any worth mentioning for a new car – so that's very promising. I think the second factor, which is really important, is that there will be speed in the car. It's a very good product, a very good package and I think it will astonish some people next year."

ABOVE & BELOW Extensive development work has been done to get the GT3 into the right performance window prior to the BoP evaluation

LMP2 RACES INTO A NEW ERA

The vision of a new breed of cost-capped LMP2 sports cars became clearer when the Ligier JS P217 hit the racetrack. **Sophie Williamson Stothert** reports

WITH the first of a new generation of LMP2 cars finally having broken cover, what exactly has changed over the current setup? Well, quite a lot, actually.

Onroak Automotive's Ligier JS P217 is the embodiment of the new guidelines for 2017, agreed by IMSA and the FIA, which seek to ensure the long-term success of the category. To achieve that, three strands have been pulled together: a reduction in costs; a guarantee of stability in the regulations; and the intent to bring the performance of LMP2 cars closer to that of the current LMP1s.

With the LPM2 field whittled down to just four chassis constructors – Onroak, Dallara, Oreca and Riley Tech/Multimatic – and one engine, Gibson, what will differentiate between them? The early indications are that aerodynamic and cooling efficiency will be the key battlegrounds.

On the Ligier JS P217, a project which has been developed by chief engineer Nicolas Clemencon, Lucas Berger (electronic systems) and Mathieu Jouanneau (responsible for development and testing), special attention has been paid to the air supply of the engine radiators, cooling of the front and rear brakes, aerodynamic efficiency and finesse, managing the weight and optimising mechanical efficiency of the front and rear axles. The biggest challenge of all, though, has been the €490,000 cost cap.

"This financial target is a challenge for us, for sure," concedes Sebastien Metz, Le Mans director at Onroak Automotive. "As a constructor we have certain targets to reach in this programme, from performance and reliability to low running costs. This cost cap forced us to make sacrifices on certain components and the entire strategy has been a big compromise on all those parameters."

The JS P217 project has been a year and a half in the making. While it incorporates many of the lessons learned on its predecessor, its carbon monocoque is completely new. Indeed, the technology beneath the bodywork of the new breed is very different to that found on the existing cars – Metz estimates that only 15 per cent of the parts on the P217 are carried over from the current the JSP2.

With an emphasis on safety, the new cars feature wheel tethers, Zylon panels and a rear crash structure. The Onroak team has worked with a new material, T1100, to increase the overall stiffness of the monocoque, accommodate the extra crash protection and yet still meet its target weight of 930 kg.

ABOVE Onroak's Ligier JS P217 is unleashed for the first time

The aerodynamic programme has featured wind tunnel and CFD work, run in parallel. Encouraged by having found good correlation on the previous P2 project, the team has returned to RUAG's 40 per cent scale facility in Switzerland, and to its existing links with EXA.

"We needed to evaluate a high level of different configurations in the wind tunnel – we are more or less talking about 220 runs," says Metz. "In order to validate the different options, we have carried out a batch of 30 runs of the CFD. We achieved an extremely efficient result with EXA on our LMP3 car, a project handled using only CFD."

The new P217 has been optimised with both high and medium downforce bodywork, with a quick fastening system for the front and rear structures. A specific low downforce kit will be available for the Le Mans 24 Hours as an extra.

One of the biggest changes for everyone is enforced – the switch to a sole engine manufacturer. The 4.2-litre Gibson Technology V8, to be offered to teams on an hourly rental basis, is based on the 2011 3.4-litre unit. In order to reduce costs, it doesn't use direct injection. The target horsepower is approximately 600 bhp.

The majority of the LMP2 field had converged on Nissan engines, but Metz is upbeat about the switch. "The new Gibson engine," he says, "is a real racing unit. Honestly, the integration was pretty easy and having a stronger engine means increasing the top speed and overall performance while decreasing lap times – a high downforce car with less drag and a generous top speed should result in a great show for everyone competing.

"As the engine is the same for everyone, it was important for us to fit the configuration in the most optimal layout – and the cooling is clearly a major point. In order to make sure we can reduce both the water and oil temperature in warmer climates, we have used a new technology for LMP2, a concept already used massively in F1 and LMP1."

Onroak has worked on the cooling system with Mezzo Technologies, a supplier that has conducted innovative work in F1. "Working with them, we believe we have made a major step in evolving the cooling concept, improving overall efficiency and decreasing the drag," says Metz. "It's one of the developments we are most proud of.

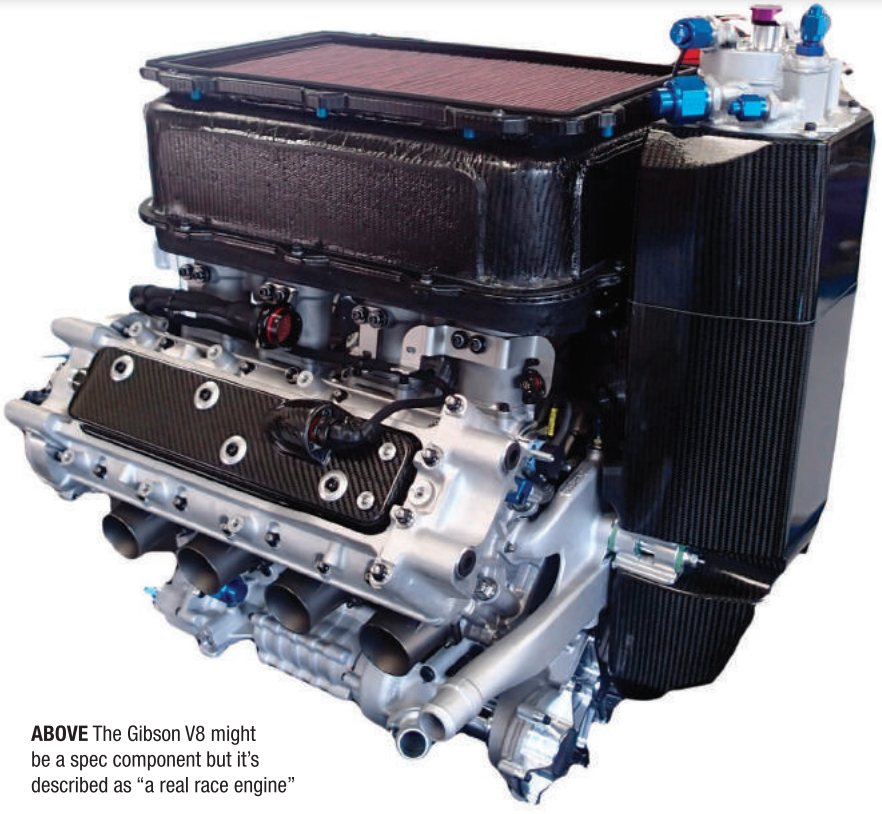
> *"We have used a cooling technology used in F1 but new to LMP2"*

"This concept allows us to reduce the quantity of dust and rubber getting stuck in the cooler, reduces the overall surface of exchanger by using a higher thermal ratio, while also reducing the drag. I would say that this has been our biggest challenge."

The previous LMP2 engine was run as a stressed member but with an additional supporting frame and the same philosophy of engine mounting has been carried forward onto the new car. "We have two lateral A-frames," says Metz. "We think that it's important to have a high level of torsional stiffness from the monocoque to the rear axle in order to keep the engine on a low stress profile."

Cosworth Electronics will become the sole electronics supplier for ▶

DPPI



ABOVE The Gibson V8 might be a spec component but it's described as "a real race engine"

the ACO/FIA series from 2017. It will supply a range of equipment that includes the Hewland pneumatic shift system, Kayaba electric power steering, a Cosworth MQ12Di data acquisition system and integrated telemetry to the ECU, a Cosworth carbon steering wheel, two lithium batteries, McLaren alternators and powerful headlights optimised with LED technology.

"The main bulk of the electronics is delivered by Cosworth as it's a common package for all constructors," says Metz. "In order to drop the price and make the electronic package more basic, the FIA/ACO benchmarked different suppliers, and we finally ended up with the choice of Cosworth, which supplies us with the steering wheel, the power box, ECU, dashboard and the switchboard."

FREEDOM

While each LMP2 constructor will utilise the same Gibson V8 engine and Cosworth electronics, they have freedom in selecting gearbox and suspension partners. In this instance, the Gibson will be linked to a 6-speed sequential Hewland TLS-200 gearbox. Meanwhile, the car's suspension will be developed by PKM Consulting – a partner that previously worked with Onroak on the Morgan LMP2 and the Ligier JS P2.

The new P217 features a semi-automatic pneumatic Hewland steering wheel paddle system, an oil exchanger cooling system, two sets of homologated gear ratios (as an option), and an extra set of gear ratios for Le Mans. A specific bellhousing has been developed for the Gibson unit, including a magnesium crankcase and a specific installation of the starter engine on the spacer.

The design team has also had to focus on improving the speed of tyre changes by designing a new axle, nut, and rim package, as well as improving access for the mechanics at the front of the monocoque – easing the transition from the Sprint version to the Le Mans version by reducing the number of bodywork pieces.

Of course, the chassis is nothing without its components, and the P217 will run AP Racing master cylinders, 380 mm AP Racing front and rear carbon discs, AP Racing brake pads and Brembo 6-piston callipers.

It will also feature optimised suspension geometry, including double wishbones, pushrods and torque rods at the front of the car with the latest generation of 4-way shock absorbers, axles with an automatic security system, and an adjustable anti-roll bar system. The P217 will ride on 18-inch magnesium rims.

Jacques Nicolet, president of Onroak Automotive, says: "After more than a year's work by all our departments we're really looking forward to presenting our brand-new Ligier JS P217 in a few days with a certain sense of pride.

"Designing a new car isn't exactly a stroll in the park as there are several question marks and important choices to be made between the first sketches from the design department and the first laps of the track.

"Our experience in the construction of sports prototypes, in particular in the LM P2 category, and the close collaboration that we enjoy with our technical partners and our clients, have helped guide us through the different stages to achieve the best possible result." RT

Why the change?

THE saying goes: "Why fix something that isn't broken?" The outgoing LMP2 regulations had attracted many teams and suppliers, so why the change to a spec engine and just four chassis constructors?

"These new regulations will lead to a more efficient, cost-capped, viable economic model," argues Pierre Fillon, president of the ACO. "Our priority is to supply the teams and drivers entered in this category with the best options and solutions to race in endurance on a long-term basis. This will help ensure a global market for cars that can race in North America, Asia and Europe."

Jean Todt, FIA president, adds: "The FIA, ACO and IMSA have agreed to the unification of sportscars so that the same cars and same teams can race on both sides of the Atlantic.

"Safety has also been at the core of these new LM P2 regulations; they will integrate all of the knowledge that we have developed through current LMP1 regulations, with new requirements such as utilising a closed cockpit, rear crash test and wheel tethers."

"This is a realistic approach to creating economies of scale and should make endurance racing even more dynamic and attractive," concludes Lindsay Owen-Jones, president of the FIA Endurance Commission. "This 2017 concept for LMP2 and the limitation to four chassis manufacturers will help establish greater return on investment by presenting more opportunities to race the same type of cars, and by avoiding excessive fragmentation of the market." RT

PSP Images

ACCESS ALL AREAS

Andrew Charman discovers how the British Touring Car Championship is constantly seeking to improve its product, whether it's making the racing safer or giving the fans a better show

SUNDAY July 31 2015 was 'one of those days' for the British Touring Car Championship. At the end of it, most involved in the UK's biggest motorsport series were simply glad to get away from the Norfolk circuit of Snetterton after unprecedented mechanical carnage.

No one could remember the last time two successive BTCC races had been brought to a stop by red flags, the first caused by an expensive multi-car crash on the fastest part of the circuit during race two.

It was, however, the sight of Hunter Abbott's Chevrolet barrel-rolling along the straight at the start of race three, finishing up atop a barrier having demolished a TV camera gantry, that seared itself on the memories of both spectators and the live TV audience. All were glad to see both Abbott and the cameraman walk away, the latter having remarkably kept focused on the car as it flew towards him.

In a strange way, however, when one looked under the surface a day which no-one wanted to repeat also served to illustrate just how the BTCC is seeking to constantly upgrade its product across all areas. While the accidents highlighted the reason for the latest evolution of the series' safety package, clearing up the carnage also showed how the BTCC is constantly trying to please its fanbase with more racing and fewer delays.

SEAT OF THE ISSUE

Safety has always been a prime concern of the BTCC and all involved. Part of the wide appeal of the series is the body-rubbing nature of the racing, but this inevitably results in clashes, causing much mechanical damage but thankfully seldom resulting in injuries to drivers. Series officials, however, can never be complacent.

Since 2015 the BTCC Next Generation Touring Car (NGTC) formula has also been specified as the TCN-1 regulations of the FIA, the world motorsport governing body's major national Touring Car formula and effectively the step below

the FIA's lead series the World Touring Car Championship (WTCC).

As BTCC technical director Peter Riches explains, generally the NGTC way with regard to safety is to introduce any changes a year after they have been adopted by the WTCC. So before the 2016 season, BTCC teams were informed that they would need to upgrade their driver seats from the previous 8858-1999 FIA safety standard to the new 8862-2009 version.

The latter standard is mandated for most FIA series at global level, including Le Mans, GT3 and the World Rally Championship, and was created following a number of fatalities resulting from 8858-1999 standard seats failing in crashes. David Black of New Zealand-based seat manufacturer Racetech helped write the 8862 standard, which particularly features an upper back mount connecting the seat to the car's roll protection structure. This concept had been originally developed in 2002 for the Dodge Viper race project by the late Dr John Melvin, a much-admired independent racing safety consultant to the FIA, Indy Racing League and NASCAR.

As David Phillips from Racetech Europe explains, under 8862-2009 the seat is effectively integrated into the structure of the car, particularly around the head and shoulder areas – the most critical – so that impact loads are transferred to the chassis.

"Integrating the seat into the chassis at shoulder level produced much greater strength and improvement to how the driver was kept safe in a crash, rather than the seat deforming and allowing movement in the upper part of the driver's body," Phillips says.

The 8862-2009 seats also have to survive a much more intensive testing procedure: "The seat has to be a lot stronger; the destructive forces the test puts them through are a lot higher. But equally you can't effectively make the seat out of concrete, so that it is absolutely rigid – it has to have some energy absorbency, to help keep the driver safe."

Installing such seats into cars requires modifications to the roll cage, principally to provide a means of attaching the rear mount, in addition to the usual rails. In the case of the BTCC, the MSA's rollcage homologation document gained a one-page addendum allowing for the installation of an extra bar on which to attach the seat back mount.

"The roll structure has to have some way of holding the seat, but it is fairly simple," Phillips says. "Some roll cage manufacturers weld threaded bosses into the roll cage, while some just use a clamp to attach the mount to the cage, and this is also perfectly acceptable – there are a number of ways of doing it."

The arrival of the 8862-2009 standard ▶

LAT

PSP Images

OPPOSITE, ABOVE & BELOW Safety first: That Hunter Abbott emerged unscathed from his Chevrolet's destruction of a camera tower at Snetterton owed a lot to the upgraded design of his race seat

significantly increased Racetech's involvement in the BTCC. In recent years the two major seat suppliers to the series have been Corbeau, which was able to produce its own 8862-2009 standard seat, and Telford-based Cobra, run by Mark Dunsford, which did not make a seat to the new standard but did have contacts with many teams. With Cobra already enjoying a relationship with Racetech and the latter having sold its first 8862-2009 seat as long ago as 2008, a tie-up was the obvious move, and between them Cobra and Racetech now supply 23 of the 32 cars on the BTCC grid.

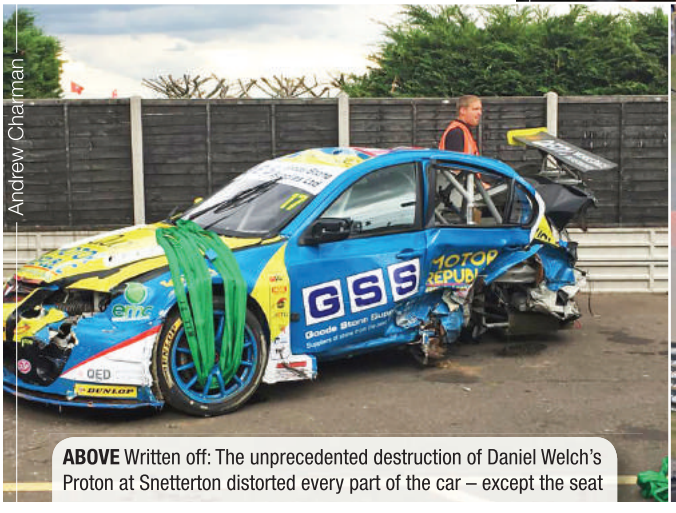
Despite the apparent simplicity of the engineering involved to incorporate the new seats, the changes produced inevitable resistance from BTCC teams, principally on the grounds of cost and weight. The extra material in the seats, and the more extensive testing involved, made them significantly heavier, allied to a cost around double the price of the previous 8858-1999 seats – though the new seats do have a 10-year life cycle compared to the five years of their predecessors.

Teams were able to choose between a cost-focus or weight-focus – the Racetech seat is made in four sizes (standard, wide for what Phillips describes as "Drivers with success ballast", tall and tall & wide), and in two materials, carbon Kevlar or glassfibre composite. The former are twice the cost of the latter, but also half the weight, and not surprisingly most BTCC teams went the carbon Kevlar route. "Teams do complain about the cost of them, but in proportion to the cost of building and running a car it's nothing," says Phillips.

The major difficulty Phillips experienced with BTCC teams in the winter 2015-2016 period, however, was the timescale ▶

PSP Images

ABOVE & BELOW Sitting comfortably: Two views of the 2016-spec seat supplied by Cobra/Racetech in the Speedworks Toyota Avensis of Tom Ingram and Gordon Shedden's Dynamics Honda Civic



Andrew Chatman

ABOVE Written off: The unprecedented destruction of Daniel Welch's Proton at Snetterton distorted every part of the car – except the seat

BELOW Straight into disaster: The accident on the straight at Snetterton caused major damage to several cars, but their drivers all walked away

Ebrey/BTCC

KIMBERLEY
MEDIA GROUP LTD

FOUR NEW WEBSITES

- **Breaking industry news**
- **Exciting video content**
- **Leading international directories**
- **Free newsletters**

kimberleymediagroup.com

racetechmag.com

historicracingtechnology.com

trackcarperformance.com

Ebrey/BTCC

BELOW Head strong: In this view of the Cobra seat in the Speedworks Honda Civic of Matt Simpson the upper mount can just be seen

provided in which to install the seats. "Our ability to perform and deliver was tested," he admits. "Teams were reluctant to make the changes and we didn't get the go-ahead until really late, just before the season started.

"Each seat takes a week to make and they are manufactured in New Zealand, so they need shipping over. We had all-nighters helping teams install seats leading up to the first round of the series but we still managed to get everybody on the grid for the first race."

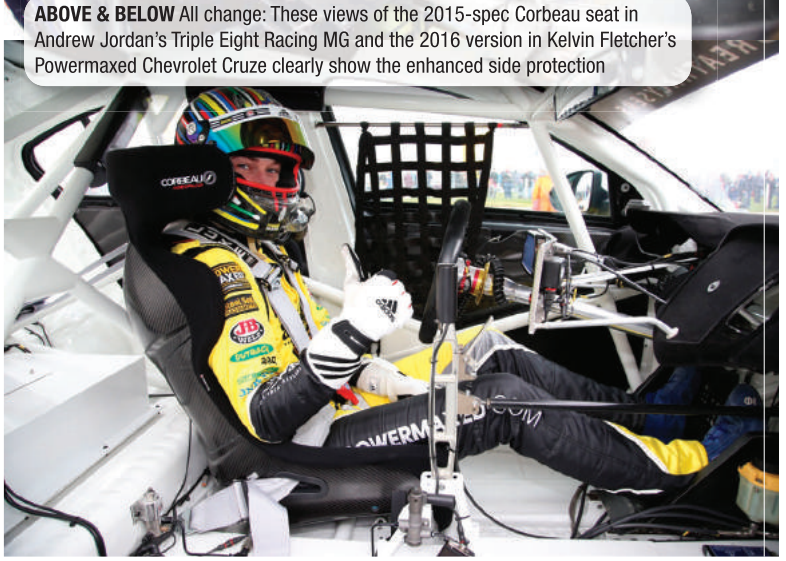
Initial reaction to the seats from drivers was somewhat negative, until they realised that the gains were not just in safety. "I spoke to (Honda's) Matt Neal when he first had his seat, and he didn't like it, said it was uncomfortable," recounts Phillips. "Just a few weeks later I spoke to him again and he said he'd got comfortable in it and loved it.

"(BMW driver) Rob Collard told us that the seat gave him such better feedback – he's now up at the front of the grid contending for the championship and we think it's because he can better feel what the car is doing."

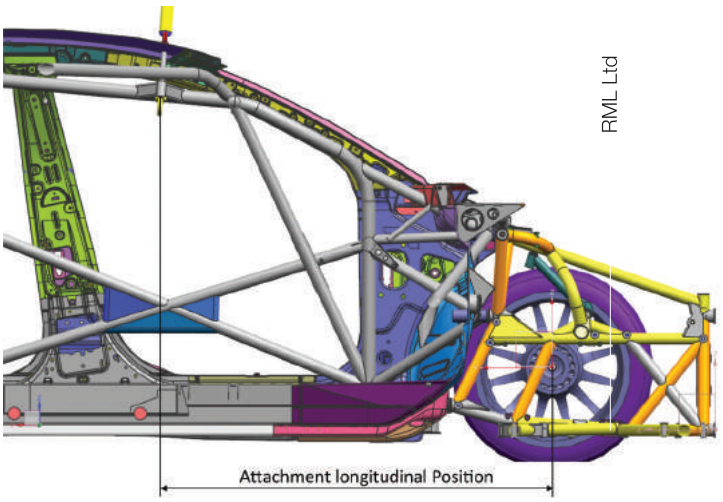
The real value of the seats, however, was proved beyond doubt at Snetterton. Following his wild roll along the barrier Hunter Abbott was able to step out of his Chevrolet, which was fitted with a Corbeau seat to the 8862-2009 standard. Earlier in the day Daniel Welch had walked away from an impact to his Proton that left the car written off with an unprecedented level of damage.

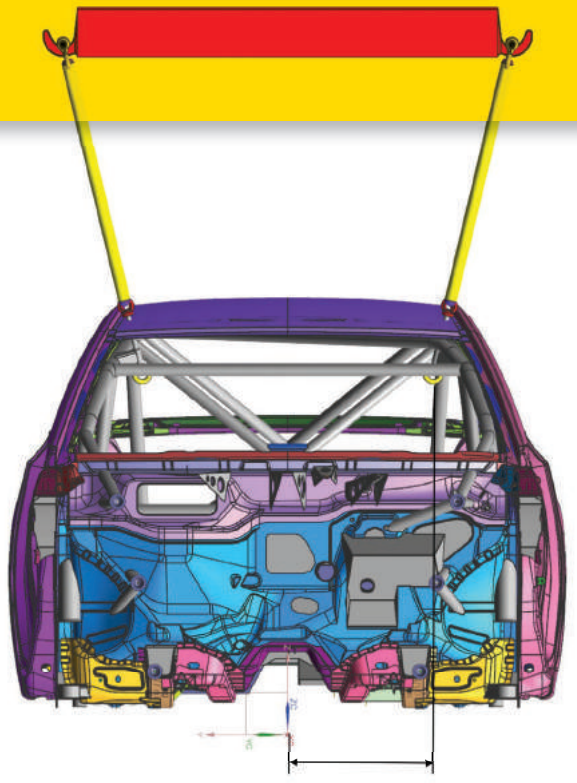
Welch was so impressed with his Cobra/Racetech ▶

Ebrey/BTCC



ABOVE & BELOW All change: These views of the 2015-spec Corbeau seat in Andrew Jordan's Triple Eight Racing MG and the 2016 version in Kelvin Fletcher's Powermaxed Chevrolet Cruze clearly show the enhanced side protection





ABOVE These CAD drawings show the new design of lifting eyes devised by RML Ltd and mandatory for 2017-spec BTCC cars

seat he phoned Mark Dunsford on the Tuesday following the race to thank him. "The only straight bit of the car following the crash was the seat," says Welch. "Every part of the car was distorted except the seat and its mounting – it did its job in the impact.

"We actually wanted to fit these seats to our BTCC cars three years ago, we were running them in our endurance car at the time – they are so much safer and you get a much better feel for driving the car."

Phillips believes that lessons have been learnt in the installation of the new seats and any initial issues won't be seen in future: "It will be a lot easier for car builders to integrate the seat. There is some variation – if you know the angle the driver wants the seat positioned at, it's easy to integrate it into the roll structure. But if the driver's not involved in the construction they may require the angle changed once they've sat in it and some engineering will be necessary to make an interface change. But it's not difficult, only a case of making brackets in the correct materials, nothing a BTCC engineer can't do."

He believes that after initial resistance, the teams and the drivers understand the value of the new seats, and not just in terms of safety, saying: "Quite simply, the seat enables the driver to drive faster for longer."

LIFTING THE SHOW

Safety is of course the leading concern for all involved in the BTCC but another significant priority is the show itself. Series head Alan Gow has never hidden his appreciation for, and inspiration from, the fan-centric attitude displayed by such US series as NASCAR, and has always been concerned with the quality of the action presented to the fans at the circuits and watching on the TV.

Over the past couple of seasons such attention to detail has expanded beyond the cars themselves to the 'support team'. As was so clearly demonstrated at Snetterton, the close, action-packed nature of the BTCC inevitably results in accidents, and while red-flagged races are rare, laps behind a safety car while crashes are cleared away are routine – at this year's Rockingham meeting one race alone was broken up by three safety-car periods.

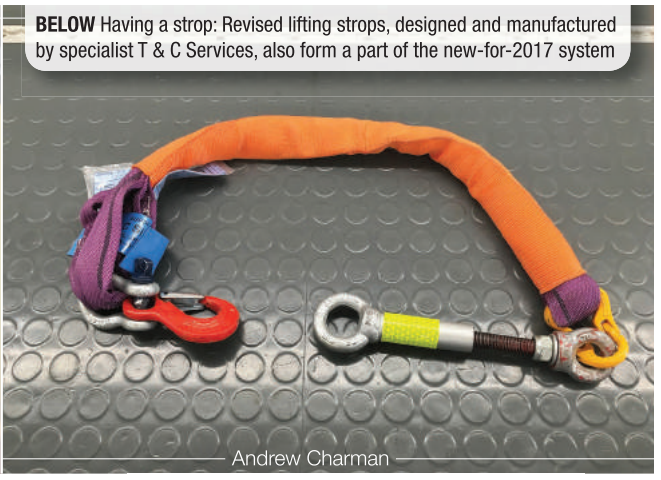
Gone are the days when the BTCC race was a single event of many laps, so that a safety-car period made little difference to the outcome. Today there are three races at each meeting, and each one can be of as little as 16 laps. The first three laps lost under the safety car are added to the race distance, but even so running around in convoy frustrates the drivers and particularly the fans, as well as potentially putting a tight programme orchestrated by TV timing requirements behind schedule.

So the BTCC has focused on the efficiency of the clean-up process. The first moves in this area were seen last season with the launch of the 'BTCC Genius', a more effective and more rapid method of dealing


Andrew Charman

ABOVE The Team Parker Ford Focus of Alex Martin was selected to test the new lifting system and the eyes installed

BELOW Having a strop: Revised lifting strops, designed and manufactured by specialist T & C Services, also form a part of the new-for-2017 system


Andrew Charman

with track debris such as oil spillages or mud. A specially-adapted pick-up truck is now part of the emergency team at all BTCC meetings.

The major issue for clean-up teams, however, is recovering damaged cars, particularly immovable examples in need of placing on a flatbed truck – the lengthy process of ensuring a car can be safely lifted without tipping forwards or backwards can soon eat into time. After Hunter Abbott's Snetterton startline accident the rescue teams remarkably had everything ready to go within 45 minutes, but coming at the end of a difficult day the inevitable result was a reduced race distance and the postponement to a later meeting of a round of the Ginetta Supercup, due to race after the BTCC.

Therefore early in 2016 the BTCC set its new chassis supplier, RML Ltd, the task of producing a more effective solution. After studying the problem, the chosen way forward was to adapt a method used in the Porsche Carrera Cup support series. All cars competing in this series must be fitted with lifting eyes at their centre-of-gravity point, which allows them to be easily connected and transferred onto a recovery vehicle.

While all the cars in the Porsche support series are the same, however, BTCC grids comprise a variety of body shapes, front and rear-wheel-drive formats, with corresponding variations in the centre of gravity. As a result the design of a lifting system to work across all formats proved quite complex.

A solution was arrived at based around two lifting eyes built into the car and a new design of strop and lift beam, which were designed and built for the series by specialist T & C Services, based near Buntingford in Hertfordshire

The Dextra Racing with Team Parker Ford Focus entry of Alex Martin was selected as a 'guinea pig' and fitted with the new lifting eyes prior to the mid-season tyre test at Snetterton, so that recovery crews could practice with the system. Further tests were carried out at the Knockhill meeting in August, with excellent results. Ironically, following the startline crash at the Snetterton race meeting, Martin's damaged car became the first to be lifted out of necessity using the new system.

For the 2017 season the BTCC will be issuing circuits with several sets of the new strops and lifting arms. A technical bulletin has also been issued informing teams of the requirement to install the lifting eyes.

These will be combined with twin steel towing eyes front and rear, with a two-tonne capacity, an upgrade to be adopted by the MSA across all appropriate series in 2017. Recovery crews will be provided with appropriate towing straps that will ensure that when a car needs to be pulled away from a parallel position against a barrier, an equal load is put on both towing eyes.

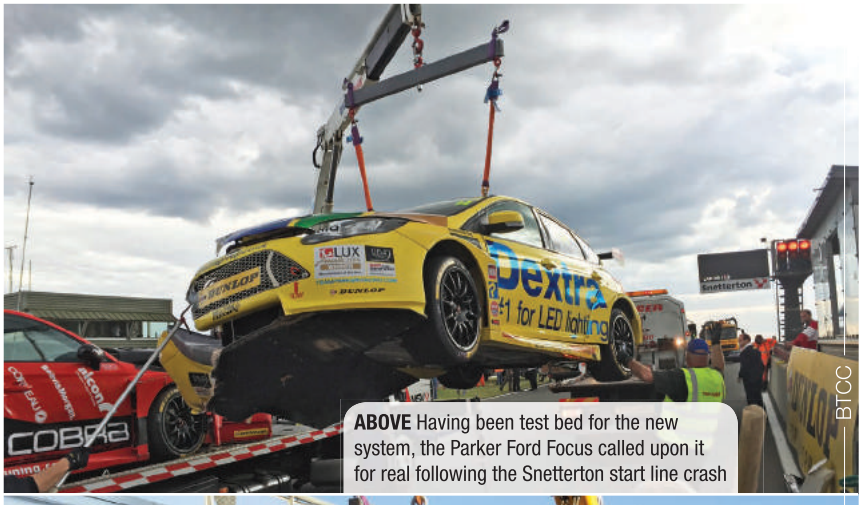
Few BTCC fans will ever be aware of these behind the scenes changes – but as a result of them, they will enjoy more laps of racing, and fewer laps of high-speed convoys… RT

No net gain

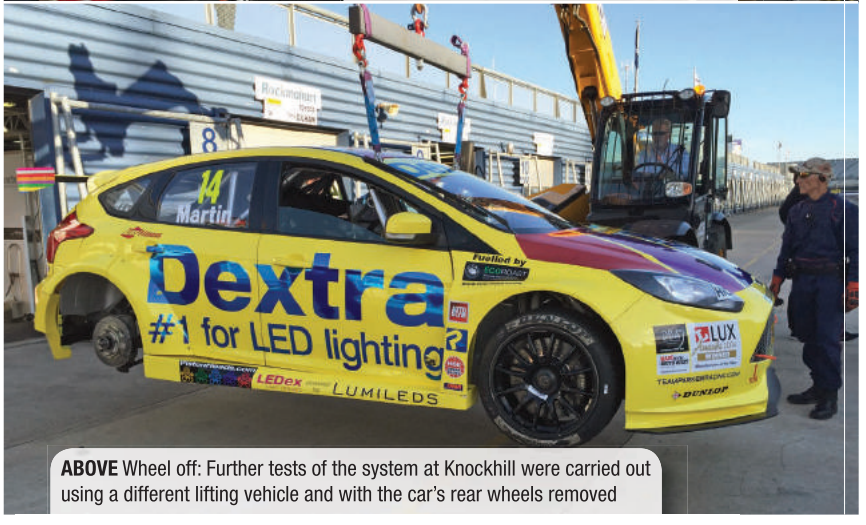
WHILE as stated in the main text the BTCC generally adopts the safety upgrades of the WTCC a year later, this is not always the case. As well as mandating the new seat requirements for 2016, this season's technical regulations also informed teams that for 2017 the series would change its protective window net regulations to a new format already applied to the WTCC. However this move has now been postponed.

BTCC technical director Peter Riches explains that the new net standard had originally been created for GT3 racing, where the driver sits in a much more laid-back position compared to that of a Touring Car.

"We have decided to delay this move as the new nets are not ideal with the upright seating position of a touring car with regard to mirror visibility and stick shifting – we have drivers' elbows catching in the net when turning the steering wheel," Riches says. He adds that the BTCC will now be looking for a more practical solution. RT



ABOVE Having been test bed for the new system, the Parker Ford Focus called upon it for real following the Snetterton start line crash



ABOVE Wheel off: Further tests of the system at Knockhill were carried out using a different lifting vehicle and with the car's rear wheels removed

THE MAGNIFICENT SEVEN

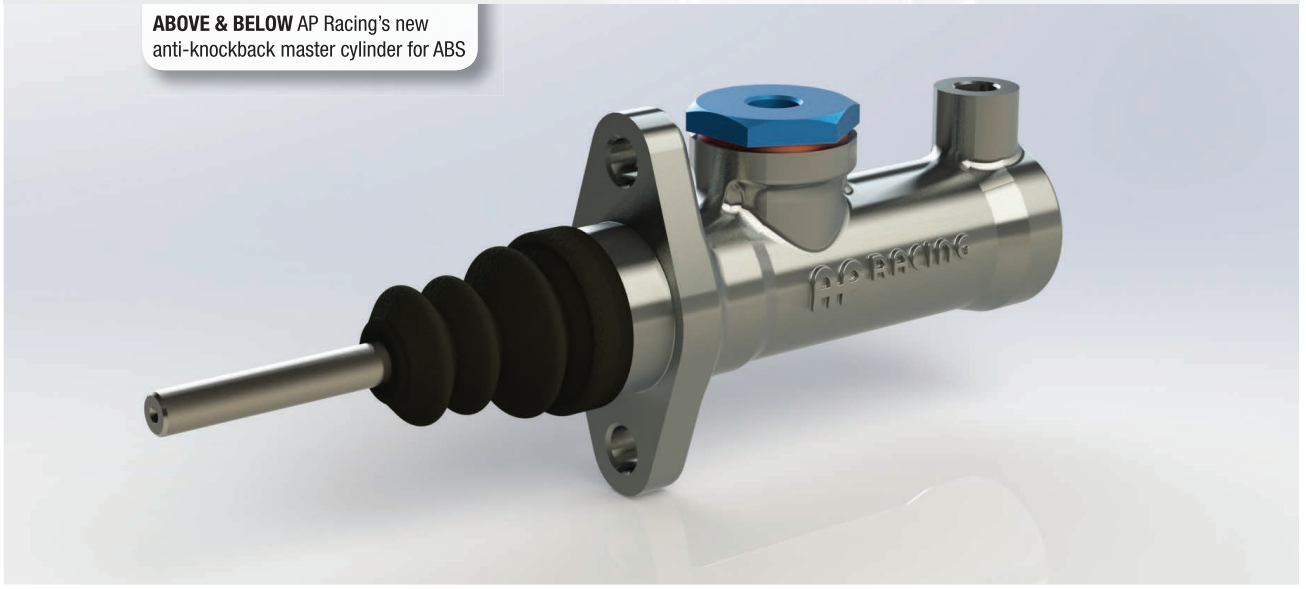
William Kimberley considers the contenders for the Most Innovative New Motorsport Product of the Year award, to be presented at next month's Race Tech World Motorsport Symposium

2016 has been another phenomenal year when it comes products that have been principally developed for motorsport but which are commercially available. Electronics is always at the cutting edge but that is not to ignore the more mechanical products and driver aids. Here are the innovations that have caught the eye over the last 12 months.

AP Racing

NEW ANTI-KNOCKBACK MASTER CYLINDER FOR ABS

AP Racing has been developing a new anti-knockback master cylinder for ABS. If a standard master cylinder is used, it downloads pressure into an accumulator and towards the end of the braking event



ABOVE & BELOW AP Racing's new anti-knockback master cylinder for ABS

ABOVE Bosch's PBX90 which can replace conventional relays, fuses and circuit breakers and simplify harnesses

it pumps the fluid back through the master cylinder and into the reservoir. This causes a particular problem with heel nibble on the seals as they are pressurised before the cut-off point is passed.

AP Racing has been focusing on getting rid of that cut-off point on the master cylinder and replacing it with a centre valve system. According to AP Racing designer Richard Bass, "The centre valve system comprises a small valve up the centre of the piston that doesn't have the main seal travelling back across it, so still has the same travel to cut-off. The travel to cut-off on a main seal just creeps over this small port that's about 0.75 mm in diameter and then there's still around 5 mm of seal to travel over the port. With the centre valve there's the typical 0.75 mm of travel and there's no seal that can extrude. That works really nicely with the ABS system as it has proven to be a cleaner cut-off and there's been a reduction to about 0.5 mm of travel, making the tolerance better.

"Adjacent to that valve, we've put an anti-knockback function in. Traditionally we put anti-knockback springs behind the pistons in the calliper. You can only go so far with those before you induce drag into the brake system and putting very strong springs in can mean temperature problems with the induced drag and loss of top speed.

"What we've done is put a valve system into the piston rather than in the cylinder that sits adjacent to the centre valve. It's a relatively simple system which makes it a much nicer application and installation."

Bosch Motorsport

PBX90

Weighing just 835 grams, the PowerBox 90 (PBX90) is an intelligent control and distribution unit for the electric grid in a modern racing car which is seamlessly integrated into the Bosch Motorsport system architecture. It is capable of replacing all conventional relays, fuses and circuit breakers and simplifying wiring harnesses. It boasts 36 individual high current outputs warranting a continuous current of up to 80A while also being able to provide diagnostic information with the use of CAN/Ethernet communication.

The power supply itself can deliver up to 120A continuously and is able to peak at 180A. The power distribution unit also comes with Bosch Motorsport's PBX Suite – one computer licence per unit – to enable users to configure and develop their own functions and commands. These range from simple ones, such as flashing headlights, to incredibly complex ones such as limp home mode. Should more than 36 outputs be required, two PBX 90 units can be used in a single system.

Another great advantage for those already using Bosch Motorsport electronics is that the PBX90 is able to be integrated into the Bosch Motorsport system architecture, such as logging, seamlessly and hassle-free.

Delta Motorsport

MITRE - MICRO-TURBINE TECHNOLOGY

Delta Motorsport's new micro-turbine technology is aimed at helping electric cars match petrol or diesel-powered equivalents. Dubbed MiTRE, the new system was developed with support from Innovate UK and is specifically designed for use as a range extender for electric vehicles, including electric race cars. Delta has produced two complete MiTRE prototype systems with 17 kW power output and has fitted one into its in-house EV, the E-4 Coupe. ▶

BELOW MiTRE: a £3.1 million collaborative R&D project that could help us kiss goodbye to range anxiety?

Niche car manufacturers Ariel and Morgan have already signed up with Delta to develop 17 kW and 35 kW power output versions of MiTRE, and the potential for this technology is vast. When scaled to 35 kW output power, MiTRE is approximately 40% smaller and 50% lighter than an equivalent piston engine device, yet still achieves a target of close to 30% thermal efficiency (280 g/kWh) with extremely low emissions. It is also adaptable. It can be run on a range of fuel, and fitting a larger heat exchanger improves thermal efficiency to nearly 35% (240 g/kWh).

"This is an exciting and challenging project," says Simon Dowson, Delta Motorsport's managing director. "One of the main issues seemingly holding electric cars back is the lack of range, but this technology changes that. We demonstrated proof of concept when we fitted one of the prototypes to our E4 Coupe electric sports car. Our projections show the cost of the system is low enough to be attractive to the automotive market, so we have a really potent solution to advance the take-up of electric vehicles."

Lifeline

ZERO 3620 SYSTEM

Representing a step-change in driver safety, Lifeline Fire and Safety Systems' new fire suppression system, the Zero 3620, meets the FIA's demanding 8865 test and safety standards. It has been awarded the FIA Gold Standard for use with unleaded petrol, diesel, ethanol and E85 fuels. Following the homologation, it was mandated for use in the World Rally Championship in 2016 and officially recommended for all other categories by the FIA.

It has undergone extensive testing, development and validation in both the motorsport and defence sectors. It is deployed in both the engine bay and cockpit, as per the new, stringent FIA regulations.

The engine-focused side of the system features Lifeline's patent pending dual discharge technology – the primary side of the cylinder quickly knocks the fire out and is then supplemented ▶

LEFT The Zero 3620 system has found applications in defence, as well as motorsport

DELIVERED DIRECTLY TO YOUR DOOR!

40% Off SUBSCRIPTIONS

...or find digitally on

Available on the App Store

ANDROID APP ON Google play

available on kindle fire

By subscribing online
www.racetechmag.com

ONLY

£43.00 12 Issues, UK
£71.00 12 Issues, Europe
£89.00 12 Issues, USA/Rest of the world

RACE TECH is the only technology led motorsport engineering magazine that focuses on every aspect of the racing car, from the drawing board to the race track. News reactive and highly topical in its content, it covers everything from the design and manufacturing processes to the cutting edge products that are constantly being developed for racing. To be kept up to date on the hottest technology in the motorsport world, subscribe to **RACE TECH**.

ONE YEAR/ 12 ISSUES	FULL PRICE	YOU PAY
UK	~~£71.40~~ Free P&P	£43.00 Free P&P
EUROPE	~~£118.00~~ Incl P&P	£71.00 Incl P&P
USA	~~£149.00~~ Incl P&P	£89.00 Incl P&P
ROW	~~£149.00~~ Incl P&P	£89.00 Incl P&P

Subscribe online at www.racetechmag.com

with a secondary discharge, using the residual energy from the first, to deploy a specifically blended coolant fluid to prevent any re-ignition.

The cockpit-facing system is available in two sizes – 2.0 kg for up to 2.3 CuM and 3.0 kg for 2.4 to 4.0 CuM – and features Lifeline's compression discharge technology, with the option of either a fixed or remote outlet.

The entire system is controlled by a unique microprocessor which constantly monitors the state of the system and battery and will advise the user of any potential issues. Lifeline has also homologated a remote activation facility, enabling the system to be deployed wirelessly from the pits or safety crew.

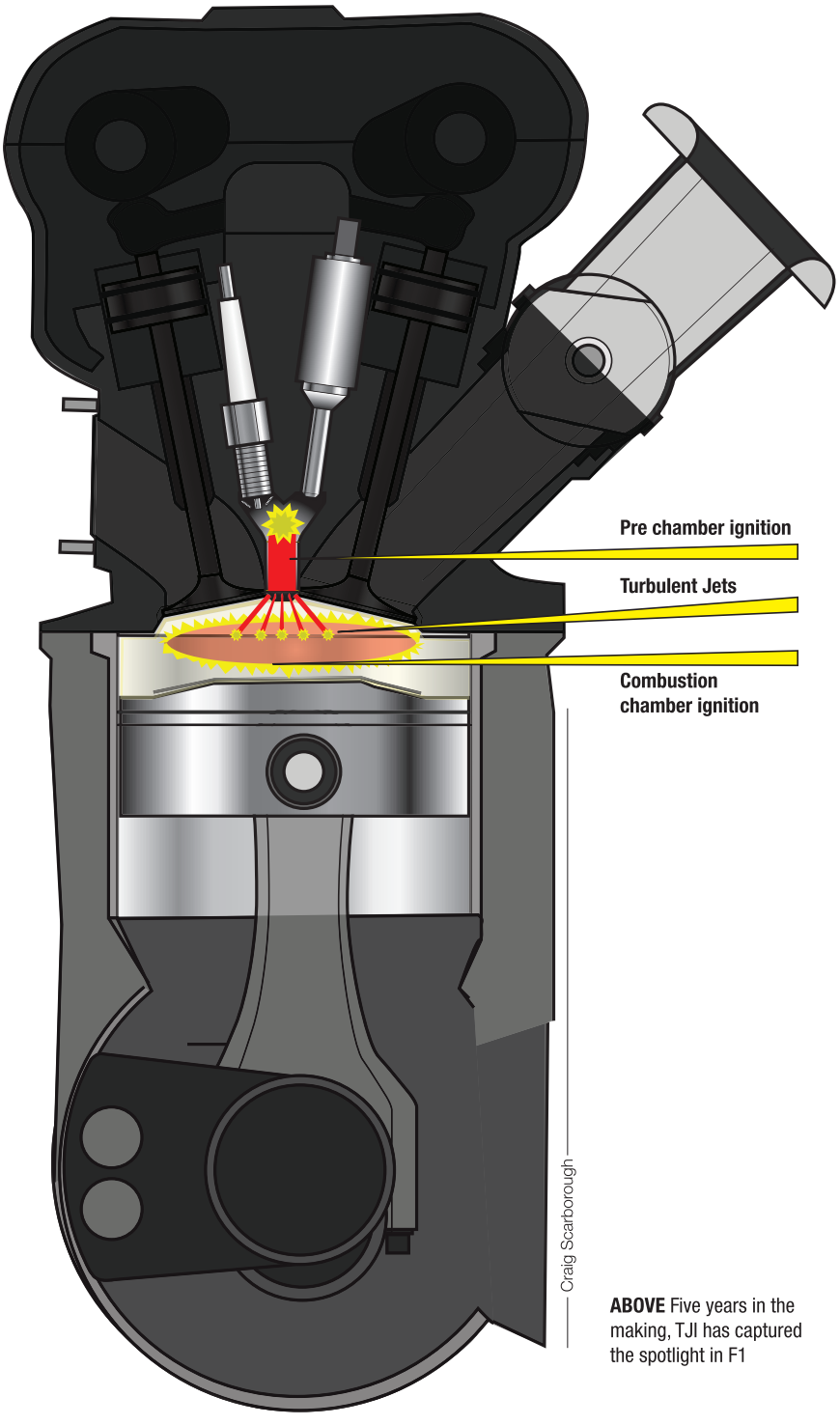
MAHLE Powertrain

TURBULENT JET IGNITION

Turbulent Jet Ignition (TJI) utilises a spark-initiated pre-chamber combustion process in an otherwise conventional gasoline engine to achieve fuel economy improvements of up 20%. Engine-out NOx emissions are also virtually reduced to zero levels, negating the need for lean NOx aftertreatment.

Existing jet ignition systems involve the creation of hot gas jets from a pre-chamber which are then introduced into the cylinder where they rapidly induce ignition of the main in-cylinder charge. Mahle's TJI system is characterised by auxiliary pre-chamber fuelling, small orifices connecting the main and pre-chamber combustion cavities and a very small pre-chamber volume. The smaller orifice size causes turbulence in the hot gas jets which then penetrate deeper into the main combustion chamber and cause a distributed ignition effect. This process then allows extension of knock limits and increased compression ratios – up to 14:1 – combined with lower combustion temperatures and reduced throttling/pumping losses to achieve thermal efficiencies in the region of 45%.

The combustion gasses effectively act as multiple spark plugs. While ignition normally takes place in the centre of the cylinder, with Jet Ignition it essentially takes place from the outside toward the inside which allows significantly better combustion of the fuel.



ABOVE Five years in the making, TJI has captured the spotlight in F1

Magneti Marelli

HIGH-SPEED CAMERA

Tasked by the FIA to develop a camera that could record in milliseconds the movement of a driver's head during the crucial moments of impact, Magneti Marelli developed a product which is not much bigger than a USB and could record 400 frames per second compared to the previous standard of 25 fps.

When played back in slow motion, it shows high-speed events in far greater detail than was previously possible. Video footage from the camera is compressed in real time to a H.264 codec for the ease of storage. It can record for up to 90 minutes before it returns to the start and rewrites, the time restriction having been enforced to limit the amount of compression to the file. ▶

PUSHING CARS TO THE LIMIT

Pushing cars to the limit

INTERNATIONAL

TrackCar performance

Sub prices:

One year/4 issues
UK - £18
Europe - £34
USA & ROW - £44

Two years/ 8 issues
UK - £33
Europe - £62
USA & ROW - £79

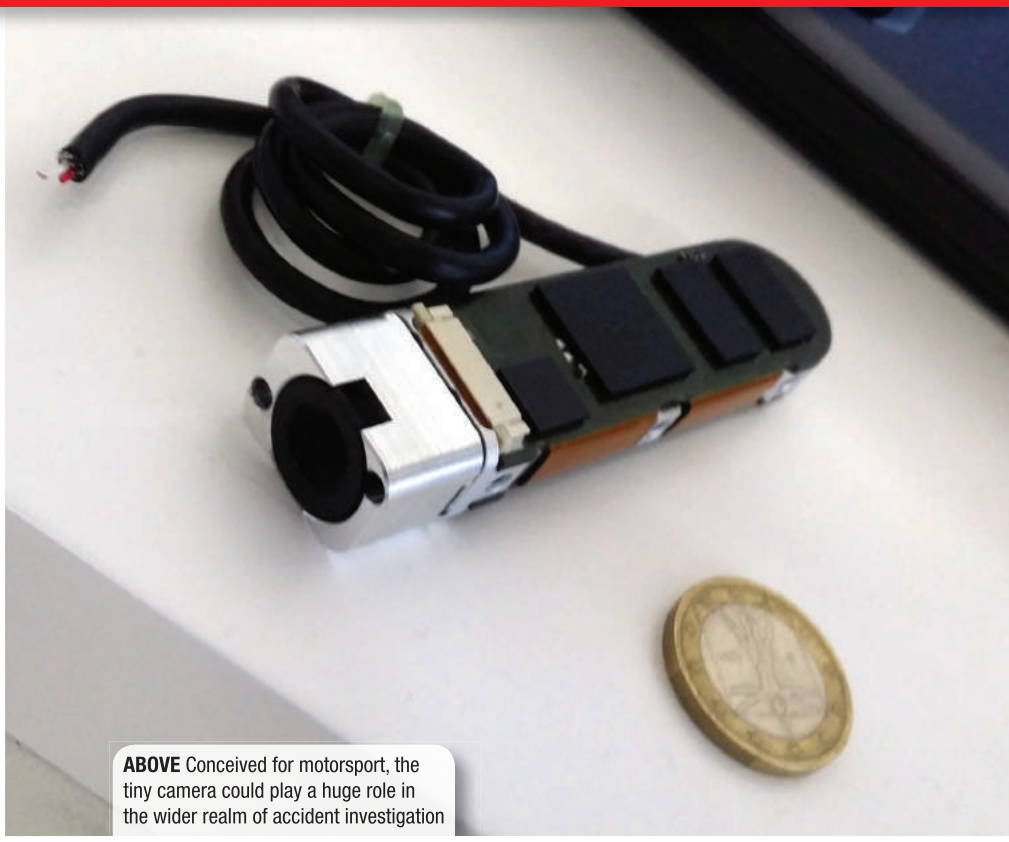
Written and edited by RACE TECH's Editor-in-Chief William Kimberley along with former Track Driver Editors Mark Hales and Carl Owen, Track Car Performance magazine focuses on how to make your cars more competitive and what to look for when kitting them out. The magazine will appeal to everyone from the person who just wants to take their car to the track for a bit of fun to the high-end track car owner who all have the same mission in mind – and that is to go as fast as possible along a given piece of track. • Track Day Drivers • Club Racers • Professional Drivers • Online Racing Enthusiasts • Engineers • Motorsport Enthusiasts.

www.trackcarperformance.com

The video is stored on the car's accident data recorder and synchronised to the telemetry. Teams can therefore analyse the exact speed and force at the point of impact and understand the mechanism of driver injuries and accurately determine the first point of contact. Lessons learnt will help develop cockpit safety.

The camera is so compact that when compared to an 'off the shelf' setup with parts available in the public domain, it is one third of the weight and takes up just one eighth of the space in comparison to a bulkier standard setup.

After a year being used in Formula 1, Magneti Marelli plans to release a budget version that nonetheless still retains the 400 fps to lower formula race series. Eventually this new technology will be introduced to the automotive industry, whereby it should be instrumental in accident investigations.



ABOVE Conceived for motorsport, the tiny camera could play a huge role in the wider realm of accident investigation

Racelogic

VBOX VIDEO HD2

In a short space of time, the Racelogic Video VBOX has become standard kit for race teams, whether they are contesting world championships or racing at club level.

The original one was launched in early 2009, with an updated version followed by the Video VBOX Lite in late 2010. Since then it has produced a range of products to suit all pockets. The latest is the VBOX Video HD2, which moves the range to the next level with a 1080p HD dual camera video that can record at 30 or 60 frames per second to an SD card or USB stick. Its 64 incoming CAN channels are double that of the existing VBOX HD1.

It also allows for a main view with embedded picture-in-picture along with a live graphic overlay, so in real time will record the graphics in stunning high definition. The lenses are wide angle, ensuring that every moment of track action is captured.

With the high resolution afforded by the 1080p output, this gives the user great scope for fantastic dashboard and gauge layouts. The graphics are fully customisable but several default scenes are available. It is also wireless and Bluetooth enabled so can connect to a remote start/stop logging switch via Bluetooth. It will also be possible to connect to a wireless heart rate monitor that can be put into the video and logged into the data.

As a result of this, Racelogic has created an app for Android and iOS devices that connects via the VBOX Video's inbuilt WiFi to aid in getting the view just right, with real-time camera output being displayed on the mobile device's screen. The app also features some elements of the system setup for absolute convenience. RT

ABOVE Two 1080p cameras allow a main view with embedded picture-in-picture

Deliver On Track with D.O.T

It's on the track where it matters. Everything else is merely a distraction. When it comes to logistics, this distraction can become expensive and time-consuming.

Delivered On Time have over 80 years of collective experience in global motorsport logistics including Formula One, WRC, Superleague Formula, Macau GP and A1 GP World Cup of Motorsport as well as global events like the Olympic Summer and Winter Games and the FIFA Football World Cup.

D.O.T are therefore ideally placed to support your efforts in the ALMS, as well as the WEC and the 24hrs of Le Mans.

Our services include:

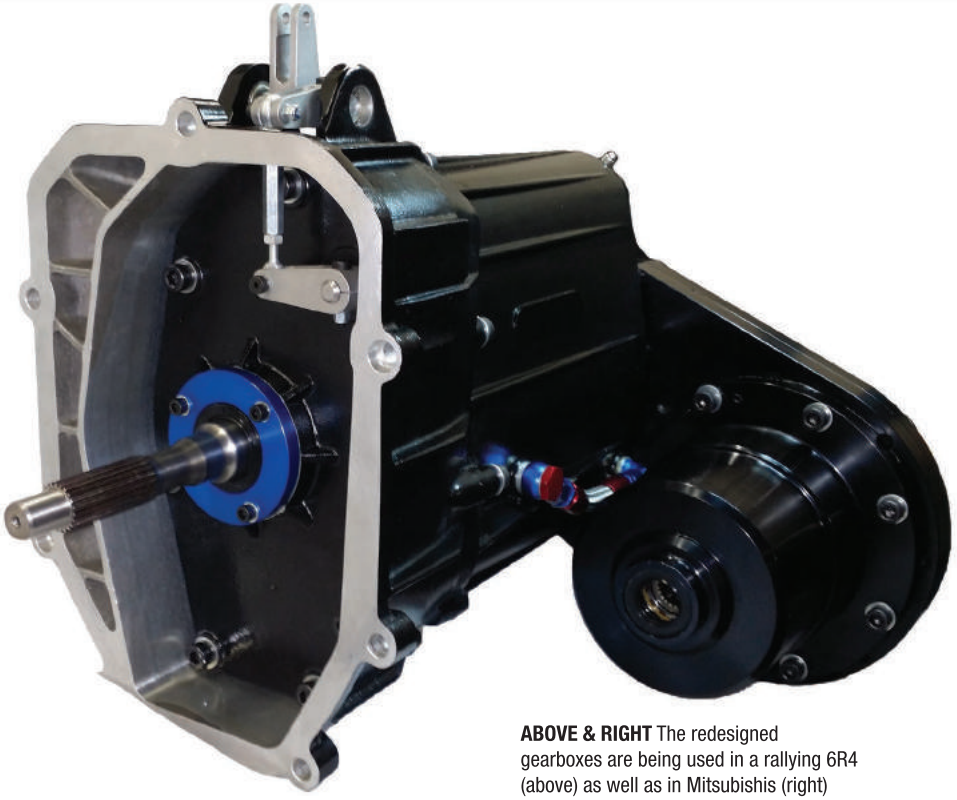
- Express service within the USA and Europe for all motorsport events
- Dedicated project team for total event logistics
- Air and sea charters to meet your event requirements
- In house ATA Carnet service – easing movement of your operations
- Network of approved international agents
- Round the clock operations, 365 days a year
- Ability to move cargo via air, land and sea
- Customs clearance anywhere around the world

Contact us today to find out how D.O.T. can help you make the most of your logistics so you can focus on what really matters.

T: +44 (0)20 8890 5511
W: www.deliveredontime.com
E: sales@deliveredontime.com

D.O.T delivered on time
location . logistics . specialists

Image: Jakob Ebrey Photography



ABOVE & RIGHT The redesigned gearboxes are being used in a rallying 6R4 (above) as well as in Mitsubishis (right)

THE ULTIMATE VOTE OF CONFIDENCE

Hal Ridge reports on a trio who liked the product so much, they bought the company

WHAT do you do when you invest a fortune in a rallycross car and base it around a transmission that doesn't work?

That was the question faced by experienced mixed-surface racer Steve Hill, whose Mitsubishi Evo X Supercar was created using a transmission supplied by British firm Maktrak. Despite being competitive, Hill's Evo X was frightfully unreliable and regularly broke down with transmission-related issues.

But, despite the unreliability, the car had pace. Hill believed in the basis of the product to such an extent that when Maktrak closed its doors, he hatched a plan.

SGS Racing Transmissions was formed a little over 12 months ago, by Hill, Steve Clews and Gerald Nicholson, with the aim of resolving the known issues with the transmission system. Their mission was to create an alternative, cost-effective, reliable solution to the Sadev, Selholm, Xtrac and Quaife systems used widely in rallycross, rallying and circuit racing.

The fledgling firm not only had the advantage of having been through at least part of the development process in the product's initial incarnation, but also that it had Hill's Evo X as a testbed in one of the harshest motor racing environments, rallycross.

"We've invested a lot of time, money and effort into this project. I really wouldn't have done that if we didn't believe in it. It would have been much easier for me to write a cheque out and buy a transmission from somebody else to go racing with, but that's not what we wanted to do," explains Hill. "We've completely redesigned the products, changed the materials and changed the suppliers. It's effectively completely new. We all agreed that we want a very good product that you can put your name to, and that worked. Having something you've got to keep buying bits for is no good to anybody and to some extent we've already overcome that."

600 BHP TESTBED

With four-wheel drive rallycross Supercars producing close to 600 bhp, transmissions are put under significant loads, not rivalled by many, if any, other motorsport disciplines. The short number of laps that races take place over mean there is no room for missed gear changes. SGS believes that by using rallycross as a testbed, it's able to refine products that can be used in any

motor racing arena.

"The main thing is ensuring we use the correct suppliers who understand the importance of the right materials, heat treatment and the integrity of the components. The main cause for failures usually comes from material and heat treatment errors," says Clews. "The hardest thing is to make everything substantial enough that it's not going to break, but not so heavy that it affects performance. You've got to get the balance right. Going from loose to tarmac in rallycross is a good challenge, and means we have a product that works in other types of motorsport too."

With SGS transmissions currently being used in rallycross, rallying (in a Metro 6R4 and Mitsubishis) and World Time Attack, SGS says it is now able to produce a package ▶

> *"It's near-impossible to miss a gear"*

ABOVE SGS is using rallycross as a testbed for its products

for any car, rather than just the transverse Mitsubishi and 6R4 its products were initially designed for.

Hill says that one of the reasons he believes so heavily that the SGS gearbox can be a success, is that the gear change is smoother than many of the alternatives on the market.

SMOOTH OPERATOR

"Everybody that has driven with it says the gear change is much better than anything else – it's seamless," he explains. "There's no physical effort, it always selects a gear and feels very positive. I've worked closely with drivers who have had problems with their 'boxes, and need constant maintenance on dogs. We just don't have that."

Clews says that however aggressive you are with the gear level with the SGS gearbox, it's near-impossible to miss a gear: "The selector mechanism has a locking system that stops the barrel over-rotating. A lot of systems are on ratchets, so once the red mist comes down and you pull really hard on the gear level, the barrel can over-travel and half-select the next gear, but once you go into gear with this, it's in gear. That's it. That's why the change is so positive.

> *"Rather than compromise with a one-piece layshaft, one part splines inside the other"*

"The reliability is about getting the right materials in the right parts of the system. For instance, the layshaft requires two materials to effectively make one shaft. One of the materials is for gears, the other is for shafts. Rather than having it (the layshaft) made in one piece and having a compromise between either element, the parts are made out of separate aerospace-spec materials and one splines inside the other. The shafting element requires a degree of 'twist'. We're working hard to make something that's competitive and reliable. There's no reason why our transmission can't be used in any application with the right packaging. That's something we're working on, machining casings so suit different solutions."

SGS currently has a range of around 25 different gear ratios, that spread from 110 mph top speed for single-venue rallies to a max speed of 180 mph for World Time Attack cars. The firm also produces differentials, and is working on a number of bespoke products for customers. "We're happy with where we are but we want to expand what we're doing and broaden our range," concludes Hill. "But, the proof is in the pudding; my own car has been very reliable this year, so we are heading very much in the right direction." RT

ABOVE The new-found reliability of Hill's Mitsubishi is testament to the new company's progress with the gearbox


SAVE THE
DATE
12-15TH JANUARY 2017*
AUTOSPORT
INTERNATIONAL
THE RACING
CAR SHOW
TRADE & TECHNICAL AREA
IN ASSOCIATION WITH
Driving Technology into Pole Position
INTERNATIONAL
RACE TECH
Motorsport Engineering
"YOU CAN ENJOY EVERYTHING TO DO WITH MOTORSPORT AT AUTOSPORT INTERNATIONAL AND WHET YOUR APPETITE FOR THE COMING SEASON." DAMON HILL, OBE
AUTOSPORTINTERNATIONAL.COM
*12TH AND 13TH TRADE DAYS ONLY

THE AGE OF EFFICIENCY

Seb Scott highlights a number of successful case studies in the area of materials and coatings

MOTORSPORT has changed its ways dramatically since the start of the decade, ditching its concept of the all-out, unlimited resource, assault on performance. Instead, the focus is now on chasing the once-unimaginable goal of high performance by way of efficiency and reliability.

That push has led to major breakthroughs in the reduction of rolling resistance, inspired by new materials and low friction coatings.

BEARING GIFTS FROM AFAR

BASED in Gothenburg, Sweden, SKF is a leading supplier of bearings in Formula 1. Its dedicated application engineers support most of the major teams, including Ferrari, which has been a partner since 1947.

Due to the dynamic nature of motorsport SKF products can be found on various components in categories ranging from Formula Student to Formula 1. Its heavy involvement in the latter means it assumes a lot of responsibility for a car's reliability, providing ball, roller and plain bearings for the wheel hub, gearbox, clutch, engine, turbo, MGU and suspension components.

To ensure the components it supplies in the cutting edge of motorsport are working to their optimal performance, SKF uses high-speed condition monitoring systems to track component performance. "The products we provide to Formula 1 teams are all 100 per cent customised for the individual application," explains Andrea Rifici, SKF application engineer for Scuderia Ferrari. "This is an industry where the leading players are looking for solutions that go to the absolute limits of what is possible."

As Rifici points out, long-term life isn't the focus in racing. "Reliability is vital in these applications, but it is a 'limited' reliability," he notes. "For example, coatings and materials might need to perform properly for just five races."

Five races might seem like a lot, for in some racing series they constitute a full season, but when translated into distance the life expectancy is just 1,500 km – just shy of 1,000 miles. It might be a short life, but it's a demanding one: the acceleration, deceleration and cornering forces are enough to cause carnage, so SKF places tight tolerances and constraints on itself to cope with the extreme loads, speeds and operating temperatures.

These tolerances are also applied to component dimensions, keeping weight and size in check. With some of its components found on MGUs, a bearing's mass can have a high impact on the motor's rolling resistance. The impact is two-fold on the wheels and hub, as unsprung mass is a disadvantage too if no excess weight is trimmed, placing a demand on certain materials.

"We use very hard powder metals for gearbox and wheel bearings, high nitrogen steels, including our proprietary nitromax alloy, and M50 (an extremely hard and heat-resistant tool steel) for turbos," says Jeroen Wensing, the company's innovation manager for racing. "In most cases, bearing rollers are ceramic, in order to

ABOVE & RIGHT The cross-section images reveal the complex and tightly packaged structure of SKF's bearings with the angular contact ball bearing and pinion bearing pictured here

ABOVE The car turns heads but the technology harnessed on the Mono is spectacular too

reduce friction and save power. Cages may be made from PEEK (a high-performance polymer), titanium or steel. Plain bearings for suspensions and similar applications are made in steel, titanium or even aluminium, with special liners in PTFE and ceramic coatings on the ball."

Like many technical partners at the forefront of motorsport, SKF has been able to learn much from its involvement in Formula 1. A bespoke product selection and development process has been designed to cope with the unique development pace. "The speed of development is enormous compared to mainstream industry and several product updates are required over one season to improve the performance of the cars," says Wensing. "This requires a lot of flexibility for everyone involved, from product development to the factories." Application engineers like Rifici usually meet with partners and customers on a weekly basis, providing 24/7 support to them throughout the year.

Coatings are an area that can really push both performance and reliability to another level, boosting a material's capability under high temperature and loading. Manganese phosphate, diamond-like-carbon (DLC), and ceramic coatings are applied where needed on different bearing components. Seals and plain bearing liners are also treated with special low friction coatings.

Almost as quickly as parts are developed in motorsport, so too are regulations. They continue to pile the pressure and expectation on teams to deliver more reliable and efficient vehicles, which is why SKF is committed to dedicate itself to this process.

WORLD FIRST FOR GRAPHENE

THE BAC Mono is so unique and technically exciting that even as a fully fledged road-legal car it is able to make it into this feature, largely thanks to Haydale Composite Solutions.

First observed in the early 1960s, graphene was only isolated as a material in 2004. Like all things new, upon its discovery it was an incredibly exotic and expensive material due to the amount of research involved and the sheer difficulty of isolating the material.

This expense has subsided somewhat now, allowing for an increasing number of applications – hence Haydale Composite Solutions making use of it for bodywork on the latest BAC Mono. Graphene is essentially made up of one atom thick honeycomb lattice carbon sheets, resulting in it being at least 100 times stronger than steel and even outperforming the likes of carbon fibre, despite being around 20% lighter.

For now, the application of graphene in vehicle design has been reserved for the rear wheel arches of the BAC Mono, where it has demonstrated the ability to be manufactured as a complex part.

FROM CARBON TO GOLD

A SIMPLE engineering concept that still drives motorsport forward is a vehicle's power to weight ratio. In cycling, likewise, it is the dictator of performance – so much ▶

so that a reduction in grams can warrant a saving of seconds.

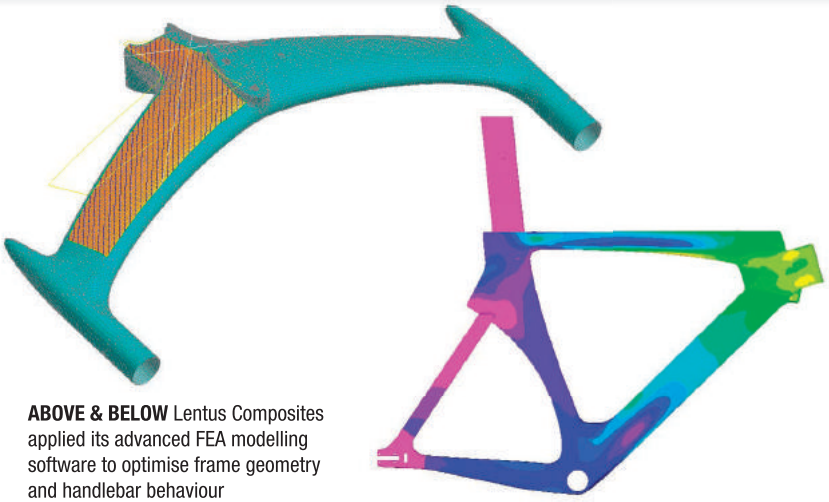
Back in June 2015 Lentus Composites was commissioned by bicycle manufacturer Cervélo to develop the stiffness and weight of its UKSI bike, still retaining its efficient aerodynamic design. The product produced would go on to be used in the 2016 Rio Olympic Games.

Lentus Composites analysed a range of details, including material selection, tooling design and manufacture, laminate design and component finishing, in order to optimise the frame's characteristics. The final composite design was reached by analysing over 50 different solutions using virtual modelling software.

From the extensive testing programme that followed, it became evident that for the targets set out by Cervélo to be met, two different frames would be required. The two frames would be destined for different racing categories – one for short distance racing and the other for longer distance disciplines.

The result was a lower drag endurance variant with increases in stiffness and reductions in weight. Improvements to the sprint frame were achieved with revised geometry.

Aside from frame development, Lentus Composites was able to apply weight saving parts, made from composite, polymer and metallic materials, on areas such as the handle bars where metal additive layer manufactured components were applied.



ABOVE & BELOW Lentus Composites applied its advanced FEA modelling software to optimise frame geometry and handlebar behaviour

ABOVE Uncoated engine tappets (left) with very heavy wear evident after 250 km. Right, Balinit DLC-coated after 1,000 km showing almost no wear

On camshafts:

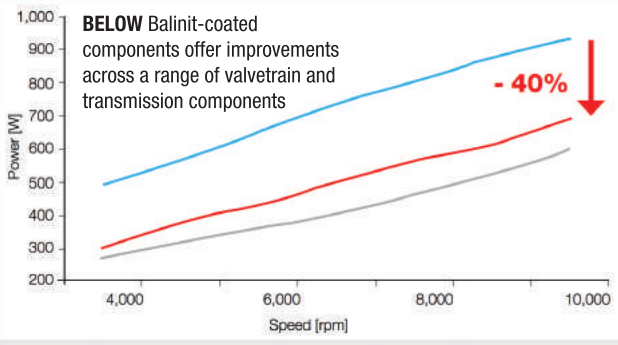
- 40%

friction

Camshaft and finger follower coated

Finger follower coated

Uncoated



BELOW Balinit-coated components offer improvements across a range of valvetrain and transmission components

INVISIBLE PROTECTION

FOR 70 years Oerlikon Balzers has been heavily involved at the forefront of the coating business. The French company has spent nearly half of that time invested in the world of motorsport too, developing thin film coatings for various applications in the engine, gearbox and even on the car itself.

The thickness of its range of Balinit coatings is now measured in microns, yet they are harder than steel. They offer incredibly low friction and exceptionally hard wearing durability, especially given that the thicknesses of such coatings is invisible to the naked eye.

Thanks to the amount of time and resource that is invested in the development of Balinit, Oerlikon can offer tailor-made coatings to suit a user's needs, taking into account the usage environment, projected longevity of the part and budget restrictions. RT

Feeling the Heat

LIFELINE Fire and Safety Systems has released the Zero 3620 Firemarshal, a development of the Zero 3620 system that has been revamped thanks to more series organisers stipulating the use of systems that comply with the FIA 8865 suppression standard. The new system has been tested and developed specifically to target petrol, diesel and E85 fires, while offering a significant cost saving compared to other systems meeting the FIA 8865 suppression standard that are currently on the market.

The suppression fluid is discharged into the cockpit and engine bay and activated by the Zero 3620 control box that continuously monitors any potential thermal events. Aluminium compression fittings and sufficient lengths of tubing are included for the system plumbing to be packaged as per the vehicle with the suppression fluid housed in a fabricated aluminium cylinder.

Lifeline's patented dual discharge technology is used for two coolant outlets that support the main 1.0 kg discharge of 3M NOVEC suppressant for engine bay fires. Should the two supporting coolant outlets be insufficient Lifeline has included an additional two outlets that can be fitted to cool further areas in the engine bay in case of re-ignition.

The cockpit system disperses 3.0 kg of 3M NOVEC suppressant which is three times the amount needed for the engine bay. However, it is discharged through two cloud burst outlets that have been specifically designed for optimal dispersion throughout the entire cockpit.

According to Lifeline's managing director Jim Morris, "we can now offer a real cost-effective alternative to the many teams and competitors that require FIA 8865 approval for their fire suppression system. We took a significant step forward in terms of driver safety when we introduced the Zero 3620 system, and with Zero 3620 Firemarshal, we have made another leap." RT

ABOVE Lifeline's new Zero 3620 Firemarshal that has been developed specifically to target petrol, diesel and E85 fires

Head on the Block

INDY Cylinder Heads has engineered a 223MK billet rear main seal master kit, a new solution for big-block Chrysler owners. With over 35 years of Mopar engine experience this Indianapolis-based company has come to the rescue of those owners who have struggled with leaking rear main crankshaft seals. CNC machined from billet aluminium, it has designed a holder for the crankshaft seal, rubber-ring side seals and alignment pins without the need for block alterations. RT

Gearing for the Future

ABOVE Xtrac's new family of electric vehicle gearboxes

XTRAC has recently revealed its brand-new family of electric vehicle gearboxes. Developed initially for ultra-high performance and luxury road vehicles, its project P1227 Integrated Lightweight Electric Vehicle (ILEV) transmission system offers a range of installation possibilities including front-wheel drive, rear-wheel drive and four-wheel drive configuration. The new transmission system also achieves a significant 20 per cent reduction in mass compared with its previous P1092 torque vectoring transmission.

"Close discussion with electric motor suppliers including YASA, GKN and BorgWarner have been a key part of the ILEV's design and development, and the optimised integration of the electric motor and the transmission as a single unit has led to significant weight and packaging benefits," says James Setter, head of Xtrac's automotive and engineering business unit. "With the increased trend towards vehicle electrification and hybridisation, you need innovative lightweight transmission systems designed specifically for these new methods of vehicle propulsion to suit their unique operating characteristics."

Xtrac reports that it has received significant interest in the transmission system from a number of OEMs and tier ones leading to a rising order book for the transmission. RT

The real deal?

Simulation has been a buzzword young engineers have grown up with, but **Sergio Rinland** reminds us that the technology has its roots in a long-forgotten world

THE term "simulation" can sometimes be confusing. After all, "simulator" is used for anything from the computer game a seven-year-old plays in his bedroom to the latest Driver in the Loop (DiL)/Hardware in the Loop (HiL) simulators that have revolutionised the way top teams approach Formula 1.

Computer games have been around since the mid-70s, starting at the games arcades and developing as personal computers became more available. We had to wait until the early to mid-2000s to see simulator games like Grand Prix Legends, or rFactor. The latter is used these days by racing drivers and gamers alike to learn tracks and even how to drive certain cars since the physics behind the models are quite realistic taking into consideration the inexpensive price of them.

However, in terms of vehicle dynamics and tunability, games are far from what an engineer needs to develop a car. As an example, typical games would run in the area of 50 Hz (some already 500 Hz), where real professional simulation software would run over 2 kHz.

Simulation might seem like the latest craze, but the first Lap Simulator we have news of dates back to 1954-1955, used by the Mercedes Benz team. The main purpose of the MB simulator was to calculate gear ratios and speed for the different corners of a track. Looking back, people think they must have been barbaric compared to today's technology but, according to Stirling Moss, one of their drivers at the time, it was so accurate it could sometimes tell the drivers the speed at which they should take a section of the track. There is also the belief that Mercedes Benz had such a tool during their dominating years of 1937-1939.

At the same time, in the US, Bill Milliken at the Cornell Aeronautical Institute had something similar, which he used to design the Watkins Glen track to ensure a lap above an average of 100 mph.

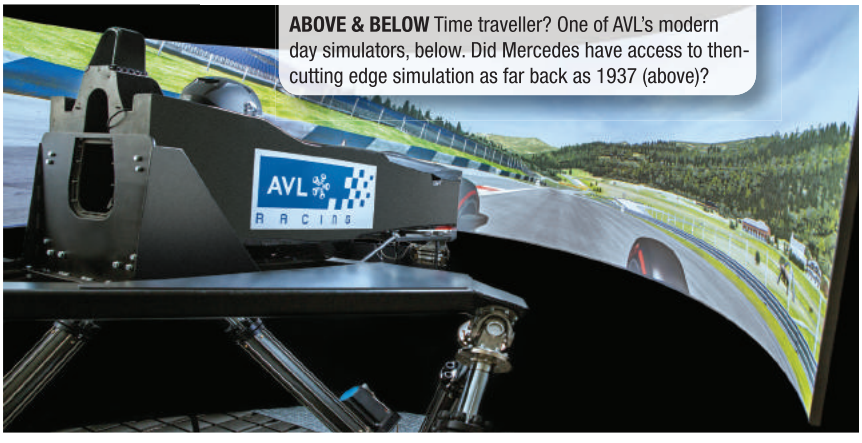
The simulators used by Mercedes and Milliken in the '50s were very simple mathematical models where the basic suspension performance and engine power was calculated to find the speeds and lap time. It was a back and forth vectorial calculation, in a similar manner to the quasi-static programmes of today. They calculated the maximum speed at the apex and then calculated backwards for the braking, forwards for acceleration and where those two accelerations met, that was the braking point.

It took until the early '80s to develop the kind of simulator we have today that deals with tyre and aerodynamic data as part of its calculation methods. By the early/mid-'90s every Formula 1 team worth its salt had a lap simulator to try new ideas and to develop the cars.

By the mid and late 2000s, DiL simulators were starting to become popular with F1 teams due to the ban on testing. These simulators, McLaren being the first, developed from being mere driver training equipment with an accurate enough car model to what they are today: a fully functional car development tool where the drivers interact and contribute to the initial design and concept of a car.

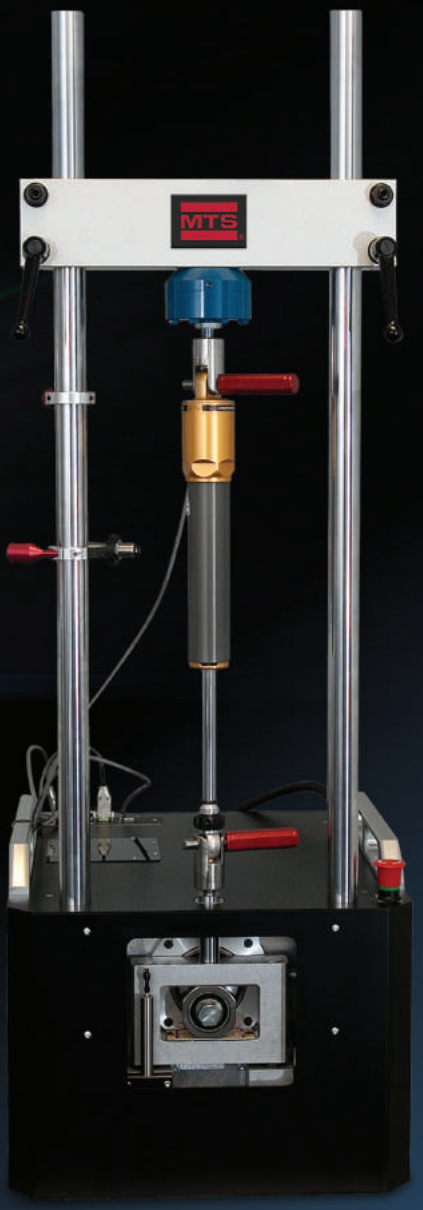
HiL simulators have also been in use for some time now. Initially they tested the electronics, then real engines and gearboxes replaced the virtual models. Today, AVL has developed a system where the DiL simulator runs parallel to the complete car in a full vehicle dyno.

F1 operations and the top three LMP1 teams now have a quasi-static lap simulator to test the 'low-hanging fruit' in car design and set up, where they can do thousands of simulations to combine different parameters. Then they have the DiL simulator, which is fully dynamic, and the drivers assist the engineers to shape the car's characteristics and setup to the minutest detail. RT



ABOVE & BELOW Time traveller? One of AVL's modern day simulators, below. Did Mercedes have access to then-cutting edge simulation as far back as 1937 (above)?

The Original



MTS ROEHRIG CRANK DYNO

Kurt Roehrig's original electric crank dyno remains the trackside tool-of-choice for testing and tuning racing vehicle dampers.

Deployed by racing teams worldwide, MTS Roehrig Crank Dynos provide the basic sinusoidal testing capabilities needed to quickly and accurately optimize vehicle performance for specific track and race day conditions.

All-electric MTS Roehrig Crank Dynos feature:

» Accurate and repeatable performance
» Compact, portable designs
» Easy-to-use software
» Clean, energy-efficient operation
» Minimal facility and maintenance requirements

Learn how MTS Roehrig Crank Dynos can help you meet critical damper performance testing needs with speed, efficiency and confidence. Contact MTS today.

Telephone: 1-952-937-4000
Toll Free: 1-800-328-2255
E-mail: info@mts.com
www.mts.com

MTS GROUND VEHICLE TESTING SOLUTIONS

be certain.

Congratulations on continuing the legacy!

Thank you for choosing PFC BRAKES

Ryan Briscoe Richard Westbrook
Mike Hull Mike O'Gara Mel Harder Brad Goldberg
Ryan VanKlompenburg John Hennek Ken Brooks Brett Knostman Phil Binks
Jessica Mace Chris Snyder Tyler Montgomery Kevin Edgley Reid Esquivel
Shelby Tracey Robbie Fast Bob Terrando Spence Hall Tyler Rees Damon Elff
Steve Namisnak Kris Badger Brian Beck Ashley Parlett Lee Blackwell
Jason Richardson Lee Orebaugh Grant Weaver

1st ***Continental Tire Monterey Grand Prix*** *Mazda Raceway Laguna Seca*

1st ***Sahlen's Six Hours Of The Glen*** *Watkins Glen International*

1st ***Mobil 1 Sportscar Grand Prix*** *Canadian Tire Motorsport Park*

IMSA WeatherTech SportsCar Championship

Ford | Ford Performance CHIP GANASSI RACING

PFC BRAKES

www.pfcbrakes.com

800.521.8874