KILLING OR SAVING F1?

Controversy as more common components spearhead F1 revamp

INTERNATIONAL

Driving Technology Into Pole Position

RACE TECH

Motorsport Engineering

JULY 2019 No. 224 UK £5.95 USA $11.99

racetechmag.com

LE MANS SPECIAL

PORSCHE 917

How a monster, unleashed 50 years ago, became a Le Mans legend

+ Aston Martin engine tech

TOYOTA PLANS FOR DISASTER!

9 771356 297055 07

www.racetechmag.com

TOTAL excellium

Fuelling performance

Photo credit: DPPI.

TOTAL
Committed to Better Energy

WEC | TOTAL | 24h LE MANS
OFFICIAL PARTNER

Total is proud to be the official fuel supplier of the FIA WEC* until 2022, the ultimate proving ground of a car engine's long-lasting performance being pushed to its limits. TOTAL EXCELLIUM, the advanced fuel technology, will ensure engine cleanliness and optimal efficiency for every team during one of the toughest endurance car races in the world, including the 24 hours of Le Mans. Tested on the track, available to everyone.

*World Endurance Championship

excellium.total.com

RACE TECH
Motorsport Engineering

Volume 26 Issue 8
Published June 2019
The next issue will be published in early July 2019
ISSN 1356-2975

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

Overseas copies are sent via air mail
Special offer 12 issues for the price of 10
12 issue subscription UK: £45.00
Europe: €97.50, US/Canada: US$127.40
Rest of World: £75.00
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, 192, 193, 194, 195, 196, 197, 198, 199, 200, 201, 202, 203, 204, 205, 206, 207, 208, 209, 210, 211, 212, 213, 214, 215, 216, 217, 218, 219, 220, 221, 222, 223
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: Porsche AG

Design & Production:
Maluma Design Associates

COVER STORY PAGE 66

ECR Engines Rely On ARP Fasteners

automotive Racing products

ECR Engines utilizes off-the-shelf and custom ARP fasteners for the engines that powered the Cadillac V-8s that won both the 2019 Rolex 24 at Daytona and the Mobil 1 12 Hours of Sebring in the DPI division of the IMSA WeatherTech SportsCar Championship.

ARP fasteners provide strength and reliability for every type of racing.

5,000 catalog items and specials by request

Made In USA

All ARP fasteners are manufactured entirely in our own facilities in Southern California – and raced all over the world.

ARP-bolts.com

Toll-free in the U.S.A 1.800.826.3045
1863 Eastman Ave • Ventura, CA 93003
Outside the U.S.A. +1.805.339.2200 • Special Orders +1.805.525.1497

EDITOR
William Kimberley

CONSULTANT EDITOR
Mark Skewis

DEPUTY EDITOR
Alan Stoddart

HEAD OF DIGITAL CONTENT
Sara Kimberley

PHOTOGRAPHY
LAT

ART EDITOR
Paul Bullock

ACCOUNTS MANAGER
Vikki Amour

ADVERTISING
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

SENNA'S LEGACY

IT has been a quarter of a century since the death of Ayrton Senna at Imola, but it still seems like yesterday. The shock is still palpable.

Back then, there was a sense that Formula 1 had moved on beyond the appalling decades when fatalities in motor racing were part and parcel of what was to be expected if you participated in such a dangerous sport. After the carnage of the 1950s, '60s and '70s, the '80s were so much better thanks to the FIA really putting all its effort into making racing safer.

By 1994, there had not been a death in Formula 1 for eight years since Italian driver Elio de Angelis lost his life in a test session driving a Brabham at Circuit Paul Ricard in May 1986. But that air of complacency was shattered when Roland Ratzenberger was killed in qualifying at Imola, the day before Senna.

In part, that good run was inspired by Jackie Stewart's tireless campaigning and a string of safety initiatives introduced by the FIA. The list was extensive: crash tests for the car's safety cell and fuel tank became mandatory; the driver's feet had to be behind the front axle; a permanent FIA race director was appointed; track safety walls were addressed; larger rear-view mirrors were required, as were detachable steering wheels; rescue training for drivers became compulsory.

Tests for roll-over bars, seatbelts and survival cells were introduced in 1991, while the following year saw the advent of the official Formula 1 safety car and stricter crash tests.

In 1993, the area of drivers' head protection material around the cockpit was increased from 80 to 400 square centimetres.

Despite all these initiatives, two drivers still died in San Marino in 1994.

This further spurred the FIA into introducing even more compulsory safety features. Professor Syd Watkins, for so long at the heart of those initiatives, acknowledged that the horror of Imola marked a turning point for the sport. Hereafter, to an unprecedented degree, the *science* of safety was studied. And its findings acted upon.

One of the most controversial results of that process was the introduction of the Halo. Initially it was generally criticised as it inhibited the view of the driver in the cockpit. One year on, does anybody really notice it?

The FIA's research had been thorough. Its hard work and tough stance were vindicated when, at the start of last year's Belgian Grand Prix, Fernando Alonso's McLaren was rear-ended by Nico Hulkenberg's Renault and propelled up and over Charles Leclerc's Sauber, making contact with his Halo device.

There is no question that the advances made in Formula 1 safety have moved on in leaps and bounds since the death of Senna, but it's not a reason to be complacent, as Jules Bianchi's death at the Japanese GP in October 2014 reminded us. But we are headed in the right direction: the odds are so much more in the drivers' favour than they were during the first 100 years of motor racing. RT

William Kimberley
EDITOR

Craig Scarborough

ABOVE A move towards a common brakes package is just the tip of the iceberg

Formula 1 at the crossroads

Dumbing down or sensible cost cap policy? Winners? A few. Losers? Many. **William Kimberley** reports

IN an initiative to control costs, Liberty Media and the FIA are ramping up plans for a revamp of Formula 1 in 2021. It includes potentially controversial proposals for teams to run a raft of standard components without damaging the authenticity of F1.

This month the FIA is considering feedback from suppliers bidding to win three contracts for which it has recently invited tenders: a spec brakes package; standardised wheel rims; and key elements of the fuel system. It is also considering a similar approach for a variety of other areas on the car, ranging from safety structures to steering wheels, driveshafts and even the teams' pit equipment.

The question is whether the Formula 1 enthusiast really cares about the components he or she cannot see, such as the steering wheel or pit equipment. In most cases, probably not. Stripped of their paintwork and decals, many would find it hard to distinguish between a Mercedes, Red Bull or Renault anyway. They go to a grand prix or tune in to watch their hero win a race, hopefully with a few dramatic moments to enliven things. What's under the skin of the car is of little interest.

It was in 2008 when McLaren Applied Technologies, then called McLaren Electronics Systems, won the contract to supply every Formula 1 team with its ECU. It was not liked by the teams, especially Scuderia Ferrari which complained vociferously and very publicly after the first race of the championship in Melbourne when it blamed the McLaren ECU for its cars' poor performance. Ferrari fans claimed it was a McLaren conspiracy to conceive an ECU that presented challenges to Ferrari's design, which was patently untrue. Eleven years later, such accusations are a distant memory. The success of the ECU contract offers a potential template for the introduction of more spec parts.

For those in the supply chain, though, the standardisation of parts is a threat to their business where there will be a few winners but many losers. Missing out on winning the tender could be calamitous.

In different interviews, Ross Brawn, Formula 1 managing director, has said

Dunbar/LAT

ABOVE The 'Haas Model' using the non-Listed Parts approach is seen as a good template to allow young teams to compete with the established outfits

that the Haas F1 Team, which only entered Formula 1 in 2016, taking non-listed parts from Ferrari, with which it has a close relationship, is a good template to follow.

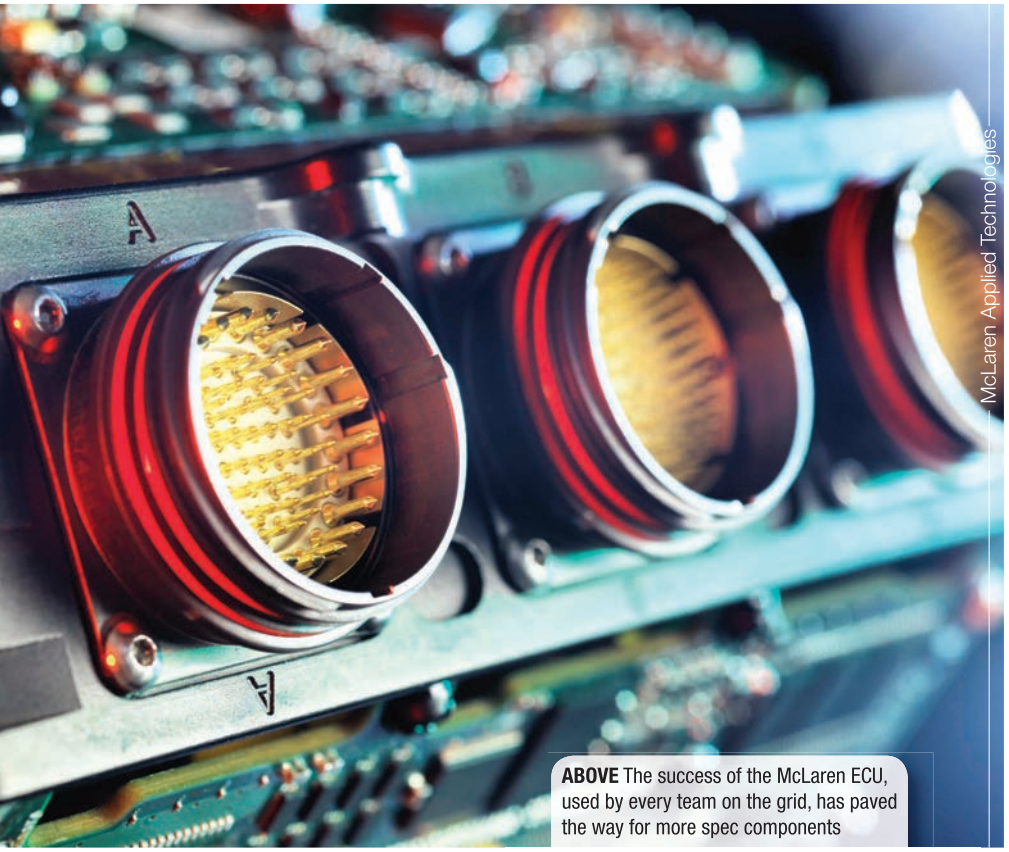
"The Haas model is interesting," Brawn told Sky Sports' Martin Brundle. "It has been very successful and it's something we have to maintain for the future, for it to be possible for a small team to be able to come in and be pretty respectable. There is some trimming we need to do to what they have been able to do. I don't see a big change in the Haas model.

"But we need to make sure we remove the doubt some teams have about their co-operation with the big team, which is Ferrari. We need to make sure it's well defined and everyone knows what you can and can't do. There are grey areas we need clarity on. Haas is a good model, we don't want to spoil it, but we want to make sure of its place in F1."

> *"Standard parts mean that one supplier has a lot of work (but not much profit) while all others lose out"*

Brawn also told Brundle that those components not related to performance should be standardised.

"For example, we want every team to have the same pit equipment. There is a lot of stuff we have common ground on. There is some stuff we all agree shouldn't change and there's stuff in the middle being argued about. Everyone makes their own fire extinguishers. It's a nice technical challenge, but it doesn't add performance. We can standardise those and help reduce the costs."



McLaren Applied Technologies

ABOVE The success of the McLaren ECU, used by every team on the grid, has paved the way for more spec components

SUPPLY CHAIN UNEASE

However, the reliance on the use of standardised components has prompted some unease among F1's traditional supply chain.

Nevertheless, Guenther Steiner, Haas team principal, has endorsed the plans for the survival of teams. He believes that the future of Formula 1 depends on the Haas business model continuing into the future and hopes that it will encourage other teams to enter the sport and add to the competition.

Commenting on whether Formula 1 is therefore going down the route of the spec car and ruining or at least damaging F1's DNA in the process, or is levelling the playing field so that teams with more limited resources have a greater chance of competing against the better funded teams, a Formula 1 insider who works for one of the teams fighting for the best-of-the-rest title commented: "I think FOM/the FIA are doing both. They are damaging the DNA of F1 (or at least changing it significantly) but they are also reducing the range of performance from the front to the back of the grid. That anyway is the aim.

"Today F1 teams spend (close to) unsustainable amounts of money. If that spend is cut and that is a specific target of the regulations, then someone has to lose out. Suppliers are very likely to lose. Standard parts mean that one supplier wins a contract and has a lot of work (but not much profit) while all others lose out.

"There is certainly going to be some discussion re the new suspension rules – less freedom (when the present rules are already very restricted).

"The aero rules haven't been released yet either. That may well be where the big fight starts. It is likely that very little freedom will be allowed there either. I imagine a spec floor could be in the offing…." RT

Motorsport mourns Niki Lauda's passing

THE world of motorsport has paid tribute to three-time Formula 1 World Champion Niki Lauda, who passed away on Monday May 21 at the age of 70.

Hugely respected in the sport, he is perhaps best remembered for his rivalry, then friendship, with James Hunt. In an increasingly politically-correct world, the outspoken Austrian has been a refreshingly candid character in the modern-day Formula 1 paddock.

He made his Formula 1 debut at his home race in 1971 driving for March. In 1974, after two uncompetitive seasons with March and the fading BRM team, Lauda was signed for Ferrari, with which he won two World Championships in 1975 and 1977.

That figure would have been three if it wasn't for his horrific crash in 1976 at the German Grand Prix, where Lauda was badly burned and suffered lung damage after his car burst into flames. Despite the severity of his injuries – he was considered bad enough to be given the last rites – he made a miraculous recovery to return to racing at the Italian Grand Prix, just 40 days after his accident. He lost the title by just a single point when, amid torrential rain in the finale in Japan, his frayed nerves could stand no more and he withdrew.

Following his title victory in 1977, Lauda moved to Brabham for two seasons, and had a brief stint as an airline entrepreneur, before being coaxed back to the driver's seat by McLaren in 1982. It was with the Woking-based team that he claimed his third and final title in 1984, beating his team-mate, a young Alain Prost, by just half a point.

The following year after 25 wins from 171 starts, Lauda ended his career as a driver. However, he did not give up Formula 1 entirely, playing roles with Ferrari, Jaguar and, most recently, Mercedes AMG F1. The most hands-on of these jobs was as team principal at Jaguar in 2001-02. Famously single-minded as a driver, his approach wasn't always a passport to popularity with a big workforce, however.

"Niki will always remain one of the greatest legends of our sport – he combined heroism, humanity and honesty inside and outside the cockpit," said Mercedes' team principal Toto Wolff. "His passing leaves a void in Formula 1. We haven't just lost a hero who staged the most remarkable comeback ever seen, but also a man who brought precious clarity and candour to modern Formula 1."

Formula 1 chairman and CEO Chase Carey, meanwhile, added that Lauda's passing marked the loss of a 'hero'. "His love of racing and the courage he demonstrated were simply extraordinary, and he inspired so many fans," he said.

"His passing is a great loss for the entire Formula 1 family and motorsport as a whole." RT

Renault F1 restructures to strengthen tech department

THE Renault Formula 1 team is seeking to improve its fortunes after a tough start to the 2019 season by making organisational changes in its technical department, both at its chassis headquarters in the UK and its engine base in France.

Former Ferrari engineer Christophe Mary will join the team on August 1 in the newly-created role of director of engineering. Mary will report to engine technical director Remi Taffin at the team's engine facility in Viry. Also reporting to Taffin will be Stephane Rodriguez, who has become the technical department's project and purchasing director.

ABOVE Renault hopes to "strengthen its technical departments" with personnel changes

At Renault's chassis facility in Enstone, meanwhile, deputy chief designer Matt Harman who last year joined the team from Mercedes, where he was head of powertrain integration and transmission design, has been promoted to engineering director.

These changes, says Renault, are to "reinforce its management and strengthen its technical departments" adding that "beyond their impact on the 2019 and 2020 seasons, the changes are a significant step towards preparing both organisations for the challenges of the 2021 season, and meeting the objectives of the roadmap set in 2016." RT

Focus on victory.

You almost hear your heartbeat inside your helmet, and feel the pulse of power for the perfect start. You give your best – just like ZF does: the high-tech racing partner you trust blindly. **zf.com/motorsports**

ZF motorsport

see. think. act.

ZF

ABOVE WAE is to supply the batteries for the electric version of the popular TCR category

Williams Advanced Engineering to supply ETCR batteries

WILLIAMS Advanced Engineering will produce and supply batteries for the planned ETCR electric touring car series, which is set to get underway next year.

Promotor WSC Group has chosen WAE to design, develop, manufacture and supply both the batteries and vehicle control modules (VCMs) for the electric series, the world's first "electric multi-brand Touring Car racing series".

WAE will use its Formula One and Formula E developed technology, which powered the first four seasons of Formula E, in its new venture in ETCR. "The team at Williams Advanced Engineering is delighted to be able to bring our award-winning expertise in electrification to ETCR," said Iain Wight, business development director of Williams Advanced Engineering. "With the experience, skills and know-how accumulated within Williams from electrifying motorsport and road-going cars, we're excited to work with the team at WSC Group to continue the progress of electric vehicles and racing to inspire the future of sustainable mobility."

ETCR events are expected to take place on both permanent and street circuits with cars using a common fully-electric powertrain. So far SEAT's Cupra e-Racer is the first known ETCR machine to have been developed as a prototype, released last year. The Cupra e-Racer weighs around 400 kilograms more than the current CUPRA TCR, but accelerates from 0-100 kph in 3.2 seconds, and 0-200 kph in 8.2 seconds. When the car was launched, the rear-mounted motors delivered 500 kW (680 horsepower) to the rear wheels.

"Williams is synonymous with success in motorsport," said WSC president Marcello Lotti. "The company's achievements speak for themselves. We are proud of this agreement that associates the Williams name with a new and ambitious brand like ETCR. We are delighted to work together with a partner that knows all about motorsport and whose expertise will surely contribute to make ETCR successful. WSC Group is the owner of the TCR brand, arguably the most successful motorsport category in recent years, that has completely reshaped Touring Car competition globally. It was a logical step for the company to use its vast know-how in the application of new technologies."

WAE, which won the FIA process tender last year to develop and supply batteries for the proposed Electric World Rallycross Championship, will also supply batteries to the new Extreme E concept. It is not yet known if WAE will continue to develop batteries for the new Projekt E category within the World RX structure when it is introduced. RT

Venturi first team to commit to Extreme E

MONEGASQUE electric vehicle manufacturer Venturi Automobiles has become the first team to announce that it will compete in the electric SUV off-road racing series, Extreme E.

The Formula E race-winning team has already established a reputation for innovation and adventure via its record-seeking automotive expeditions designed to show the capabilities of electric mobility.

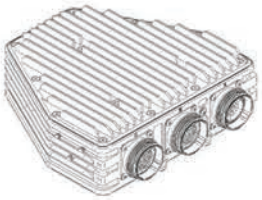
Among its achievements, the outfit designed the first electric vehicle for operation in the harsh conditions of the Antarctic and has previously achieved a 14,900 km unassisted distance record for an electric vehicle, travelling from Shanghai to Paris and on to Monaco.

"I'm a true adventure seeker and as a consequence I've always had a passion for experiencing some of the most remote regions of the world," said Gildo Pastor, President of Venturi Automobiles. "The new partnership with Extreme E represents a new opportunity to show the capacity of electric vehicles in the most extreme environments. We're beyond proud to join this innovative and entertaining concept."

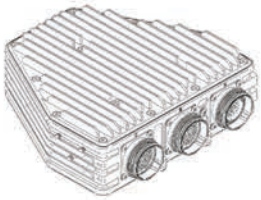
Like all teams competing in Extreme E's five challenging environments, Venturi will add its own powertrain and bodywork to the common package provided by Spark Racing Technology.

This package is set to undergo prototype testing in July this year, before the opening race in January 2021. RT

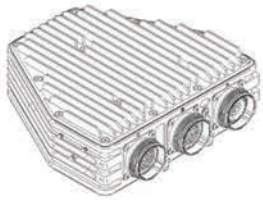
BELOW FE team Venturi has become the first outfit to commit to Extreme E



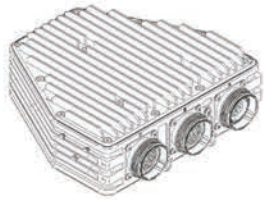
2008



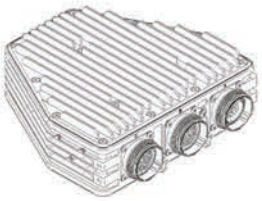
2009



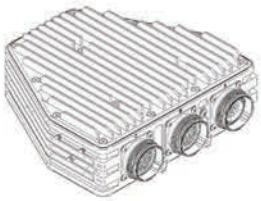
2010



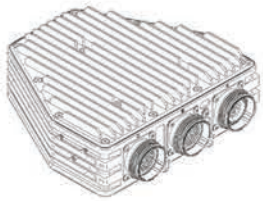
2011



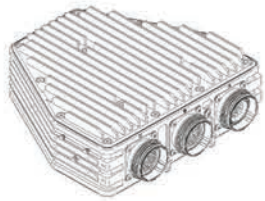
2012



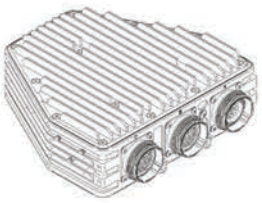
2013



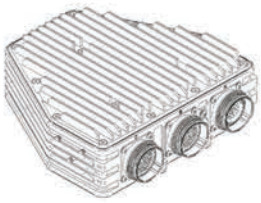
2014



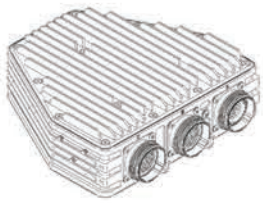
2015



2016



2017



2018

2019

Same, but different.

The TAG 320 has been the standard powertrain processing unit for all Formula 1 teams, because of its unrivalled performance and reliability.

The new TAG 320B has the same size, shape and reliability as its predecessor, but with a 75% increase in performance and a 65% reduction in data offload time.

Speak to us to learn more about how the new standard in electronic control units can optimise your performance.

mclaren.com/appliedtechnologies/ECU
sales@mclaren.com

McLaren
APPLIED TECHNOLOGIES

The fearless pursuit of advantage

ABOVE DragonSpeed to focus on Indy efforts at expense of LMP1

DragonSpeed to pull out of LMP1

AMERICAN racing team DragonSpeed has revealed that it will pull out of the LMP1 class in the World Endurance Championship at the end of the season.

The team, which won 2017's European Le Mans series, said that it was drawing out of the championship in order to shift its focus to an expanded IndyCar programme in 2020.

Explaining the move, DragonSpeed team principal Elton Julian said: "The Le Mans 24 Hours next month will be our final LMP1 and regular WEC outing, allowing us to ramp up our IndyCar efforts on both the technical and marketing fronts.

"We're not leaving the WEC entirely," he continued, "as we plan to enter our #21 LMP2 Oreca 07-Gibson in individual rounds, including Spa, Brazil and Le Mans, with Le Mans of course subject to us earning or being granted an invitation. We are also considering running Daytona and Sebring with IMSA again."

Julian also noted the commercial rationale behind the decision, explaining that "potential for growing DragonSpeed as an engineering and commercial concern is far clearer in IndyCar than anywhere else in the sport given the quality of racing and stable formula.

"That is what has driven our decision." RT

Supercars opens damper tender to cut costs

SUPERCARS is investigating the use of a control damper from 2020 onwards, and has released an invitation to tender for the contract.

At present, teams are able to use dampers from a range of suppliers, with the supply and development of that part being open. From as soon as next year, however, "the governing body of Supercars Australia is looking to introduce a control damper from a single supplier," reads the invitation to tender published on the series' official website.

The document also notes that Supercars is considering both two-way and four-way dampers, but that they must be sealed and achieve higher mileage than those currently in use. In addition, the supplier must also be able to provide support at events.

The tender for the supply closes on June 5th, with Supercars looking to sign the final contract on August 30. The decision will be "at Supercars complete discretion," adds the note, while also mentioning that "there is no guarantee that a bidder will be successful." RT

ABOVE Supercars is looking into cutting costs with spec dampers

FERODO®
RACING

FERODO RACING'S NEW STANDARD
DS 3.12

Brake pads for heavy duty race use

Available for ordering
Suffix code G

www.ferodoracing.com

NASCAR returns to single-car qualifying

NASCAR has reverted to a single-car qualifying format for the Cup, Xfinity, and Truck championships.

The switch, which will be in place for all races except those on road courses, comes after a third-round session earlier in the year in which all 12 Cup drivers failed to reach the timing line within the five-minute limit after waiting too long to take their laps. This problem of waiting occurred because of the reliance drivers now place on drafting to post a competitive lap time, with no-one wanting to put themselves at a disadvantage by going first.

Under the new format, drivers have the chance to make two timed laps at circuits shorter than 1.25 miles, while they only have a single lap to post a time at tracks greater than 1.25 miles long. The order in which drivers take their qualifying laps is determined by the starting line-up of the previous race, with the first 20 starters in the previous race taking their qualifying lap in positions 21-40, with the remainder of the drivers drawing to qualify in positions 1-20.

On road courses, qualifying will still be conducted in the group format. RT

ABOVE After shambolic sessions in previous rounds, NASCAR has brought in single-car qualifying

NASCAR adds aero ducts at more races

NASCAR has announced that aero ducts will be added to the rules package for upcoming Monster Energy NASCAR Cup Series races at Pocono, Darlington and Homestead-Miami Speedway.

This year's Cup Series aerodynamic rules package features two variations, one that is typically for shorter tracks and another for longer tracks. At most of the shorter tracks the package includes front aero ducts, while at the longer tracks brake ducts or block-offs are used.


ABOVE NASCAR has amended the aero package for some races

The races at Pocono, Darlington and Homestead-Miami Speedway were originally set to use the shorter track package, but without the front aero ducts.

However, after reviewing data from the second race of the season at Atlanta Motor Speedway, NASCAR has now added the front aero ducts to the package.

"When we originally looked at which elements of the package to race at each track, we wanted to err on the side of caution at a few tracks where there may be some brake cooling concerns," explained NASCAR's senior vice president of innovation and racing, John Probst. "After reviewing data from Atlanta, and with what we've learned over the first 11 races, we believe we can use the ducts without issue. In conversations with the teams they emphasised the desire to focus on one race package, which will continue to improve the racing." RT

BBS Motorsport GmbH
Im Mühlegrün 10
D-77716 Haslach i. K.
Tel.: +49 (0) 78 32 / 96 09 5-0
info@bbs-motorsport-gmbh.com
www.bbs-motorsport-gmbh.com

BBS MOTORSPORT

A12/18 www.merzcreativ.com

ABOVE Proflex has acquired fuel systems specialist TKM

Rationalisation in the motorsport fuel systems industry

WITH over 50 years of experience working within the safety fuel bladder tank industry covering motorsport, marine, aircraft and defence, Proflex Advanced Technology UK Ltd has acquired TKM Systems, a refuelling, hose and fittings and fuel systems specialist. Earlier this year it had won the Proflex Advanced Technology contract to market and co-engineer the new Proflexcell safety fuel bladder tank.

Manufactured from an ultra-lightweight, aramid-based fibre (Kevlar) and reinforced with a high-tensile, fuel resistant elastomer, Proflexcell successfully achieved FIA/FT3-1999 approval.

Commenting on the acquisition of TKM Systems in April, Simon Dewar, managing director of Proflex Advanced Technology UK said: "TKM Systems was already chosen as a distributor for Proflex Advanced Technology UK Ltd and it has played a key role in co-engineering many customer fuel system projects for Proflex since our company launched at Autosport 2019.

"Whilst TKM Systems supplied all the in-tank fuel system and refuelling components to each of our fuel bladder tanks, it made perfect sense to acquire TKM Systems and bring all its stock, equipment, knowledge, technical expertise and personnel under one roof. We will now operate entirely under the name of Proflex Advanced Technology UK Ltd and we will grow together while working closely with our expanded workforce. We are convinced this acquisition will be key in our future growth, as we can now offer our customers a complete one-stop fuel system and fluid transfer package."

"When Proflex Advanced Technology UK Ltd first selected TKM Systems Ltd as an official distributor, we were absolutely thrilled to be one of only two companies chosen worldwide," said Kevin Molloy, managing director of TKM Systems. "Since the launch of our collaboration at Autosport Engineering, TKM and Proflex have been in regular contact working closely together on almost every customer fuel bladder tank project. When the proposal to buy out TKM Systems was first mentioned by Proflex, it was an easy decision to make as both companies simply complemented each other's specialty. With Proflex already having larger, established premises for fuel bladder tank manufacturing, it made perfect sense to move all TKM stock and assembly equipment into their premises, which was completed at the end of April." RT

TitansRX granted FIA international series status

TITANSRX, the new European-based rallycross series created for 2019 that was initially called GRC Europe, has been granted FIA international series status.

The name switch "in accordance with FIA requirements" for the MJP Promotions-run series came together with confirmation that the 12-round championship will now only feature MJP's single-make class for its new tubular space-frame, four-wheel drive, front-engined Pantera RX6, having originally planned to run a class for conventional Supercars alongside the new machines. Additionally, national support classes like SuperNational, Super1600, Crosscart and Retro Rallycross will now be run at events over the course of the season, while former World Rally Champion Ari Vatanen has been named as series ambassador.

"The past few months have been both challenging and exciting. Now all pieces have fallen into place and we have received FIA International Series status for TitansRX," said MJP Promotions owner Max Pucher.

TitansRX hosted a test event at Fuglau in Austria recently and ran its single-make Pantera RX6 against conventional World Championship-specification Supercars.

"Seeing TitansRX Europe come together at the MJP Arena was truly fantastic despite the freezing cold and rainy weather," said Pucher. "I want to thank everyone at MJP Promotions and our partners for the smooth organisation. Engineering delivered a set of exciting Pantera RX6 cars, which drivers and spectators enjoyed immensely. The cars have proven competitive, reliable and easily serviceable, which raises high expectations for a good season. Most of all, it was good to see that the Lion RX3 FIA Supercars and the Pantera RX6 delivered close-up racing action running side-by-side at similar performance." The TitansRX series will use control Hoosier Racing tyres and will be broadcast on Eurosport. RT

ABOVE TitansRX has been granted international series status by the FIA

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

RACE TECH

WMS

World Motorsport Symposium

Tuesday 3rd and Wednesday 4th December 2019

Proud to partner with IET The Institution of Engineering and Technology

MOTORSPORT LEADING THE CHARGE

Discovering emerging technologies and where they are heading

Artifical Intelligence & Data | Future of Powertrain | Aerodynamics | Green Technology

The RACE TECH World Motorsport Symposium has become an institution since it was first established in 2005 both influencing and impacting the politics and development of technology and engineering in the motorsport and the automotive sectors. These two days in London gather the industry to discuss how technology will shape the future of the sport and in turn influence engineering sectors across the globe. As a must-attend event for the motorsport and transport community, early bird tickets are now available for a limited time only.

POWER TECH | AERO TECH | DATA

Bcomp® sharc EVOLUTION MEASUREMENT ILEY DESIGN

RACE TECH Motorsport Engineering HISTORIC RACING & Technology TrackCar Performance Bernoulli

Institution of MECHANICAL ENGINEERS FORMULA STUDENT Institution of MECHANICAL ENGINEERS

The Davos of Motorsport Engineering & Technology

THE CHAIRMEN

ULRICH BARETZKY
Director, Audi Motorsport
Engine Development, Audi AG

JOHN ILEY
Founder and Director,
Iley Design Limited

THE CABINET MEMBERS (Confirmed to date)

PAT SYMONDS
Chief Technical Officer Motorsport
Division, FORMULA 1®

VINCENT BEAUMESNIL
Sport Director, ACO

PASCAL VASSELON
Technical Director,
Toyota Motorsport GmbH

DR DAVID SALTERS
Chief Engineer -
Engine Technical Leader,
Honda Performance Development

THOMAS KRÄMER
Director Motorsport Quality
Management, Porsche Motosport

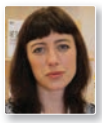
DAVID FLOURY
Technical Director,
ORECA Group

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

RODI BASSO
Motorsport Director,
McLaren Applied Technologies

BRYN BALCOMBE
Chief Strategy Officer,
ROBORACE

MARC HILBERT
Team Lead: Data Science in
Engineering and Production
Technologies, Volkswagen
Data:Lab Munich



DR ANNA BONNE
Transport Lead, Institution of
Engineering & Technology (IET)

SERGIO RINLAND
Managing Director,
Astauto Limited

STEVE SAPSFORD
Managing Director, SCE Limited

TECH | GREEN TECH | SAFETY TECH

CPD CERTIFIED
The CPD Certification Service
Collective Mark

#WMS19

worldmotorsportsymposium.com

KIMBERLEY MEDIA GROUP LTD

Promote your technology and services

Take advantage of the World Motorsport Symposium audience by exhibiting in the elegant Maxwell Library where all the break out sessions will take place throughout the two days.

ABOVE Nicolas Aubourg, Head of Performance & Simulation at the FIA chats to Richard Bardwell, Director at SHARC about their latest technology

RAPID TECH | EMERGING TECH

Early Bird Packages - LAST CHANCE

£595 + VAT
RRP £695 +VAT

Two day delegate ticket
(including lunch & refreshments at The Institution of Engineering & Technology IET, Savoy Place, London)
& Networking Awards Evening
(including Champagne Drinks Reception, Three Course Meal and fine wine at the Millennium Gloucester Hotel, London Kensington)

£495 + VAT
RRP £595 + VAT

Two day delegate ticket
(including lunch & refreshments at The Institution of Engineering & Technology IET, Savoy Place)

Early Bird offer ends 31st May 2019

RACE TECH

WMS

World Motorsport Symposium

Proud to partner with IET The Institution of Engineering and Technology

FREE TO ENTER THE GREEN TECH AWARD 2019

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

All 2019 awards

- Green Tech
- Most Innovative New Motorsport Product
- Race Powertrain
- Racecar Aerodynamicist

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

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

worldmotorsportsymposium.com

KIMBERLEY MEDIA GROUP LTD

Pirelli

BELOW When a car runs in a rival's wake, directly behind, it typically loses 30 to 40 percent of its downforce. Studies suggest that figure could tumble to just five percent under F1's 2021 rule changes

THE BATTLE TO SAVE US FROM *OURSELVES*

Quizzed by Sky Sports F1's Martin Brundle, Ross Brawn made a startling revelation. Our **Expert Witness** says the changes suggested by F1's motorsport chief can't come soon enough

THERE comes a point where a view from outside, a fresh perspective, is required to reinvigorate a situation that is definitively not delivering to its potential.

When you add into that mix a severely ramping commercial pressure, plus the need for revenue to increase, sooner rather than later, what are the changes that are going to work?

What you must not do is panic. You must identify the correct directions, put a plan in place to execute them and then be allowed to follow them through in the appropriate timescale. Welcome to the current challenge that is facing Formula 1, motorsport as a whole, and a couple of grandee teams in particular.

In Ross Brawn, Liberty have the right man – in my view the *only* man – to deliver this from a technical and sporting point of view, ably supported by an increasing team of experienced ex-F1 staff. If they cannot do this, or are not adequately supported to, then F1 is irretrievably broken, done.

They are the clichéd poacher turned gamekeepers. The task is now to be neutral and provide a framework, utilising all that experience and strategic capacity to plot the right course for the future, 2021 and beyond – saving F1 from itself.

So, what does this emerging picture look like with only 19 months to go? Ross has said you have to look first of all at the integrity and core of F1 to make sure the pinnacle of motorsport is maintained and protected. Keep the key ingredients that the avid fans and the teams require, but find elements that add value and broaden appeal.

At its very centre, the priority is the quality of the racing. Any show needs to be close, interesting and entertaining, otherwise why bother to watch it? But the puzzle has two parts…

AERO REVOLUTION

The cars must be able to race in close proximity with each other, the solution being a fundamentally new aero package that allows the cars to not lose the up to 50 percent of downforce they do now when following, nose-to-tail. The CFD and wind tunnel research is going really well, with numbers for the new solutions being quoted as reducing that drop in downforce to as little as five percent. A tenfold improvement. Impressive.

However, part two is to make sure the whole field is much closer together, while allowing excellence – of the car, team and driver in the right ratio – to still ultimately win out. We need to add an aspect of more opportunity or, crucially, hope, for others to win or be much more involved in the results. This is harder to implement, as historically biggest infrastructure, budget and staff normally have a profoundly positive effect on the results. Teams in this position are also the least likely to welcome those ▶

IndyCar

ABOVE F1 seems likely to follow the technical direction of IndyCar, which harnesses more ground effects on its 2019 cars

circumstances evolving. We are talking vested interests, not bigger picture.

You can simplify the cars down, so that the areas you can spend the money on make much less difference to the lap time. You can also increase the amount of parts that are uniform for everyone, making the cars ever more similar. The 'Haas Model', creating contention over how far this line has been pushed, is being broadly supported by Liberty Media as a way forward, but perhaps with some further clarification. Gearboxes, brakes, wheel rims and now elements of the fuel system have most recently been added to an ever-lengthening menu for F1 tender.

Another approach is that you can try to control the amount of money teams can spend so that the difference between the front and the back of the grid is tens and not hundreds of millions. The aim would be an actual performance competition, rather than a spending contest.

This control of budget, regulations, revenue and what parts are able to be shared is at the very heart of what has been F1 and has been quoted recently as still "the elephant in the room". If you have the largest budget, greatest revenue – irrespective of results – and a rules veto, why would you give that up? To save the category, perhaps?

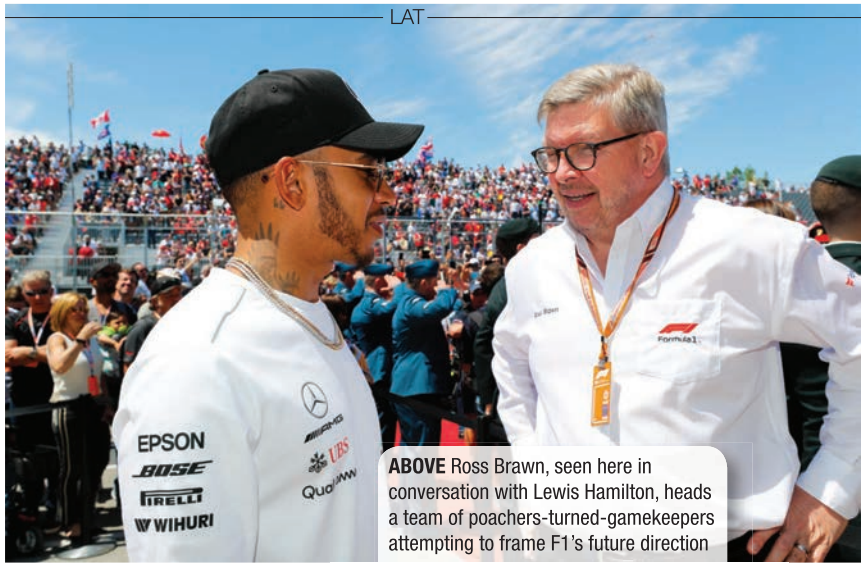
This is where Liberty's familiarity with other sporting models, for example the NFL, can help transform these other aspects,

> *"A new aero package could see the following car lose as little as five percent of its downforce, rather than the figure of up to 50 percent we have now"*

also required to be in place for 2021: governance, costs and revenue. The best teams in the NFL today still win, maybe not as much of the time, but now every team makes a profit, survives, prospers and the sport is much healthier for it. The opposite is true in F1. With the current 10 teams in danger of dwindling still further, the question is: how bad does it need to get before the fundamental issues holding back the sport are addressed?

Beyond getting the whole grid closer together and able to race each other, essential to get an audience, how well looked after is the spectator once they have engaged? Here is where greater and better- ▶

LAT



ABOVE Ross Brawn, seen here in conversation with Lewis Hamilton, heads a team of poachers-turned-gamekeepers attempting to frame F1's future direction

Delivering Excellence Through
Innovation & Technology

RICARDO

Winning with Ricardo

The transmission technology behind a winning partnership across all racing formulas

For decades, Ricardo has designed and delivered transmission solutions in all forms of top level motorsport including Formula 1, sportscar, single seater, rally, and electric race series.

Top tier motorsport customers demand competition-ready, proven transmission systems available in a range of configurations with high levels of reliability.

This is why the world's leading OEM's turn to Ricardo for both their on and off circuit applications. Ricardo's process driven design, manufacture, assembly and end of line testing ensures customer demands are met at every level.

Ricardo are experts at delivering highly effective, low maintenance, winning transmissions.

Delivering the right product, for the right application, first time - every time.

Find out how Ricardo can help with your transmission development

Email: info@ricardo.com Tel: +44 (0)1926 319319

www.**ricardo**.com/motorsport

quality access has to be developed, and not just at the new and more numerous venues – 22 races, 24? – that F1 is intent on exploring.

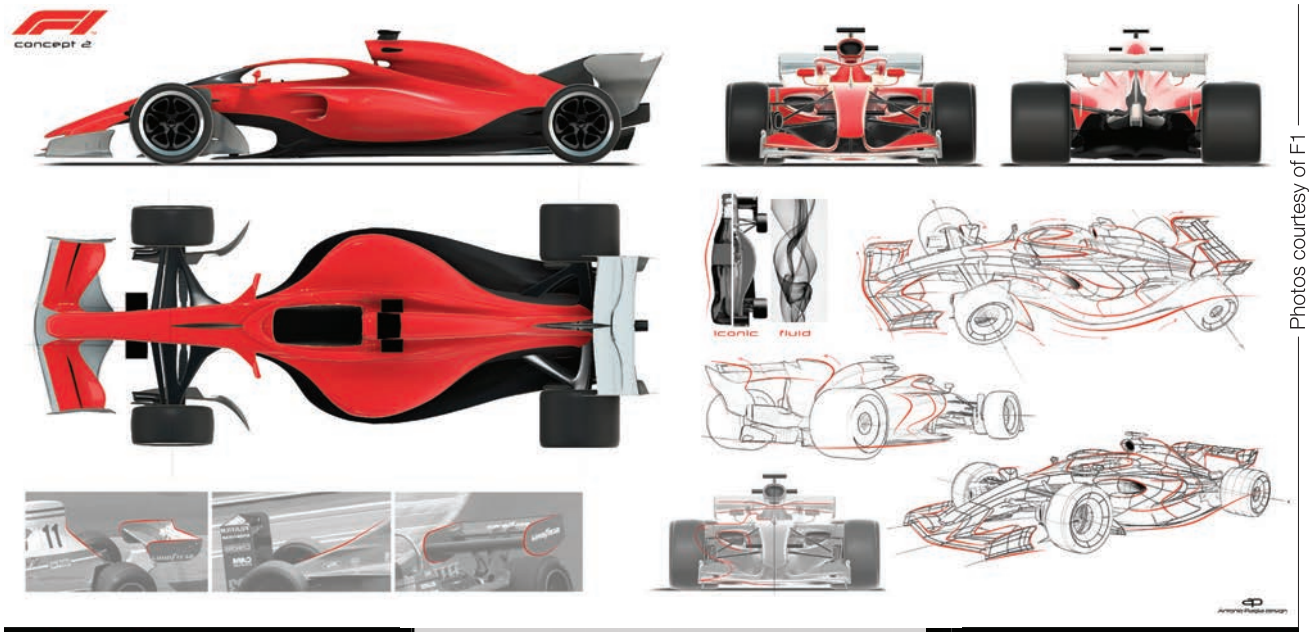
Once at the track, properly designed for the future, can I see the cars, meet the drivers, have information streamed to me – even previously confidential data or radio transmissions? What other hospitality and entertainment is available to my family and is it included to make my whole day and experience worthwhile?

Over social media and TV, the same applies: how can the viewing be improved and totally immersive? Graphics, VR, AI, the compelling stories are actually already there, it just needs increased freedom to tell them and get across to both a traditional and new fanbase. In an ever more environmentally conscious world, the message of F1 developing the most fuel-efficient powertrain in history has never been properly broadcast.

> *"If Ross and his team don't succeed, then F1 is irretrievably broken"*

F1 needs to be the pinnacle of the sport, but it ought also to showcase the formula – in more ways than one – required to take motor racing as a whole forward. Make the racing series better, more accessible, less expensive, sustainable and deliver a technological vehicle that can answer today's toughest technical challenges in the shortest timescales.

If more people participate, engage and watch because it's good entertainment and it costs less, then you have the foundations for the motorsport of the future. RT



Photos courtesy of F1

ABOVE & BELOW Whatever technical format the 2021 cars follow, Brawn concedes that the business model that underpins the sport must be more sustainable than at present

progressive braking

Leading the way in braking innovation

At Alcon, we push brake technology as hard as you push on the track. For over 35 years, Alcon have been supplying winning solutions to competitors in series ranging from F1 to grassroots motorsport and everything in between.

Alcon constantly push the boundaries on caliper, disc and actuation technology and new materials. So whether you compete off-road or on the track, you can rely on Alcon's expertise to help you win.

Contact us today to see how Alcon can help with your brake or clutch requirements.

HEAD OFFICE UK +44 (0)1827 723 700

alcon
specialist brakes & clutches
www.alcon.co.uk

LAT

ABOVE The McLaren MP4-4 is just one of many iconic cars on Murray's CV. It boasted a win rate of 93.75 per cent and the biggest margin of victory ever achieved at that point in the Constructors' Championship

IS THE BEST ABOUT TO GET BETTER STILL?

Lifetime achievement gongs and the publication of a book usually bring down the curtain on a stellar career. But **Alan Stoddart** finds Gordon Murray hard at work on a "mind-boggling" new project that could eclipse even his greatest designs

MOTORSPORT is an industry which offers only rare opportunities for reflection. The usual practice is one of assessing what is current and envisaging something better to replace it, and then repeat. It is unusual, then, for a designer or an engineer to be able to stand back and cast his eye over a portfolio of work, taking each creation on its own merits rather than being restricted by the context of the time.

This however, is the opportunity that was presented to Gordon Murray CBE in the production of the retrospective One Formula exhibition and book that he created in conjunction with Philip Porter and his eponymous Porter Press. Thanks in part to Murray's extensive collections of drawings, diagrams, notes, reports, memos and other paraphernalia from his 50-year career, he was able to revisit old designs, and refamiliarize himself with the details that he carefully wrought many years ago, as well as rediscovering forgotten elements, and even entire cars that had been left behind by the frantic pace of motorsport development.

This process, says Murray, was "good on so

ABOVE 'One Formula' is a two-volume blockbuster that covers in detail every one of Murray's 70+ designs, including those he never built

many different levels.

"First of all it was great just to remind ourselves of how many cars there were. It was also great too, without sounding big-headed, to look at some of the cars again and look at some of the detailed designs because I had forgotten how innovative some of them were in the detail, not the overall car – the overall concepts were quite wacky for some of them like the [Brabham BT]44, but in the detail design and the thought that had gone into weight saving or making the car easier to work on for the mechanics in really detailed areas.

"You know," he continues, "you do the car and it wins a few grands prix or wins the championship or something and you just think 'well that was a good car', but actually what doing the book has done for me has shown that there actually is one formula that you can read as light weighting, but it's also been the way I design cars, and I had to remind myself, and I did remind myself, just how much time I spend on the detail design of the motorcar."

Compiling the book was also a chance for Murray to think about the other important aspects of car design, even those elements that weren't necessarily to do with the technical decisions in creating a championship-winning car. For example, Murray, who cut his teeth building his own cars to race in South Africa, highlights how crucial it was that he had intimate knowledge of every part of a racecar. He says that if in a motorsports team, the chief designer or technical director wasn't able to draw every part of a car, and had to hand off the engine installation or the design of the gearbox or the aerodynamics or the cooling system to another designer, the result wouldn't be as integrated a design as one that was created by a singular vision.

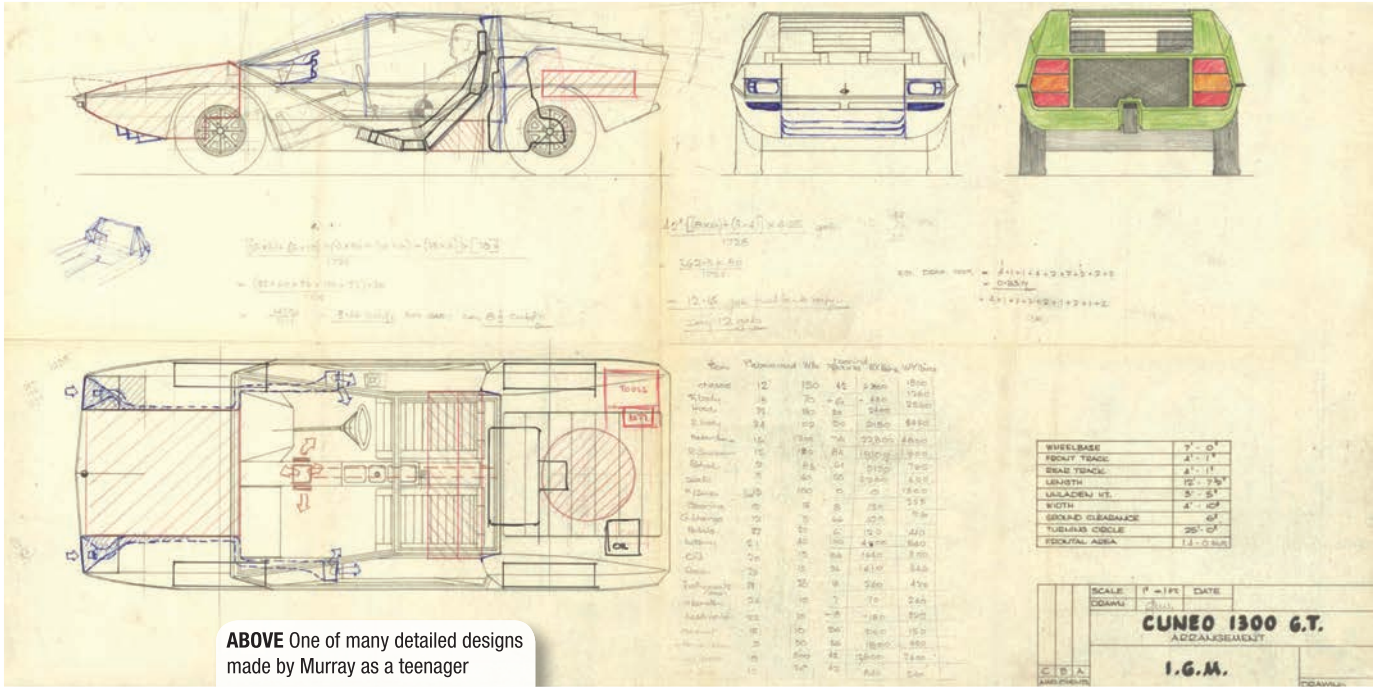
A HOLISTIC VISION

He also points out that taking ownership of a complete design was also a pragmatic necessity, noting that, "Until mid-'76 or '77 it was just me, so I had to design everything!"

But this, Murray adds, was also one of the secrets of a truly complete, holistic design. "I think it produced the good cars," he says, "and if you look at car design generally, the iconic cars are what I call 'single-person cars'.

"If you look at the Mini it was all Issigonis; the little Fiat Cinquecento was Dante ▶

> *"Where a lot of car designs go wrong these days is that they go through committees"*



ABOVE One of many detailed designs made by Murray as a teenager

ABOVE The Brabham BT49C that carried Nelson Piquet to the 1981 world title is just one of many of Murray's milestone cars

Giacosa; these and all the other really iconic cars tend to be single-person cars. So where a lot of car design goes wrong these days from an engineering point of view and a style point of view is that the design goes through committees.

"There are dozens and dozens of people involved that are making decisions, and then it has to go up through all the bosses, whereas, I think in the '70s and even into the '80s, a lot of the really good designs in racing were single-person cars."

This was a result of not only the purity of vision that stems from having a single designer oversee a whole car, but also the type of designer that is in charge of the project. Murray explains that there were really two different types of designers in the '70s: there were some that excelled in engineering, who primarily produced evolutionary, rather than revolutionary designs; then there were the designers that Murray describes as visionaries such as himself and Colin Chapman. These designers were more willing to take a chance, but of course this meant that sometimes the designs didn't work out as planned.

So, with the benefit of hindsight, does Murray regret taking this more revolutionary approach to design; would he have done things differently? "Well obviously, in retrospect it's easy," he says. "The ones that didn't work, I know why they didn't work and I could now make them work."

"But it's difficult to answer that because at the time you think you have done everything as well as you can do it, but there were also things like time constraints. In some instances, I know I would have done things differently had I had another month or another week to finish the design, but at some point you had to stop yourself because you wouldn't be able to make the first race.

"But," he continues, "there are still a lot I would change. I now know why the surface cooling car [the Brabham BT46] didn't work and I could make it work now, and I know why the laydown engine didn't work in the BT55. If I'd had another three months though, ▶

BELOW The BT46-Alfa Romeo, which initially featured a radical cooling layout, is one of Murray's regrets, for he now knows how he could have sorted it

VBOX VIDEO

VBOX VIDEO HD2 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 HD2** represents the ultimate in tough, reliable motorsport video loggers.

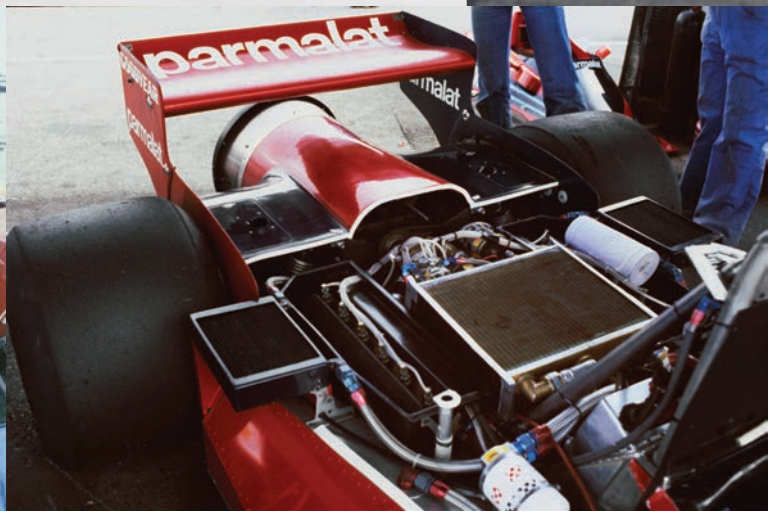
VBOX VIDEO HD2 comes with **CIRCUIT TOOLS**, an intuitive analysis software package designed to help drivers improve their track performance and accelerate the learning process, ultimately leading to better lap times.

- Synchronised video and data
- Dual camera 1080p
- Heart rate monitor
- Class leading driver training software (Windows, macOS & iOS versions)
- Configurable pre-record buffer
- Camera preview over WiFi
- CAN interface
- CAN signal database

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

www.vboxmotorsport.co.uk

ABOVE & BELOW The BT46B 'fan car' took ground effects to new extremes. It was never actually banned, insists its creator, although paddock pressure led to its withdrawal after a dominant victory in the 1978 Swedish GP



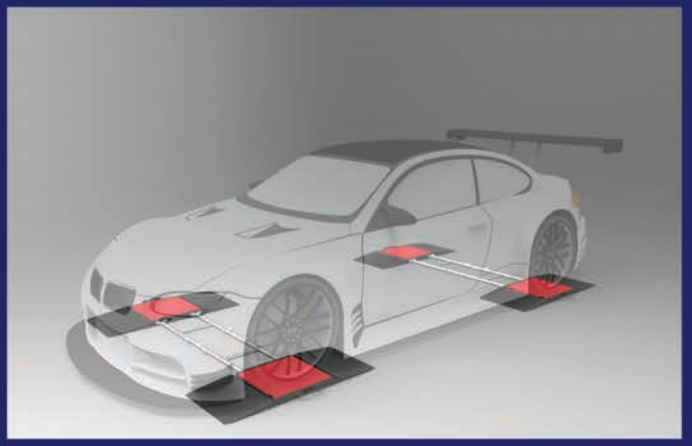
I probably would have got it to work."

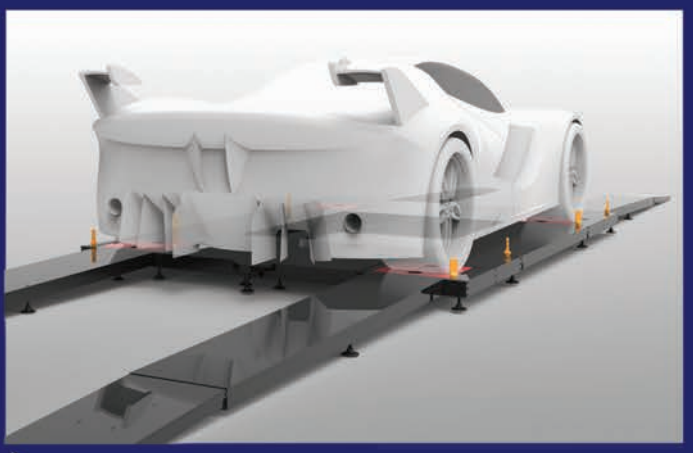
This isn't merely a professional boast, or Murray excusing himself for a less-than-stellar season; instead, the lowline concept with the very low engine, and a driver in an almost recumbent position to aid the aerodynamic efficiency, was successful. It just took until 1988, by which time Murray had moved to McLaren, and the embodiment of the concept was now known as the McLaren MP4-4.

"What I brought with me – and this is the beginning of the MP4-4 – was the knowledge of the BT55," Murray recalls in the book. "Although the Brabham was a complete flop from a results point of view, I understood why. I knew from the figures that the aerodynamics on the car, with the low centre of gravity, with the lay-down driving position, were phenomenal. So, I brought with me just simple drawings. I didn't bring a lot of drawings with me from Brabham because they were in my head anyway, but what I did bring was a layout drawing of the 55 with the driver position, the pedal position the centre of gravity and so on."

Key in getting the lowline concept to work at McLaren, where it had failed at Brabham, was the engine. Instead of using the four-cylinder BMW that was harnessed in the Brabham, the McLaren used a smaller turbocharged V6 made by Honda. Even this 'tiny' engine was higher than what Murray thought ideal, so he shared his vision with Honda, which was able to lower the engine further, reducing the crank height by some 20 mm. "This," says Murray, "was fantastic because then the engine sat well below the driver's shoulder line."

Of course, the proof of Murray's belief in this concept was in the results it eventually managed to bag. While the Brabham BT55 managed to secure only ninth place in the 1986 F1 Constructors' Championship, the McLaren MP4-4, piloted by Ayrton Senna and Alain Prost, arguably the greatest pairing of all-time, achieved the most dominant team performance ever. Out of the 16 races in 1988, the MP4-4 won 15 of them, with ▶





BREDA RACING
racing components and equipment

30 *years supplying motorsport equipment*

BREDA RACING srl Via 11 Settembre, 29 (Fraz. Ronchi) 35010 Villafranca PD Italy
Tel. +39 049 9070456 info@bredaracing.com www.bredaracing.com
North & South America Exclusive Distributor - info@bredaracing.us

> *"The ones that didn't work, I know why they didn't and I could now make them work"*

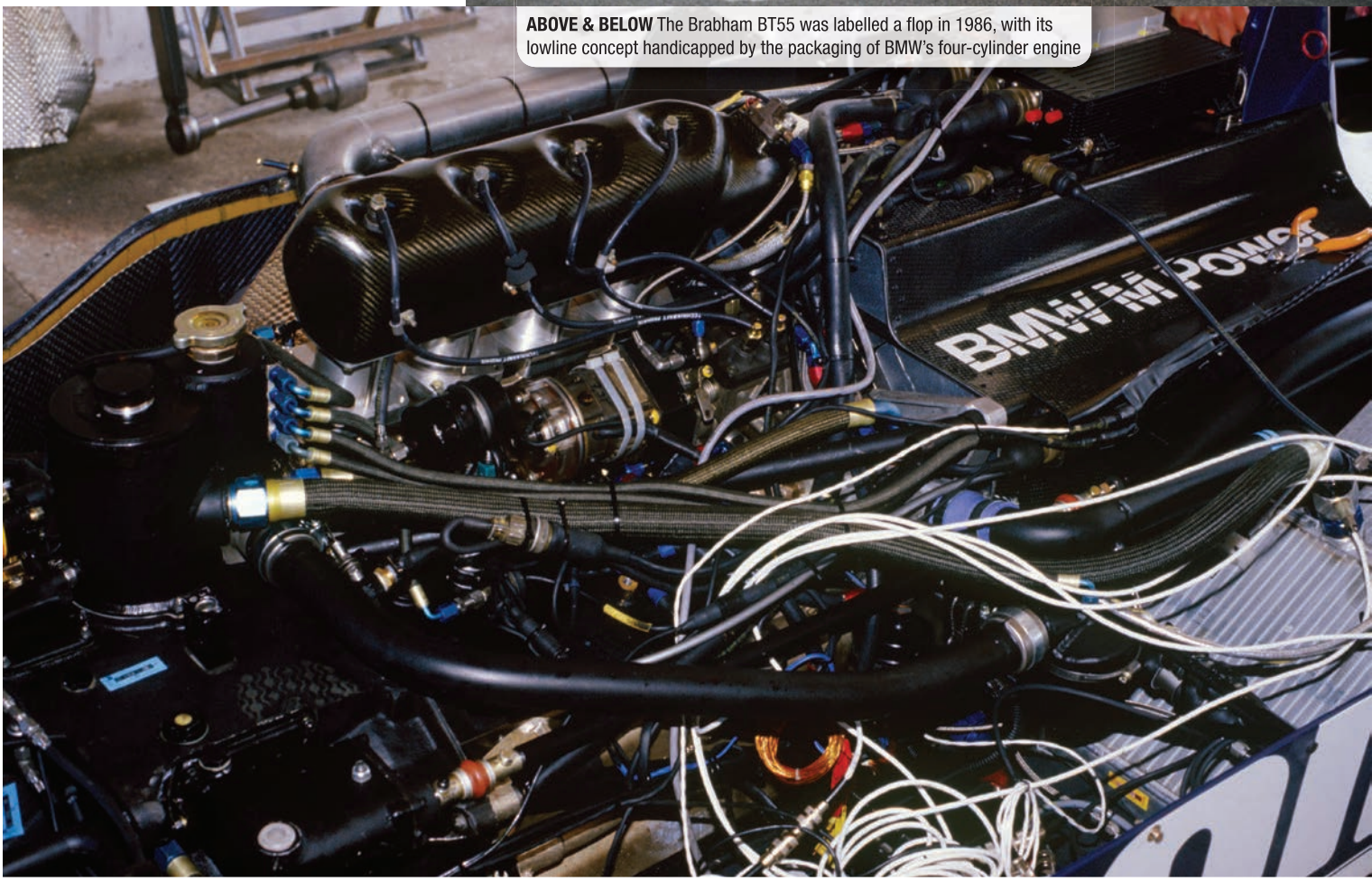
10 being McLaren one-twos. Such was the dominance of the MP4-4, which had a win rate of 93.75 per cent, that it had more than tripled the points of Constructors' Championship runners up Ferrari, besting the Scuderia 199 to 65.

As well as the more revolutionary aspects of the car being key to this staggering run of success, Murray also highlights the importance of its more everyday attributes.

"The MP4-4 has gone down in history as the most winning car, but when you analyse it, it was radical but it wasn't radical," he says. "It was radical because it had the Brabham lay-down, very-low style, which was much lower than any other car on the grid. The centre of gravity helped, but mainly it was the aerodynamics.

"So that was radical, but the car itself – the chassis, the suspension – there was nothing trick on it at all. It had the old Brabham rod-operated suspension, carbon brakes, typical McLaren very simple monocoque, very simple aerodynamics, no trick front wing, no trick rear wing – just a very simple, very straightforward motor car."

The problem of running out of time to perfect a design, as was the case with the BT55 for Murray, is a complaint that will resonate with many across all walks of motorsport, but the South African also suggests that the opposite can be a problem. He compares it to his painting, where his 'worst nightmare', which is shared by many other painters, is not appreciating when a work is complete, and instead continuing to daub on more and more paint, and in doing so take the work further and further away ▶



ABOVE & BELOW The Brabham BT55 was labelled a flop in 1986, with its lowline concept handicapped by the packaging of BMW's four-cylinder engine

LifeRacing

Professional engine, chassis and gearbox control electronics

Providing control solutions for Le Mans LMP1, WRC, WTCC, Indy Lights plus many production formulas.

Direct injection, stand-alone or integrated paddle shift systems, drive-by-wire, intelligent power distribution, electronic fusing and high reliability wiring systems are all manufactured for the most demanding applications. Life Racing has extensive experience developing turbocharged and normally aspirated engines and supporting diverse racing series including F1, WRC, WEC and Le Mans, WTCC and more…

Contact us to find out more about our products…

Life Racing Ltd
6 Repton Close , Basildon, Essex, SS13 1LE, UK
Tel: +44 (0) 1268 904124 Email: info@liferacing.com
www.liferacing.com

ABOVE Ayrton Senna, who won his first world title at the wheel of the MP4-4, ponders things with Ron Dennis and Gordon Murray

ABOVE & BELOW Where Brabham's BT55 had failed, Murray got the opportunity to vindicate the lowline concept when it was mated to the compact Honda V6 to form McLaren's all-conquering MP4-4

from the original inspiration. This is the same with motorcar design, with too many people working on a problem, too great a budget or even just having too much time can lead to the spoiling of a design. In short, there is a definite point when designs should be considered finished.

There were designs that Murray definitely doesn't consider finished however, with some of the most frustrating being ideas that were nipped in the bud before ever being allowed to blossom, thanks to regulation changes or other external limitations. "There are dozens of designs I'd loved to have pursued further," he recalls. "Loads and loads of times I have thought 'I just wish the regs would allow us to do that', or I have thought 'if only I could just get hold of that material', and then just before you can, it's banned.

"Sliding skirt technology was one of those. We were always experimenting with different wear strips and different rollers and different low friction systems to make them work and make them better and better. Then, with the low friction skirts we were looking at all these new materials and technologies, but then, suddenly they were gone. It was really annoying that."

FAN CAR FURORE

However, the rules of Formula 1 weren't always the reason that designs couldn't be pursued. Even in the case of the infamous Brabham BT46B fan car, which is often remembered as Murray's most famous innovation to be banned. Strictly speaking however, explains the designer, this never happened.

"After the race [the 1978 Swedish Grand Prix which was won dominantly by Niki Lauda in the fan car] the CSI, which was the technical body of the FIA then, sealed the back of the car and got us to put the car on the back of the truck and then sealed the truck.

"The basis on which I had said the car was legal was aerodynamic article 3.7. It stated that if anything on the car moves relative to the sprung mass of the car, its primary function can't be to influence the aerodynamic performance of the car."

With this being at the heart of the case for the BT46B's legality, the CSI took the sealed car back to the Brabham factory. There it unsealed it and then tested it with an anemometer to ascertain once and for all whether the main effect of the fan at the back of the car was for the benefit of the car's aerodynamics or to improve cooling, as Murray insisted.

The inspection ultimately proved the latter.

"I've actually got a letter from them saying that the car was legal, but that they were changing the loophole in article 3.7 at the end of the season so we could only run it until then.

"However, [Colin] Chapman, who had just invented the ground effect car, could see ▶

his '78 season running away from him… So he got all the constructors together, and got Andretti to tell people the car threw stones out the back, which it didn't. He tried everything.

"Ultimately Bernie [Ecclestone, who then owned the Brabham team] caved in because the other constructors told him that if he continued to race the car, they would collapse the Formula One Constructors Association… so he came to me and talked me into withdrawing the car, which we did.

"But I was so pissed off by it!"

LIBERATED BY TECHNOLOGY

Another element crucial to winning grands prix and championships was identifying and harnessing the right technology, something that Murray excelled at. Instead of having an idea and lamenting the fact that it couldn't be implemented because the technology the team was using wasn't up to the job, Murray used technology as a solution, seeking out new innovations that hadn't yet been used in motorsport and using them on a racing car. His record bears this out, from being the first designer to use a composite wing in 1974, to being the first to make a carbon road car in 1992.

Murray says that instead of being limited by technology, he actually found it liberating. Such is the case with the carbon brakes that were first used on the BT45 in the 1976 season. Murray had read about carbon brakes being developed for use on Concorde by Dunlop Aviation. As well as being lighter than conventional brakes, they had a higher coefficient of friction and were able to operate at far higher temperatures without succumbing to fade. These qualities, he thought, would make them the ideal material to make F1 brakes out of. The actual process of getting them to work wasn't straightforward, but the ability to look at technology beyond that usually employed in motorsport gave Murray's designs a definite technical edge.

ABOVE The combination of Murray and Bernie Ecclestone, seen here flanking Carlos Reutemann at Zolder in 1975, proved a powerful one as F1 pioneered new territory

MCLAREN F1: THE PERFECT SUPERCAR

This technical advantage was perhaps most comprehensively demonstrated by what is often thought of as the best, most complete car to have ever been produced: the McLaren F1.

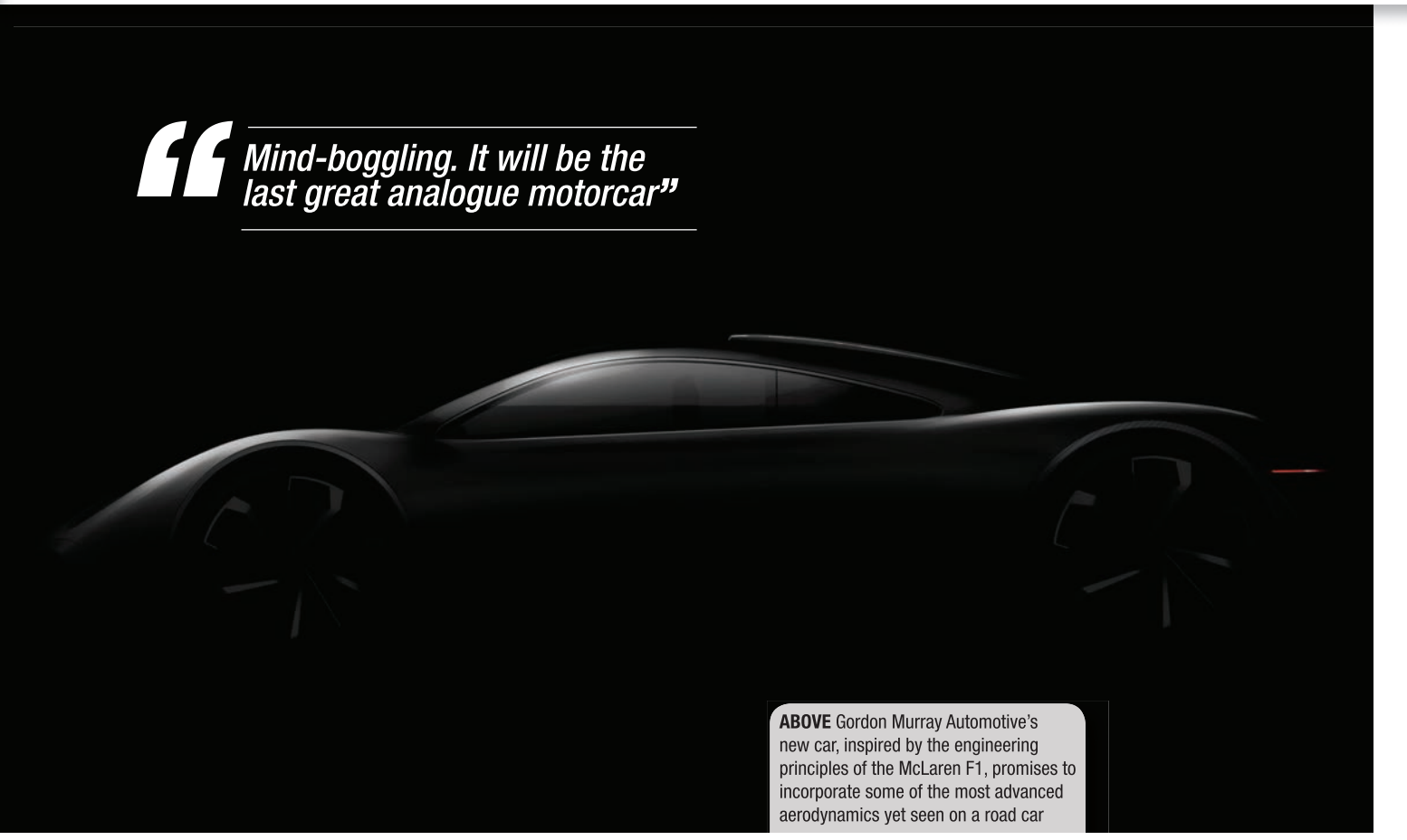
Murray attributes the almost legendary success of the F1 to the lack of compromise involved in making the car. He explains that the design was an almost entirely blank sheet of paper, so between the lack of budget for the individual cars, which allowed the use of the now famous gold foil among other things, and Murray's oversight of every tiny detail, there was nothing that needed to be compromised on the entire car. Everything was relentlessly aimed at creating the perfect supercar.

This focus, he says, was key, particularly

McLaren

ABOVE With seven World Championship titles to its credit in the previous eight F1 seasons, McLaren turned its attention to a new challenge for 1992: the road-going McLaren F1

> *"Mind-boggling. It will be the last great analogue motorcar"*



ABOVE Gordon Murray Automotive's new car, inspired by the engineering principles of the McLaren F1, promises to incorporate some of the most advanced aerodynamics yet seen on a road car

to the car's execution. "Making a lightweight concept? Ticking that box is easy. The difficult bit is controlling every single nut and bolt to make sure it doesn't run away from you."

Despite this, and the list of incredible firsts achieved on the F1, such as being the first production car with a carbon monocoque, the first car with active aero, the first car with active brake cooling etc etc, Murray never thought about how truly ground-breaking the project was. In fact, he makes the designing of the greatest supercar of all-time sound almost simple.

"I just sat down and thought this is a clean sheet of paper, you've got all this background knowledge on materials and suspension and aero, just make the best car that anybody has ever made.

"Just make the most driveable car you can, and the most driver-focused and lightest car that you possibly can, and it'll turn out okay. That was it, nothing more complex than that."

ABOVE The F1 won Le Mans at its first attempt in 1995. In GTR form the car offered privateers a platform with which to race on the world stage – an interesting backdrop to the WEC's plans for its new hypercar category

"BETTER THAN THE F1"

Opportunities to design as freely as this are rare. But impressively, for someone whose career already spans 50 years, encompasses multiple F1 World Championship-winning cars, and one of the most celebrated road cars of all-time, Murray says that some of his most exciting work is that which he is currently doing at his own company, Gordon Murray Design. Among the projects that he is working on at the moment, is one tantalising prospect that will set the heart of any car fan aflutter.

"The F1 was the freest, cleanest sheet of paper I've ever had, but I'm doing a new one now and talk about having more tools in the toolbox! The materials and systems have moved on so much, so this one is just mind-boggling. It's going to be the last great analogue motorcar.

"You could ask me about it when it is public, and point at anything on the F1 and say 'why is it better on the new car' and I would be able to tell you exactly.

"It really will be better than the F1 in every single way, from the styling to the aero to the structure and packaging.

"What's more", adds Murray, "it is being created with the same simple aim as the F1. To make the best, purest and most focused sports car ever." RT

KILLING F1, OR *RESCUING* IT?

Tee/LAT

Will the stampede towards the use of more spec parts make F1 fairer, opening up a previously closed shop, or does it erode the sport's very DNA? **Craig Scarborough** tackles a thorny question

FORMULA 1 has always been meritocratic. Winning on the ability to design a better car might seem only fair, but it does not necessarily make for a tightly-packed field and exciting racing. The last GP won by anything other than a Mercedes, Ferrari or Red Bull was back in 2012!

Under Liberty's new ownership of the sport, the 'show' is becoming ever more important and equalising the field to allow more teams to be competitive, to give at least a chance for someone other than the Big Three to win, is a key goal. One obstacle to this objective is the cost of constructing the car.

F1 is often termed the pinnacle of motorsport and has always been a constructor-led series, with individual teams manufacturing much of the car. Indeed, to enter, you now must be a constructor and make the main structure of the car yourself. F1 is very much a prototype category, but designing every part of the car adds cost, brings complexity and separates the 'haves' from the 'have-nots'.

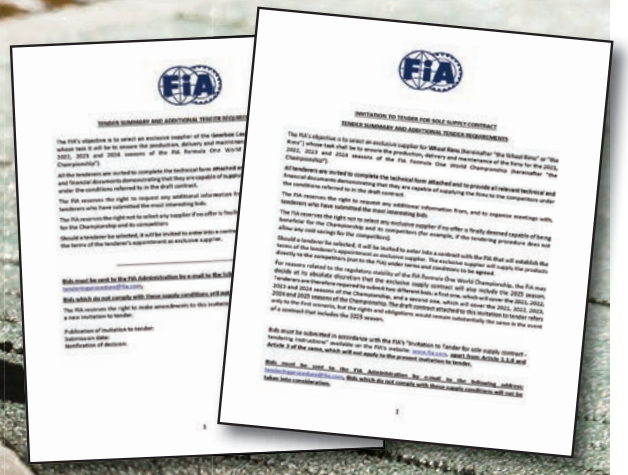
The big shake up of the sport for 2021 includes many changes, one of which is to extend the list of spec parts, reducing the differentiation between the teams. So, should F1 go with more spec parts or does that deviate from the DNA at the very heart of the sport?

WHY SPEC?

If you consider how many parts go into the modern F1 car – around 11,000 components in a chassis and a further 6,000 in each engine – the scale of the task facing each

LEFT Like it or loathe it, the 'Haas Model', taking advantage of non-'Listed Parts' to elevate the smaller teams nearer to their big brothers, would appear to provide a template for F1's future direction

> *"There are around 11,000 components in a chassis and a further 6,000 in each engine – the scale of the task facing each squad is enormous"*



ABOVE The FIA has already invited tenders for several components as its 2021 overhaul ramps up

squad is enormous.

Every part starts life in the CAD PLM system, everything from the monocoque down to the smallest bracket that holds a single cable steady between sensor and loom. Someone sits down and designs each part, considers its role and functional needs, works hard to improve it: the pressure is always on to make it more efficient, lighter, stiffer, smaller, streamlined or with less friction.

Often there is also an incremental development loop of improving and revising the component in the light of structural or fluid simulation, or its interaction with other parts around it. Then each part needs the tooling designed, made and eventually there is its manufacture and quality inspection. Its life on the car is meticulously tracked before eventually it is withdrawn from use and scrapped or stored away in the team's archive.

Anyone who has been near an F1 car, or its component parts, quickly realises how everything is highly optimised. This applies throughout the car, right down to the humble bracket being machined on all faces for light weight, or the electrical connector with just one mounting flange to save weight.

Even components bought in from outside suppliers are bespoke to each team: items such as seatbelts, steering wheel switches and the brake callipers. While the component part is largely the design and IP of the supplier, teams will want slightly different specification, revised mounting points or push harder for weight savings.

The sum of these parts makes the car ▶

Daimler AG

ABOVE The current system perpetuates the dominance of the Big Three at the front of the field

faster and more reliable, in order to gain success at the track. But, of course, some of them contribute more to lap time than others. A front wing design or suspension rocker will have a primary effect on speed, while the steering column or throttle pedal much less so. Regardless, these parts are reconsidered for redesign each year, taking up resources or time and money to do so.

It's not exactly breaking news that teams do not have the budgets they'd like. The commercial funding has changed away from big tobacco money to smaller sponsors and, nowadays, commercial/technical partnerships and prize money to fund the development and operation of the team. The virtuous loop that sees more cash from partners and prize money go to the successful teams, means that midfield squads suffer from less funding and thus R&D dollars, exaggerating the gap between the current top three teams and the rest.

So, it's not unreasonable for F1, via FOM and its new owners Liberty, to want to reduce costs to equalise the field. There are many methods of doing this and one now in progress for 2021 is that of evaluating spec parts.

CONTROVERSIAL

At first glance, this approach is anathema to F1 aficionados, wary that the pinnacle of the sport might be reduced to a spec series like current F2 or F3.

Upon closer inspection, there are actually a lot of common parts on the cars, a situation which predates the current regulations by decades. Back in the seventies, most of the grid ran a Cosworth engine, a Hewland gearbox and brakes from AP Racing. Currently all the teams run the same tyres, ECU and sensors, while the Halo, fuel tank and much of the electronics are from homologated suppliers. Meanwhile, Haas buys nearly every component aside from the tub, crash structures and bodywork from Ferrari; Toro Rosso runs the entire rear end from Red Bull, suspension and all; while Williams is the only team to produce a gearbox entirely on its own.

So, there is a precedent for going further with spec parts, but there is a balance to be struck: go too far and F1 becomes a spec series; not far enough and the costs will continue to escalate, and the gap in the field between the big teams and the stragglers widen.

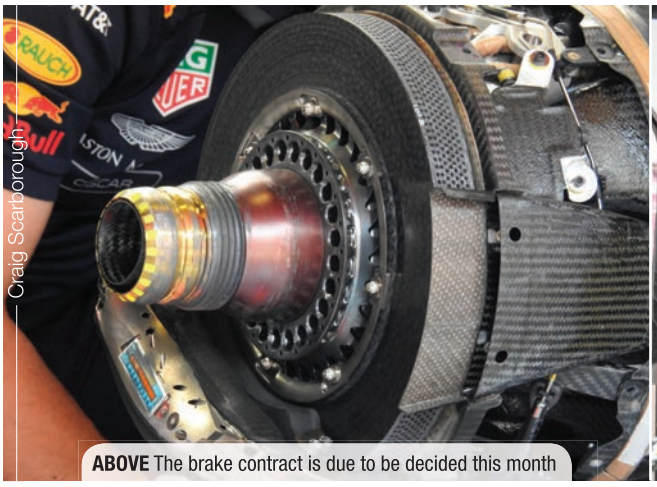
ROBUST PROCESS

For F1 to enforce spec parts, there needs to be a clear process by which the suppliers are chosen and how the parts are then used by the teams. As there are already spec parts, suppliers and designs in place, so the FIA already has a robust process for this.

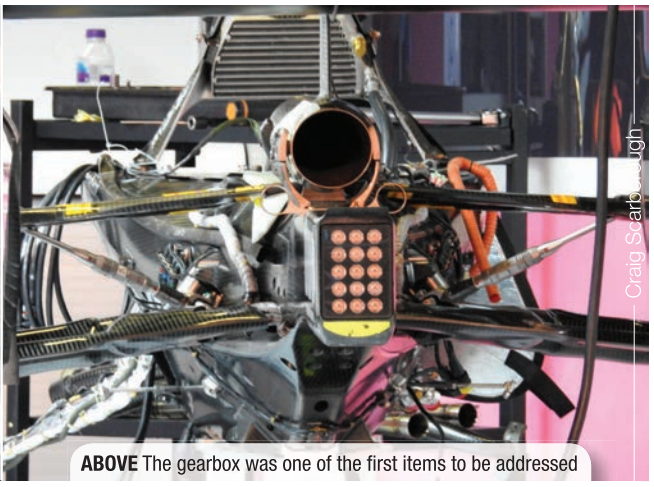
There will be a tender process for each spec component, which is typical of any business seeking new suppliers. The FIA will issue an invitation to suppliers for the supply of a specific part or system. This is all openly on display on the FIA website, where the requirements and timings of the tender responses are fully detailed. Upon receipt of the tenders and after the closing date, the FIA technical department will assess each bid and offer the contract to the successful company.

At that point the sporting and technical regulations will be revised to include the demand to use that specific part/system, plus any conditions under which that part may be used, altered and monitored.

So far only the gearbox cartridge, brakes and wheel rims are openly being tendered, while the FIA, Liberty and the teams agree the details of the 2021 regulations. However,


Craig Scarborough

ABOVE The brake contract is due to be decided this month


Craig Scarborough

ABOVE The gearbox was one of the first items to be addressed

there is a shortlist of other parts which the FIA intends to include in future tenders. These are quite far-ranging and vary from common parts bought in from outside sources already, to some of a semi-specific nature and other components with lesser performance impact.

Bids for the gearbox supply have already been submitted, as the closing date was March 2019. Having a spec gearbox harks back to the garagiste era of the '70s and '80s, where most teams bought in their gearbox from Hewland. Back in 2010 there was an Xtrac spec gearbox available to the three new teams entering the sport under a proposed cost-controlled regime.

Again, the purist might argue that a spec gearbox conflicts with current F1, but in fact there are currently only four gearboxes in F1, with Ferrari, Mercedes and Red Bull each supplying their unit to their Power Unit customers, while Williams makes its own. The prevailing gearbox rules demand that the same eight ratio pairs and final drive are run by all teams. With the additional demand that gearboxes last six races, thus no more than four are required for a full season of 20-21 races, the scope for in-season development is limited. So, the switch to a spec unit is not a huge step from the status quo.

When talking of the 'gearbox', this isn't the entire gearbox/transaxle case as might be first thought. Current F1 rear ends are modular, with the 'gearbox' now considered to be the gear cluster, selection mechanism, ▶


LAT

BELOW The spec parts route is nothing new: back in the seventies, a common engine, gearbox and brakes platform enabled many privateers to have a tilt at the big guns

> *"The engineers were tearing their hair out when we went to a fixed eight ratios; now nobody talks about it"*

differential and oil system, which are all contained within a sealed casing. This unit is known as either a cartridge or, in FIA parlance, a cassette, which sits inside a rear casing that bolts the engine, crash structure and suspension together. The wider performance implications of a spec rear end casing, with associated suspension geometry and wheelbase impact, are therefore avoided. Teams will continue to make their own rear end casings, typically in carbon fibre, to fulfil the structural demands, while having the gearbox cartridge bolted inside.

Motorsport maintains a healthy range of gearbox suppliers around the globe, so the competition for the F1 tender should be strong, potentially going wider than the existing F1 contractors and suppliers.

"If you believe you are designing a gearbox better than the next guy, you don't want to lose that advantage," acknowledges F1 motorsport boss Ross Brawn. "Even if the margin is small and the cost is high, if there's an advantage, you want to preserve that... But if you look at many of the components in a Formula 1 car, they are either not known about by the fans, or they are low performance differentiators.

"I don't know how many fans know that we went to a fixed eight ratios. The engineers were tearing their hair out; now nobody talks about it. An IndyCar gearbox is about 100,000 dollars – a fraction of what is being spent now in F1."

PUTTING ON THE BRAKES

For all the disquiet at spec parts encroaching on previously competitive territory, momentum is growing. The latest contracts due to be ruled upon later this month are for the brakes and wheel rims.

The brake tender is split into two elements: one involves brake pads and friction discs; the other a brake hydraulics system that comprises the front and rear brake callipers, a master cylinder and brake by wire components. "The aim of single source supply is to retain current levels of braking performance at a much-reduced cost, while also removing the requirement for competitors to design or source their own brake hydraulics," says the FIA. "The components can be carried over between seasons, thus removing the need for costly continual performance development."

This is perhaps one of the less contentious issues for the teams and fans, given that Brembo already supplies 80% of the grid's brakes. AP Racing and Akebono also supply callipers, with Carbone Industrie supplying disc/pad material.

Any concerns regarding brakes from teams will be for either driver preference or consistency. Some drivers prefer a different brake material to the dominant Brembo supply; equally, others prefer different brake material for wet conditions. In both of these cases, the 'feel' of the material is the key ▶

Red Bull

ABOVE Carefully orchestrated, the reduction in the number of components teams have to manufacture for themselves is, some suggest, a no-brainer

Photos: Craig Scarborough

CLOCKWISE FROM ABOVE In the firing line: driveshafts, crash structures and pedals could all follow wheel rims into the common parts section of the regulations

factor, rather than a distinct performance difference. The task of supplying 20 cars for over 20 races with at least two sets of braking material is a substantial challenge. Given the lead time to produce carbon braking material and the looming start date, the availability and consistency of the finished products will be critical in order to ensure fairness across the grid.

The tender for spec wheel rims is perhaps a more surprising addition to the list. While there isn't at first glance a lot of performance in the wheel, they are a key area of visual differentiation between the teams. Most squads do not currently buy their wheels, instead taking a supply from technical partners, so having to buy wheels from a spec supplier will be an added cost for many.

Wheels for 2021 are expected to be larger in diameter, as there is a push for Pirelli to supply 18" tyres as part of the overhaul of F1. Assuming the brakes aren't going to be upscaled within the larger wheel, then the potential greater gap between the brake disc and wheel should reduce the heat transfer effect currently exploited by teams. At present they have the ability to control tyre temperature by varying heat conducted through the brake ducts and wheel into the tyre.

Plus, on the aero side for 2021, Ross Brawn's R&D team are considering wheel covers to reduce the wake created behind a car in order to make following a little easier. If that is the case, then the 'look' of the wheel hidden under a carbon fibre frisbee will be immaterial.

Again, there is a huge potential range of manufacturers able to bid for this deal, with potentially huge marketing opportunities to be seen as the wheel supplier to F1.

FUTURE TARGETS

If the first spec contracts are not that surprising, the inclusion of suspension components is more progressive, if quite targeted with which parts are being considered. So far, the key elements are the stub axles and wheel nuts, with other similar components such as the steering column and perhaps the wheel bearings being considered.

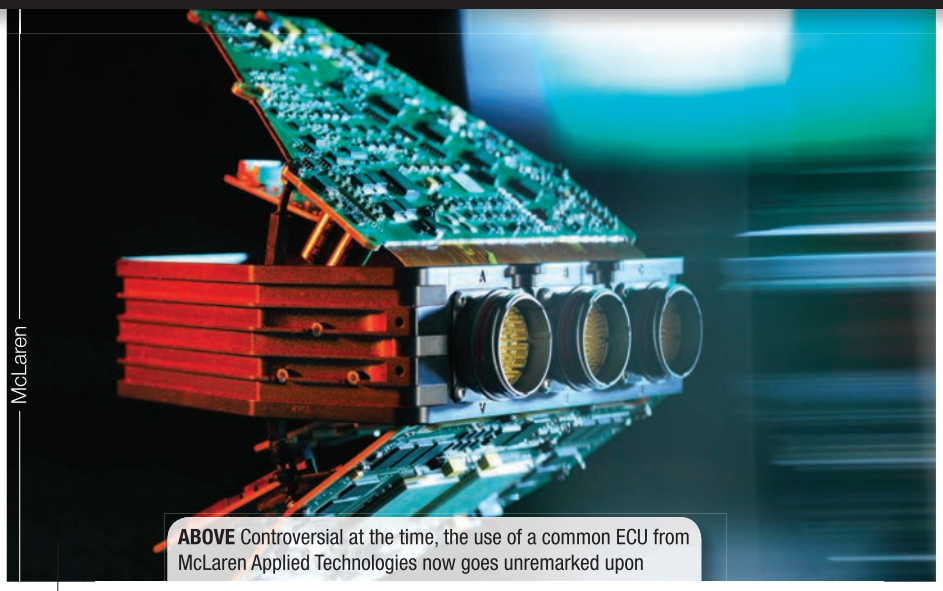
Having the rotating assembly spec removes the issue of inadvertently specifying suspension geometry through the introduction of a common upright. The stub axle design also ties in with the spec brake supply, with the brake disc bell being an interface between the two parts.

Meanwhile the rear hubs need to accommodate a potential spec driveshaft, as this makes sense to be a common part. Already most teams sub-contract the driveshaft manufacture to suppliers such as Pankl. This would form a spec drivetrain from gearbox, through to driveshaft, to the rear hub.

This invites the potential to bridge the two tenders, supplying the entire assembly from axle to brake. This could involve one supplier or perhaps a partnership of two current protagonists bidding for the work.

Also partially linked to the parts, the pedals might be another common item. F1 cars run just two pedals, for throttle and brake. They are not just unique to each team, but also often to each driver, to get the right 'feel'. As the braking effect must primarily come from the mechanics of the pedal, drivers want a bias that shifts during braking. This behaviour can be achieved through the design of both the bias bar and valves in the system. By having a spec brake pedal, this variation would be lost. It potentially compromises the car's performance if the driver is uncomfortable with the pedal feel.

Teams already run a specified design of side ▶


McLaren

ABOVE Controversial at the time, the use of a common ECU from McLaren Applied Technologies now goes unremarked upon

impact structure. The 2021 tender may go further to include the rear crash structure, with perhaps both parts coming from a specific supplier. Less sensitive aerodynamically than the front structure, the rear and side crash protection would reduce crash testing requirements for teams, making for a simple inclusion to the common parts list.

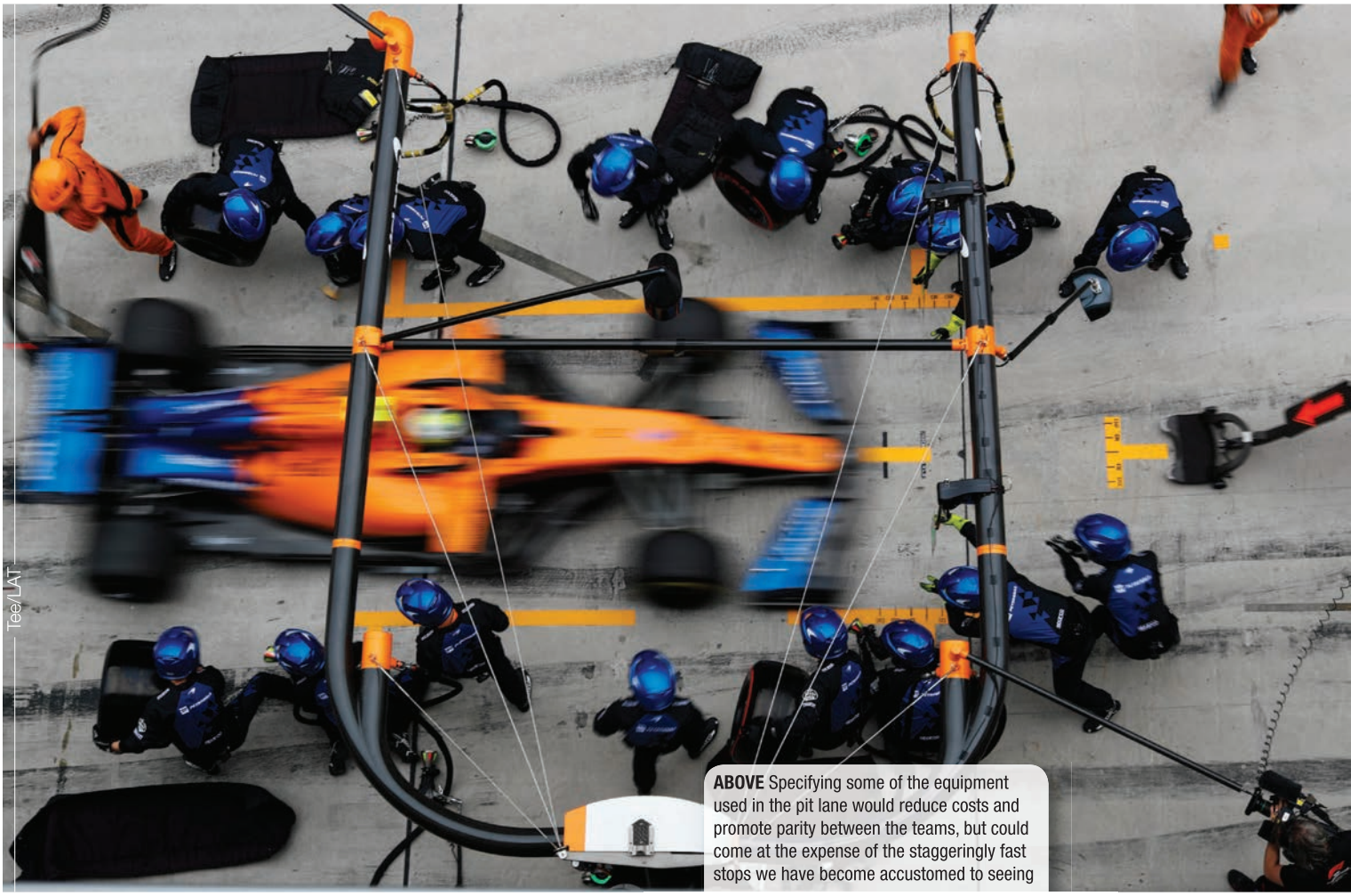
As much as the fuel tank itself is different for each car, in order to accommodate the diversity of monocoque shapes among the teams, there is a surprising level of commonality for the car's fuel system. The fuel tank must be from an FIA-approved supplier, this typically being ATL.

The fuel flow sensor and the high-pressure direct injection pump are homologated parts, provided by just a few suppliers. To extend this the FIA is suggesting that all the fuel tank internals, such as lift pumps, high-pressure pumps and collectors, are standardised too. The key performance from the fuel tank is in ensuring the fuel slosh and pick up are controlled, which is part of the team-designed fuel tank, not the suggested spec internals.

SUCCESS STORY

When it comes to the car's electronics, the spec ECU has been supplied by McLaren since 2008. Now in its third iteration, this must clearly be seen as a success story for FIA spec parts in F1. This isn't just the case with the ECU, for there is already a long list of spec parts and homologated sensors, so the electronics are not a major target for the new rules.

The steering wheel is another part that is being debated within the sport. A hugely complex assembly, the steering wheel already uses the same spec dash and interface unit. Going further would need to include the switches, loom, paddle mechanisms and carbon fibre shell. This would not obviously reduce costs or contain performance, so its inclusion is less likely than other parts – especially as it's


Tee/LAT

ABOVE Specifying some of the equipment used in the pit lane would reduce costs and promote parity between the teams, but could come at the expense of the staggeringly fast stops we have become accustomed to seeing

another area of driver personalisation and team differentiation.

The last potential area for spec parts sits not in the car, but on the pit lane, with the pit equipment: items such as the wheel guns, jacks and the pitlane gallows. Wheel guns may well be commonly bought from Paoli, but thereafter the guns are stripped and tuned to give the sub two-second pitstops we have become so used to seeing. Having a common wheel gun would reduce unnecessary extra costs and, into the bargain, ease the strain on the operator's shoulders from having to withstand the huge torque the tuned-wheel guns deliver.

MASSIVELY COMPLEX

Conversely, the quick lift jacks are wholly team-designed and massively complex. Rules demand that the jacks cannot lift the car via powered means, so the mechanic has to pull the handle to raise the car. From there the rules peter out, so the teams have pivot mechanisms to allow the front jack to swivel out of the path of the car, then both jacks have release mechanisms to drop the car. These latter systems are split between the top teams and the midfield. Better-funded teams have the release mechanism linked to the pit light system, so that when the car is cleared by the head mechanic to exit the pit stop, the release pin is pulled by a hydraulic/pneumatic system and not the mechanic.

In many respects the pros and cons of the arguments here typify the debate raging on the sport's future direction. Not without risk of a false release, these systems do speed up the pit stops. Having a spec jack front and rear might detract from the spectacle of the incredibly fast pit stops for which the sport is renowned, but will equalise the field, leaving pit stops to the human skills of the pit crew rather than their hardware.

ABOVE Dying breed: Williams has remained steadfastly true to the concept of each entrant being a constructor in their own right

ABOVE The dash display is already standardised. Could the complex steering wheels themselves follow suit? Daimler AG

"We are assessing new ways of doing things and 70-80 per cent of the teams want the things we want, and are encouraging us to do them," says Brawn, "but there is a small percentage of teams who want to preserve the status quo.

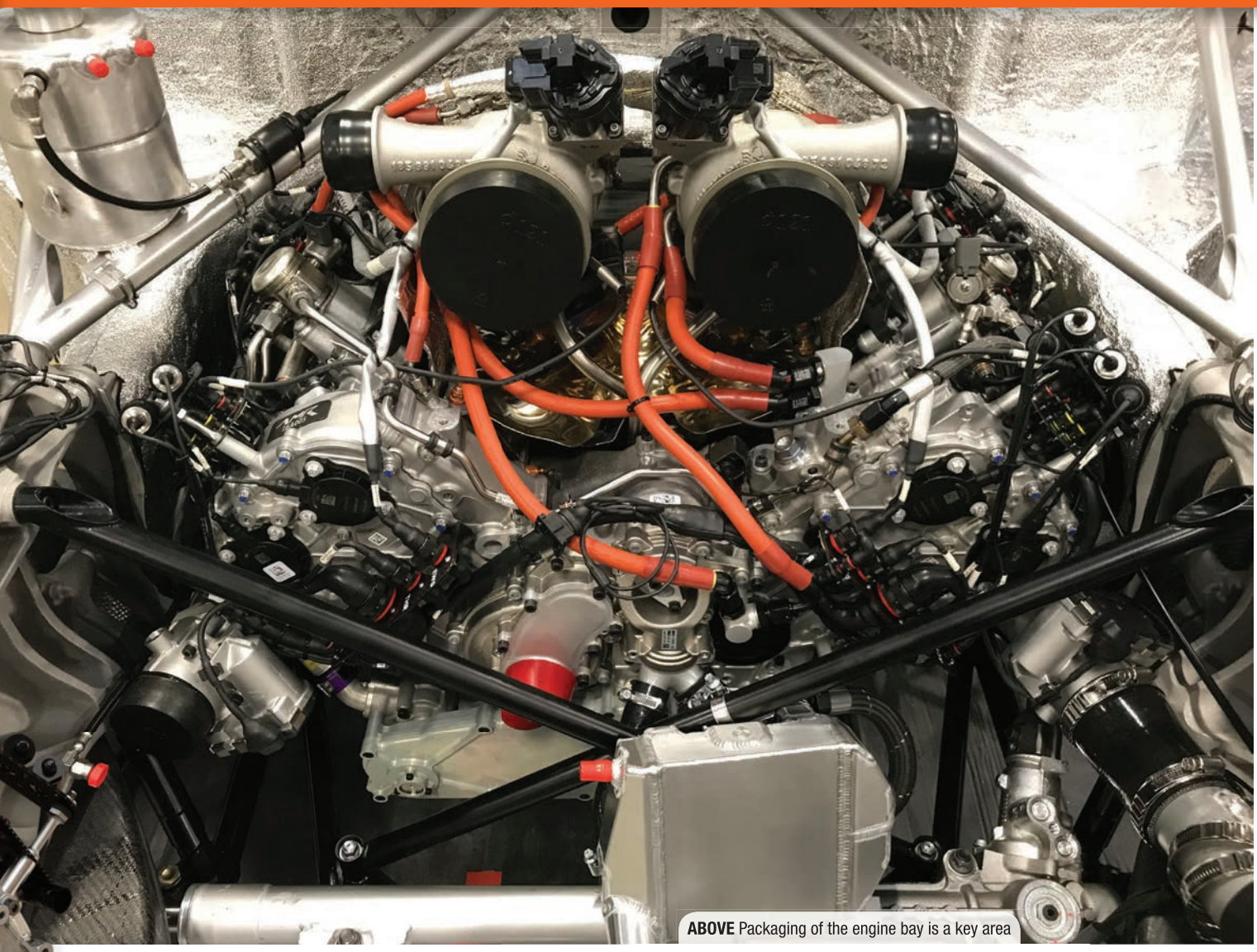
"I've seen both sides of things. When you get to a team like Ferrari, the money you are prepared to spend to gain an extra tenth is a lot higher than if you are a team like Williams. But we want the sport to be exciting. It must never become just an engineering exercise." RT

ASTON TO REKINDLE ANNIVERSARY MAGIC?

Sixty years on from its milestone win, Aston Martin returns to Le Mans with very different technology but the same ambition: glory. **Chris Pickering** reports

THIS year marks the 60th anniversary of Aston Martin's first Le Mans win. Back in 1959, the company won the event outright with an emphatic one-two finish that saw the two works DBR1s cross the line some 20 laps ahead of the

ABOVE AMR's new 4-litre twin-turbocharged V8 marks an exciting departure for the engineers from the venerable naturally aspirated V8



ABOVE Packaging of the engine bay is a key area

following pack. It would take a monumental upset in the prototype categories for that to happen these days, but victory in the GTE classes is a distinct possibility, with the new Vantage GTE fresh from winning its class at the Spa Six Hours.

Almost nothing was carried over from the old Vantage GTE when the current car was introduced at the beginning of the 2018/2019 World Endurance Championship (WEC) season. Most notably, the venerable 4.5-litre naturally aspirated 'R12' V8 is gone, replaced by a 4-litre twin turbocharged V8 based on the AMG-derived engine found in the Vantage road car. This marks a significant departure for the engineers at Aston Martin Racing, who had been working with the old 'R12' V8 for the best part of decade, in between a number of other road and race projects.

"Picking up the new Vantage engine was quite an exciting prospect," comments

> *"What's striking about this top-level works GTE engine is just how much of it still comes from the production car"*

Aston Martin Racing's chief engine engineer, Arthur Shaw. "It represented a different approach to the same problem – a 500 cc lower capacity, turbocharged engine. Working with our colleagues on the road car side at Aston Martin is always great and it was really good to build some links with AMG too."

The German company kindly supplied, through AML, some technical data and CAD models for the base engine from the road car. This included details such as target cylinder pressures, fluid flow rates and design loadings for the castings used for the road car engine design, which helped Aston Martin Racing to evaluate how much of the production engine could be retained for the GTE unit.

At the beginning of the project, the design requirements were split into three different categories: durability, performance targets and regulatory constraints. Some of the earliest work revolved around simulation to predict temperatures and pressures inside the cylinder, which were then compared to the design targets for the original production engine. From that, a picture started to emerge of which parts would require redesign.

"We did a lot of 1D simulation work early on to estimate the cylinder pressures in the race engine," comments Shaw. "We had plenty of data on the road car engine from AMG and we also did some FEA work in-house to satisfy ourselves that the castings would be robust at those levels."

Similarly, the exhaust temperatures could potentially be a factor on a turbocharged ▶

race engine, but Shaw and his colleagues had already taken the decision to redesign the exhaust manifold and the turbocharger system in search of performance gains. This work was carried out in-house and in partnership with the team's turbocharger partner Borg Warner.

"The exhaust gas temperatures in the manifold might be 150 to 200 deg C more than they would be in a naturally aspirated engine and the back pressure is 400 to 500 millibars higher, but we simply took those conditions into account when we designed the new system," he comments. "I wouldn't say that makes a turbocharged engine any harder to develop at this level, it's just different."

The new Vantage GTE may be a clean sheet design, but the fundamental layout was sufficiently close to that of its predecessor to give the Aston Martin Racing engineers a good idea of the performance window that they'd need to target. Understandably, Shaw isn't able to give us a specific figure, but he confirms that most GTE cars are "around the 500 bhp mark", which means it's not greatly different to the road car's 503 bhp. It's the duty cycle that differs, however, with the cars on full throttle for the majority of the lap: "At Le Mans, it's a 70 per cent full-load duty cycle, so the requirements are quite different to those of a road car engine. However, the fact that we're relatively close to the power output of the road car is extremely useful, because it means that we're dealing with castings and components that are designed to take similar loads."

In terms of regulations, the main constraint for turbocharged GTE engines is boost

ABOVE The squad enters Le Mans buoyed by the new Vantage GTE's Spa success, its second win of the FIA WEC Super Season

pressure. The FIA and the ACO publish a table that gives the maximum boost pressure for a given capacity. From that, Shaw and his team were able to establish the air flow rate required for the competition engine. Again, it was a question of referencing these targets against the capabilities of the production engine – particularly where the porting and the turbocharger setup were concerned.

"What was clear to us from the start was that the boost limits given in the regulations were quite low for the power levels that we were targeting. That meant the volumetric efficiency of the engine would have to be quite high," comments Shaw. "We spent a lot of time characterising the base engine and it quickly became apparent that we would have needed 1.8 or 1.9 bar of boost to get the performance level we needed from the standard porting, which was way outside the sort of boost levels that the FIA were quoting at the time."

Much of the early work focused on getting the breathing right at the high flow rates and comparatively low boost demanded by the regulations. This involved optimising the port geometry and the cam profiles, with MTS manufacturing bespoke camshafts to Aston Martin Racing's design, while larger intake and exhaust valves were supplied by Del West.

Ordinarily, one of the benefits of working with a turbocharged engine is that the volumetric efficiency is less critical than it would be in a naturally aspirated engine (without a turbocharger to push air in through the ports). That means you can sacrifice a certain amount of volumetric efficiency to optimise the charge motion, explains Shaw: "We did increase the port area to improve the mean gas flow, but we needed to balance that against tumble characteristics. The road car is set up to run an extremely high amount of tumble; we do run quite a lot of tumble on the competition engine too, but it's reduced slightly to favour air flow.

"We redesigned the inlet port to give us more suitable geometry for this application. The exhaust was rather more complicated, because the spark plug is mounted in between the two exhaust valves, with a centrally-mounted injector, which limits the space available to expand the valves. As a result, we spent a lot of time optimising the space around the spark plug."

Data from previous projects gave the team quantifiable targets for the combustion characteristics they would need and validating these was the first priority once they had an engine running on the dyno. Performance indicators are typically the crank angle for 50 per cent and 90 per cent mass fraction burned and the coefficient of variance for the indicated mean effective pressure (IMEP).

The cylinder pressures are somewhat higher than they would be in the equivalent naturally aspirated engine, but the differences aren't night-and-day, we're told. This engine concedes just 500 cc to the old naturally aspirated unit and gains two turbochargers in the process, so it's a very different prospect to something like a World Rallycross engine, which squeezes more than 600 bhp from half the capacity. Here, the boost pressure is around 1.4 bar – comparable to a road-going hot hatch. As a result, the increase in cylinder pressure is relatively modest at around 15 bar compared to the old GTE engine.

EXHAUST LAYOUT

One of the more fundamental changes, relative to the road car engine, is the exhaust layout. The production unit uses a sophisticated approach to balance out the exhaust pressure pulses as they reach the turbocharger, which involves separating out the two exhaust manifolds on the left- and right-hand cylinder banks. The individual cylinders then run different cam profiles to optimise the pressure wave reaching the turbocharger. This works very well in the road car, but it reduces the volumetric efficiency of some of the cylinders, so the Aston Martin Racing engineers made an early decision to re-order the exhaust system.

> *"Impressively, there's now said to be less than a litre of oil in the engine when it's running on the track"*

On the GTE car, the exhaust is a bespoke in-house design manufactured by Akrapovič, which features a crossover layout, linking the two banks to provide a regular, evenly spaced pattern of exhaust pulses. This sounds simple in theory, but it's deceptively complex to engineer with different thermal expansion characteristics between the aluminium cylinder block and heads running at 80 deg C and the cast iron and stainless steel exhaust sections running at 1,100 deg C. This may well explain why this outwardly simple solution is not employed on the road car.

Sizing the turbochargers was also extremely ▶

important in order to get the engine into the boost window defined by the FIA. "We need high air flow at relatively low boost, so we developed a new compressor map to suit that application," notes Shaw.

In fact, the whole area of the exhaust design and the hot vee turbocharger layout was a major focus of the project, he explains: "Boost pressure is the key tool used to restrict turbocharged engines in the GTE class, so it's paramount to have accurate wastegate control. You want to keep as close to the limit as possible without exceeding it."

What's striking about this top-level works GTE engine is just how much of it still comes from the production car. At the beginning of the project, for instance, it was decided that the race engine would keep not just the road car unit's 3,982 cc capacity, but also its somewhat undersquare bore-to-stroke ratio (83 x 92 mm). In the end, even the crankshaft and connecting rods were carried straight over from the production engine.

"One of the main reasons that we were keen to retain this part of the design is that the block uses an aluminium liner with a coating applied," explains Shaw. "The block is designed for 140 bar cylinder pressure as standard, which we calculated would be sufficient for the race engine. Removing any material from the liner would effectively reduce the wall thickness of the casting, which would decrease its cylinder pressure capacity. It would also remove the coating on the base material, which would either mean re-coating it or introducing a sleeve. We do have budgetary constraints in the WEC, so we try to spend money where it will have the biggest impact and avoid re-engineering things unnecessarily."

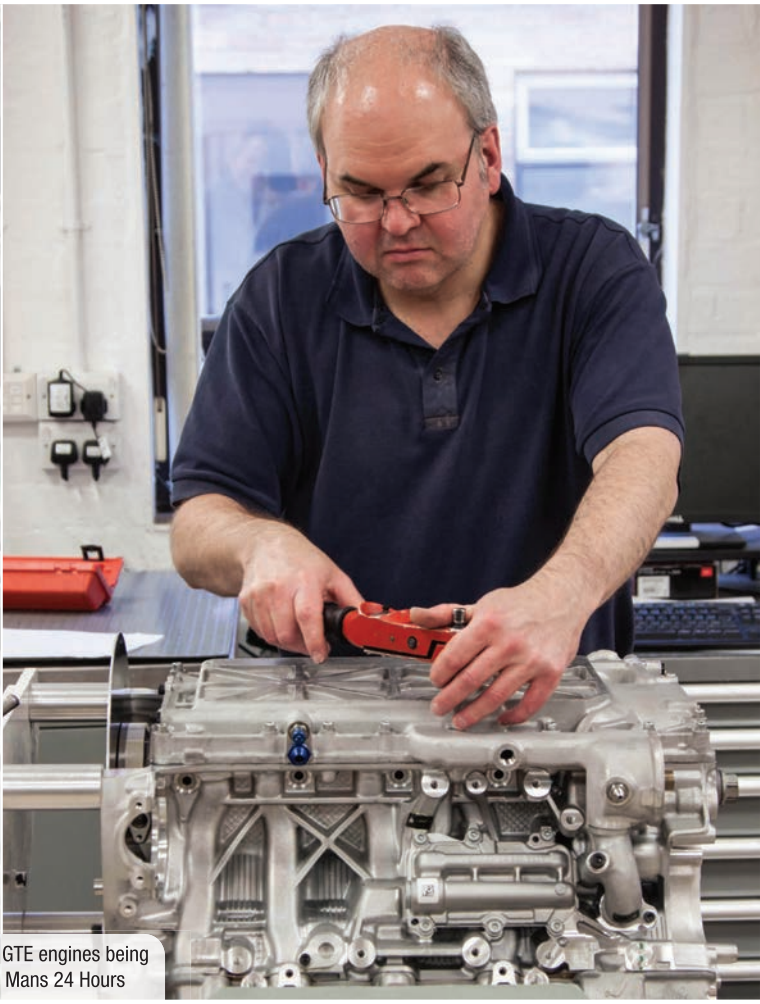
STANDARD BLOCK

Unlike the heavily ported cylinder heads, the block is a completely standard part taken straight from a production engine. Perhaps surprisingly, another element that's carried over from the road car engine is the hydraulic lifter design. Historically, Aston Martin's competition engines have always used solid lifters, but the standard lifters were found to perform very well in terms of valve control and they also provide auto lash adjustment which helps to increase engine life.

"By limiting our peak engine speed and careful cam design we were able to retain the hydraulic system," says Shaw. "Being a boosted engine, and with the other modifications, we were able to get our required performance at a lower engine speed than with the previous N/A V8."

The pistons, on the other hand, are a bespoke design, manufactured by Capricorn. This decision was taken partly for the sake of durability, we're told, but also because it gives the engineers a straightforward means of changing the compression ratio. GTE cars run on a spec 102 octane race fuel supplied by Total, so the compression ratio is relatively high for a turbocharged integration.

The dry sump oil system is all new for the Vantage GTE. Impressively, there's now said to be less than a litre of oil in the engine when it's running on the track. The scavenge system also helps to reduce the pressure inside the crankcase, which minimises windage losses and improves ▶



LEFT & RIGHT The GTE engines being prepared for the Le Mans 24 Hours

TAKE THE LEAD WITH NEXT GENERATION CONNECTIVITY

Few environments are more punishing than the modern racetrack. Extreme heat, vibration, grit, oil, grime, solvents, corrosion, and mechanical stress wreak havoc on traditional connectors. Winning components must not only survive, but outperform in the most extreme conditions. And when victory depends on a difference measured in milliseconds, compromising on connector quality is simply not an option. Learn how DEUTSCH and TE Connectivity are leading the pack in designing the next generation of connectivity solutions. Learn more at **te.com/autosport**

EVERY CONNECTION COUNTS

TE connectivity

CARTEK MOTORSPORT ELECTRONICS

GO TO OUR WEBSITE TO VIEW OUR FULL RANGE OF MOTORSPORT ELECTRONICS

www.CARTEKMOTORSPORT.com

POWER DISTRIBUTION PANELS

A switch panel and Power Distribution Module in one. Our Power Distribution Panels are a fully integrated solution designed to replace all the fuses,switches and relays of your race car.

- CONFIGURE CHANNELS IN 5A STEPS UP TO 30A.
- CHANNELS CAN BE PROGRAMMED TO CONTROL HEADLIGHTS/WIPERS/RAD FANS/STARTER MOTORS etc.
- EACH OUTPUT IS PROTECTED FROM SHORT CIRCUITS AND OVER-CURRENT.
- ADDITIONAL INPUTS ALLOW CHANNELS TO BE CONTROLLED BY ECU OR SWITCHES ON STEERING WHEEL.
- COMES WITH LABEL SHEETS FOR FULL CUSTOMISATION - RETRO EDITION NOW AVAILABLE.
- NO COMPLEX CONFIGURATION SOFTWARE - AMP SETTINGS AND LOGIC FUNCTIONS ARE SELECTED THROUGH THE FRONT PANEL.

8 and 16 channel versions available

SOLID STATE BATTERY ISOLATORS

Cartek Battery Isolators are designed to overcome all of the problems and restrictions associated with mechanical and electro/mechanical battery disconnects.

- FULLY ELECTRONIC WITH NO MOVING PARTS - COMPLETELY RESISTANT TO SHOCK AND VIBRATION.
- MUCH SMALLER AND LIGHTER THAN TRADITIONAL KILL SWITCH.
- MEETS NATIONAL AND FIA REGULATIONS.
- STATUS LED FOR FAULT DIAGNOSIS.
- SEALED INTERNAL AND EXTERNAL SWITCHES REPLACE TRADITIONAL PULL CABLES THAT ARE PRONE TO SEIZING.
- MOUNTS CLOSE TO THE BATTERY FOR REDUCED CABLING.
- QUICK AND EASY TO INSTALL.

BATTERY ISOLATOR XR
Designed for motorsport ECU's/PDM's

BATTERY ISOLATOR GT
Designed for OEM ECU's/Ignition systems

ABOVE Setting up a turbocharged engine provided a very different challenge for the team

efficiency. There's also a new sprocket and chain system to drive the oil pump off the front of the crankshaft. Similarly, the road car's dual mass crank damper was found to be unnecessary, through analysis and physical torsional vibration testing, in the competition engine's operational rev range, so that was deleted. Likewise, the flywheel has been significantly lightened, which reduces inertia – benefitting not just performance and driveability, but also less obvious things like gearshift control.

Careful design of the dry sump system has allowed the engine to be placed some 100 mm lower in the chassis compared to the road car. Generally speaking, the integration has been fairly straightforward, Shaw explains, because the current generation Vantage was designed for turbocharging from the outset. A single heat exchanger is used to cool both the water and the oil, while two large air-to-air charge coolers sit at the front of the car.

"The packaging of the engine bay was an area of much attention when we were designing the car," he says. "The layout of the cooling pack was integral to the CFD simulations that were carried out for the aerodynamics. We sit right next to the chassis guys, so there was a lot of dialogue involved – we did a lot of analysis at the start to give them heat rejection targets to hit in terms of airflow through the coolers."

Thermal management was to play a large role in the development. Being a hot vee engine, there's a lot of heat concentrated in one area and the engine bay is effectively sealed in order to improve the aerodynamic performance of the car. Heat rejection from the hot components in the exhaust and the turbocharger system was very carefully analysed and managed. It appears to have paid off too, with no heat-related issues experienced thus far, while other teams running hot vee configurations are known to have suffered.

LESSON LEARNT

The development process has benefitted from new techniques, such as improved simulation methods, Shaw points out: "We always try to front-load every project with simulation so everything works as intended once the engine hits the dyno. Every project gets a little bit better from that perspective and we devote a bit more time and budget to the computational analysis. This is probably the project where we've used that most extensively to date. Compared to when we first did the R12 V8 a decade ago, we probably now spend three times the resources on front-end analysis."

The engine was also subject to extensive testing, clocking up some 20,000 km of running before the new car made its race debut at the 2018 Spa Six Hours event. It has proved reliable straight out of the box, but there have still been lessons learnt during the course of the project, says Shaw: "The control systems get more complicated for every project we do. You have to spend more and more time on the calibration and the boost control. I'd say the biggest learning curve with this engine has been finding methodologies to refine the driveability characteristics. We come across a wide range of ambient temperatures and pressures in the WEC, which adds to that complexity, particularly on a modern turbocharged engine with a lot of closed loop control systems."

Sophisticated hardware helps to empower the calibration engineers, with Cosworth Electronics supplying the electronic control unit, while the fuel system comes from Bosch.

For Le Mans this year, the expectation is

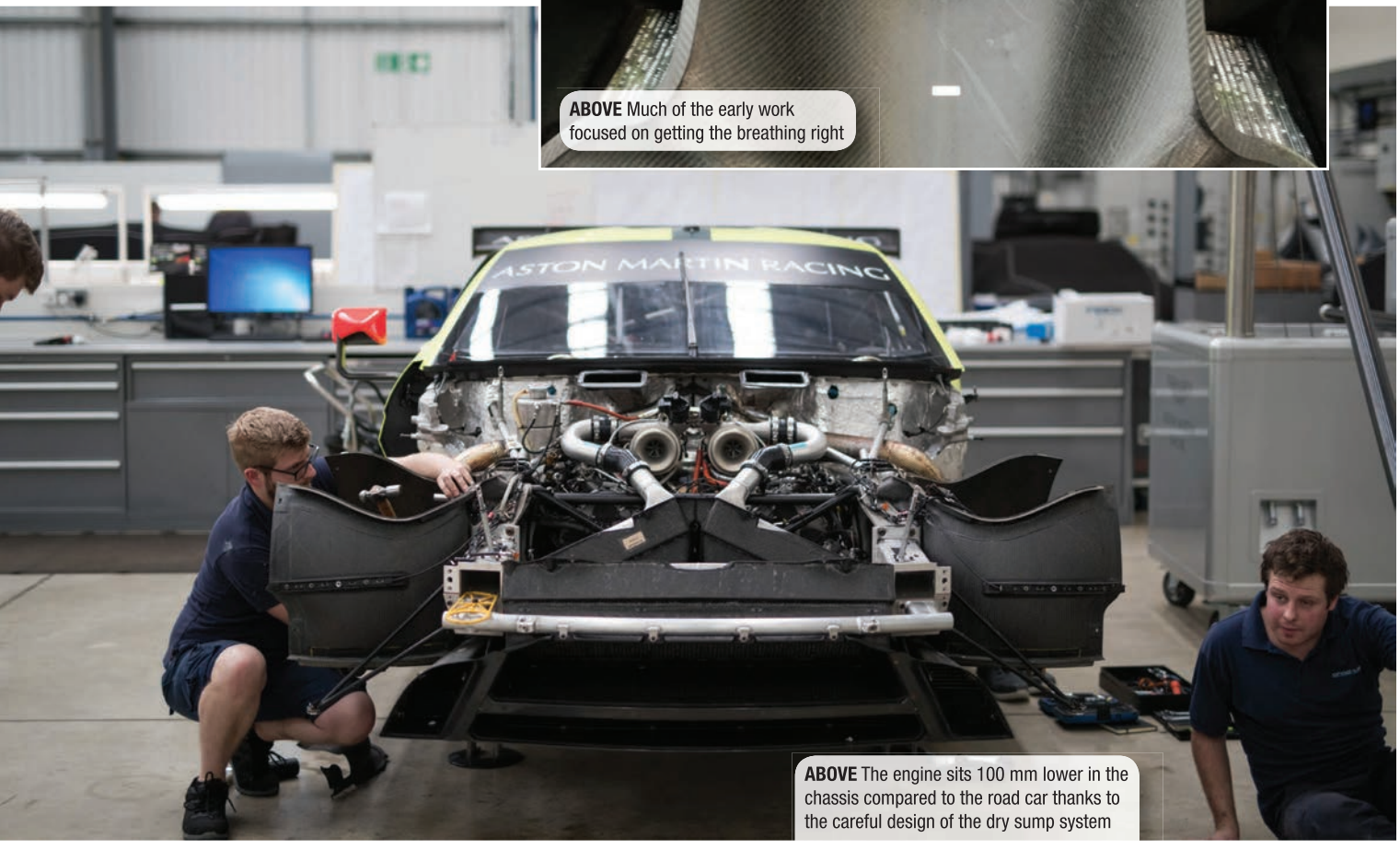
that the engine will be running the same boost limit and overall power as it did in 2018. A lot of incremental development has taken place on the car since then, however, which saw it gradually become more competitive over the course of 2018.

One change for this year, which applies to all cars in GTE, is the addition of fuel flow sensors. These are similar in operation to those found in LMP1, but they are currently only used for monitoring balance of performance parameters such as fuel tank size. As such, they've not had any real impact on the operation of the cars and there's no immediate sign of fuel flow restrictions being introduced.

"There has been talk in the past of introducing fuel flow limitation to the GTE class or monitoring performance via driveshaft torque. I can't see either of those things coming in for another few years, but they're not out of the question," comments Shaw.

For now, the main focus is on the final round of the 2018/2019 super season. That brings us back to Le Mans, where Aston Martin Racing is hoping to clinch its fifth class victory since 2007. There would surely be no better way to wrap up the new car's debut season. RT

ABOVE Much of the early work focused on getting the breathing right

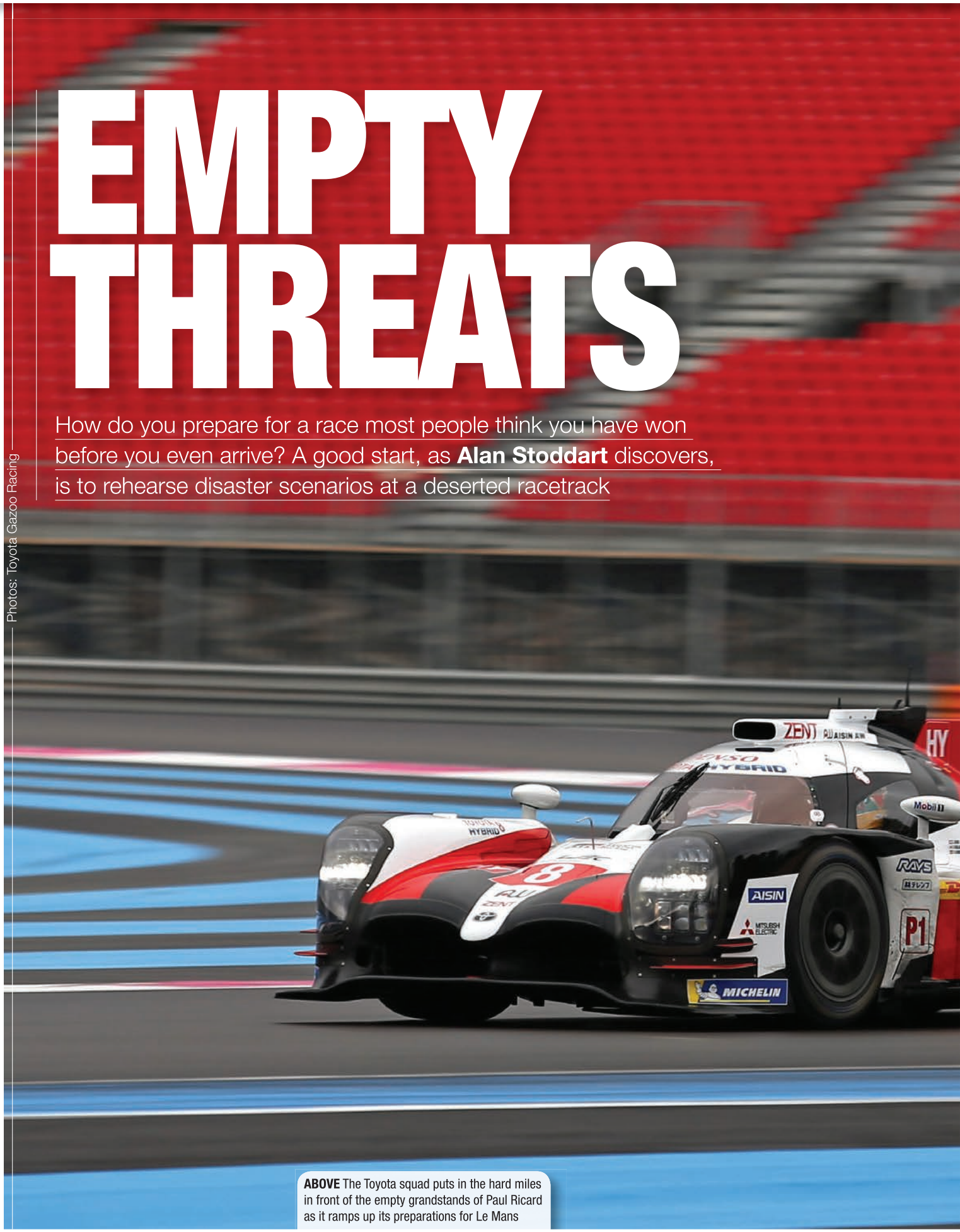


ABOVE The engine sits 100 mm lower in the chassis compared to the road car thanks to the careful design of the dry sump system

EMPTY THREATS

How do you prepare for a race most people think you have won before you even arrive? A good start, as **Alan Stoddart** discovers, is to rehearse disaster scenarios at a deserted racetrack

Photos: Toyota Gazoo Racing



ABOVE The Toyota squad puts in the hard miles in front of the empty grandstands of Paul Ricard as it ramps up its preparations for Le Mans

THIS year's 24 Hours of Le Mans, like last year's, will only see one team backed by the might of a major manufacturer in the race's top LMP1 class. However, this isn't cause enough for the reigning champions, Toyota Gazoo Racing, to rest on their laurels. Everyone in the squad knows all too painfully how quickly an advantage can be overturned, so the team is working as hard as ever to ensure that it once again gets the job done.

This is no better emphasised than by a mantra within the Toyota fraternity: "One Le Mans starts when the other Le Mans stops," says Toyota Motorsport GmbH chief project leader, John Litjens. "What this means is that as soon as the cars come back after the race, we look at them and see if there is anything that needs to be changed and review all the operations from the Le Mans race that has just happened."

This inspection yielded positive results, says Litjens, despite last season's winning car having run 3,286 miles, around 85 per cent of which were at full throttle. The victorious TS050 was, he notes, "in really good shape".

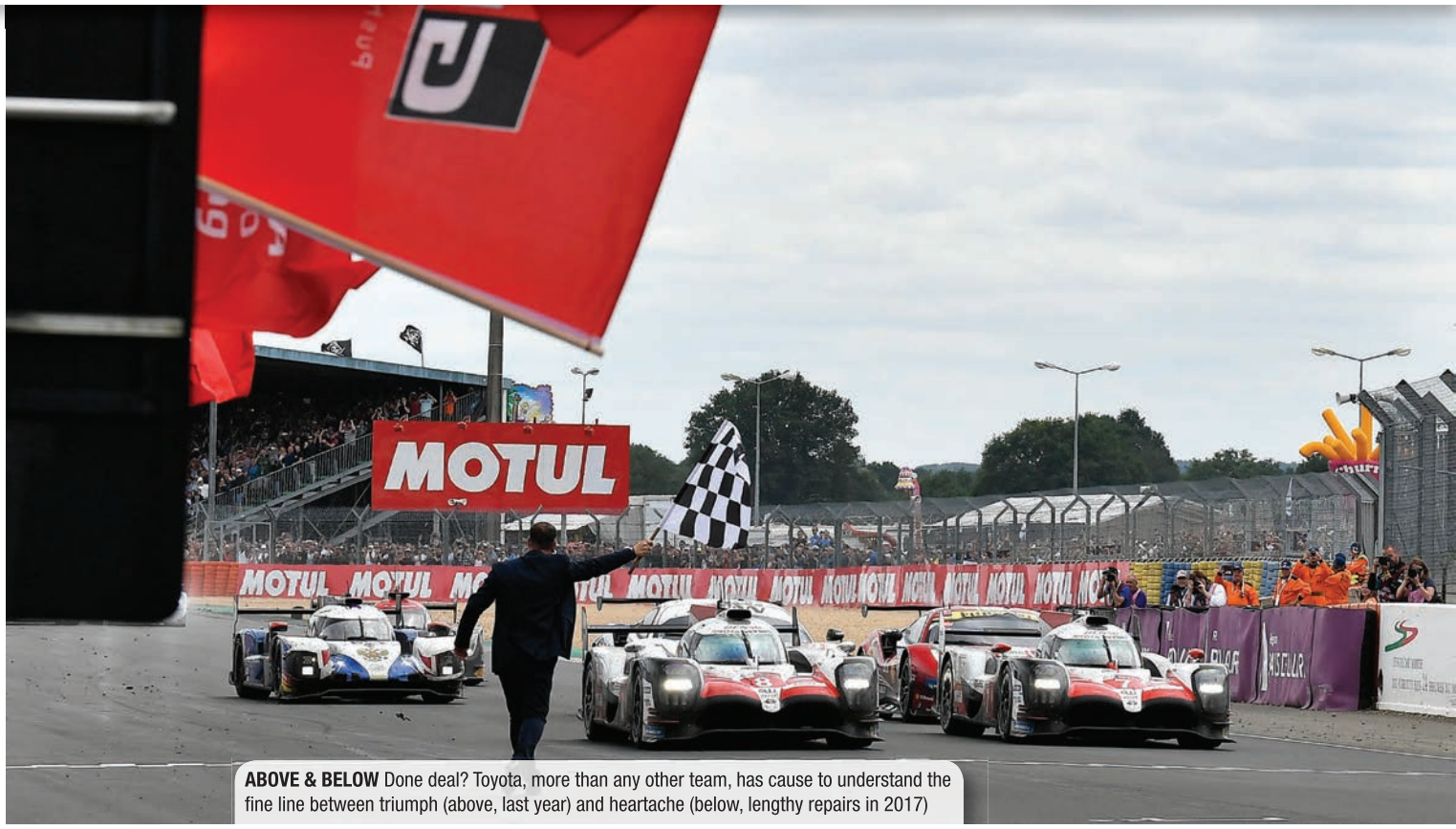
"We always joke that we should have just cleaned it up and used it again this year," he reveals. "We didn't do that but there were really no issues, no leakage, no seepage, everything was dry. So from a technical side there was nothing wrong. As such we decided to run the same car in 2019 as 2018.

"We were also limited by season homologation rules as well, so there was little scope for the development. Everything was homologated for the first race in Spa in 2018, and so we must run the same car as we did then."

Even work with technical partners was limited. Litjens points out that Toyota monitored technical developments that partners were making, and assessed ▶

> *"The outfit simulates many problems that are relatively minor, but could have significant impact on the team's race"*

LEFT 'Fake news' was the buzz term 12 months ago, in sportscar racing as well as in politics



ABOVE & BELOW Done deal? Toyota, more than any other team, has cause to understand the fine line between triumph (above, last year) and heartache (below, lengthy repairs in 2017)

their developmental directions, but anything that is brought to the team must be validated. This is a particularly crucial step given that Toyota already knows it has a car in its garage capable of winning races. With brake materials for example, Toyota's supplier didn't stop innovating and was ready to provide the team with new parts, but even after trying them, Toyota still chose to use those from 2018 given that it had no issues at all.

RISK VS REWARD

"In the end the question is: are technical changes a risk or an opportunity?" says Litjens. "I think if you were dealing with a reliability issue, then for sure, making a change would be an opportunity to work on hitting our targets, but if we have something that is already proven and reliable, then it would be a risk to change it.

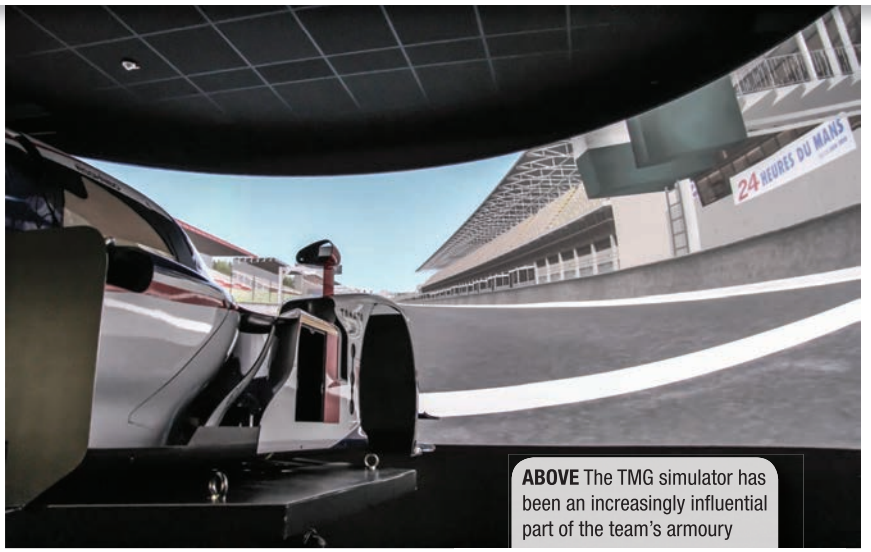
"That's why we normally only start changing things for the six-hour races, and then validate it then, do some extensive track testing and then take it to Le Mans. As we had no issues at last year's race however, we didn't change anything for this year's car."

However, Litjens does point out that there were changes on the operations front, rather than the technical side of Toyota's effort.

This continues from the work the team was doing to prepare for last year's running of the 24 Hours of Le Mans. "It was the best opportunity to continue with the practice scenarios we completed. We were testing both the drivers, to keep them up to speed, as well as the race engineers," Litjens reveals.

He explains that much of this year's work is a continuation of last year's preparation, which saw the outfit simulate many different problems and situations that often were relatively minor, but could have significant impact on the team's race; just the kind of problems that affected Toyota in the years it had victory snatched away in the last minutes. After all, in 2014 it was only an issue with a sensor, which would have taken minutes to fix, that stranded Kazuki Nakajima; 2016's gut-wrenching problem, just minutes from victory, was attributed to a fractured air-line between a turbocharger and an intercooler.

To prepare for these sorts of unusual problems, test scenarios ranged from the truly outlandish, such as running the car with a tyre missing from one of the wheels – to enable the team to work out just how quickly the car could be brought back to the pits in the event of a puncture – to the more prosaic issues. The latter included practising changing components that don't frequently require replacement, and how the drivers react in surprise situations such as losing radio contact. By simulating these problems in practice, not only were the drivers and engineers able to experience issues in as close to race conditions as possible, but the team was also able to ▶



ABOVE The TMG simulator has been an increasingly influential part of the team's armoury

ascertain how much time could be lost in such scenarios and improve its strategy-based decision-making accordingly.

Litjens says that all this work means that the drivers and crew are ready for almost anything, which has proved its worth during real races. "One example was at Sebring, when car 7 had a small accident with a GT car, and as a result the turbo pipe failed," he says. "The car came back and we were able to change the pipe and get it out again quickly. Okay, so we lost two laps, but that was it, and the work needed to be done, but it was done without panic and done calmly. If you compare that to 2016, there is definitely a better reaction to problems now."

COMPLETE CONTROL

However, Litjens also cautions that you can never be 100 per cent confident that you have practised every conceivable scenario on track. Regardless of how thoroughly prepared the team is, there can still be an issue that has slipped through the cracks. Preparing for 2019 then has also involved making these cracks as small as possible, and to do this has led to the outfit placing enormous weight on its quality control procedures.

"Because we have a carryover car, and we have now built basically the same car, and have produced what is essentially a new batch of parts, we have to make sure there are no mistakes with materials or assembly," he points out. "If something is different to how it was before, then being able to race for thousands and thousands of kilometres without any problems can quickly change."

To head off any potential problems with any bad batches, TMG pays close attention to the detail. It makes sure that parts come from a batch that has already been evaluated in pre-race testing to ensure there are no issues.

"We have had some very good years where the cars were really quick, but in the end there were details that stopped us from winning," Litjens says. "So we know we can do it but we also know that we have to keep paying attention to the small things, and we have to keep practising with the parts because we know anything can happen at Le Mans."

Preparation for the race has also taken place away from the racetrack. Although work in ▶

ABOVE The team's ability to deal better with issues, due to its rehearsal of disaster scenarios, was illustrated when a turbo pipe failed at Sebring

ABOVE Hope for the best, plan for the worst: there's no glamour involved in testing, just meticulous attention to detail

the wind tunnel was last conducted in 2018, just before that year's Le Mans package was made, simulation work has been ongoing. It remains part of TMG's internal preparation for each round of the WEC, helping it to fine-tune certain setups ahead of the races themselves. This is helped by the constant improvements in the team's simulation tools.

PROPER PREPARATION

"They are constantly developing, and through each one of the events we learn more and more about how to use the hybrid energy more efficiently, for example," explains Litjens. "So at the same track in the same car we will have done our simulations, and based off of that work and the outcomes of the free practice on Thursday to corroborate the information, then we can use it for the race."

Despite the obvious importance of the simulator work being undertaken by Toyota however, there are no special priorities attached to it. Instead, adds Litjens, it is about trying to fine-tune settings for the hybrid and fuel arrangements, as well as making sure that some setup work is completed. As the team also pursues further and further gains on the car, it uses the simulation work to ensure compliance with legality limits, making sure that plank wear, for example, can be properly controlled in a given setup.

As *Race Tech* goes to press, the team is assembling the cars ready for the prestigious endurance race. They will then be taken to Spa, where they will undergo a shakedown to ensure that all the parts have been correctly assembled and all the components are installed correctly. All of this, alongside the months and years of preparation, will hopefully ensure the team enjoys a problem-free 24-hour race.

> *"3,286 miles, around 85 per cent of which were at full throttle"*

Litjens says that that the thoroughness of preparations has led to a cautiously optimistic mindset in the Toyota camp: "We are looking forward to Le Mans because we have won it once, and we know as well as you that we have to win it three times to be able to keep the trophy in Cologne. That is still the target now.

"We are also excited about the Drivers' Championship," he continues. "We won the Manufacturers' title, but the Drivers' title is still undecided. It is definitely going to be a Toyota driver, but the chance is there for both crews, so both teams are really motivated, perhaps even more so for them because they can become the Drivers' champion!

"So on the one hand we are all part of one team, but on the other the racing between teams is still there and we still look to be as competitive against each other as we were last year."

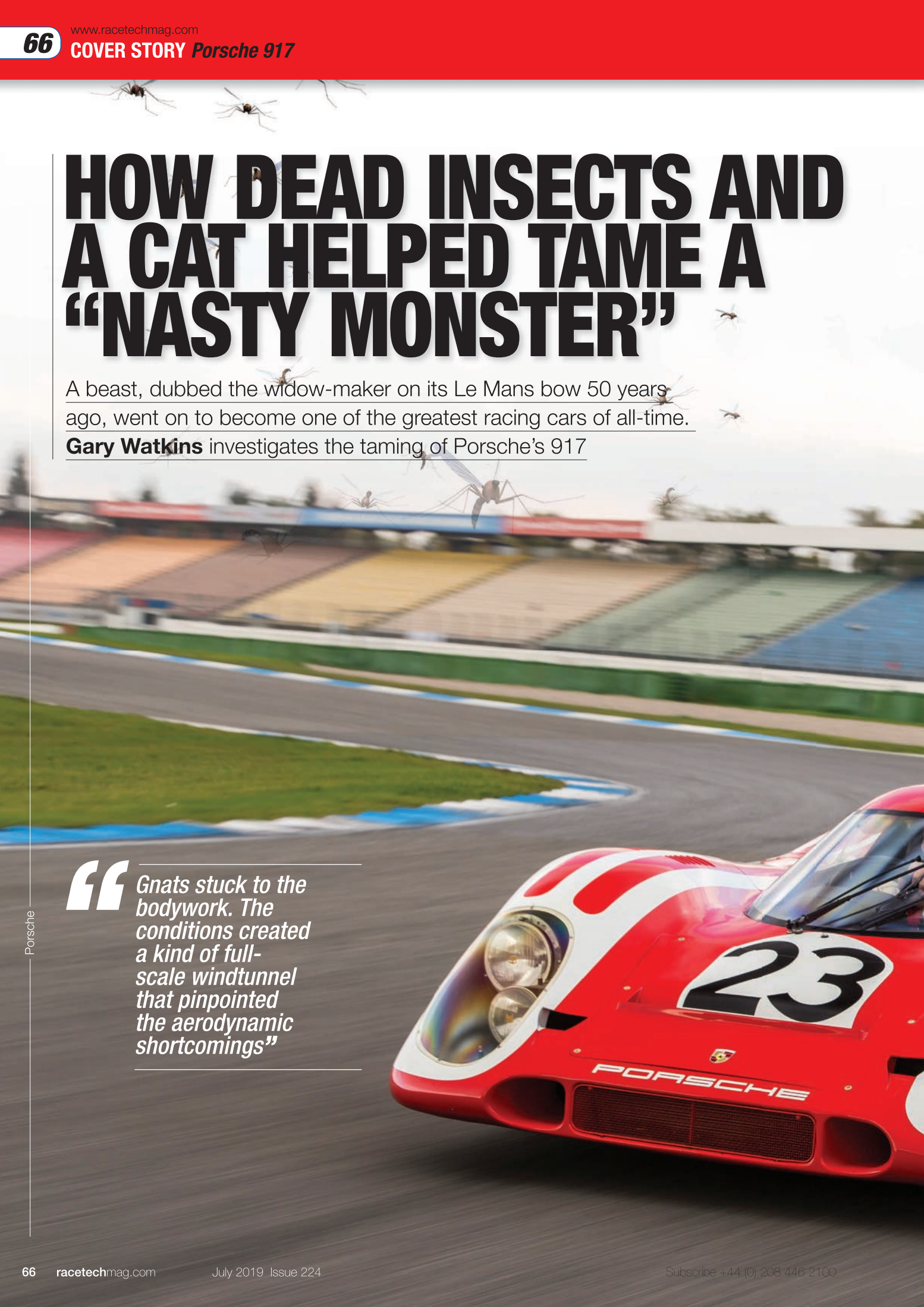
However, the memory of the gremlins of the past hasn't been entirely erased. It has influenced the endless nightmare scenarios the team tirelessly rehearses, the meticulous focus on the provenance and worthiness of all the materials used in the construction of the TS050s, and the obsessive analysis of simulation data. Beyond that, the close calls from 2014, 2017 and particularly 2016 have stoked a mentality verging on that of an underdog.

"As it was said last year," says Litjens, "Toyota can only lose if it doesn't win because of issues, but when we win, they say we are dominant. But look at last year, I think we showed that we don't back off: we were still looking at the statistics of the lap time, but the battle might be amongst the cars rather than with another manufacturer.

"Nevertheless, we will be racing. It's going to be a nice fight between the two cars." RT

HOW DEAD INSECTS AND A CAT HELPED TAME A "NASTY MONSTER"

A beast, dubbed the widow-maker on its Le Mans bow 50 years ago, went on to become one of the greatest racing cars of all-time. **Gary Watkins** investigates the taming of Porsche's 917



"Gnats stuck to the bodywork. The conditions created a kind of full-scale windtunnel that pinpointed the aerodynamic shortcomings"

Porsche

"**NOW** we have a race car." The words were uttered by Brian Redman and their subject was the Porsche 917. The straight-talking Lancastrian had just completed a short run in a hastily-modified version of one of the German manufacturer's prototypes at the Osterreichring in October 1969 and he reckoned the vices that had made so many drivers shy away from the car in its short life had been cured.

Redman and every driver who would go on to enjoy success in the iconic two-time Le Mans 24 Hours winner had the clear blue skies and unseasonable conditions that greeted the factory Porsche team in Austria to thank for the sudden turnaround. The air was rife with gnats, and they stuck to the bodywork of the cars lapping the high-speed home of the Austrian Grand Prix. Or at least the bits of the car prone to the airflow. The conditions contrived to create a kind of full-scale, real-time windtunnel that pinpointed the aerodynamic shortcomings of Porsche's Group 4 prototype.

THE WIDOW-MAKER

The 917, already nicknamed the widow-maker after privateer John Woolfe's death in one after an accident on the opening lap of the 1969 Le Mans 24 Hours, was an unstable machine to begin with. So much so that driver after driver got behind the wheel and then politely requested to drive something else from the Porsche fleet. Redman and his regular team-mate Jo Siffert were among the drivers who rejected the chance to drive one of the first 917s on its race debut at the Spa 1000Km in May '69 and went on to win the event aboard a 908 Coupe.

Redman only did two laps aboard a short-tail car in the wet at Spa without a windscreen wiper – it had fallen off before he left the pits – but he did get more time in the car at Le Mans during practice. It wasn't a rewarding experience.

"It was so unstable on the Mulsanne Straight," recalls Redman, who drove a 908/2 Flunder spyder long-tail with Jo Siffert in the race. "It would wander from one side to the other all the way down and your hope ▶

ABOVE Once tamed, the 917 in short-tail configuration went on to become one of racing's most iconic machines. It is seen here in the 'Salzburg' livery in which it achieved Porsche's first outright win at Le Mans

LAT

ABOVE The 917's 'active aero' at work, one flap up and one down, at Le Mans in 1969. A trim tab on each rear corner of the tail was linked to its respective suspension upright

was that you'd be on the left-hand side of the road when you arrived at the Kink."

That's a reference to the need to use all the road to get through the fast right-hander before the infamous Mulsanne hump.

Vic Elford describes the original 917 as a "nasty little monster" and had been another to turn down the chance of racing the car at Spa, though he reckons he was "probably the only one who really got on with the original 917". There were any number of reasons for that. For a start, he'd "fallen in love" with the car on seeing it on the Porsche stand at the Geneva motor show that March, and then there was his rallying background and a familiarity with cars "wandering or swooning around in a straightline".

He also wanted the fastest car possible, which is why he lobbied to race one of the two 917s, both in long-tail configuration, entered by Porsche at Le Mans '69. His team-mate for the race, Richard Attwood, was less enthusiastic. Even though they came within three hours of victory, and led by six laps at one point, he was far from distraught when the car retired as a result of a broken bellhousing that precipitated an oil leak onto the clutch.

"I was elated to get out of the car when it broke," he says. "I couldn't have cared less about winning because that car was a killer. It was floating all over the road. It was a horrendous car."

> *"I was elated when it broke. I couldn't have cared less about winning because that car was a killer"*

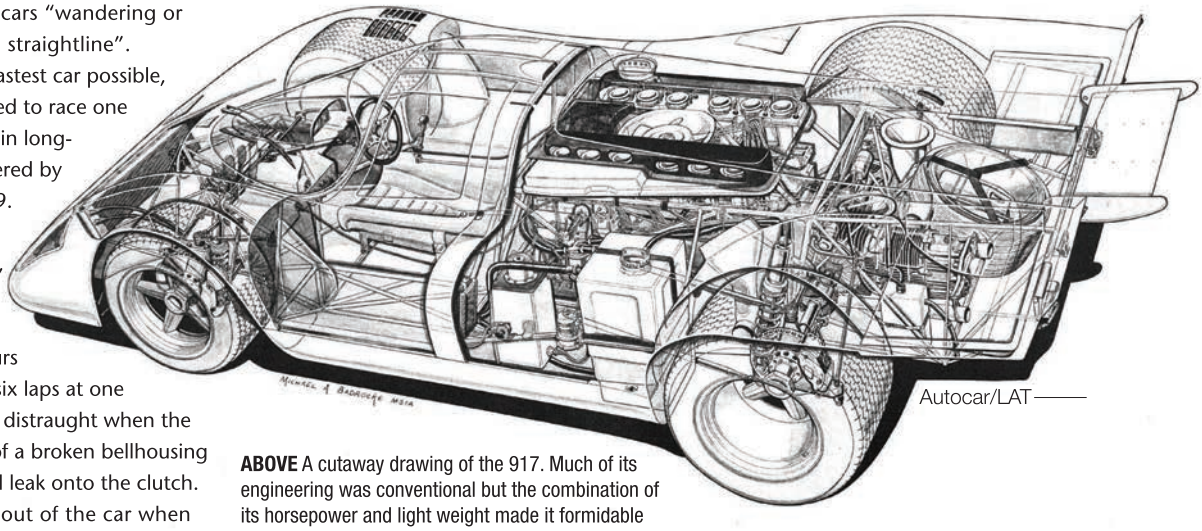
OBSESSION WITH STRAIGHTLINE SPEED

Elford's desire to have the fastest car possible meant, at Le Mans, having the quickest car in the straight line. And flying down Mulsanne Straight, a then uninterrupted four-mile blast of public road, was key to a quick lap around the Circuit de la Sarthe.

"The last thing I actually wanted to be doing was racing other cars," says Elford. "I wanted to be driving past them on the straight."

Better still was the fact that the reputation of the 917 for unruliness preceded it.

"When other drivers saw us coming out of Tertre Rouge, it was as if they were frightened," he continues. "It was almost as if they queued up on the right of the track and



Autocar/LAT

ABOVE A cutaway drawing of the 917. Much of its engineering was conventional but the combination of its horsepower and light weight made it formidable

ABOVE & BELOW Taming of the beast: the 917 in long-tail guise above, and its short-tail configuration, below

Photos: Porsche

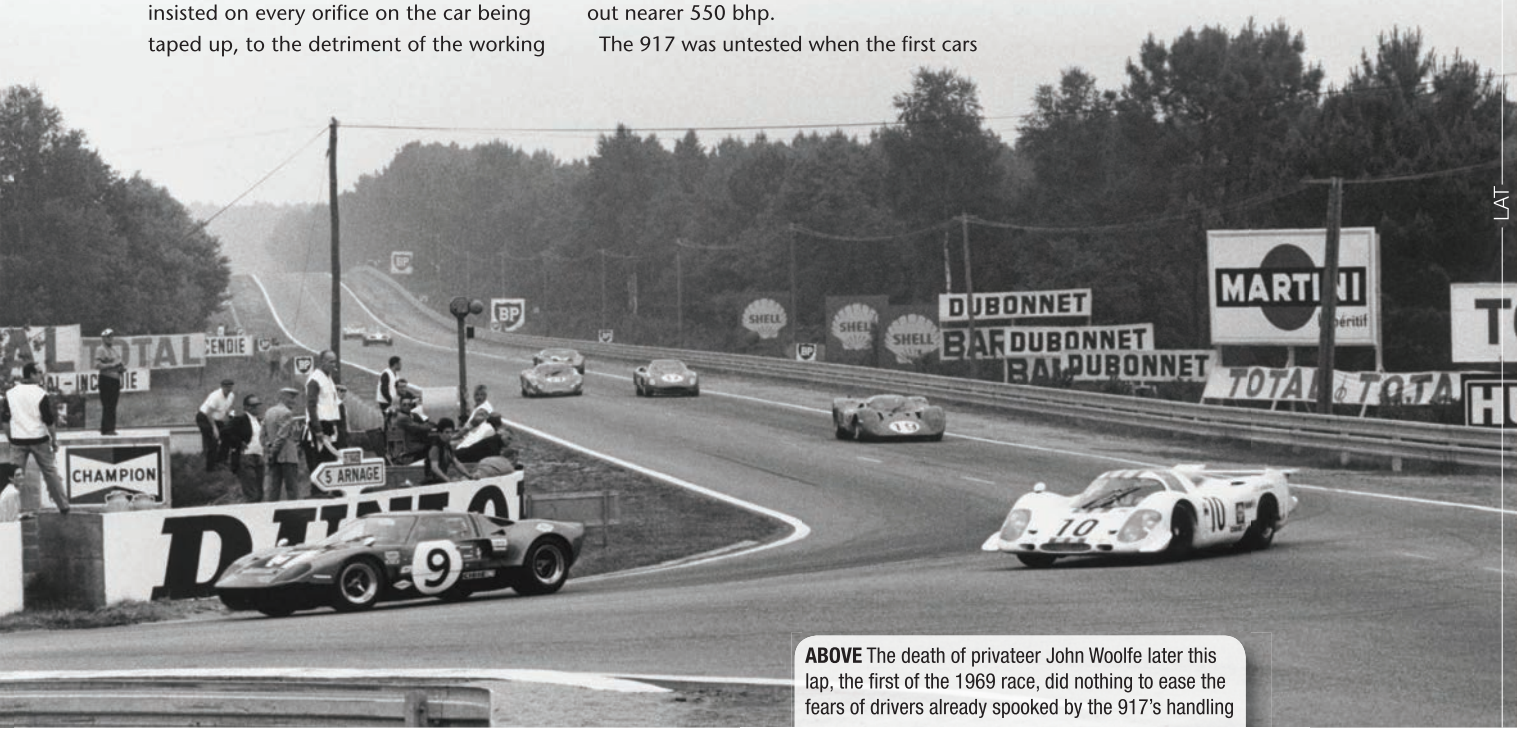
waited for us to pass. Which was lovely!"

The aerodynamics of the 917 drew their inspiration from those of the 908LH *langheck* or long tail that had first raced at Le Mans in 1968. Ferdinand Piech, the architect of the 917 as Porsche's research and development boss, had an obsession with straightline speed. So much so that on the car's debut at the Le Mans test weekend, at the end of March in '69, he insisted on every orifice on the car being taped up, to the detriment of the working environment of the driver desperately trying to hang onto the thing.

The difference was that the new car had a 4.5-litre flat-12 powerplant in the back rather than the three-litre eight of its predecessor. The 908 had somewhere in the region of 350 bhp, whereas the new engine with 50 percent more cylinders and 50 percent more capacity was initially rated at 520 bhp, though was said to be pushing out nearer 550 bhp.

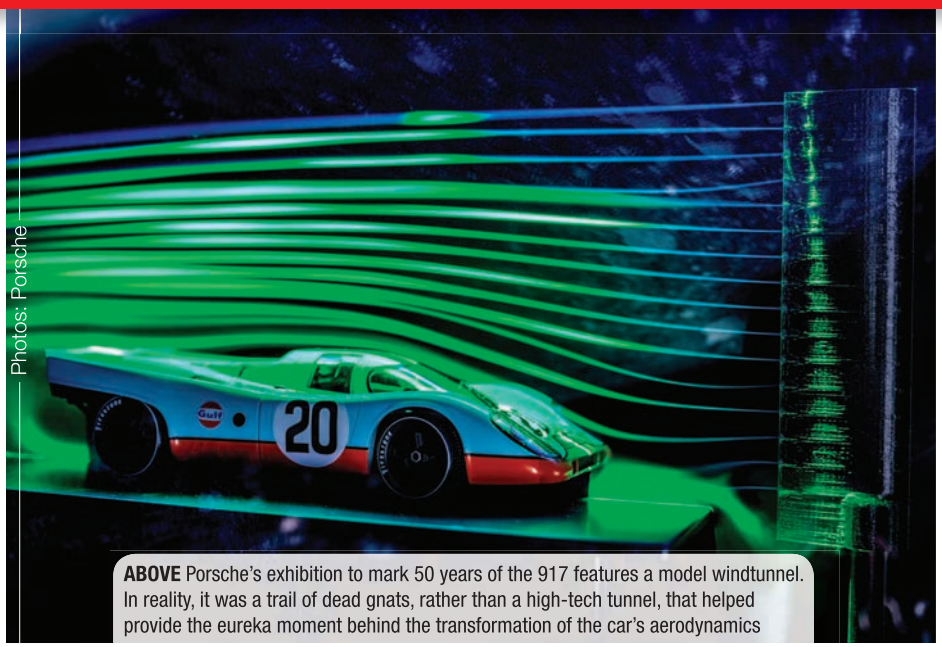
The 917 was untested when the first cars rolled off the truck at the Le Mans test weekend after Porsche had missed the initial homologation date for the car. The programme was behind schedule and the prerequisite 25 cars demanded by the Group 4 regulations weren't completed in time for it to race in the Monza 1000Km at the start of April, though that didn't stop it from taking part in the Le Mans test.

The instability issues that would dog the ▶



LAT

ABOVE The death of privateer John Woolfe later this lap, the first of the 1969 race, did nothing to ease the fears of drivers already spooked by the 917's handling



Photos: Porsche

ABOVE Porsche's exhibition to mark 50 years of the 917 features a model windtunnel. In reality, it was a trail of dead gnats, rather than a high-tech tunnel, that helped provide the eureka moment behind the transformation of the car's aerodynamics

first version of the car were apparent from the get-go. The cars couldn't run flat-out and were limited to somewhere short of 200 mph, though that didn't stop Rolf Stommelen from topping the times with a 3m 30.07s lap.

There were revisions to the suspension geometry and steering in an attempt to make the 917 a more raceable machine in time for the race in the middle of June. Officialdom had designs on making the car less raceable, however.

The Commission Sportive International (CSI), the FIA's sporting arm, had issued a blanket ban of what it termed supplementary aerodynamic devices. This followed two serious accidents at the Spanish Grand Prix at Montjuich Park in Barcelona as a result of the collapse of the raised suspension-mounted wings that were proliferating in Formula 1. The aerodynamics of the 917, as well as those of the 908, came under scrutiny.

The active aero of the original 917 pioneered on the 908 coupe were more than an early version of a Drag Reduction System. Two trim tabs, one on each corner of the rear of the tail, were linked to their respective suspension upright by an arrangement of torsion bars and bell cranks. These flaps, as they have always been known, would rise as the rear suspension was extended under braking and fall as the rear dipped under acceleration. Because they worked independently, the theory was that they would counter roll during cornering by placing a higher load on the outside wheel.

Porsche argued that the 917 had been homologated with the flaps and would be unsafe to race without them. Stommelen was dispatched during practice with the flaps fixed to prove the point.

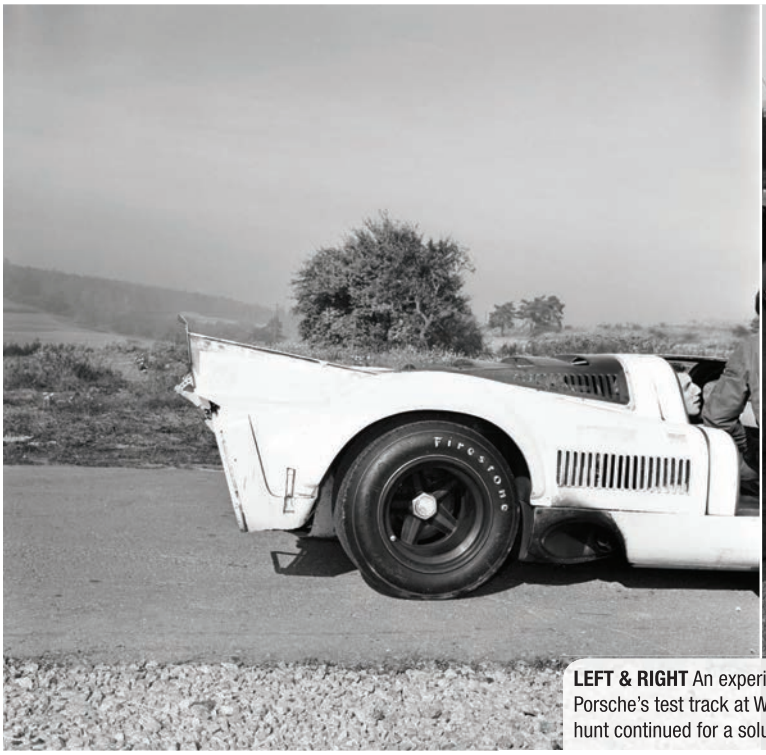
"Rolf did an absolutely masterful job of showing that without them the car was an absolute monster," recalls Elford. "He made it look like the car was an accident waiting to happen."

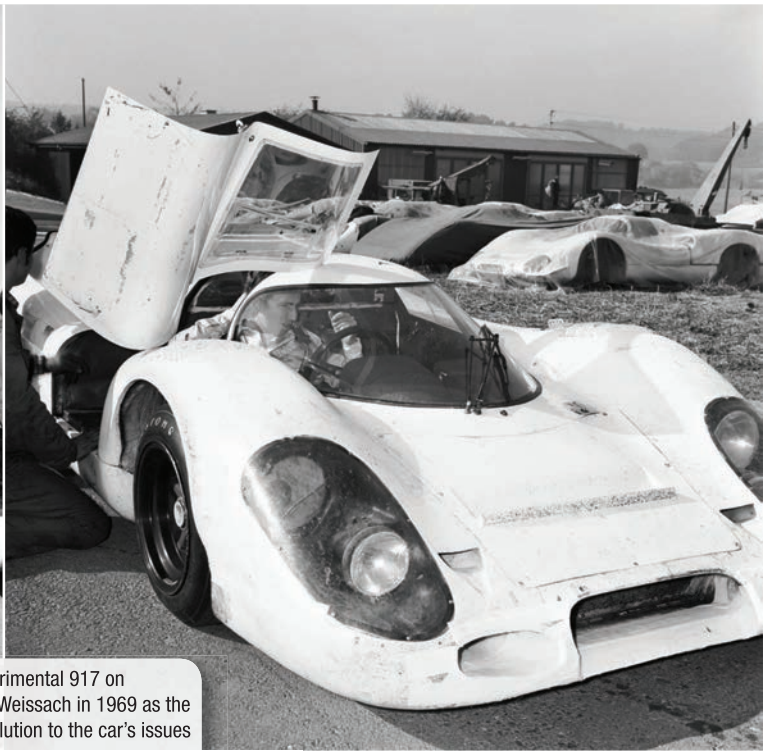
A compromise was reached whereby the 908 longtails that were also running flaps would race without them, but the two 917s could keep them for the race.

FIRST VICTORY

The next race for the Porsche 917 yielded its first victory. Jo Siffert and Kurt Ahrens took the win in the Osterreichring 1000Km in August with a factory-run car entered under the banner of customer Baron Karl van Wendt. Redman was third together with Attwood in another works car that was destined for David Piper.

The car, back in the short-tail configuration in which it had raced at Spa and the Nürburgring ahead of Le Mans, was still running the moveable flaps, though they were set to reach a higher angle. The 917 ▶





LEFT & RIGHT An experimental 917 on Porsche's test track at Weissach in 1969 as the hunt continued for a solution to the car's issues

Photos: Porsche

ABOVE & BELOW Chassis 001, the car that Elford had fallen in love with at Geneva 50 years ago, is now running again after engineers past and present invested a year in its restoration

remained highly unstable, however. Worse than that, it was slower than the best of the opposition. Jacky Ickx had qualified JW Automotive's Mirage on the pole at 1m 47.6s, while Siffert could only line up fourth on the grid with a 1m 48.1s.

Porsche's race team manager Peter Falk has claimed that he and his lead engineer, Helmut Flegl, understood that the problem was an aerodynamic one. This doesn't appear to be borne out by the events of the test when Porsche returned to the Osterreichring nearly two months after the race at the Austrian venue.

"NOTHING MADE ANY DIFFERENCE"

"On the first day of the test, Ahrens and I went out and did one or two laps at a time and nothing seemed to make any difference, and we did everything," remembers Redman. "We'd change the wheels and tyres, and the camber and caster, nothing made any difference."

Redman recalls he and a number of other drivers believing that the problem was a structural one with an ultralight spaceframe chassis that tipped the scales at 42 kg: "We all thought the chassis was flexing."

Present at the track near the town of Zeltweg were a contingent from JW Automotive, the winners at Le Mans in 1968 and '69 with the Ford GT40, who'd led the US manufacturer's World Championship of Makes campaign in the first of those years. The team led by John Wyer had been sounded out by Porsche on the possibility of becoming a factory squad in 1970 as early as the Sebring 12 Hours in March. "The best engineers for developing a weapon," reckoned Piech, "are not the best soldiers." A deal was in the offing, though not signed, by the time of the Osterreichring test.

John Horsman, JWA's engineering boss, takes up the story in his motorsport memoir, *Racing in the Rain: My Years with Brilliant Drivers, Legendary Sportscars and a* ▶

KIMBERLEY
MEDIA GROUP LTD

Essential BOOKS for the motorsport engineer's library:

The Carroll Smith collection

Engineer to Win: £25

Current state of the art in racing technology by a foremost expert in the field. Covers all forms of racing cars and includes a thorough analysis of metallurgy, metal fatigue and general materials technology. Details specific components and specific activities such as heat treatments, stress relieving, etc. Plus aerodynamics, ground effects, brakes, tools, and more.

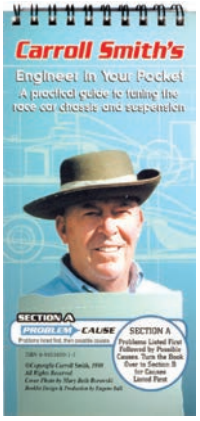
Tune to Win: £20

Covers the development and tuning of race car by clearly explaining the basic principles of vehicle dynamics and relating these principles to the input and control functions of the racing driver. An exceptional book written by a true professional.

Prepare to Win: £20

One of road racings top professionals presents here a vast amount of his accumulated car preparation knowledge. Covers fasteners, plumbing, riveting and welding, basic metal work, braking system, clutch, suspension, wheels and tires, engine, gearbox, electrics, fuel cells, paint and paperwork.

Engineer in Your Pocket: £15



Store all the answers in your hip pocket! This handy pocket guide written by racing professional Carroll Smith suggests realistic solutions to common race car handling problems. Formatted listing causes and possible effects, and problems and possible causes. Spiralbound, 3 1/2"x 7 3/4," 32 pgs.'

To order these fine books and many others, please go to www.kimberleymediagroup.com/shop or phone +44 (0) 20 8446 2100 where our friendly staff will take your order.

kimberleymediagroup.com

RACE TECH Motorsport Engineering
racetechmag.com

HISTORIC RACING & Technology
historicracingtechnology.com

TrackCar performance
trackcarperformance.com

> *"Porsche and JWA managed to teach the monster some manners"*

Dedicated Team.

"In the clear, still autumn air of the Austrian hills there were clouds of gnats flying around and their remains were splattered all over the nose and windscreen of both closed 917s," he recalled in the work published in 2006. "I noted that there were hardly any dead gnats on the rear spoilers, which by now had been raised into near-vertical positions [and fixed in position] during the course of testing with no discernible effect on handling.

BREAKTHROUGH?

"I knew that because they were very small and light, the gnats would flow over the bodywork exactly as the air flowed, similar to the smoke from wands used in wind tunnels. Any gnat remnants on the white paint would indicate that air had touched that surface. This proved to me that airflow was barely touching the rear spoilers. I knew immediately that we had to raise the rear deck and then attach small adjustable spoilers to the trailing edge."

The JWA crew set to on modifying one of the two 917 coupes present at the track with whatever materials came to hand. Chief mechanic Ermanno Cuoghi, who would go on to F1 success with Niki Lauda at Ferrari, and his assistant Peter Davies then reshaped the rear of the car.

"I explained to Ermanno and Peter what I had in mind, which was to extend the line of the tail from the top of the rear wheelarch at a slight upward angle until it reached the top of the spoilers, which ▶

ABOVE & BELOW An accident involving a cat led to the 917 trialling a new nose, similar to that in use on the open top 917 Spyder Can-Am car also being tested in Austria at the same time. Brian Redman, above, is seen here in the Can-Am version, with the prototype Le Mans car behind

Photos: Porsche

KIMBERLEY
MEDIA GROUP LTD

BREAKING NEWS | LATEST VIDEO CONTENT | LEADING SUPPLIER DIRECTORY

kimberleymediagroup.com

Driving Technology Into Pole Position
INTERNATIONAL
RACE TECH
Motorsport Engineering

racetechmag.com

HISTORIC RACING
& Technology

historicracingtechnology.com

Porsche

ABOVE Porsche race team manager Peter Falk (left, with glasses), seen here at the Osterreichring test at which the 917 was tamed, has always maintained that the solution to the aero problem was found at the same time by Porsche and Wyer personnel

would act as supports," recounts Horsman. "Then adjustable trim tabs were to be added to the trailing edge.

"We had to cut the aluminium to fit around the base of the Perspex window, which covered the engine bay, and rivet it securely in place. Using the steel Armco railing as a hammering buck, we bent the sheet to fill the gap now open behind the rear wheels."

EUREKA MOMENT

Horsman had always claimed credit for the eureka moment that tamed the 917 even before the publication of his autobiographical work, though he too believes that Falk and Flegl knew the problem was aerodynamic. The suggestion is that they were hamstrung by Piech's insistence on maximising straightline speed.

> *"The Porsche 917 became a joy to drive"*

Falk insists that it was much more of a collaborative affair.

"All the British newspapers wrote, 'JWA tests at Zeltweg and improves the handling of the 917' and all the German papers wrote 'Porsche tests at Zeltweg and improves the handling of the 917'," he says. "Both were absolutely right."

Falk describes an episode in which Porsche and JWA "managed to teach the monster some manners" in his own autobiographical work *Peter Falk – 33 years of Porsche Rennsport and Development*.

"Wyer didn't do it, Porsche didn't do it," he says. "The idea of why the car didn't work came to us all at the same moment. We had tried everything, we fitted a different front axle, we tried different tyres, other suspension set-ups, all the usual homework material.

"After the 917 had turned a couple of laps and came into the pits, Flegl, Horsman and I took a look at the rear and saw that the dead insects were only stuck to the top part of the spoiler. We realised the spoiler only worked on the top and we needed another shape that didn't slope but rose gently to the back."

Wherever the truth lies, the fact is that the classic shape of the short-tail 917K *kurzheck* was born. When Porsche began its 1970 world championship campaign, it was with a car that clearly resembled the test hack cobbled together in the Styrian hills.

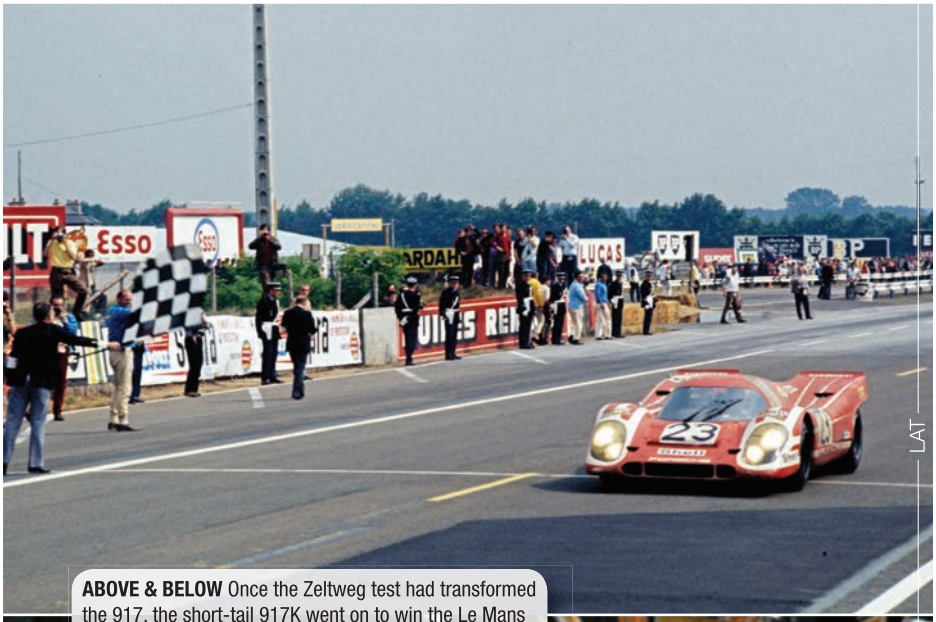
Redman's initial enthusiasm was matched on the stopwatch. The Brit quickly eclipsed Ickx's pole time from the race two months before and then Ahrens posted a 1m 43.3s, five seconds quicker than he had managed earlier in the test.

NEW NOSE

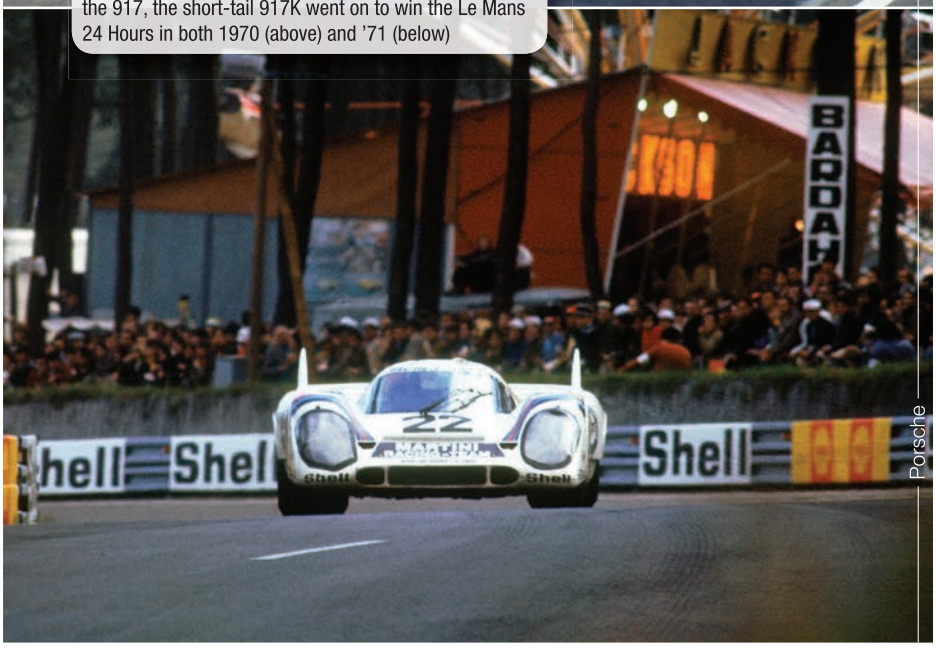
Further progress was made over the course of the Osterreichring test. A new nose, similar to that in use on the open top 917 Spyder Can-Am car also being tested in Austria, was fitted to one of the two coupes after Ahrens hit a cat. The new tail was then transferred to this car. Firestone, on whose tyres JWA's GT40s ran, joined the test after initially sitting on the sidelines, unwilling to offer up its products until the handling of the car was sorted. Various specifications and size of tyre were tried, the cars ending up on 10in and 17in front and rears compared with the 9.5in and 15in of the Dunlops on which the cars had so far raced.

After the Osterreichring bodywork was productionised for 1970, Porsche went on to dominate the WCM over the course of two seasons before the 917 was legislated out of world championship sportscar racing. It was a *kurzheck* that notched up Porsche's first two Le Mans victories with the Porsche Salzburg team and then Hans-Dieter Dechent's Martini International squad in 1970 and '71 respectively.

"The Porsche 917 became a joy to drive," says Elford. "Wherever we raced the short tail it was easy and comfortable to drive. It was a car with no vices"



LAT



Porsche

ABOVE & BELOW Once the Zeltweg test had transformed the 917, the short-tail 917K went on to win the Le Mans 24 Hours in both 1970 (above) and '71 (below)

RELIABLE BATTERIES FOR DEMANDING TEAMS

Whether on two wheels or four, an old car or new, serious racers all demand the same high performance from their batteries. As **William Kimberley** discovers, this is something BF-Akku delivers

ABOVE Honda Holzhauer is one of the teams that relies on BF-Akku batteries

THERE are a wide range of manufacturers that produce light batteries, but one specialist company that stands out for producing a range specifically for motorsport applications is German company BF-Akku.

Its first product specifically developed for motorsport came about through motorcycles. A world champion team that was continually experiencing problems in finding a reliable starter battery contacted BF-Akku to see if it could help. This led to the German company developing the BF-Akku Extreme.

"We were asked to develop an extremely light, low-maintenance but still very robust and reliable starter battery for the team in question," says Thorsten Reinhard, CEO of BF-Akku. "This led to us developing a completely new concept with the first BF-Akku high-performance battery. That was born in close collaboration with this professional motorcycle champion team.

"The concept worked because our battery held the professional requirements a full year, and no maintenance or replacement was necessary during that time. Since then, we are the exclusive supplier of this championship-winning team for high-performance batteries.

"Our specially developed innovations include the battery housing made of carbon, ultra-hard heat-resistant coatings, special low-vibration materials and individually tailored and application-adapted production of electronics, that we have protected by numerous patents, utility models and designs.

"The carbon case is of course not for the optics. The exact tuning of our components and the processing of solid precious metals instead of thin nickel sheets makes our BF-Akku Extreme batteries last longer, while giving the customer security, especially in professional racing. We guarantee faultless functionality of our high-performance accumulators, and before leaving our plant a final optical quality check is carried out."

"Acid and liquid-free, they can be installed in any position. Furthermore, a common OEM battery can be easily replaced by a BF-Akku battery thereby achieving a much more reliable and long-lasting functionality at a fraction of the weight and size.

"BF-Akku batteries are always on the cutting edge of LiFePo4 storage technologies. Our many years' experience and know-how, and the findings from the ongoing collaboration with the leading international professional racing teams, form the basis from which we have developed the symbiosis of energy density combined with the highest level of reliability and quality of each of our starter batteries."

Motorcycle teams that have switched to the BF-Akku batteries include Honda Holzhauer, one of the top teams in the German racing scene, which won three Superbike titles in 2007, 2008 and 2010 in addition to 28 IDM (International German Motorcycle Championship) titles, and Ten Kate Racing.

BF-Akku batteries are also used in other forms of motorsport, adds Reinhard. "All BF-Akku Extreme accumulators are suitable for installation and operation in all standard alternators on cars, boats, planes and motorcycles. We also build batteries for GP2, DTM, VLN, GT3 and 4, Dakar, Formula 3 and the Boss GP Championship."

While the batteries are widely used in all forms of motorsport, they are beginning to be used in historic race cars as well. "In older Formula 1 cars, where the vibrations are always a problem, our BF-Akku Extreme Batteries are poured with a special gel and the individual cells are thermally decoupled so that the BF-Akku Extreme battery does not get too hot. In all forms of racing, they have never failed in a race and there has been no fire since the emergence of BF-Akku Extreme in 2008."

Reinhard also gives a Lola T-222 with the BF-Akku Extreme battery being built into the floor as an example of where his batteries are used in an historic racing car. We didn't interfere with the technology of the car, but just exchanged the original battery with the BF-Akku Extreme. Nothing else has been changed on this historic vehicle as the regulations wouldn't allow that. Every year the vehicle still drives at historic races here at the Hockenheimring." RT

ABOVE BF-AKKU's range is designed to be lightweight without sacrificing durability

HISTORIC RACING & Technology

UK £6.99 USA $12.00

Today's technology in yesterday's cars

FREE access to digital edition with all print subscriptions

	6 Issues	12 Issues
UK	~~£42~~ £31.50	~~£77~~ £58
Europe	~~£66~~ £49.50	~~£119~~ £89.50
USA & ROW	~~£81~~ £61	~~£146~~ £109.50

Including post and packaging

HISTORIC RACING TECHNOLOGY brings a unique perspective to the business of restoring, preparing and maintaining historic competition cars in the 21st century, with in-depth technical articles on the engineering and craftsmanship behind this fast growing industry.

Where **Historic Racing Technology** differs from existing titles is a clear focus on the challenges and opportunities of running these cars in the modern era. From laser scanning through to five-axis CNC machining, historic racing specialists are increasingly blending modern methods and traditional techniques. As a result, it's now possible to produce authentic parts with an unprecedented level of accuracy. In some cases this goes a step further, re-engineering aspects of the car to deliver improved safety or reliability... and sometimes performance.

Featuring technical articles from some of the industry's most experienced journalists and engineers, **Historic Racing Technology** is dedicated to the classic motorsport scene across the globe. It takes a fresh new approach, looking at the future of historic motorsport as well as the past.

The perfect Father's Day Gift - Save 25%

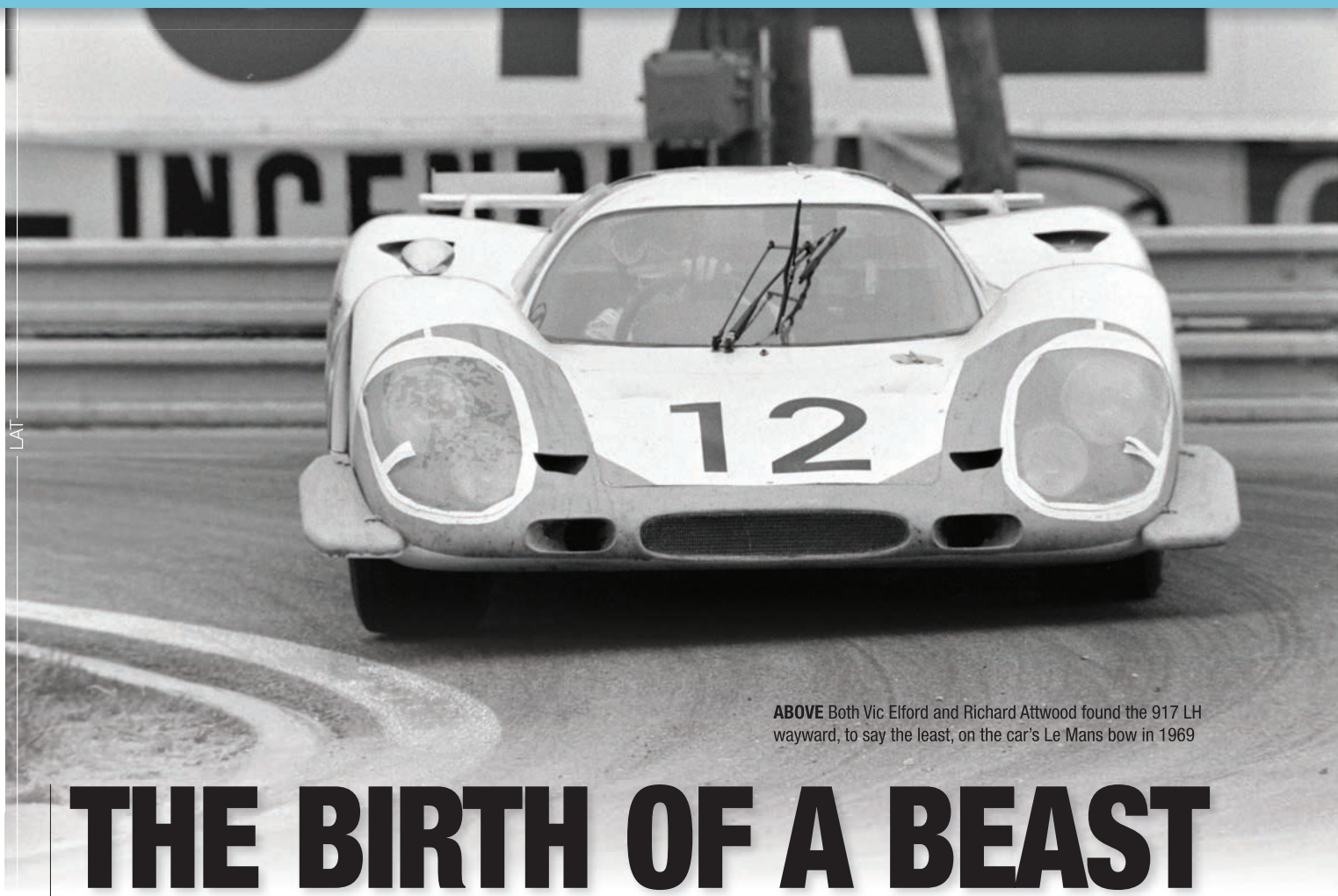
Available in Print

Available on the App Store

ANDROID APP ON Google play

available on kindle fire

www.kimberleymediagroup.com



LAT

ABOVE Both Vic Elford and Richard Attwood found the 917 LH wayward, to say the least, on the car's Le Mans bow in 1969

THE BIRTH OF A BEAST

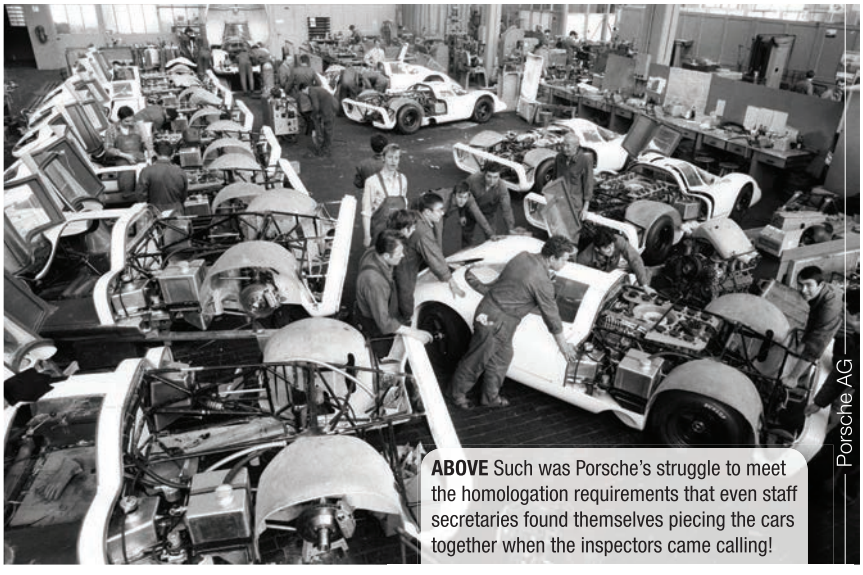
Sergio Rinland reflects on Porsche's 917, which made a Le Mans debut that was memorable, for all sorts of reasons, 50 years ago this month

FIFTY years ago, an icon was born: the Porsche 917. It came about, as ever, through the governing bodies' typical underestimation of the competitors' ingenuity.

At Le Mans 1967 we had witnessed the victory of the Ford Mk IV with Foyt and Gurney (the day Dan 'invented' the champagne spraying on the podium). That car was so fast and powerful that the governing bodies at the time decided to put in place some limits to avoid speeds getting out of hand. For that reason, they devised the Sports Prototype regulations for 1969, allowing prototypes with 3-litre engines – coincidentally the same as Formula 1 – in the hope of developing some synergies between the two.

At the time there were a host of privateers with Ford GT40s and Lola T70s with American 5-litre engines making up the grids, so it was decided to create a 'sub-category' for those cars, mandating a minimum production run of 50 cars in a 12-month period to enter in this GT group. There were not sufficient GT40s and T70s to comply, however, so the rule-makers lowered the production run to 25 and went to relax, completely underestimating human ingenuity.

Ferrari and Porsche saw an opportunity here and produced the 512 and 917 respectively. The latter was a brand-new prototype with a 12-cylinder flat engine (in fact two 6-cylinder engines of the Carrera 6 put together with a centre power take), aluminium tubing spaceframe and fibreglass bodywork. It was 300 kg ▶



Porsche AG

ABOVE Such was Porsche's struggle to meet the homologation requirements that even staff secretaries found themselves piecing the cars together when the inspectors came calling!

The perfect Father's Day Gift

12 issues from £35.70 inc p&p & digital edition

SAVE 50%

kimberleymediagroup.com

Telephone: +44 (0) 208 446 2100

Bloxham/LAT

ABOVE The 917s made for a magnificent sight when they took to the track at Goodwood to mark the 50th anniversary

> *"The 917 single-handedly killed Can-Am as we knew it"*

lighter than the Ford MK IV (which was a monocoque construction) and with 513 HP, boasted a power to weight ratio of 0.64 HP/kg. For comparison and to highlight just how short-sighted the rule makers were, the 1967 Ford MK IV had 0.48 HP/kg (530 HP and 1,100 kg). Ferrari was not too far off that, but not close enough.

To suggest that the original Porsche 917 was a handful to drive is an understatement. We only have to remember the comments from Frank Gardner or the versatile Vic Elford, who were 'honoured' to race the first version of the car at the Nürburgring and Le Mans. They reckoned it was "undriveable".

PRESSURISED COCKPIT

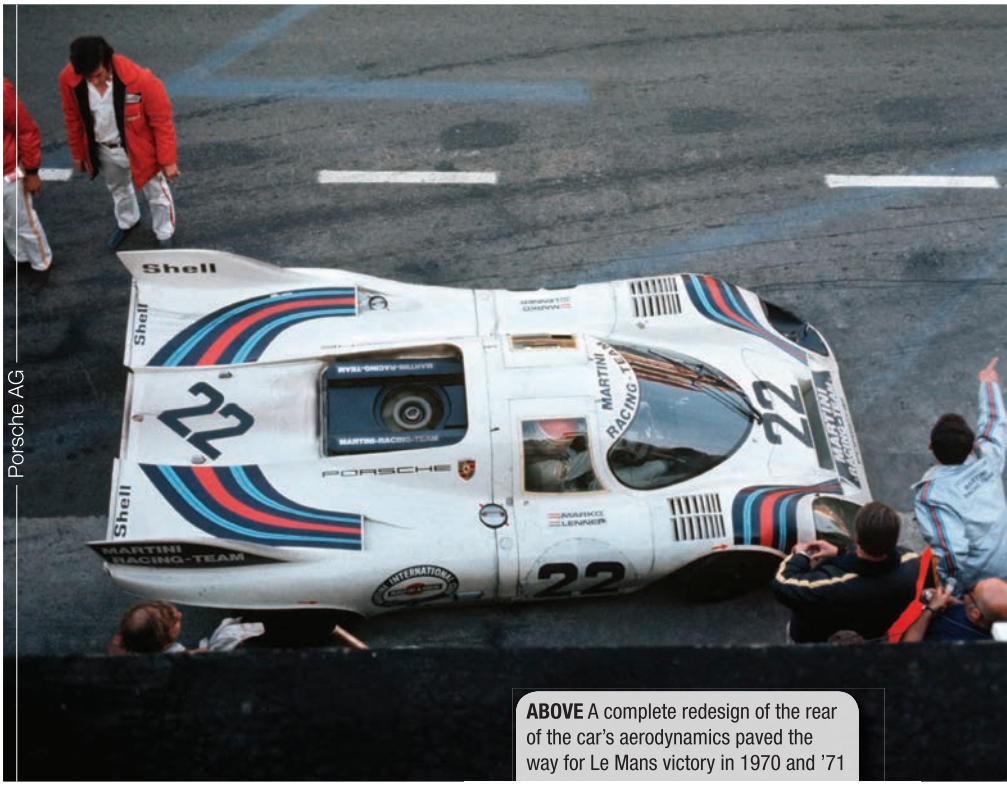
From the engineering point of view, the strength of the 917, in LM and Can-Am versions, was always the powertrain. The chassis was a work of art aluminium spaceframe, with a certain fragility (that is why it had high pressure air inside and a manometer for the driver to know if it cracked) but very rigid. It had very good and robust suspension and conventional aerodynamics with great emphasis on straight line speed. At a time when all F1 cars were aluminium or magnesium monocoques, and in Can-Am the McLaren, Chaparral and Lola were also monocoques with very advanced aerodynamics, ground effect in the case of the McLaren, we could say that the 917 chassis technology was conventional.

By the time the 1970 season started, the 917 was transformed and became one of the most iconic racing cars of all time, thanks to the efforts of the Porsche engineers (led by one Ferdinand Piech) and the John Wyer team in England. It gained stability in the UK and power in Germany; the rest is history.

By then the governing bodies realized their underestimation. So, the 5-litre Sports Cars division was cancelled for 1972, leaving all those beautiful Porsche 917s and Ferrari 512s redundant. Porsche saw the Can-Am opportunity. It had started to send cars to those races to 'try the water' since 1969 with Jo Siffert, a timid effort with a spider version of the 'std' 917. Such was the domination of the Penske Porsche team in 1972 and 1973, developing 1,100 HP with turbocharged 5.4-litre engines and aggressive aerodynamics, that the design single-handedly killed Can-Am as we knew it then.

The last Porsche 917/30 can-Am and the very first Porsche 917 chassis were reunited at the recent Goodwood Members' meeting. It was a joy to behold those magnificent machines running at speed on the historic track.

When I went to work at Sauber in 1999, I was introduced to the head of R&D, a soft-spoken German engineer. "This is Walter," they told me. "He worked for many years at Porsche." We got to know each other very well and developed a friendship. It transpired that this "Walter who worked at Porsche" was none other than Walter Naher, the legendary Porsche race engineer from 1969 to 1989, who worked on all the 917 development cars and then wrote the book 'Porsche 917', the ultimate 917 publication. I consider myself very fortunate to have worked in motorsport with great people: Walter, who sadly passed away two years ago, was the 'cherry on the cake'.



Porsche AG

ABOVE A complete redesign of the rear of the car's aerodynamics paved the way for Le Mans victory in 1970 and '71

NATIONAL MOTORSPORT ACADEMY

WORLD'S FIRST *ONLINE* Motorsport Engineering Degrees

BSc (Hons) Motorsport Engineering And Final Year Top-Up*

MSc Advanced Motorsport Engineering*

NEW MASTER'S DEGREE *NOW ENROLLING!*

https://motorsport.nda.ac.uk

NATIONAL MOTORSPORT ACADEMY

95% OVERALL SATISFACTION
National Student Survey Results

DE MONTFORT UNIVERSITY LEICESTER

Apply *ONLINE* Today! +44 (0)1159 123456

*All degrees awarded by our Academic partner De Montfort University.

FOR SALE

CHAMPIONSHIP WINNING MOSLER MT900

Beautifully maintained by the **NMA Team**
Full support is also available for GT Cup, Britcar, Supercar Challenge etc. at cost

£POA Contact Kevin Riley **07973 675734**

Out Of The Box...
Into The Winner's Circle

- CarbonMetallic® Race Pads
- ZERO FAILURES™ V3 Discs
- ZERO DRAG™ Calipers
- RH665 Racing Brake Fluid

PFC BRAKES

www.pfcbrakes.com

800.521.8874