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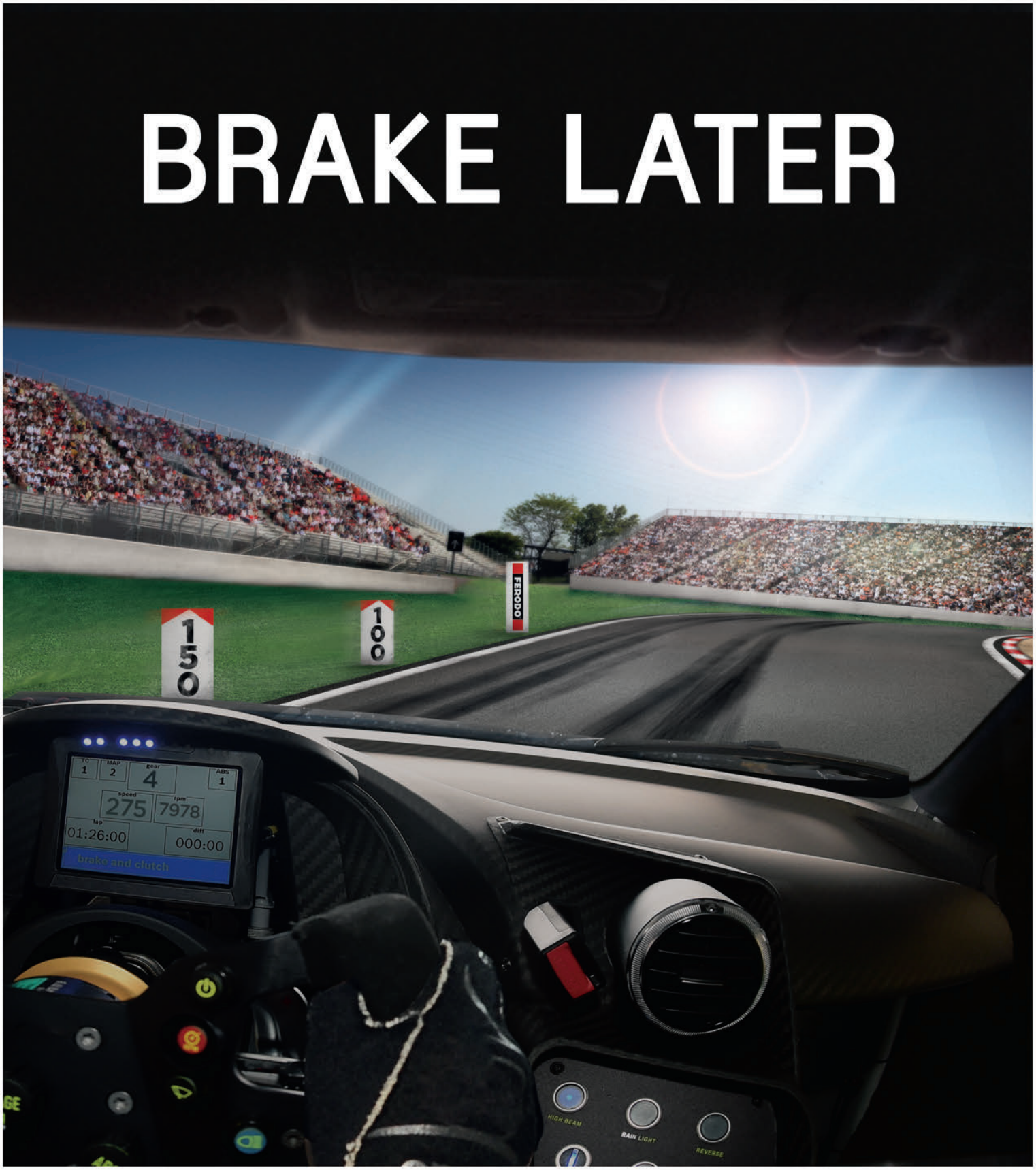

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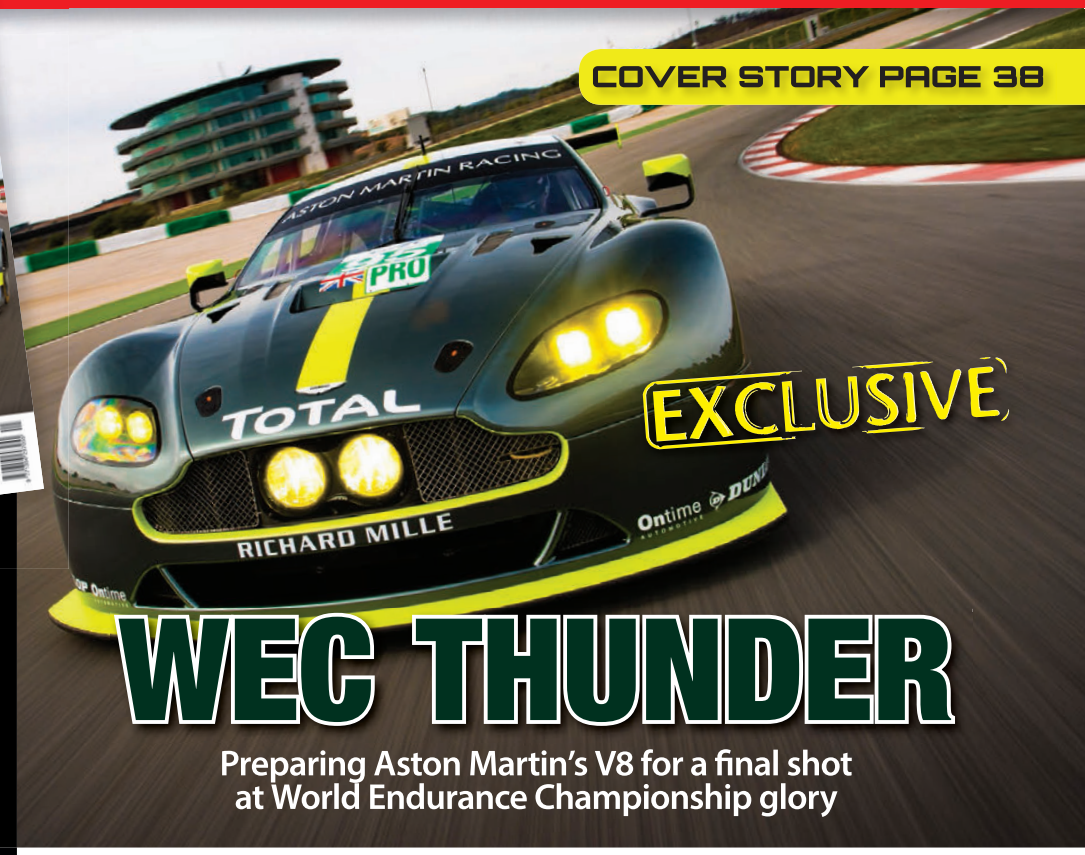

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THE VIRTUE OF PATIENCE

I WAS reading with interest a recent announcement that Formula E and the FIA have created a 'Smart Cities Initiative', a new programme created to promote the use of safe, sustainable and accessible e-mobility solutions in cities. The initiative aims to form synergies between the motorsport and mobility pillars of the FIA, bringing industry experts, public authorities and mobility specialists together to identify and tackle issues facing overpopulated, heavily polluted cities.

Three races have been selected to hold Smart Cities conferences during the 2016/17 Formula E season along with a special event in Paris, with each focusing on a key area linked to e-mobility and urban growth. The first Smart Cities Forum, in Mexico City, will highlight the advancement of green mobility while during the Berlin ePrix the initiative will address new mobility models. During the season finale, taking place in Montreal on 29/30 July, the Smart Cities Forum will discuss the rise of Smart Data and its capabilities.

The Smart Cities Start-up, established in conjunction with investment fund company Digital Leaders Ventures, will take place during the week of each race and will identify, support and invest in some of the most innovative and relevant technology companies on a concept that could help revolutionise how cities approach e-mobility issues, sustainability, safety and being connected.

It reminded me of a press release I have in front of me, and I quote: "The time has come for car makers and component suppliers to put their combined weight behind the development of practical and environmentally friendly electric vehicles…..Those who want to wait for some miracle battery will only delay the introduction of the electric car instead of promoting it. There is no reason to wait any longer. The aim must now be to implement what is feasible." Too true, but to put that into perspective, it was a press release from battery company Varta dated 20 January, 1994. That is almost quarter of a century ago.

Of course, the automotive landscape has changed fairly substantially since then, but if you take a step back and analyse it, it has been a very zigzag route to have got to where we are now. In Europe, for example, the diesel engine has ruled the roost in the passenger car market. Even in the UK, which like the States where diesel was rather frowned upon and lagged behind countries like France, Austria and Switzerland, it began to have a substantial share of the market during the Nineties, the taxation laws vigorously encouraging the car buying public to favour it over petrol.

Then we had the period where the hydrogen car was the ultimate goal with its zero emissions and that anything else in between, especially the hybrid, was but a short term placeholder on our journey to the hydrogen economy.

At the same time, and I have mentioned this before, when talking to a Member of Parliament two or three years ago, he told me that as a country we had to expect power cuts as a way of life as the infrastrcture could not cope with demand, and that was going to increase – and he was not even referring to the powering up of electric cars. Even now, as I park my car in my local car park and see the three recharging stations, I do imagine it in a few years time with half the places allocated to recharging stations and wonder how things will work if we assume that most people have parked their car by 9 am and start recharging their car.

To be fair to the powers-that-be at Formula E, such things are being taken into consideration. It is working with a company that has produced mobile generators that run on glycerine that are taken to each Formula E race to charge the cars. The advantage is that the fuel is clean in terms of carbon emissions and clean in terms of the local air quality, very low in NOx emissions and very low in particulate emissions. The aim is to develop this technology so that it becomes commonplace in areas where microgrids are required such as at supermarkets, hospitals and universities. I don't know, but I assume it's still a long way from being commercially viable otherwise we would know much more about it.

All this is very commendable, though, and hopefully will come to pass and I salute those who have had the courage to promote this vision and put motorsport back at the cutting edge where it belongs because the world needs to find an answer, and find one pretty quickly. Nevertheless, in reality and for all the fine words and initiatives, I think the watchword has to be patience, much as it hurts to say that. RT

William Kimberley
EDITOR

ABOVE Full house: Vauxhall is the new shape among the now five manufacturers heading the capacity BTCC grid

Tyres top of agenda on capacity BTCC grid

Andrew Charman

DONINGTON PARK: The British Touring Car Championship has named a capacity 32-car grid for a second successive year. The field, announced during the pre-season media day at Donington Park by BTCC series director Alan Gow, boasts 10 makes of car, all running on full RML-specification standard parts as is now mandated by TOCA. It also includes five teams competing for the manufacturers championship, two more than in 2016. Joining Honda, MG and Subaru in the manufacturer battle will be BMW and Vauxhall.

"I don't think, certainly this century, that we've seen the depth of quality we have through the field," said Gow. "Fifty per cent of the drivers on the grid have won races, which is an extraordinary figure.

"Among those drivers there's 329 race wins and there's probably not a driver on the grid this year who is not capable of winning a race in their own right. It's a fantastic testimony to the strength of the BTCC that we've got such quantity and quality of drivers."

As detailed in our separate story, the West Surrey Racing team has had its status upgraded to full manufacturer level after several successful seasons racing BMWs as a constructor, while Power Maxed Racing will campaign two Astras for the manufacturer

ABOVE Compound factor: New tyres with wider tread widths are focusing minds ahead of the 2017

title as part of a fleet deal agreed between PMR's parent company Automotive Brands and the manufacturer (*Race Tech* 195).

Teams competing in the series agree that tyres will form the major unknown factor going into the 2017 season. Concurrent with signing a new five-year supply agreement with the BTCC, Dunlop has changed its tyre specification.

The new 18-inch diameter Sport Maxx tyre is evolved from tyres used in Germany in the VLM Series. It retains the same compound as in 2016 but increases tread width by 20 mm, together with construction changes that Dunlop says will increase lateral grip and steering response.

FASTER LAP TIMES

Last year tyres were produced in medium compound, used in two of the three races of a BTCC meeting, and a softer option, which had to be chosen for use in one race. Now there will be three formats, 'Prime' distinguishable by its yellow sidewall marking, and two versions of 'Option', with a titanium marking. As previously the Prime will be used in two races of a meeting. At Donington Park and Silverstone, the Option for use in the third race will be of a harder compound, while at all other meetings it will be of softer compound. At Thruxton, the fastest circuit on the BTCC calendar, the Option Hard will be used for all three races.

When announcing the tyre changes, Dunlop had predicted increases in lap speeds and pre-season testing at Portimao in Portugal saw lap times cut by a second. Lap times at BTCC rounds are predicted to be drop by half a second on average.

Speaking to *Race Tech* at the Donington test, Halfords Yuasa Honda driver and three-time champion Matt Neal said that the differences in the new car were not being seen in lap times yet but the car certainly felt different to drive.

"Because the carcass is stiffer, the tyre feels harder than last year, even though the compound hasn't changed," Neal said. "You are going to have to change the way you drive the car between the two types of tyre, because you can't carry the speed in with the harder tyre. It makes it a different challenge, something else to think about."

Dunlop has also made changes to its wet tyre – a revised tread pattern and the same 20 mm tread width increase is said to improve aquaplaning resistance. RT

Works BMWs back in BTCC

Andrew Charman

SUNBURY-ON-THAMES, UK: BMW has entered a manufacturer team in the 2017 British Touring Car Championship, rejoining the series in an official capacity for the first time since 1996. The move sees the three BMW 125i cars of leading BTCC team West Surrey Racing (WSR) upgraded in status from constructor to full manufacturer entries.

WSR has been campaigning BMWs in the BTCC for 10 years, and with sustained success. The team took the 2014 drivers title with Colin Turkington, and the manufacturer/constructor title in 2016 when driver Sam Tordoff finished second in the drivers' championship after leading it for most of the season.

Unveiling the cars in the familiar blue and red striped livery of BMW Motorsport during a launch event in London on 24 February, BMW UK managing director Graeme Grieve told *Race Tech* that full manufacturer status would allow BMW more control over the marketing of the team's success.

He insisted, however, that the programme would still be run by WSR. "We've put financial support behind it to make the engine development happen, but it is very much West Surrey's design, their car."

Grieve added that the programme was a BMW UK initiative, not involving BMW Motorsport in Munich.

Up until this season, WSR's three 125i M-Sport machines have been running original 2.0 litre Super 2000 engines from 2007, converted from normally aspirated to turbos. However, 2017 BMW BTCC cars will debut new engines, designed and built by Neil Brown Engineering to the NGTC regulations of the series, and based on the latest modular units used in the BMW 125i road cars.

Meanwhile, WSR is receiving sponsorship and technical support from Physical Digital which has already 3D scanned the WSR BMW engine and provided high-accuracy data to the race engineers in time for them to make alterations and improvements to the engine before the season starts. RT

BELOW Welcome back: Familiar colours return as a BMW works team enters the BTCC in 2017

Photo: BMW

Photo: FIA WTCC

BELOW Select entry: Citroën (left) are independents in 2017 leaving Volvo and Honda to fight out WTCC manufacturer honours

No second class as WTCC field revealed

Andrew Charman

PLANS by the World Touring Car Championship to add a second WTCC 2 category have been delayed by a year. As reported in *Race Tech* 195, the series gained approval in November for a second class for cars conforming to the FIA's TCN2 formula, effectively the specification created two years ago for the TCR International category launched by former WTCC promoter Marcello Lotti.

The move was clearly aimed at maintaining grid sizes in the WTCC following the withdrawal of the Citroën and Lada works teams at the end of the 2016 season.

However, at its meeting in Geneva on 9 March, the FIA announced a year's postponement for the new class, "to allow the Touring Car Commission and the Promoter to focus entirely on the main category (TC1) in 2017."

On 14 March the WTCC unveiled a 16-car provisional entry list, and insisted that the series was set for "its most open season for a number of years." The last three seasons have been dominated by the Citroën works team – it has won the manufacturer title in all three years and José Maria López has taken all three drivers titles.

The only manufacturer entries in 2017 will be the three Civic Type R cars of Honda and the three Volvo S60s entered by Polestar Cyan Racing. Four Citroën C-Elysée cars remain in the entry, three of them under the Sebastian Loeb Racing banner, while RC Motorsport is entering two of the former works Lada Vestas.

Announcing the entry list, WTCC organisers added that the regulations permit race-by-race entries and several teams are still discussing terms.

Meanwhile, the FIA Touring Car Commission has confirmed that it wants to establish a touring car framework for regional championships that "will play a key role in establishing a touring car pyramid – as found in other disciplines with world, regional and national levels". It announced that it will soon invite various promoters to tender to run these championships. RT

2017 DTM Audi makes track debut

William Kimberley

VALLELUNGA, Italy: The 2017 Audi DTM challenger made its track debut at the Vallelunga test in mid March. It was driven by Mattias Ekström, the most successful Audi DTM campaigner of all time with 22 victories and two championship titles under his belt who reeled off 760 km in the process. The car featured bodywork of the third-generation RS 5 DTM which, compared with the variant shown in Geneva, sports additional, innovative detailed solutions.

"We tried out a lot of different things — short stints, long runs, qualifying simulations and many different set-up variants," said Ekström. "The new DTM cars are definitely more demanding in terms of driving skills. Plus, finding a perfect set-up compromise for the softer tyres and the changed aerodynamics is a great challenge. The season is going to be packed with excitement for sure!"

"It was important for us to drive the final car in this last pre-season development test and to make optimum use of the few test days available to us in the DTM," said head of Audi motorsport Dieter Gass. "That's why we're very happy to have found perfect external conditions at Vallelunga and being able to drive for three days without any issues worth mentioning." RT

Photo: Audi

ABOVE The 2017 Audi DTM challenger featured some bodywork updates compared to the car shown at the Geneva Show earlier in the month

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Photo: IndyCar

BELOW Light 'em up: IndyCar allowed extra brake cooling to be added to the cars ahead of the season-opening race in St Petersburg

Brake issues in focus at IndyCar opener

Andrew Charman

INDIANPOLIS, IN: Verizon IndyCar Series teams were permitted to make modifications to allow extra brake cooling ahead of the 2017 season-opening race, as a war of words escalated between brake supplier Brembo and the series organisers.

Teams running pre-season tests on road courses reported several instances of brake overheating, including rear brakes locking and one team reportedly exceeding the maximum temperature for the rear brake callipers, causing the piston seal to fail.

IndyCar decided following the 2016 season to change its brake supplier from Brembo to Performance Friction Corporation (PFC), after long-running reported complaints from teams over the consistency of the Brembo discs.The sanctioning body decided that for 2017 PFC discs and pads would be used with the Brembo callipers, with a full change to PFC products in 2018.

The overheating issues were said to involve the greater heat levels dispersed by the PFC pads and discs being retained by the Brembo callipers.

On 11 March, the eve of the IndyCar opening race at St Petersburg, California, Brembo issued a statement in response to what it described as an "alleged problem caused by excessive brake temperatures." The term alleged was thought to be due to Brembo not being part of IndyCar's testing procedure and thus unable to check for brake issues, the company statement even quoting a story in *Racer* magazine as the source of its information.

"For the year 2017, Brembo has not been asked to attend, contribute or participate in Indycar Series brake development (rotors, pads and bells), as Indycar, PFC and the competitors have elected to assume such responsibility," the Brembo statement read."We have no way of establishing whether there are any issues with Brembo callipers being used by Indycar competitors as the most recent, and only, brake test Brembo attended was in Road America in the summer of 2016. From that test there was no evidence of issues with the use of Brembo callipers with PFC brake components."

The statement went on to emphasise that the callipers designed and supplied to IndyCar since 2011 are specified products that have not been modified or developed due to the series regulations and Brembo's agreement with IndyCar. Competitors had been issued with technical bulletins covering all performance and safety topics of the callipers, including a series-wide bulletin specifying a maximum running temperature of 210°C in 2012.

"We recommend that each competitor operate Brembo callipers within the defined specifications. Reliability is not guaranteed outside these specifications and the magnitude of the deviation may result in extremely dangerous conditions," Brembo added.

As *Race Tech* went to press IndyCar had made no response to the statement. However. entrants in the St Petersburg race were permitted extra cooling to try to reduce rear brake temperatures. The rear ducts were extended in size and the race went ahead without further brake issues. RT

Chevrolet and Honda have both signed what are described as 'multi-year' extensions to continue supplying engines to the Verizon IndyCar series. The announcement follows similar extensions agreed with chassis manufacturer Dallara and tyre supplier Firestone, and IndyCar is hopeful the resultant stability will encourage further OEMs to join the series. Reports suggest a European-based engine manufacturer is showing serious interest in entering IndyCar, potentially from 2019. RT

IndyCar's first test with its universal aero kit under development for the 2018 season is expected to take place in early August. Continuous progress has been made since the series unveiled its first renderings of the new design at the North American International Motor Show in Detroit in January. RT

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NASCAR likes its new stage

Andrew Charman

AS reported in *Race Tech* 196, races in all three of the sport's lead series, the Monster Energy Cup, Xfinity Series and Camping World Truck Series, are now separated into three stages, the first two of equal length and the third longer. Championship points are awarded for the top 10 finishers in each stage, before the full race points are awarded based on the finishing order in the final stage. In addition, stage winners earn a bonus point to take forward to the end-of-season playoffs, should they qualify for the 10-race knockout finale.

The first three races of the season in the lead Monster Energy Cup have seen more intensive racing at the end of each stage, which appears to have gained approval from spectators both at the tracks and on television – NASCAR TV figures are up so far this season after a general decline in recent years.

The opening race of the new format, the Daytona 500, was marked by several multi-car accidents, though drivers refused to blame the stages. "I think it's the extreme of the Daytona 500 and these (restrictor) plates, the way we have to race," said A J Almendinger after the race. "Now with the stages, points being on the line, things are going to happen."

NASCAR development head Steve O'Donnell also professed himself happy with the format, saying that it had made the race flow and drivers drive hard all race long, which is what is expected of the new format.

Teams are still working out their strategy in stage races, particularly when to schedule refueling stops, and young drivers Chase Elliott and Kyle Larson both lost a chance to win the Daytona 500 when they ran out of fuel in the final laps. Elliott had started on pole and in total led 39 of the 200 laps. Retaking the lead with 25 laps to go, he looked set to score his first top-level NASCAR win until running short with three laps to go and finishing 14th.

The accidents also saw several drivers eliminated from the Daytona 500 under NASCAR's new five-minute rule, that allows teams only five minutes to repair accident damage to a car on pitlane before retiring it. Previously patched-up cars would rejoin the race many laps down in the hope of slightly increasing their points scored. RT

ABOVE Stage fright? NASCAR drivers refused to blame the new stage format for the wrecks that broke up the Daytona 500

Jerry Markland/Getty Images for NASCAR)

NASCAR ensures penalised teams do not advance

ATLANTA, GA: NASCAR has made its first penalties under recently introduced 'encumbered finish' rules.The Joe Gibbs Racing Toyota of Kyle Busch that won the second-division Xfinity Series race at Atlanta Motor Speedway on 4 March was found to be too low at post-race inspection. The team lost 10 points in the owners' championship, crew chief Scott Graves was fined $10,000 and suspended for one race, and the victory declared encumbered, which means it does not qualify Busch for the end-of-season championship playoffs, which a win normally would.

In fact, the penalty does not affect Busch as he is not competing for the Xfinity Series title – drivers that compete across NASCAR's three lead categories must declare which one they will score points in.

A J Almendinger's JTG Daugherty Racing Chevrolet was found to have only 17 of its 20 lug nuts secure at the end of the Atlanta Monster Energy Cup race. As well as a loss of 35 driver and owner points and a $65,000 fine and three-race suspension for crew chief Randall Burnett, the encumbered finish designation means the points earned for the 26th place finish will not count in qualifying for the Playoffs.

The Camping World Truck Series Chevrolet driven by Chase Elliott also failed inspection after its race for being too low, the fifth place finish being encumbered, and crew chief Jeff Stankiewicz being fined $5,000 and suspended for the next race. Stankiewicz also earned an extra $2,500 fine for a single unsecured lug nut. The team was docked 10 owner championship points but no driver point penalties were issued because again Elliott is only scoring points in the lead Monster Energy Cup. RT

ABOVE Lowdown: Kyle Busch's Xfinity Series Toyota was penalised under the encumbered finish ruling at Atlanta

Toyota Racing

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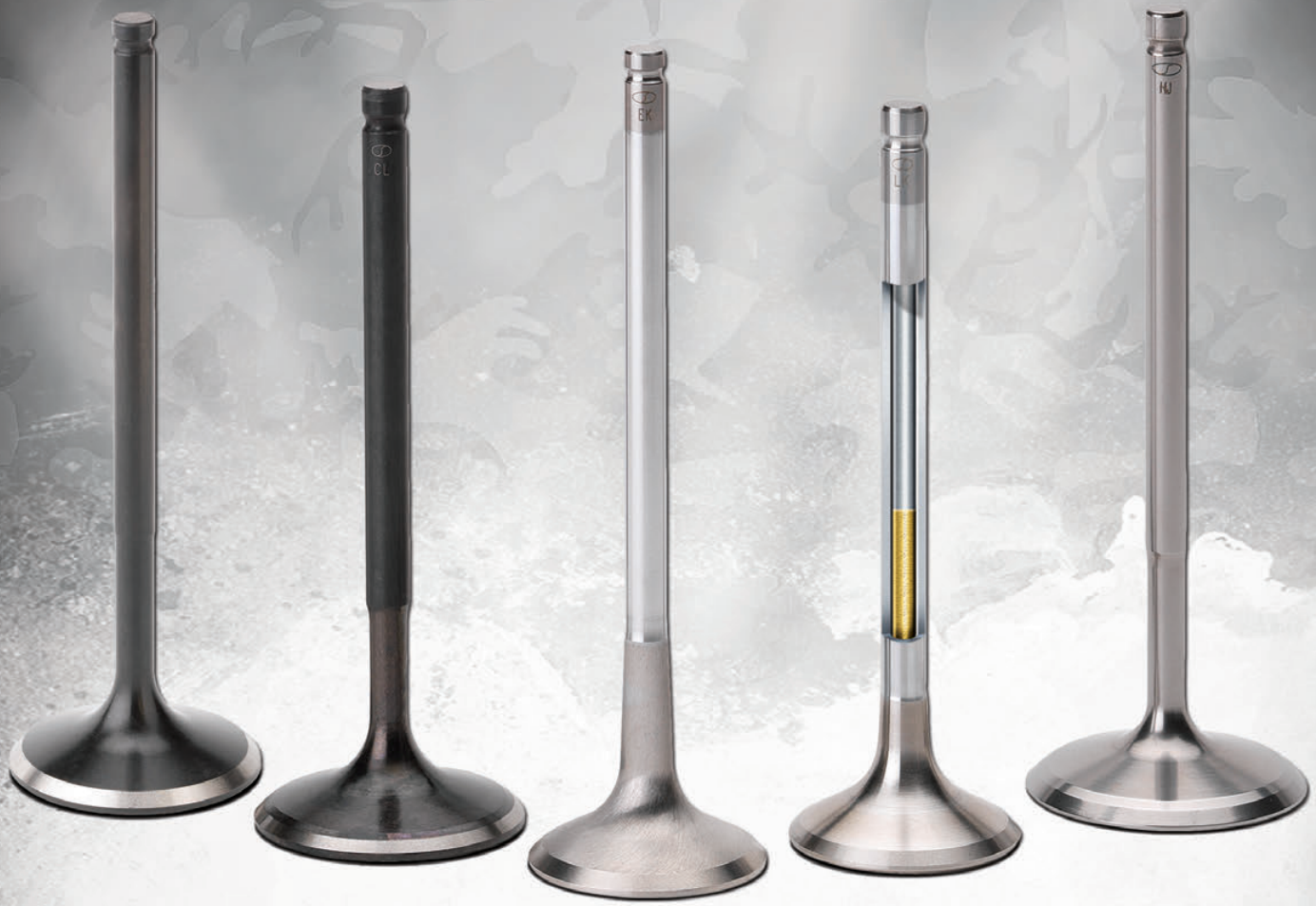

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VW Rallycross Supercar revealed

Hal Ridge

STOCKHOLM, Sweden: Ahead of the opening round of the FIA World Rallycross Championship in Barcelona, double series champion Petter Solberg's PSRX Volkswagen World RX Sweden squad revealed its 2017 Volkswagen Motorsport-built Polo GTI Supercar in Stockholm.

The Polo GTIs that Solberg and Swede Johan Kristoffersson will race this year have been built in Volkswagen Motorsport's Hanover workshops and are an adapted version of the 2014 FIA World Rally Championship title-winning machines. Volkswagen chose to use that specific year of car as subsequent variants of the successful chassis were fitted with a paddle-shift gear change system, which isn't permitted for use under FIA rallycross regulations.

"This is three and a half months of work, so it's not a revolution. We started with a well-known WRC car from 2014, so this is a rally car that we've adapted to rallycross rules," said Volkswagen Motorsport technical director, Francois-Xavier Demaison. "The transmission and cooling are very specific for rallycross and we've used a 2.0-litre turbocharged engine we've developed for the GRC (for use in the Andretti Autosport Volkswagen Beetles). This has been a big effort."

BELOW The 2017 VW Polo thathas been developed for Peter Solberg's PSRX team is based on the 2014 WRC title-winning version of the car

The car displayed at the team's launch wasn't either of the Polos that it will field in competition this season and as such didn't house a rear-mounted radiator as traditionally used in rallycross Supercars. However, Demaison says that from recent tests at various World RX circuits around Europe, the German outfit is still evaluating where the preferred location for mounting the cooling package will be when the Polo hits World RX competition. "It's much more simple to run the radiator in the front, so we would like to try that in a race for sure," he said. "It's a nice part of World RX that you don't have a homologated car like in the WRC, so you can adapt to the conditions and there are different solutions." RT

WRX ambition behind new Mitsubishi Mirage

Hal Ridge

LLANDYSUL, UK: British and European Rallycross driver James Grint has joined forces with Welsh rally team Spencer Sport and Swedish firm Mpart (formally Ralliart Sweden) to develop a Mitsubishi Mirage Supercar. The team's plan is to develop the new machine in the MSA British Rallycross Championship this season before moving to international competition in 2018, with a view to competing in World Rallycross Championship events long-term.

The new Mirage, which is based on Mpart's existing Mitsubishi R5 rally concept, features a longitudinally-mounted 2.0-litre, 16v, turbocharged engine.

Mated to the engine is a Unic 5-speed sequential gearbox, similar to the transmission used by Petter Solberg in his privately-run Citroen DS3 in recent years, while each corner houses a McPherson suspension setup and Ohlins dampers.

"We believe that you get better weight distribution by using a longitudinal engine and transmission layout," said Grint. "The way the Unic transmission is designed means that the gearbox is right in the middle of the car. I think it's going to be really well balanced. The chassis has almost no overhang so we've got the cooling package really well located in the rear of the car too."

The Mirage also uses a rallycross-specific Alcon brake and clutch package. The car is expected to make its competition debut at the second round of the British RX series at Lydden Hill on 17 April. RT

ABOVE The facelifted Mitsubishi R5 upon which the new Mitsubishi Mirage being developed by Mpart is based

Low-cost electric single-seater announced

ABOVE A prototype low-cost electric single-seater has been testing in Zolder prior to going into full production later in the year

William Kimberley

GENEVA, Switzerland: The result of three and a half years work, the Formulino E, a low-cost electric single-seater, has been revealed at a conference in Geneva. Based on a 2007 Formula 3 Dallara, it has been developed in Belgium by a consortium of specialist companies led by Punch Powertrain.

With its roots in the OE market as a supplier of CVT transmissions to the Chinese automotive market as well as to Hyundai and Kia, it offers a complete portfolio of powertrain solutions – conventional, hybrid and full electric – for the most popular passenger car segments. It has had the responsibility of developing the main technical characteristics of the Formulino E car and its drive system (EP2-R), including the battery, electric motor, power electronics and vehicle controls.

The electric motor is a unique integrated concept with a switched reluctance machine operating at 660V that delivers up to 120 kW. However, it can be upgraded to 200 kW (272 hp). Combined with the low weight of just 600 kg, the Formula 3-based car sprints to 100 km/h in four seconds and has a top speed over 200 km/h. The package lasts between 15 to 20 minutes and a one-minute battery swap is being evaluated.

Other companies in the consortium include race team Prospeed Engineering, which is providing logistic support, HERONsports that supplies engineering services for racing and automotive projects, and ACT, which is acting as the consortium co-ordinator and adviser.

With a prototype of the car having already been tested at Zolder, the objective is to go into series production and produce 20 cars by end of this year and sold at a target price of €80,000 to racing schools and promoters of support races. The project has no official link with either Formula E or the FIA but it is hoped that it might become a support series for either Formula E or the new Electric GT category.

Nine manufacturers commit to Formula E

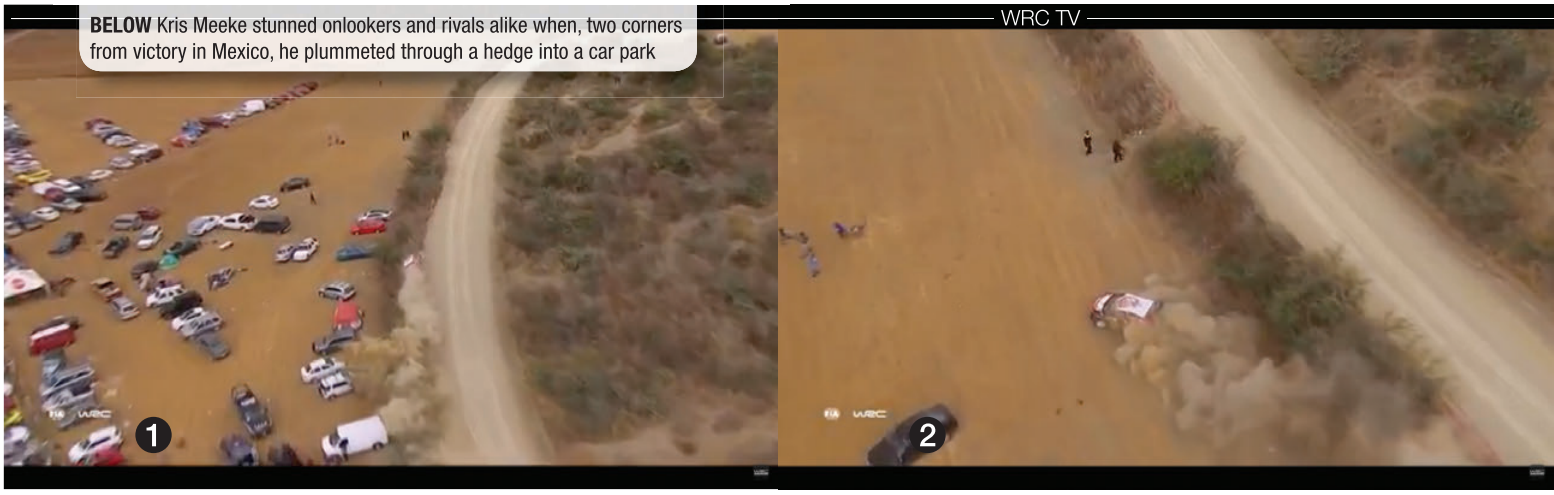
William Kimberley

PARIS, France: The FIA has released the names of the nine manufacturers that have been granted the homologation for the fifth, sixth and seventh Formula E seasons. They include ABT Formel E, BMW, DS Automobiles, Jaguar LandRover, Mahindra Racing, NextEV10, Penske Autosport, Renault and Venturi Automobiles.

The 2018/19 season five sees the introduction of cars that have to compete the entire race distance that will be powered by homologated powertrains from different manufacturers. It means that the powertrains will fall into line with the new cycle of homologation for the chassis and battery, which will remain standard up to the end of season seven (2020-21.) Therefore, any new manufacturer wishing to homologate their powertrain will be able to do so for season six for a two year period and for the next one with an annual duration.

"Motorsport serves as a tremendous research and development laboratory and I am convinced that the Formula E is the motorsport of the 21st century," said Yves Bonnefont, DS Brand CEO. "We are proud to have been selected by the FIA as official manufacturer. DS Automobiles and its motorsport division DS Performance have succeeded in forming a technological bridge that will enable our customers to drive high-performance electric and hybrid models. After DS 5 Hybrid 4WD, the DS 7 CROSSBACK will have a plug-in hybrid/petrol powertrain model, named E-Tense. In the future, each of our models will have an electric or hybrid version."

"The FIA Formula E Championship has been going for a little over three years now and already it has established itself as one of the most interesting and innovative race series, not just because of the actual format of the events but also and above all, because of its technical development," said FIA president, Jean Todt. "The homologation of the powertrains that will be used as from season five is a very significant step because it means the cars will be able to run for twice as long while, at the very least, maintaining the same performance level. This highlights how motorsport can stimulate and accelerate development of new technologies which can then be applied to road cars and in this case, it has even more of a key role, given that at the moment, electricity is one of the more practical alternatives when it comes to finding new forms of more sustainable mobility in the future."



BELOW Kris Meeke stunned onlookers and rivals alike when, two corners from victory in Mexico, he plummeted through a hedge into a car park

IN THE HANDS OF THE GODS

Kris Meeke's Mexico WRC victory – surviving an unbelievable last-gasp plunge into a packed car park – prompts **Anthony Peacock** to ask: Just how much of motorsport is down to luck?

AS Kris Meeke himself put it, his Rally Mexico victory was "in the hands of the Gods" after he unexpectedly entered that dusty car park during a dramatic final stage. Although 'entered' is something of a euphemism under the circumstances: he exploded into it sideways through a hedge, using a spectator's handily-placed Volkswagen Passat as a brake.

From our comfortable and stress-free vantage point of the helicopter images, it may have seemed obvious that the quickest way to solve this unfortunate sequence of events was simply to keep going and turn right. But that's like looking at a maze from above. Engineers place drivers and co-drivers as low down as possible in a rally car to optimise centre of gravity. From inside the Citroen C3 WRC, every one of those parked cars will have looked like a skyscraper.

Meeke's "how do we get out of here?" sounded relatively calm under the circumstances: co-driver Paul Nagle's "Jesus Christ, Kris!" moments before less so. They set off down a row of parked cars and handbraked back round them only because the row was getting narrower and Kris sensed a dead end approaching. He absolutely wasn't to know that there was a hole in the hedge – different to the one they had just created – that would miraculously grant them a way back onto the stage. It was pure luck, nothing else.

BELOW "It felt like a lifetime," admitted Meeke as his 37-second lead ebbed away, the C3 WRC frantically trying to find a way back onto the stage

And that's the thing with rallying compared to many other forms of motorsport. It's just as precisely engineered and calculated as anything else, but there are so many diverse parameters to factor in – because of the variety of distance covered – that it's much more open to chance.

It was Kimi Raikkonen, perhaps surprisingly, who put it the most eloquently. "When you go off on a racing circuit, you mostly know what to expect," he said during his first season of the World Rally Championship in 2010. "In rallying, you have really no idea."

Sometimes the odds fall in your favour – and you might find a car park with a convenient way out – and sometimes they don't. Yet the vicissitudes of fate can be equally fickle when it comes to racing drivers: Ayrton Senna, after all, didn't have a single broken bone in his body following his fatal accident – only the random pattern in which the debris flew caused the one penetrating injury that killed him. The butterfly effect of chaos theory applies to all motorsport, but particularly rallying.

Ask any leading rally engineer what the proportions are of driver skill, car excellence, and pure luck needed for success and they'll come up with a wide array of answers, but none of the four engineers we spoke to put luck at any less than 20% in the overall equation: a relatively huge proportion for sport that is meant to be predicated on science.

But that shouldn't be too surprising, because another mathematically-proven truism is that co-incidence happens more often than most people think. In 1986, Cambridge professor John Littlewood calculated that each person can expect to experience an event with odds of one in a million on average once every month: a finding that came to be known as 'Littlewood's law'. So should we be surprised, for example, that Jari-Matti Latvala's first rally was the 2002 Rally GB, which he finished on November 17, in 17thh overall, after 17 stages, aged 17?

Most of the memorable 'coincidences' in rallying are of course more to do with lucky escapes. One of the most miraculous ones was Roman Kresta on the 2002 Rallye Monte-Carlo, when the Czech driver had what can only be described as an 'Italian Job' moment, dangling on the precipice of a sheer drop, his Skoda Octavia WRC held in place only by a telegraph pole.

Another similar moment befell the Skoda Fabia S2000 on the 2012 Sanremo Rally, when Juho Hanninen (now a Toyota WRC factory driver) went off the road and ended up neatly parked on the roof of somebody's house. "It was so weird that it took some time to work out exactly what had happened," said co-driver Mikko Markkula.

Then there was Colin McRae's accident on the 1999 Rally Australia, when the bonnet of his Ford Focus WRC slammed violently sideways into a tree. "Just a few centimetres further back," said co-driver Nicky Grist, "and it would have been goodnight Mr Grist, no question."

There are hundreds of these examples every year, defying the belief many rally drivers hold that they are eternally unlucky.

"If I won the lottery one day," said Mark Higgins, denied his best-ever WRC finish after Ford withdrew all its cars from Rally GB in 2001 after Carlos Sainz hit some spectators (without lasting consequences). "I bet I'd lose the ticket." He's not the only one. As Mario Andretti famously said of Chris Amon in Formula 1: "If Chris became an undertaker, people would stop dying."

But the plain truth is that there's just as much – if not more – good luck out there than bad luck: especially in rallying. Mathematics falls firmly on the side of optimism. As Meeke has ably demonstrated. RT

ABOVE They had won, by 13 seconds, but the crew were initially too shocked to enjoy the celebrations

SCI-FI DREAM TO BECOME REALITY

The car of the future? **Craig Scarborough** finds F1 inspiration behind motorsport's first autonomous racecar, the Robocar

RACE TECH has long looked closely at the racecar, rather than the bio mass in the cockpit, the nut behind the wheel or what's more commonly called the driver. So, when a 1600 hp, sub-1000 kg racecar with F1 levels of downforce appears, it's right to scrutinise the resulting machinery. But, with Roborace there is a twist: there is no cockpit, no steering wheel. This is the first step into autonomous racing with electric cars being raced by Artificial Intelligence (AI).

Software rather than driver. This interesting new branch of motorsport is unlike anything that has gone before, but there remains a seriously impressive car here, with or without a driver.

WRAPS COME OFF ROBOCAR

When first announced, the Roborace series launched with a futuristic 'racecar' design concept to herald the new era of driverless racing. Like a scene from a science fiction movie, it was hard to believe that the Roborace car would actually appear in reality. How big was the car? How fast? What would separate the teams racing the same car with the same software?

Now the prototype car has been revealed to the public, it's clear this is a significant step in motor racing. Certainly the car is not a beefed-up radio-controlled model; this is an LMP-sized racecar, with F1 levels of downforce and power.

Testing of the hardware and software was achieved with highly modified Ginetta LMP3-based development cars, affectionately known as 'DevBots'. Used in track testing, demos and even a two-car 'race demo', they show that the autonomous software is far from an exact science, but will develop rapidly with the demands of motorsport.

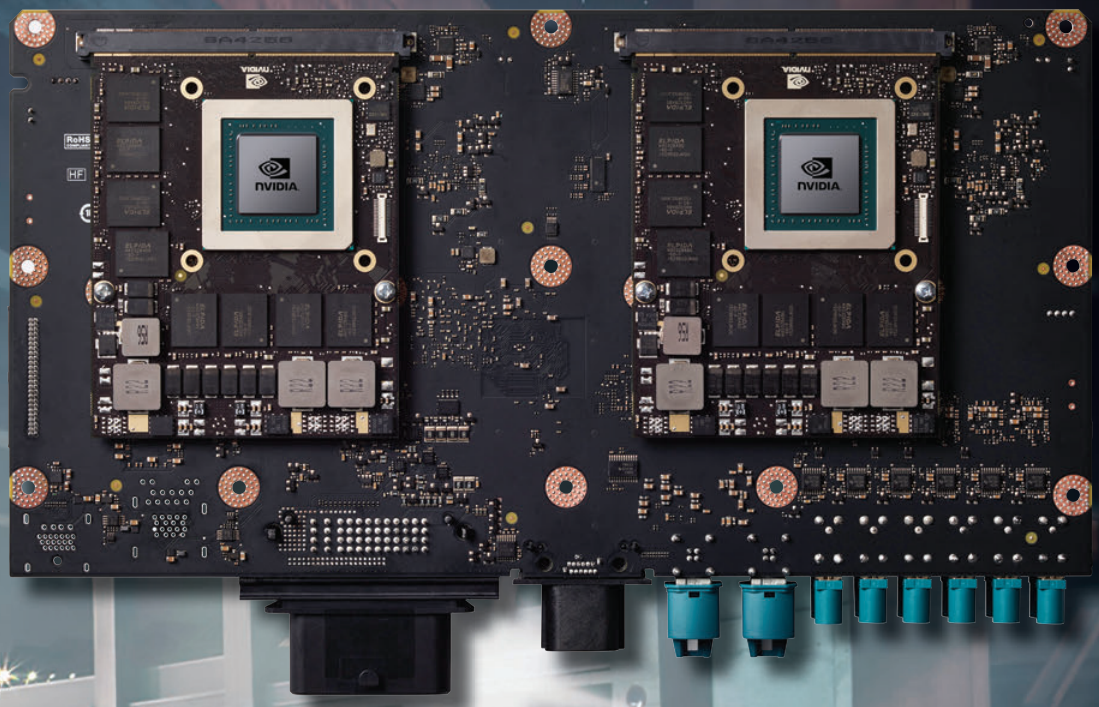
The car's striking design comes from Chief Design Officer Daniel Simon, described as a 'futurist' who has a track record of melding current and sci-fi into vehicle designs for movies. "I've worked on a lot of cool stuff – Tron, Bugatti, Star Wars – but this takes the cake," he insists.

"I am so proud of the entire team and our partners and particularly the work Daniel has done creating this beautiful machine," says Denis Sverdlov, Roborace CEO. "It was very important for us that we created an emotional connection to driverless cars and bring humans and robots closer together to define our future."

As a pioneer, the car does not have to meet any specific regulations or design criteria. So, this is a racecar unconnected to any other, with its fuselage-like central core and enclosing wheel fairings. However, the design still considers performance, so the car is equipped with a large ground-effect underbody and additional diffusers built into the nose to balance the considerable downforce created by the main Venturi tunnels.

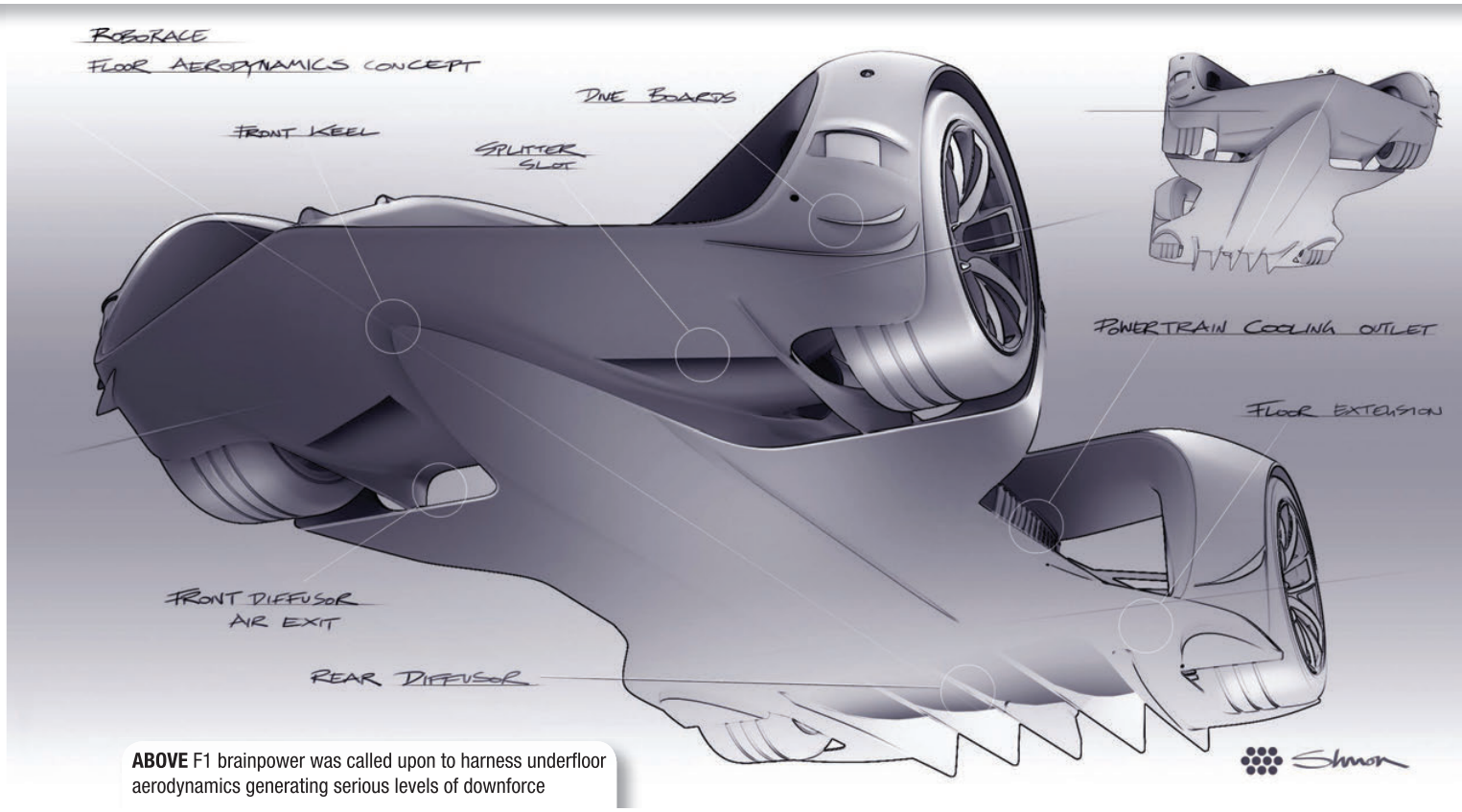
To rationalise this design and prepare Roborace for going racing, Mark Preston, formerly of the Super Aguri F1 team and currently with the Techeetah Formula E team, was brought in to advise. Working with Simon, Preston and his colleagues at PrestonEV have brought the 4m x 2.8 ▶

BELOW The brain of Robocar is Nvidia's Drive PX2, capable of up to 24 trillion AI operations per second



All photos: Roborace

ABOVE Robocar is designed to offer a platform for the world's best engineers to advance the software that could change our roads forever



ABOVE F1 brainpower was called upon to harness underfloor aerodynamics generating serious levels of downforce

concept car to life, the remit being wide from the structures, powertrain, electronics and aero standpoints.

As a result the stylized exterior of the original concept has since been refined in a wind tunnel and altered slightly to accommodate the powertrain within, but remarkably the original concept is still visibly intact. Ensuring the car's shape produces the F1 levels of downforce, it's been left to aerodynamicist Ben Wood, working in the Williams wind tunnel, to produce the final detailed shape.

At this stage, the high levels of downforce are produced solely from the underfloor. Daniel Simon explained at the car's launch that a more aggressive second generation underbody will be introduced to further increase the aerodynamic load produced by the car.

Beneath the skin, the car's chassis is based around a carbon monocoque. Between the front and rear suspension with their respective electric motors, the structure is described as an open coffin design by Rex Keen, Roborace's chief engineer. This is formed as an open box within an open box, such that the lower half bolts to mount the battery, with the void within the upper structure filled with the electronics and accessed via hatches made into the upper face. Not having to house a driver, the structure can be more compact and enclosed, which further improves the stiffness and weight numbers for the car.

To each end of the structure, the suspension is formed of conventional double wishbones and pushrod-operated springs/dampers. At the rear the geometry of the wishbones and rockers is closely matched to the Ginetta LMP3, which also formed the basis of the Devbot development car. This extends to the supply of the outboard hardware: uprights, hubs and AP Racing brakes. The rockers are mounted above the electric motor and operate coil over dampers for each wheel, an anti-roll bar and a central heave element.

The front suspension mounting, to a single-seater style narrow bulkhead, could not follow the sports prototype geometry, so a dedicated installation has been designed to balance the setup at the rear. To aid the packaging the pushrod operates a large rocker that operates torsion bar springs, separate dampers and again an anti-roll bar and heave element.

In contrast to most current race series, the wheels are sized to suit the car's styling and thus the huge wheels are oversized in diameter and slightly mismatched in width front to rear. To these wheels, Michelin provides production road car tyres, albeit the Pilot Sport S tyres also used on GT3 specification road car machinery.

Michelin's extensive facilities at Clermont Ferrand were used to assess the Robocar. Given the small startup nature of the project, Keen was impressed by the tyre giant's response. It was, he said, "to their credit" that it provided Roborace with eight days of testing, enabling the car to run on its test track and kinematics rigs, to confirm the final tyre specification.

The Robocar will test both its tyres and suspension, not just from the car weighing in at 975 kg and being loaded by considerable downforce, but also from the torque provided by four electric motors. Each radial-flux pancake-format motor is supplied by Charge, an electric truck company from the UK, and rated at 300 kW. As a package these motors give a theoretical power output of 1,630 hp and a torque output of about 1,000 Nm, the latter figure being available from just above zero RPM. These motors are driven through a Hewland reduction gearbox to drive each wheel independently. Keen recalls when putting the car through its paces in manual mode (ie the driver driving) being "easily able to light up all four wheels out of the bottom corner at Donington". With this motor per wheel format, the car can also have torque vectoring that can aid cornering performance "significantly". ▶

> *"Motor racing doesn't need autonomous tech, but perhaps autonomous tech needs motor racing?"*

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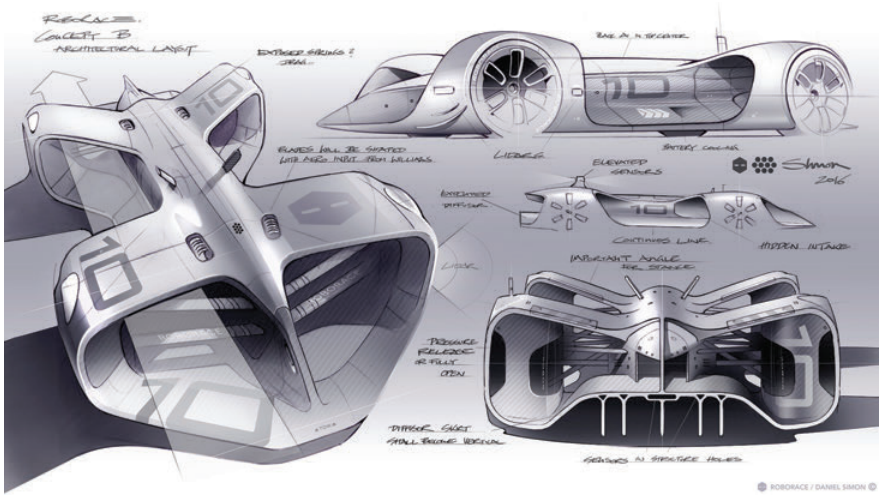
The permanent magnet synchronous motors are mounted in pairs on a sandwich plate with their separate reduction gearboxes to bring the motor RPM down to road speed. There is no multi-ratio gearbox, so the motor to driveshaft is set at a fixed final drive ratio. To supply the three-phase power to the motors, each has its own inverter supplied by Charge and mounted below the motor/gearbox assembly. Keeping weight centralised, both the motors and inverters are mounted between the axles, with little powertrain or suspension mounted beyond the axle lines. The battery packs are mounted under and inside the monocoque, there being a dedicated battery pack for each motor.

At this early stage in the project, the motors are still being matched to the inverters, which is capping maximum RPM. Subsequent calibration to match the set-up will release the full potential of the powertrain, allied to the 540 kW battery.

With such performance comes heat. There are separate cooling circuits for each system – motor, inverter and battery – there being electric pumps circulating the dielectric fluid around each system and into PWR-supplied radiators mounted either side of the chassis. These are fed by cooling inlets and outlets secreted within the fuselage, hidden by the wheel arch bodywork.

Finally, allowing the electric powertrain to operate safely is an extinguisher system. This is supplied by FEV for the electronics, while the battery gains a Formula E specification water jacket system. In the event of the battery suffering thermal runaway, surprisingly, water is used to cool rather than stop the reaction. Connectors visible through the fuselage bodywork allow fire marshals to connect pipework to then pump through significant amounts of water to keep any thermal reaction in the battery and thus temperature under control.



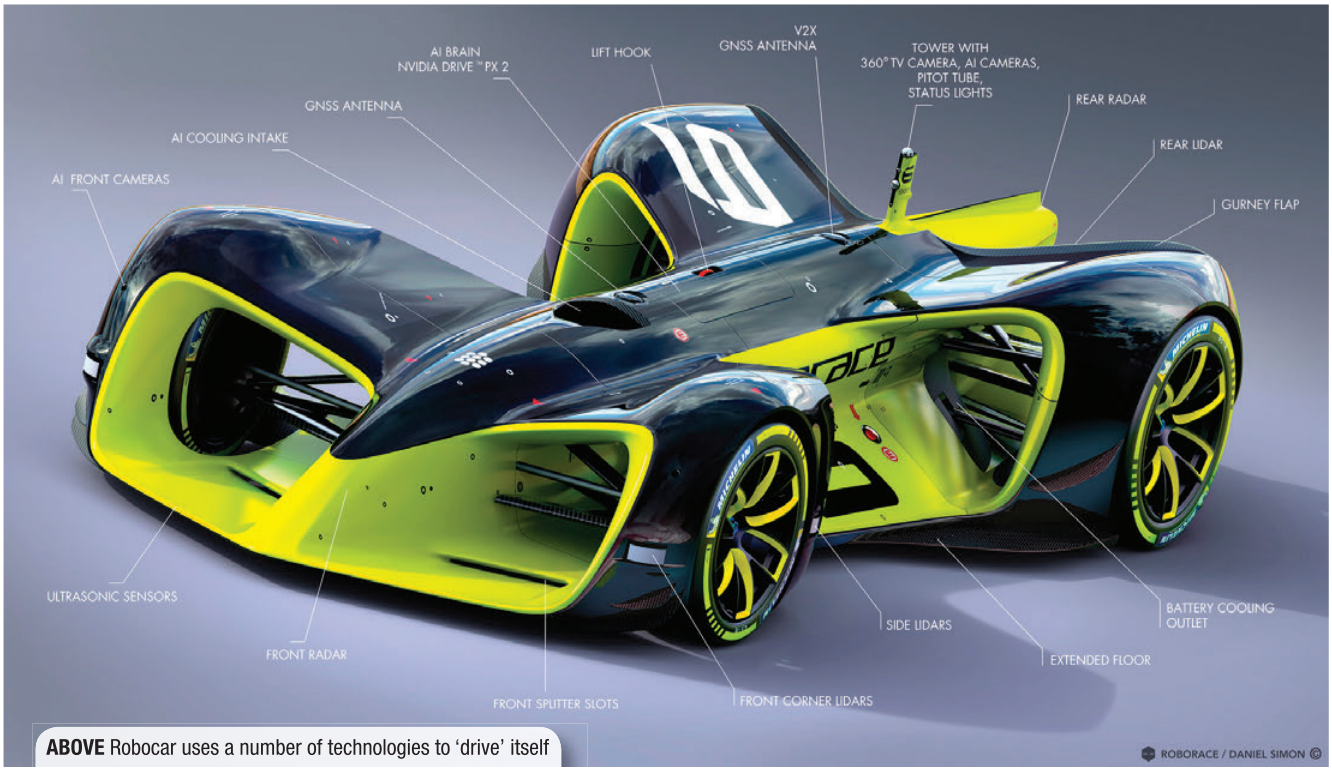
ABOVE Daniel Simon's original Roborace concept drawings

SEPARATING THE MEN FROM THE TOYS

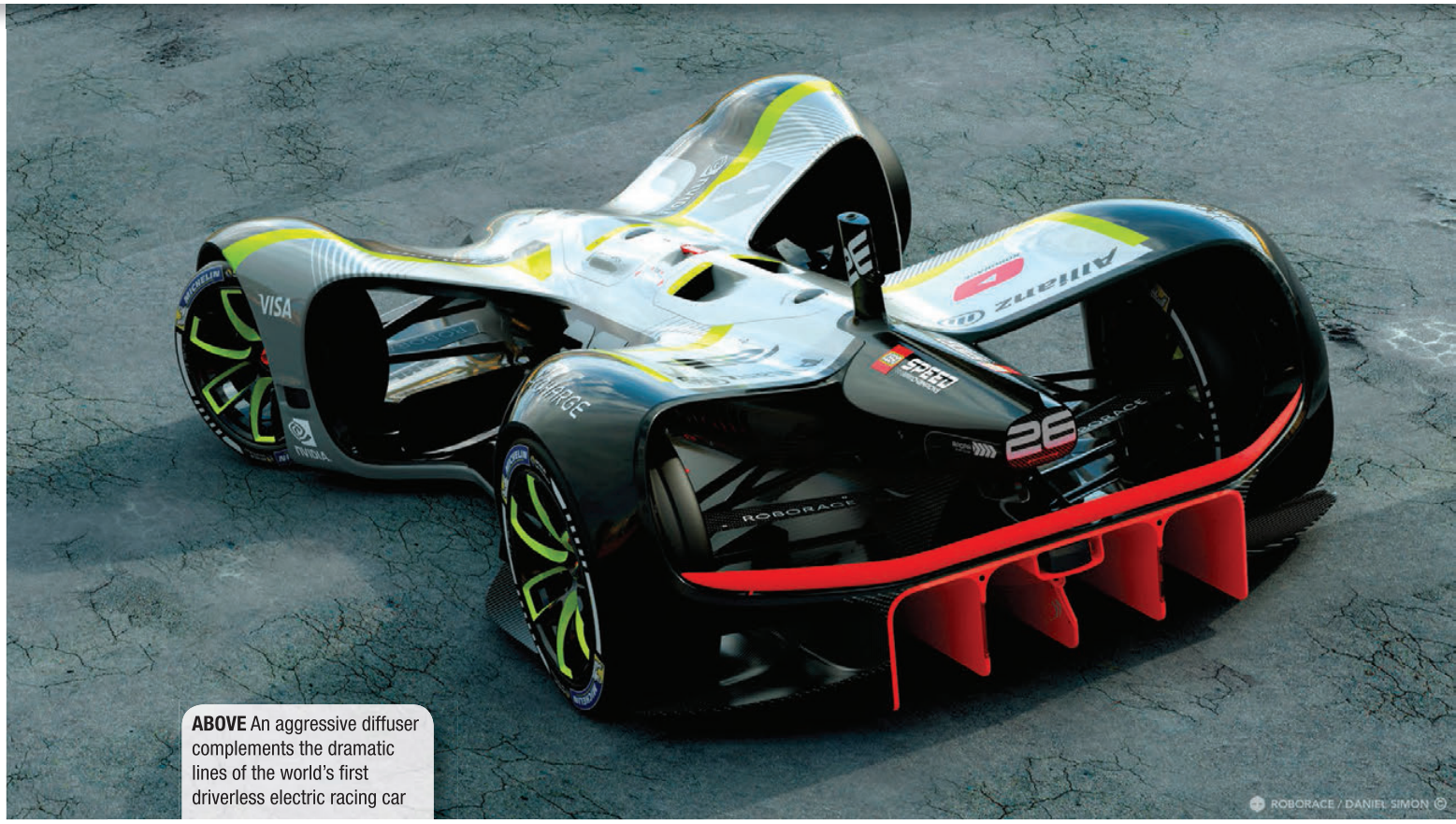
At this point in a typical racecar review, the words would stop, but for Roborace the 'driverless' aspect brings two further chapters: the control systems and the AI technology to operate them. For the Robocar, there being no 'driver', the steering, brakes and power are controlled via the AI system. Using Shiftec hardware, the brakes are pneumatically-operated, while there's a Mitsubishi electrically power assisted steering rack operated by another Shiftec controller.

Having electric final drive means there's no physical throttle, gearshift or clutch to be controlled. The application of the electric power is via a data interface between the AI and powertrain control units. While preparing for a run on track the pneumatics hiss and buzz, almost communicating in a modem-like language.

Technical partner Nvidia supplies the ▶



ABOVE Robocar uses a number of technologies to 'drive' itself



ABOVE An aggressive diffuser complements the dramatic lines of the world's first driverless electric racing car

ROBORACE / DANIEL SIMON

control unit that takes the inputs from the large array of sensors on board and with the Roborace-developed AI provides outputs to the control systems to run the car. This is a large and powerful unit, with the PX2 brain, capable of up to 24 trillion operations per second!

As well as the more typical racecar sensors, such as triaxial accelerometers and speed sensors, there is also a TPMS and Kistler wheelforce input to the AI. Thereafter, we move into new territory for racecars with five Lidars (Light Imaging, Detection, And Ranging), two radars, 18 ultrasonic sensors, two optical speed sensors, six AI cameras and GNSS (Global Navigation Satellite System) positioning.

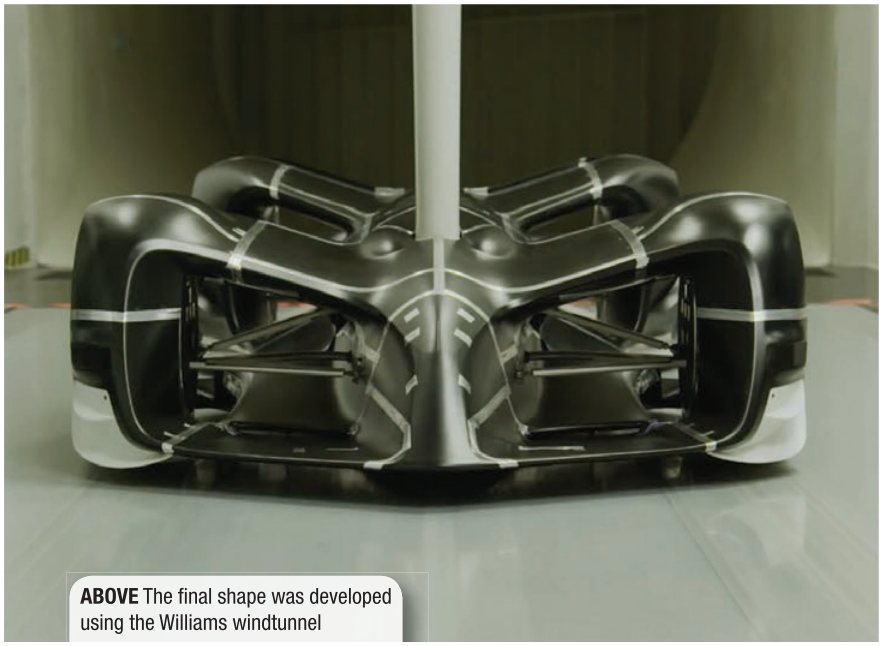
Lidars are laser-based radar systems, already widely used in adaptive cruise control and collision detection systems. Two are forward-facing, two side-facing near the front wheels and there is a single central rear-facing unit. Just as with fighter planes, radars are used with a unit looking forwards and another rearwards.

The most numerous sensors are the shorter range ultrasonic versions, arranged around the perimeter of the front and rear splitters. The AI cameras are again already common on top-end cars. They are used front and rear, with one of them mounted in the periscope-style tower towards the rear of the car. Lastly the GNSS format GPS positioning uses two aerials, with one mounted front and rear.

> *"Not a beefed-up radio-controlled model; this is an LMP-sized racecar, with F1 levels of downforce and power"*

Collectively these give the AI awareness of the race track itself and anything else on the track. While each will provide sensing for a specific size and distance, it's only when they are working collectively that the AI gains a true 360-degree understanding of its surroundings. Acquiring this full scope of 'vision' and then what the AI decides to do with the data, is what makes the autonomous system intelligent. A small team working on the Roborace project have come a long way in comparison to the huge projects run by road car manufacturers in search of intelligent autonomous systems.

Rather than the car having a 'map' of ▶



ABOVE The final shape was developed using the Williams windtunnel

the circuit preloaded into the software, the final racecar will start with learning the track and build its own maps and understanding of the layout. In testing the Devbot cars have used pre-loaded maps for safety, but even with this they still need to learn how to get the best performance from the car and track.

An example is recalled by Keen from testing, when driving figures of eight in autonomous mode. With the engineer hands-free in the cockpit, the car was probing the limits of grip. As Keen is a former race driver himself, he felt the car's AI explore the limits of traction, pushing harder to feel the slide, then ease back on the inputs to find the edge of the car's performance envelope, just as a race driver would.

THE FUTURE?

When the chassis and powertrain are fully developed, the sheer level of downforce and vectored torque will make this a seriously fast proposition. This will lead into production of the racecars, each operated as spec chassis by independent race teams. The critical task for the race team will be the further development of the base AI software. It's the nuances in decision-making, trading risk for performance when racing other cars on track, that will decide the race winner. That's far from the perceived wisdom that a series of equal cars with equal software will end up as a procession.

The coding of the AI will separate the cars, effectively giving a trademark, perhaps even personality, to the racecar, just as different drivers trade risk and performance as a human trait.

For any traditionalist race fan, there remains the question of whether Roborace, or autonomous racing in general, can be attractive as part of motorsport. After all, for many the driver is the key part of the experience.

Many of us, though, have switched on to an unknown race series on a motor racing TV channel or website, yet still enjoyed the spectacle despite not knowing who the drivers were, what their personality is, and feeling no concern for their wellbeing should they crash. In some respects, autonomous racing could provide the same spectacle.

The Roborace strapline is 'the future of motorsport'. The statement is perhaps deliberately provocative, but certainly autonomous could be 'part' of the future of motor racing.

It will still be argued that motor racing doesn't *need* autonomous tech, but perhaps autonomous tech needs motor racing? Using motorsport and race tracks as a development platform is a strategy harnessed to huge effect by road car manufacturers for decades; few buyers will risk pushing a road car to extremes of performance without manufacturers having a racing background.

Every performance car trades on racing heritage or Nürburgring track records. Perhaps it will be that future buyers of autonomous road cars won't trust the technology unless it's proven on the racetrack? Would you agree to be driven by your car through hectic traffic, if it wasn't seen winning autonomous races the Sunday before?

Clearly autonomous tech is coming, just as are electric road cars, so is this the time for motorsport to embrace this opportunity? RT

ABOVE Two 'Devbots' made history by staging the first self-driving race with two cars around the streets of Buenos Aires. The feat underlined that this is work in progress, though, as Devbot 2 crashed in a 'racing accident'

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THE inputs were clear, if not well understood or researched: "Make F1 cars five seconds a lap quicker and look faster even when they are stationary."

A Technical Group, strongly influenced by the former commercial rights holder, created the brief that has been executed for F1 2017. Wider, larger-tyred, finned and swept aero-deviced machinery has been produced, a combination of styling and a nostalgic parts bin we have seen before, but what are the actual results and consequences of this path?

Our Expert Witness casts his eyes over the launches, geometry, comments, trends and evidence from pre-season testing and asks: are we in for some long overdue classic competition, or is yet more patience required for further changes to be made, from the top down?

APPEARANCES CAN BE DECEPTIVE

Our **Expert Witness**, an F1 insider who must retain anonymity, analyses what we've learned from the first skirmishes involving the next generation of grand prix cars

Mauger/LAT

OUT TO LAUNCH

Times change, and these events are no exception. Once the domain of prestigious venues, sponsors and celebrities, practicality and schedule now dominate. The result is a quick unveiling at the track to the cameras before an official group test day pit lane opens. Or an allocated filming day, a chance to privately shake down the car over restricted kilometres and acquire some initial data behind closed doors – oh and do some filming of course.

With practicality though, comes some concessions: if the car is going to run on the track in an hour's time, then all the parts do need to be real and some of the disguised areas of important IP are less easily masked. Once testing starts a moving car, screens, parts and people can be carefully placed, but when posing hastily for the world's press outside the garage it is rather more difficult to be discreet. ▶

ABOVE Changing times. Alexandra Palace, 1997. Mika Hakkinen and David Coulthard with the Spice Girls as Davina McCall compares for McLaren, left. The trend is now more snap-and-go at the track, as for the Haas VF-17

> *"A combination of styling and a nostalgic parts bin we have seen before"*

ABOVE Dark days ahead? Testing suggested that the mission to produce faster cars had been achieved – what a shame nobody considered producing a better platform for racing

Ferrari

ABOVE & BELOW Ferrari has exploited the freedom enabling extensive turning vane assemblies with its 'letter box' solution, above. Mercedes has worked hard in this direction for some time, below

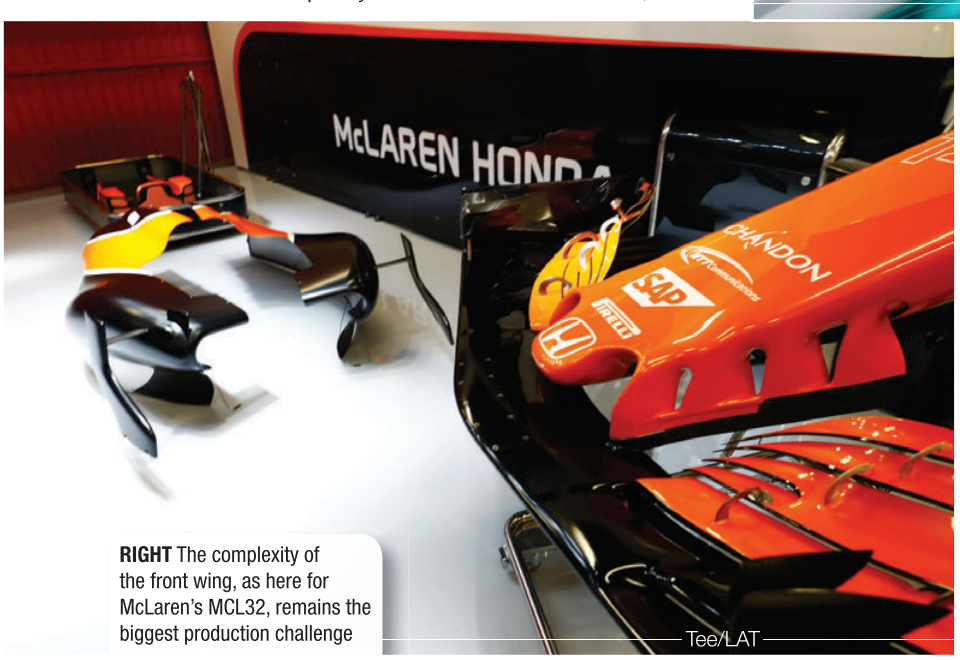
Mercedes F1

FIRST IMPRESSIONS

It's strange, isn't it? Your eyes become acclimatised to what an F1 car's proportions should be and then a rule change like this one comes along and initially the cars look not different, but wrong. Perhaps not just the car or tyre width increases, exaggerated by the lower, wider, reclined rear wing, but also the huge expanse of floor created by the ever more extreme rear bodywork packaging.

The most obvious complexity is still at the front of the cars, where legality freedom around the chassis and front of the sidepods has opened up new and extensive turning vane assemblies. Ferrari has perhaps pushed this area most, incorporating its side impact structure in its very high 'letter box'-style solution.

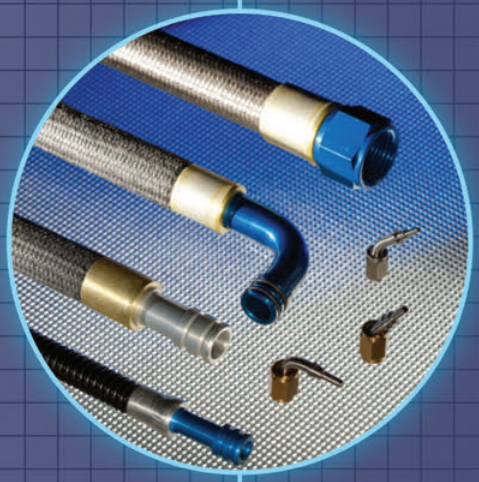
Even the front suspension, traditionally raised to stay away from the front wing wake, has been lifted to new heights with both Mercedes and Toro Rosso adopting solutions that have the top outboard wishbone mounted above the wheel rim and therefore alongside the inner tyre sidewall. It is interesting how identical these solutions are, almost as if one team member left and joined the other. Mechanically this is now a severe stiffness challenge driven by aero front and rear, with all the outer pickups at wheel centreline and above. ▶



RIGHT The complexity of the front wing, as here for McLaren's MCL32, remains the biggest production challenge

Tee/LAT

INTELLIGENCE CONNECTED



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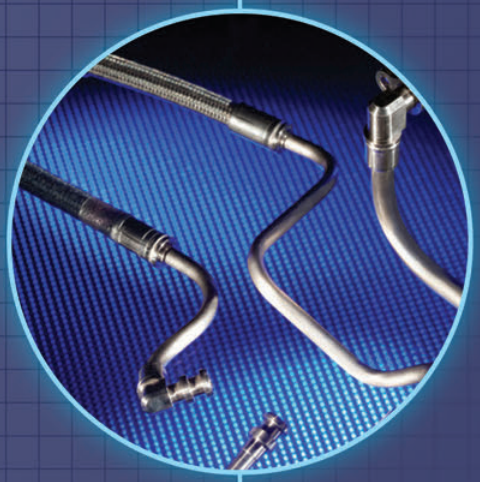

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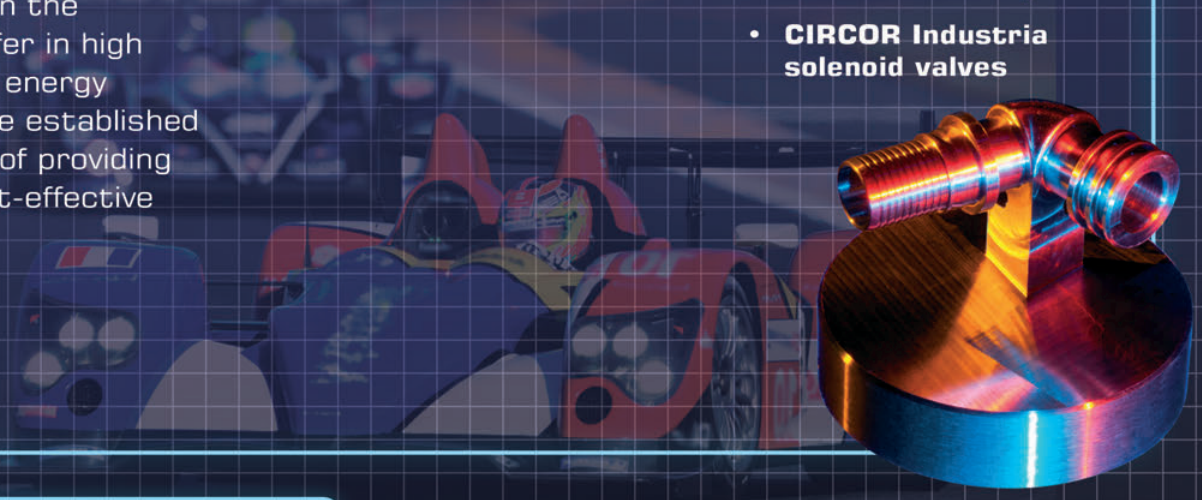

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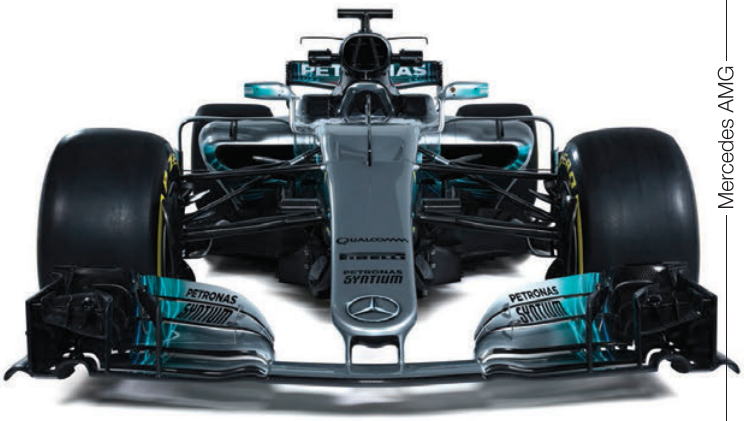
Red Bull Content Pool

ABOVE & BELOW Both Toro Rosso and Mercedes have adopted solutions that have the top outboard wishbone mounted above the wheel rim and alongside the inner tyre sidewall



Mercedes AMG

Even with the styling chevron shape, the front wings retain their place as the biggest production challenge. The sheer number of elements and complexities of design, manufacture and final assembly, coupled with the race quantities and exposure to damage, means this aero device draws more focus than any other in more ways than one.

TALKING POINTS

"We don't like the look of the new cars with engine cover fins; let's get rid of them." Well don't have space for them in the technical regulations then. The teams were belatedly asked to reconsider, there was not sufficient agreement, so they are here to stay. Fundamentally a sideforce-generating device, they would not be on the car, or so many, if it wasn't found to improve lap time. It does also seem strange having created such a significant billboard that almost none of the teams used it as advertising space in testing.

The 'T wings' at the rear corner of the engine fins make use of a slither of 50 mm dimensional legality that was left open as it was considered too small to be practically used for anything. I'll bet the team technical heads sat there and thought, 'I won't say anything and then we will,' but at least three teams have tried them so far. Expect that number to increase, per car and teams.

The most contentious aerodynamic device so far though has been suspension. Ever since active and latterly hydraulically linked suspension enabled the car's position relative to the ground to be artificially controlled, the aerodynamic behaviour of the car can be moved to its most advantageous place. Pre-season letters of clarification have been flying around to determine what interpretation is legal or not and at what point the car becomes a movable aerodynamic device. Over the last couple of seasons one car in particular, the Mercedes, seems to have controlled its ride height spectacularly well, contributing to its success. It will be fascinating to see who is now legal and how this influences pace. ▶

ABOVE Teams were belatedly asked if they would remove the engine cover fins but the horse had bolted. The use of the T-wing, seen here on a heavily-instrumented Ferrari, also surprised some but it shouldn't have

Ferrari

FORMULA 1 2015/2016 Technical Analysis

Giorgio Piola

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

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

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

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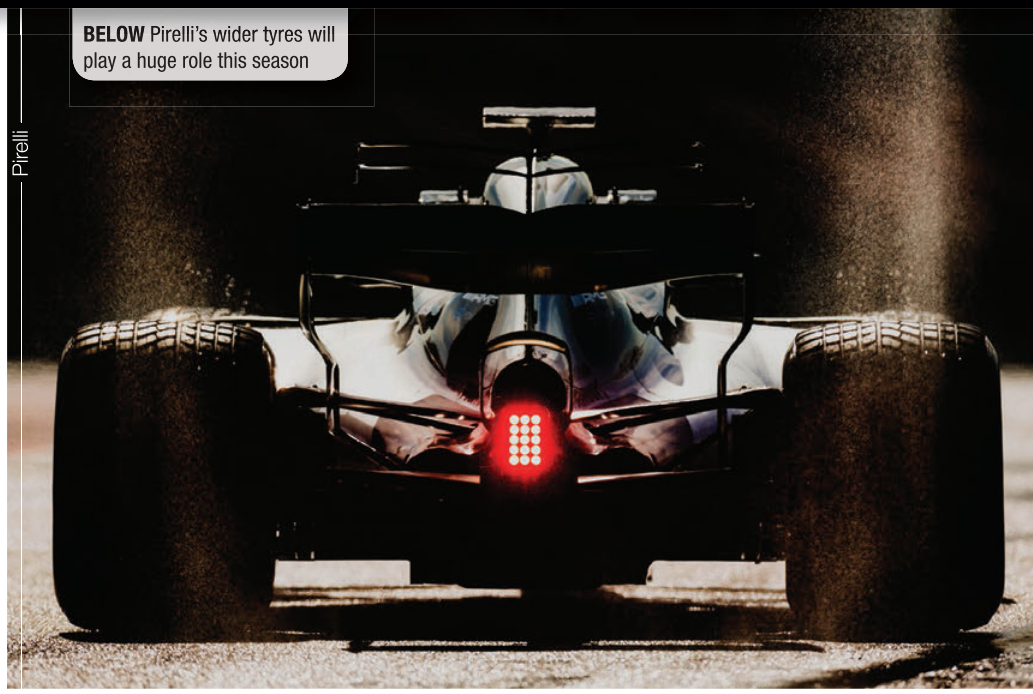

Pirelli

BELOW Pirelli's wider tyres will play a huge role this season

TRACKSIDE

As we headed into the opening races, what had we learned from the opening skirmishes of the season, in two weeks of testing at Barcelona? As expected, the cars are fast. Kimi Räikkönen's 1m 18.634s on the final morning of testing is three seconds below his circuit lap record (in the 2008 race). However, while the speed is there, particularly in the fast corners where the cars look painted to the road with the increased grip, they don't look dramatic. If anything it looks very planted, very controlled, very... ordinary.

Sebastian Vettel went further, going on to say that the new regulations "fixed everything" and here is an interesting point – at least 20 new customers are happy: the drivers. A faster car with more grip; what's not for them to like?


Mauger/LAT

ABOVE Reliability remains a weakness for Merc's rivals. This is Red Bull's RB13 being recovered at Barcelona testing

Another observation is that both these gentlemen are Ferrari drivers. One said he could have gone faster and the other deliberately backed off to make sure he didn't. Could we be seeing a resurgence from the Prancing Horse this season? While the regular Mercedes prodigious reliability has certainly been there as usual, along with the number of miles covered, the pace and even the car balance has looked just a little bit off. Mmmm.

We all know this is the dark arts of testing where sand bagging is part of the game, but when it gets to race simulations, the fuel loads and tyre degradations tend to become real. Even here, though, the red cars look strongest. The outsiders not yet mentioned are Red Bull, suspected to be waiting until Melbourne before we see the final car. It seems we have a three-cornered contest and then a packed midfield struggle for fourth.

WARNING SIGNS

Delve a little further into the feedback from this new car format and there begin to be a couple of indications we feared, but just hoped would not be there. Barcelona's layout, if ideal for testing, with its sweeping medium- and high-speed corners, has long been a notoriously difficult place to race and overtake. First evidence from running cars together is this situation has been made worse by the new rules, a wider car and tyres, a more disturbed wake and complex multi-element front devices not being an effective combination.

This has also led to accusations of an increased susceptibility to wind direction and strength. This may be more car dependent as in some teams the development approach directly addresses this aspect, but we will have to wait and see.

The fastest laps recorded at the Australian Grand Prix Albert Park circuit in Melbourne had previously been below 1m 24s: Lewis Hamilton's pole time in 2016 and Vettel's in ▶


Dunbar/LAT

BELOW Early indications from testing were that the Prancing Horse is enjoying a resurgence and could be poised to mount a serious challenge to Mercedes during the course of the season

Tee/LAT

ABOVE Honda is under immense pressure to make up ground

2011 with an exhaust-blown Red Bull. The lap record (in the race) was still held by Michael Schumacher at 1m 24.125s in 2004, which prompted wholesale rule changes on the grounds of cornering speeds being too high.

Going into the opening race of the 2017 season, the worry was that if a large-tyred and therefore draggy 2017 car – with all its final upgrades and qualifying modes – could really go five seconds faster than before, what kind of corner apex speeds would it be doing? Too high.

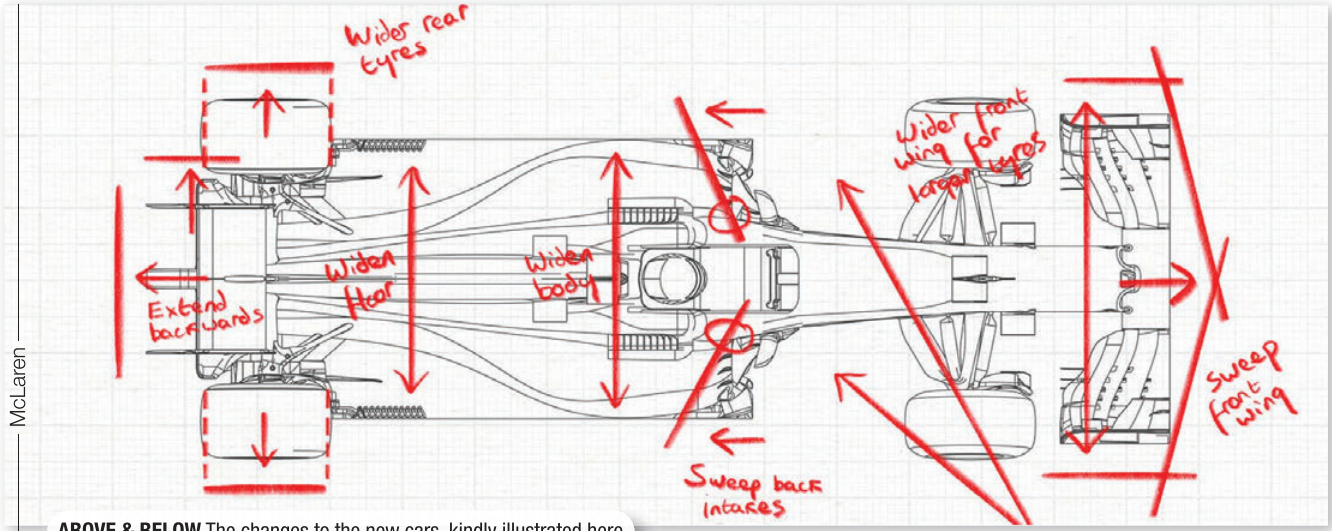
DEVELOPMENT AREAS

Pirelli new tyres will be a big factor this season. Asked to produce a more durable product, the concern was whether we will end up with single stop races and even less chance for multiple strategies. Testing did not suggest that, as the tyre and degradation does still seem to be there but with a greater stability and predictability than before.

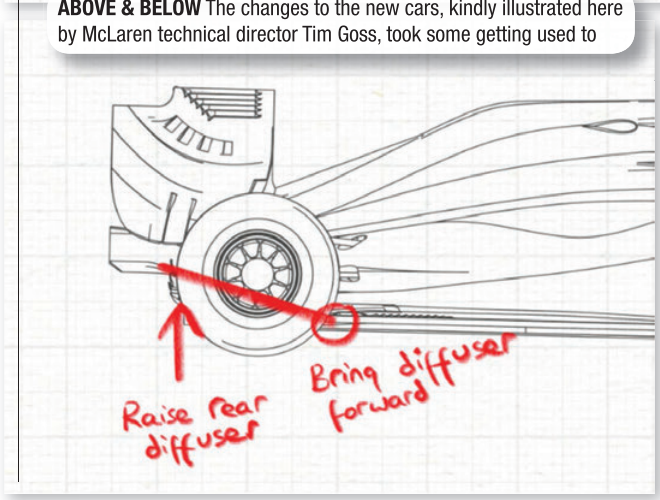
The lap time performance steps between the compounds were also less obvious on the softest rubber, but this is often the case in the unsuited much cooler pre-season testing conditions. Indications are that driver and car management of the tyre and the compound choices will remain as critical during races this season.

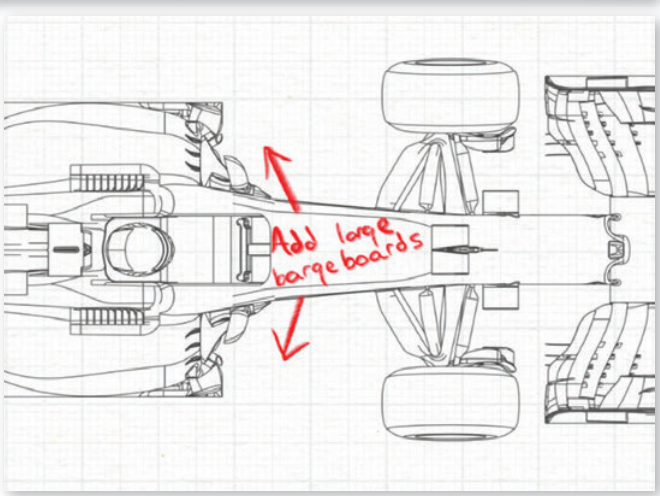
Powertrain tokens have been freed up and with one notable exception the gaps between the manufacturers seems to be much reduced. Reliability, though, still remains a weakness for all of Mercedes' rivals. It is one thing to start getting close on performance, but in this limited quantity penalty system, the race distances also must be covered. I feel like I have to mention Honda at this point. Under immense pressure to make up ground and with development available it appears it has almost started again in many areas. At the moment, this seems a very brave decision.

Despite the capacity restrictions, aerodynamics will remain the largest opportunity for the teams to make progress, as with any new set of regulations the rate of development and understanding



McLaren





ABOVE & BELOW The changes to the new cars, kindly illustrated here by McLaren technical director Tim Goss, took some getting used to

ABOVE Following the car ahead could be even harder than before

Pirelli

> *"Gaining track position in those crucial first moments of the race could become even more critical"*

is extremely steep to start with. This upgrade war, and also the gradual similarity of the best solutions being identified and adopted by the majority, will only then start to indicate the plateaus of car areas are being reached.

STARTING AGAIN

Often the most action-packed part of the race is the first 30 seconds and this season has all the input ingredients to make that even more so. Not just because standing rather than rolling wet race starts are now allowed, but because many of the mechanisms that helped a driver get his car off the line have been banned. With limited and linear torque clutch paddle movement mandatory, the margin for error is much smaller.

Once you add into the mix the wider cars, less tyre degradation and more difficulty in overtaking, you can begin to see that gaining track position in those crucial first moments of the race could become even more critical.

In many ways that's a shame, but neatly sums up the situation. I have heard it said that this season the overtaking will be more "pure", which I translate as "difficult", even though there was always stated the ability to adjust DRS gain to compensate for this.

It would have been far better to look at the fundamental package of ingredients from the perspective of the best platform for racing and start from there, rather than bolt on historic solutions for going five seconds a lap quicker.

It might still be a classic season if there are multiple teams close to each other on pace and I hope that's the case. But just imagine how good it would be if they could all actually race and overtake each other. RT

ABOVE Nowhere to hide: it's hard to avoid the prying camera lenses in testing. Bringing new developments untested to the first race, as Red Bull considered, is one option

Bloxham/LAT

FINAL FLING

Chris Pickering is given an exclusive insight into the V8 engine powering Aston Martin Racing's quest for the WEC GTE manufacturers' crown

THE Aston Martin Vantage GTE is not long for this world. Having been around in one form or another since 2008, this year marks its final season in the Pro category. But fresh from two world championships in 2016, and with most of its opposition still relatively new, the old charger looks set to go down fighting.

There's always been a hint of the iron fist in a velvet glove about Aston Martins, and the Vantage GTE is no exception. Its heart is a thunderous 4.5-litre naturally aspirated V8, based on that found in the current Vantage road car. Initially developed while both brands were owned by Ford, the engine is loosely based on Jaguar's AJ V8 and it shares the same all-aluminium construction and quad overhead cam layout.

With the exception of a small (undisclosed) change in the valvetrain to improve reliability, and the addition of a mandatory FIA crank speed sensor, the engine is mechanically unchanged for 2017. Across the board, however, all cars in GTE have been given a performance boost, aimed at further differentiating them from their GT3 siblings. Nominally this equates to a 10 kW (13 hp) power increase, but it's achieved slightly differently on the various cars, and it also depends on where they were judged to fall within the Balance of Performance (BoP) envelope when last tested.

"We'll be starting out with a 29.8 mm restrictor, having finished on 29.2 mm last year," explains Arthur Shaw, chief engineer for engines at Aston Martin Racing. "Our cars will also have a small mass change and a ride height reduction. Others have been adjusted in different ways; we see from the published data that the Ford GT, for instance, doesn't have much of a power step, but it has had a mass change."

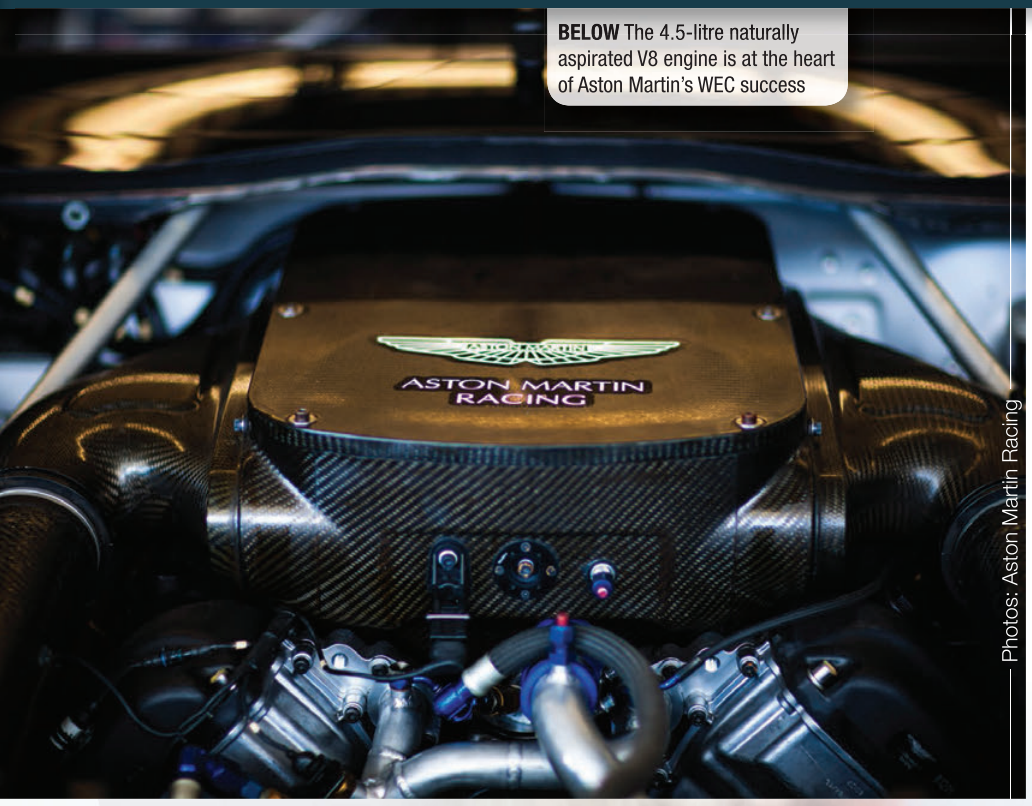
There seems to be a consensus that the FIA has more or less got things covered with the BoP system now, following a slightly shaky start when Ford and Ferrari burst onto the scene with their turbocharged engines last year. "It's similar to the argument we had a few years ago between diesel and gasoline in prototypes. To begin with there clearly was a disparity, but over time the gap became less and less, and I think the organisers are keen to avoid that sort of situation," comments Shaw.

The FIA doesn't release any power figures from the BoP testing, but boost levels (for the turbos), engine speeds and restrictor sizes (for the naturally aspirated units) are published. That means the teams all have a pretty good idea of where they sit in relation to everyone else, particularly if a car that was a known quantity undergoes a BoP change.

It's no secret that mid-engined cars tend to have a slightly smaller frontal area and a lower coefficient of drag, so the Aston Martin is thought to be towards the higher end of the pack when it comes to power figures. Officially, the company quotes 'up to 500 bhp and 500 Nm of torque'.

Fuel range is also balanced – at least to a degree – by tank volume. In theory the cars should all be capable of completing

RIGHT The Vantage claimed both the GTE Pro teams' and drivers' championships last season



BELOW The 4.5-litre naturally aspirated V8 engine is at the heart of Aston Martin's WEC success

Photos: Aston Martin Racing

> *"The more efficiently you can trap air, the lower your engine speeds need to be"*

the same number of laps per stint. What's more, the fuel rig flow rates for each car are adjusted to compensate, so all the teams should theoretically spend the same amount of time filling up, irrespective of their tank capacity.

"The fuel balancing seems to be working well," says Shaw. "Certainly towards the end of last year we saw all the cars coming into the pits on very similar laps. Obviously, strategy still plays a part, but the general feeling is that the fuelling is fairly well balanced."

PRODUCTION BASED

The Vantage GTE engine begins its life as a set of production castings. These are taken from a standard 4.7-litre V8 Vantage, and the block retains the road car's 91 mm bore spacing, albeit with a shorter 86 mm stroke to bring the capacity down to 4.5 litres. These days that makes little difference, but when the engine first appeared the restrictor sizes were calculated in 500 cc increments and the 4.5-litre category was deemed to be a better compromise than the one above.

The cylinder block is a two-piece design. Its bed plate – the bottom portion of the crank case, which carries the lower halves of the main bearing housing – is fitted and then it's line bored, with Nikasil-coated steel ▶

liners used in place of the cast iron items in the production engine. The cylinder heads, meanwhile, are taken as raw castings and machined to bespoke specifications. Although the rules in this area are not free, they are fairly comprehensive, allowing constructors to block oil ways, for instance.

Inside, it now uses a bespoke reciprocating assembly. Early iterations retained the production crankshaft, but this was found to crack after prolonged use in the racing engine. More recent versions use a specially-designed race part, developed in-house by Aston Martin Racing and manufactured by Capricorn. This follows the same crossplane configuration as the road car and it has the same overall mass in order to satisfy the FIA regulations. The specially-developed pistons also come from Capricorn, while the connecting rods are produced by Pankl.

"On the race engine we remove the twin mass damper from the nose of the crankshaft. That's good for inertia, but it can lead to torsional vibration issues," notes Shaw. "Rather than put another damper on the front to address this we designed a new crank that has a different stiffness and larger fillet radiuses in the bearings."

This has proved to be both cheaper and more reliable than modifying the production item, he points out: "By the time we'd taken a standard crank, rebalanced it for the new connecting rods and pistons, and then put a hardened sleeve on the back for the crank seal, it became economically unviable. The racing crank is a simpler solution and it's very robust. We've actually got cranks now that have done 40,000 kilometres without issue."

Interestingly, it wasn't always a foregone conclusion that Aston Martin Racing would use this particular engine for the Vantage GTE. Under the World Endurance Championship (WEC) rules, constructors are allowed to use any powerplant from the manufacturer's extended range. Aston Martin's V12 engine – fitted in some of the Vantage road cars, and indeed the GT3 racer – was considered as an option.

"We did look at that quite closely," admits Shaw. "A large capacity, comparatively low-revving V12 has its advantages. It's a very reliable way to get a lot of power and torque, and it can be made to be fuel efficient. From a powertrain point of view it's actually quite a good option, but the downsides are that it's a big, heavy engine to put in the chassis."

RESTRICTOR RACING

The Vantage GTE's valvetrain is driven by a twin chain system, with two chains going to the inlet cams and a separate chain that handles the exhaust side. These drive a set of camshafts produced by MTS to Aston Martin Racing's own profiles, with Del West valves and NHK springs.

Race-spec chains and chain guides, plus a bespoke hydraulic tensioner, are fitted to cope with the ultra-aggressive cam profiles used in the restricted engine. While these are hardly the most glamorous parts of the design, they can easily make the difference between winning a race or retiring with an engine failure.

Aston Martin Racing has also developed its own fly-by-wire throttle system using a Maxon stepper motor. This uses individual port-mounted throttles. Fuel, meanwhile, comes from a port-injection system with off-the-shelf Magneti Marelli racing injectors.

According to Shaw, the cylinder head is where the most extensive development has been carried out over the last eight-or-so years. "A lot of it comes down to improving the trapping efficiency to get the best out ▶

ABOVE Every Aston Martin Racing car, from GT4 to GTE, has its engine designed and built in-house

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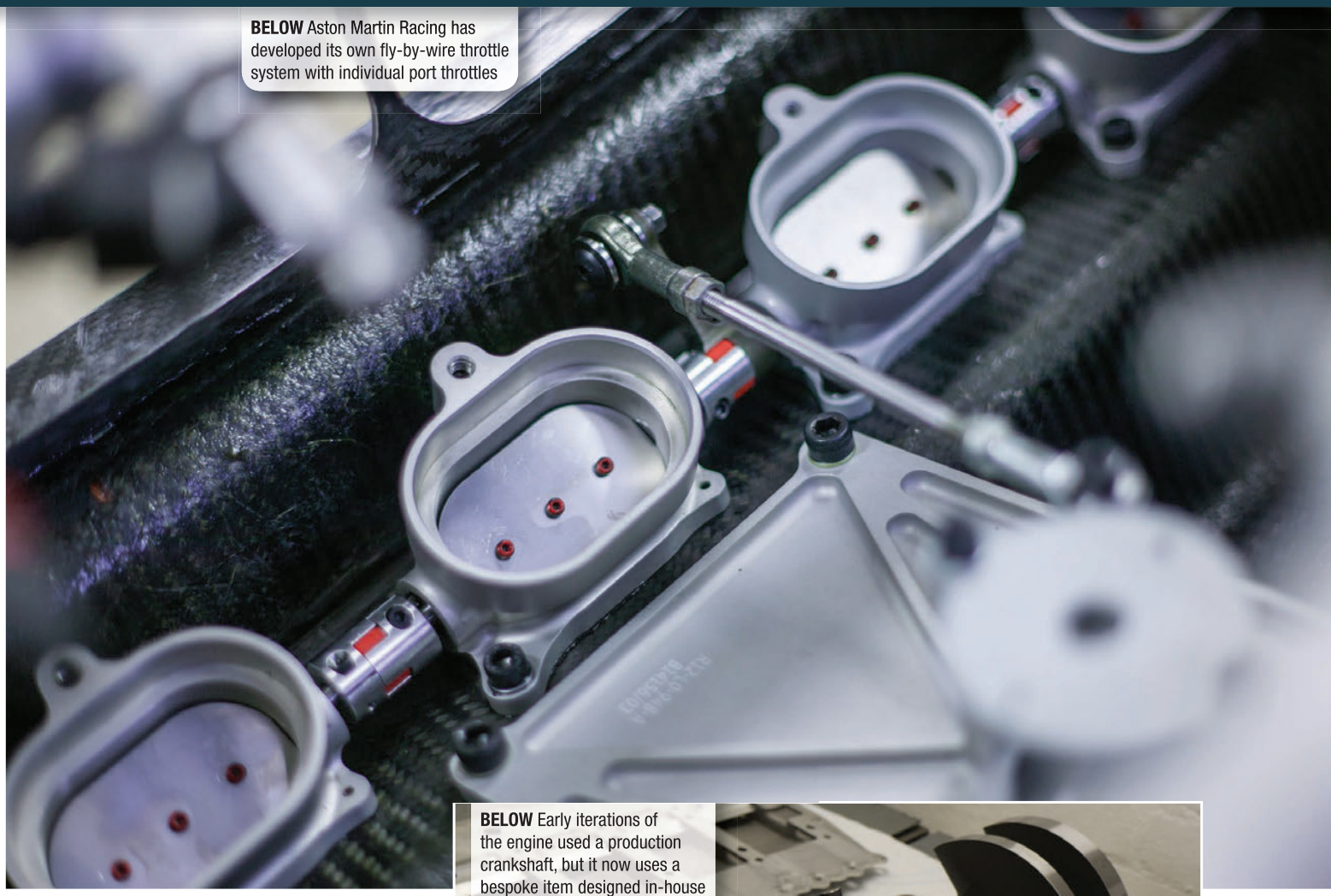
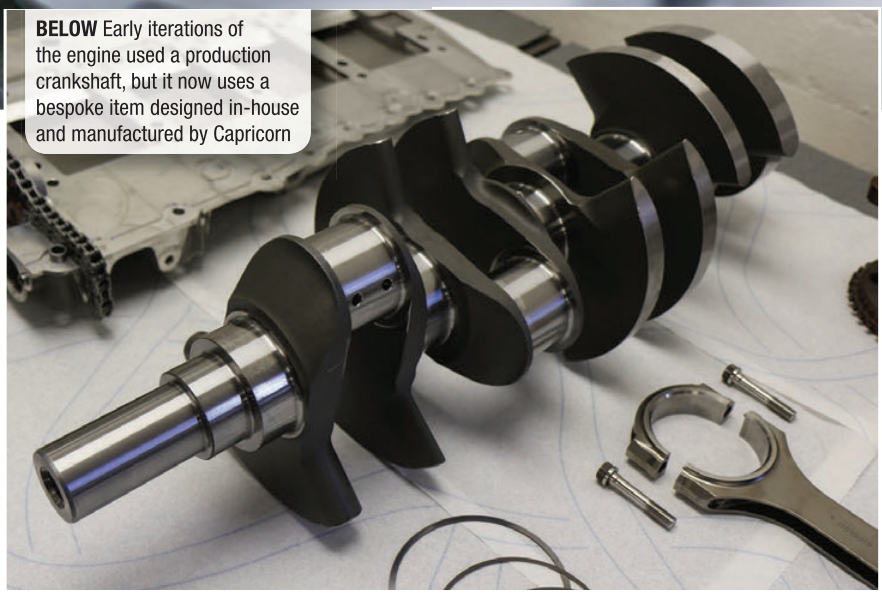


BELOW Aston Martin Racing has developed its own fly-by-wire throttle system with individual port throttles



BELOW Early iterations of the engine used a production crankshaft, but it now uses a bespoke item designed in-house and manufactured by Capricorn

of the restrictor," he says. "A restricted engine is as different from a regular naturally aspirated engine as a turbocharged engine."

To fully optimise an air-restricted engine is not a simple task. A lot of thought goes into the cam profiles, and in particular the valve overlap, to maximise the trapping efficiency. In contrast, a boosted engine or one without an air restrictor, follows far more conventional wisdom and may require less development from its production base. This certainly seems to be the thinking behind the rules for the turbocharged GTE engines, which some have dubbed 'GT3 Plus'.

There's no rev limit in the GTE regulations, but the restrictor effectively enforces a natural barrier, Shaw explains: "At some point, as the air flow increases up the rpm range, you will reach a stage where you choke the restrictor. It's still beneficial to rev the engine a little beyond that, but you're losing out, because the friction continues to build, while the air mass flow (and hence the fuel) is fixed. On the turbo cars, the boost curve is specified by the FIA, and this more or less performs the same function. Beyond a certain engine speed you're basically not allowed any more boost."

The Vantage GTE engine is optimised over a window of around 1,500 rpm, he says: "We set the gearshift speed at 7,400 rpm, but the limiter is set to 8,500 rpm for downshifts. Time and again we look at the simulation and say 'what would happen if we got more torque out of that corner?' but it always boils down to that narrow band; if you make that better you will go faster."

QUEST FOR EFFICIENCY

It's always important to reduce the losses on a race engine, but that's particularly true of a restrictor engine, Shaw explains: "You want to make sure the pumping works well so you can pull the restrictor down to a choke level, but it's what happens afterwards that's particularly important. The air pressure behind the restrictor is down to about 750 millibars, so you're running at a depression. Then it's about efficiency; you want to make sure you have very good combustion and low heat rejection."

On a restrictor engine the compression ratio is the key to compensating for the low inlet pressure. All teams in the GTE class use the same control fuel, so it's basically a question of running the highest effective ▶

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ABOVE The cam profiles are especially important in a restrictor engine to maximise trapping

compression ratio that you can. This means the engine operates close to the knock limit at virtually all times, so the Vantage GTE runs four knock sensors – one between each pair of neighbouring cylinders – with closed loop control from a Cosworth MQ12 ECU.

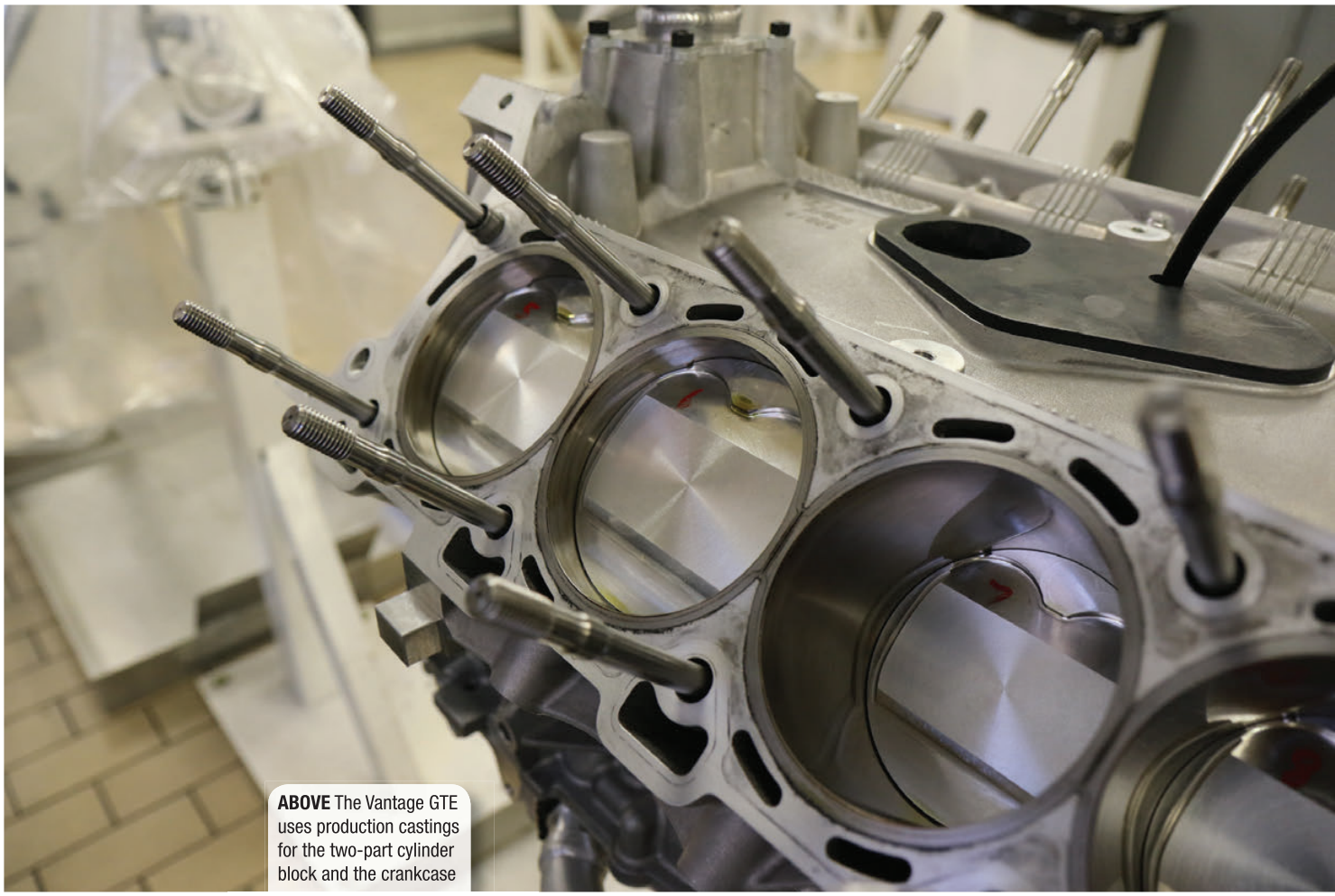
Charge motion is also critical. Anything that improves the mixture distribution will reduce the risk of knock, as well as improving overall combustion efficiency. Two years ago, Aston Martin Racing undertook a substantial CFD study on the engine to optimise this, analysing a number of design proposals for inlet port and combustion chamber geometry.

"It's always a balance between pressure drop across the port and turbulence in the cylinder (mainly tumble)," says Shaw. "On a restrictor engine the main limit on the mass flow lies elsewhere so you can compromise the port more than you normally would to get the right charge motion."

Following their CFD study, the Aston Martin Racing engineers produced prototypes of the two most promising candidates and put them onto the air flow rig to validate their findings. They were machined in metal and dyno tested for final confirmation before the best solution was put forward for homologation.

Shaw's team also used the 1D simulation package GT Power extensively for optimising the pumping loop and carrying out combustion modelling. "One of the benefits of working on the engine for a number of years is that we've got very comprehensive CAE models," he notes. "This allows us to evaluate a lot of ideas in the virtual world."

Elsewhere, the engineers have adopted a methodical approach to reducing losses wherever possible. Friction reduction is clearly a major part of this, and 'downspeeding' the engine is particularly relevant when you've got a restrictor ▶



ABOVE The Vantage GTE uses production castings for the two-part cylinder block and the crankcase

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BELOW Bahrain presents the team with a uniquely challenging environment for endurance racing

Adrenal Media/FIA

limiting the power at high revs. Again, it comes back to the valvetrain optimisation. "The more efficiently you can trap air, the lower your engine speeds need to be," notes Shaw.

Windage losses are another important area to consider, he points out, although perhaps the most frequently underestimated factor is the oil system. Even in road car form, the Vantage runs a dry sump system. The GTE car has an extremely shallow oil pan, manufactured in-house, which is designed to help the engine generate a large sump depression.

READY-TO-RUN

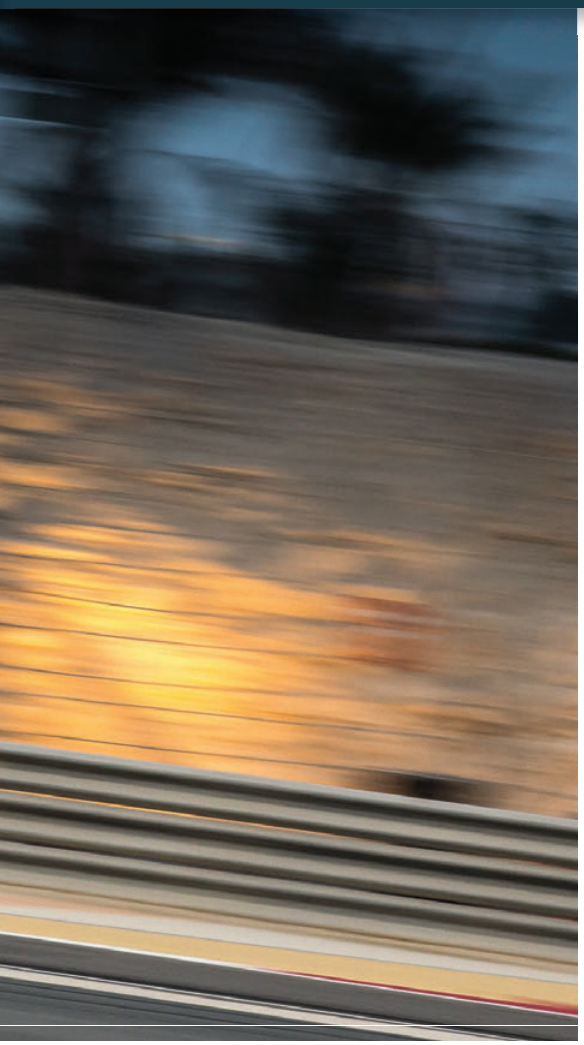
Every Aston Martin Racing car from GT4 to GTE has its engine designed and built in-house. Currently, the engine build shop is run as a satellite operation, while the company relocates to its new facility in Banbury, but the design team has already made the move.

Customer cars are sold ready-to-run, and the engines all come back to the factory for servicing. In total, there are expected to be five Vantage GTEs competing in 2018 – three works entries in the WEC and two privateer teams in the European Le Mans Series (including the semi-works entry of Beechdean Motorsport). This equates to a pool of 12 engines at any one time.

"It's a reasonably straightforward V8, so there's not a lot to look at in terms of the serviceability; the key thing in the design was extending the service life," says Shaw. "If you can do 6,000 km instead of 5,000 km it makes a big difference over the course of the year in the number of rebuilds across all the cars that are out there."

Each car has an allocated systems engineer who looks after the engine, alongside the race engineer and two travelling technicians. Since 2016 Aston Martin Racing

BELOW Aston Martin used a pre-season test with Dunlop at Aragon to figure out the impact of this season's tyre restrictions



has also had a technical partnership with Total, which provides the engine oil. As part of this tie-up, the company takes a mobile laboratory to all the GTE races – the only time it does so outside of Formula 1 – along with a dedicated engineer for oil analysis.

"The oil engineer takes samples multiple times during each event," explains Shaw. "This way we can get a breakdown of all the materials in the oil, such as lead, aluminium and steel. We keep a curve of every engine across its lifetime and from this can tell if anything's out of the ordinary. For example, if we see a raised concentration of lead it could indicate that a bearing is breaking down, while aluminium could point to piston problems."

There are other factors to watch out for. The WEC has held a six-hour race at Bahrain for several years now, and while this has proved popular it's also a uniquely challenging environment. Temperatures tend to be high, and the duty cycle is as punishing as Le Mans, with the cars on full throttle for 70 per cent of the lap. But that's not all, Shaw explains: "The first time we went to Bahrain we had a double engine failure about an hour before we were due to win the manufacturers' championship.

> *"Perhaps the most frequently underestimated factor is the oil system"*

After investigation we concluded there had been highly accelerated wear on the exhaust valve seat due to quite large particles of sand entering the engine."

After five hours or so of racing the sand had succeeded in penetrating the cotton weaves of the air filter. Aston Martin Racing then worked closely with technical partner K&N to develop a new air filter, which has run successfully ever since.

"The problems we had in Bahrain were totally unexpected. A year beforehand the GTE Am cars had contested the same race with no problems at all. It turned out that the revised aero kit on the GTE Pro cars was hoovering the track somewhat more," Shaw reveals.

Bahrain isn't the only extreme environment on the WEC calendar, either. The Autódromo Hermanos Rodríguez in Mexico City is the highest major race circuit in the world. At 2,240 metres (7,350 feet) the air is thin enough to have a marked effect on both combustion and cooling. To counteract this, Aston Martin Racing has developed a special cooling pack for this round, which is primarily intended to improve heat rejection in the oil system.

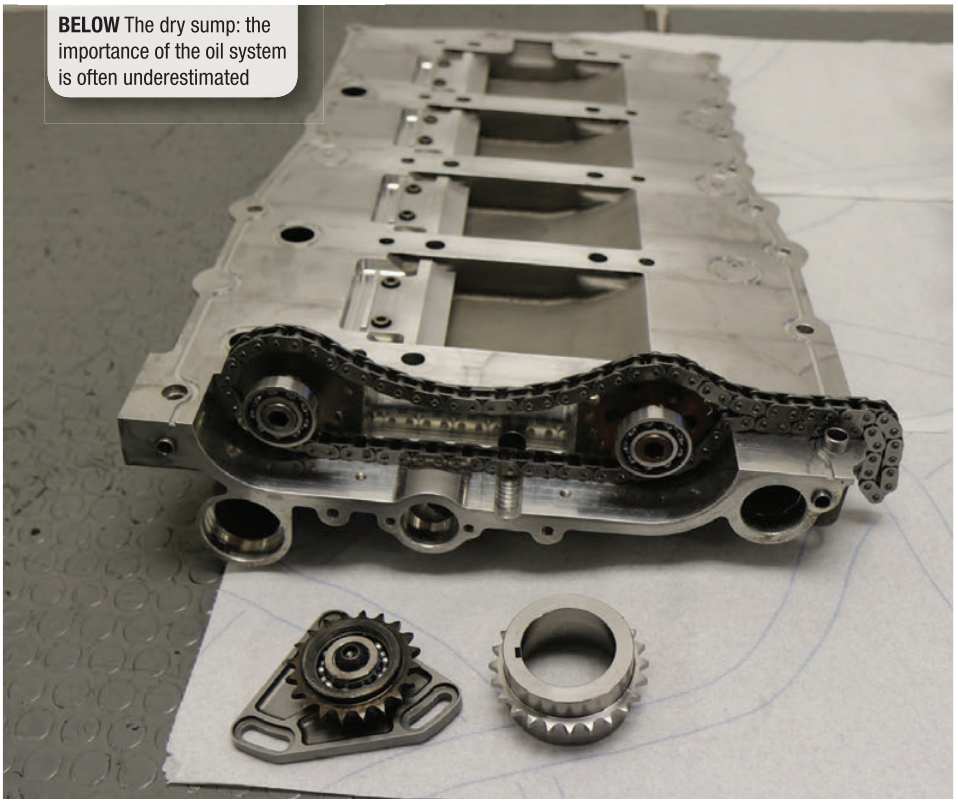
UNFINISHED BUSINESS

Despite picking up the GTE Pro teams' and drivers' championships in 2016, the manufacturers' title has so far eluded Aston Martin. This means there's more than a hint of unfinished business about the Vantage GTE's final season.

At the same time, it means the engineers at Banbury also have their hands full working on the Vantage's successor. It's been widely reported that this will come with a slightly smaller turbocharged V8, sharing its underpinnings with those found in the Mercedes AMG GT and C63.

Aston Martin Racing is currently in the thick of developing the new race engine, which will run to the same technical regulations as the current unit. Naturally, the details are still under wraps, but Shaw is clearly enthusiastic. "There are some new toys on that engine that are quite interesting to us," he says with a glint in his eyes.

Preparing for 2018 will undoubtedly absorb a lot of the company's resources, but you get the impression everyone is willing the Vantage on for one last battle. Maybe this will be the year? RT



BELOW The dry sump: the importance of the oil system is often underestimated

Ebrey/BTCC

ABOVE The big guns are back: Vauxhall, Subaru, BMW, Honda and MG go wheel-to-wheel in this year's BTCC – the biggest manufacturer contingent since the glory days of the Super Touring era

THE FULL WORKS?

Andrew Charman examines the relationship between manufacturers and the British Touring Car Championship, and asks why they are returning when the series no longer needs them…

IN March 1994, Alan Gow, managing director of British Touring Car Championship (BTCC) organiser TOCA, stood up at the pre-season media day and announced that an unprecedented 10 manufacturer-backed teams would contest that year's series.

The BTCC was at that time the fastest-growing race series in the world – OEMs wanted to be in it, and particularly to win it.

As is so often the case with manufacturer-dominated categories, there was – quite literally – a price to be paid. Just six years later spiralling costs would almost implode the series and kill off the Super Touring formula, born in the BTCC and so successfully spread across the globe.

> *"The difference is manufacturers today can't influence the technical regulations and the costs to the teams"*

Gow stood in front of the 2017 media day attendance, last month, and announced that this season will see five teams contesting manufacturer honours – the most since 1999, the penultimate year of Super Touring. But these 'works' entries will be amongst full 32-car grids – larger even than in the best Super Touring years – populated by cars of 11 different brands, and in the knowledge that today's BTCC regulations ensure a manufacturer cannot spend its way to success. The Independents have just as much opportunity to win races, and regularly do.

How has this come about? And what is the appeal that is making an increasing number of OEMs again consider a national Touring Car series a good place in which to make their mark?

A VOLATILE DECADE

Many, the writer included, believe the level of competition seen in the BTCC's Super Touring era will never be repeated. The 1994 BTCC grid contained manufacturer-backed squads from Alfa Romeo, BMW, Ford, Mazda, Nissan, Peugeot, Renault, Toyota, Vauxhall and Volvo. The grids ▶

Ebrey/BTCC

ABOVE Honda, Renault, Nissan, Audi, Volvo and Vauxhall do battle at the height of Super Touring

Nissan

ABOVE The pace of development in Super Touring's final years required large teams – Ray Mallock and squad celebrate 1999 title success. Nissan was rumoured to be working to a budget of £9 million

NGTC vs Super Touring: different eras

JUST what was it like to run a team at the height of the Super Touring era, compared to today? West Surrey Racing has been there all along, with Ford and Honda in Super Touring, MG in BTC-T and BMW today.

According to WSR head Dick Bennetts in the penultimate year of Super Touring, 1999, when his team took on the Honda programme the budget was approximately £5.5 million, whilst it's believed eventual champion Nissan had £9m and Ford £10m. Such large figures were necessary due to the pace of development allowed by the loose technical regulations.

"For a two-car team we had about 35 full-time people, to design, build, develop and race the cars," he says. "Today in the NGTC we have about 12 full-time staff running a three-car team, with 25 at race meetings where we are joined by our 'weekend warriors'.

"It's a very different arena – you are not changing uprights every second race, not changing wishbones or the aero. In Super Touring you were allowed to keep developing your car through the year."

He adds that today the race engines, in which many components must remain standard and are controlled by TOCA, are expected to last a lot longer than in Super Touring days.

"We have a fresh engine at the start of the year and then a rebuild midyear – in Super Touring it was a fresh engine for virtually every race. Some people had qualifying engines, with 8-10 hp more than the race engine, that would only do 100 km. The engine would be installed Friday night for qualifying, and replaced by the race engine on Saturday night. That would then do the two races on Sunday and the following test before being replaced by a qualifying engine.

"It was ridiculous. It didn't make the racing any better, just more expensive!"

Today, Bennetts feels, the period between race meetings is a lot less frenzied than in Super Touring days: "At the start we design the rollcage, under bonnet and internal layout of the car. Once that's done there's only a bit of winter work but not the ongoing design there was then because so many parts, gearbox, dampers, uprights for example, are controlled by TOCA."

So as an engineer, is there any aspect of Super Touring Bennetts misses? "I loved it in some ways, but it was basically a fast-moving technical formula: who could come up with something new by the next race?

"It got so competitive, became such hard work with incredibly long hours. Today the racing is just as good, if not better, at much, much less of a price – at the end of the day it's a better spectacle for TV and the spectators." RT

stretched to at times 27 cars, 22 of them works entries – remarkable considering the single-class 2-litre formula, what would become Super Touring, had only been adopted three seasons earlier.

The challenges of being part of all this were quickly demonstrated in the 1994 season. Having failed to find sponsors the Mazda team was on a very low budget. When Matt Neal's plain-white Mazda Xedos 6 rolled itself to destruction in round four at Silverstone, his season ended, and team-mate David Leslie lasted only four more meetings before the finance ran out and the team disbanded.

The arrival of Alfa Romeo that year would lead to increased costs for everyone. As documented in our feature in Race Tech 168 (Nov 2014), the Italian team took the BTCC, and Super Touring, into the world of aerodynamics. Alfa's clever interpretation of the aero rules obliged the FIA to produce regulations for wing and splitter packages across the formula, adding aerodynamic development, including several hours in wind tunnels, to the costs of teams competing.

At the same time Renault demonstrated just how important it considered success in the BTCC. The team that ran its Lagunas was replaced by Williams Grand Prix Engineering – Renault's representative in the Formula 1 World Championship. The F1 resources deployed no doubt helped Renault win the manufacturer title in that first campaign, though it still took lead driver Alain Menu three seasons to secure the drivers' title.

By 1998 there were still eight manufacturer teams in the BTCC, but by now the rampant spending was at its height, with manufacturer budgets in some cases stretching towards £10 million a year. Teams were working to top international standards. A former mechanic with Vauxhall works team Triple Eight Racing described recently how each car's suspension was effectively "thrown away" after each meeting, and every half a season every nut and bolt on the car replaced. Each bolt was £15 and there were a thousand or more on the car…

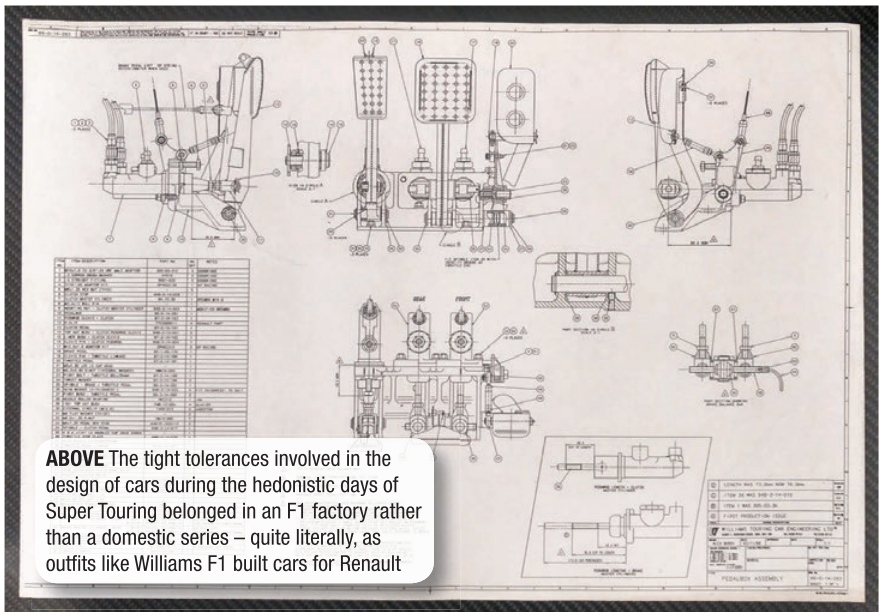
Such major spending became increasingly more difficult to justify in OEM boardrooms. At the end of 1998 Audi and Peugeot left the series – the latter having, until its last of seven seasons, been the only true works team in the BTCC. It was

BMW

ABOVE Years of success as a constructor have earned Dick Bennetts (with hand on car) a full works BMW contract for 2017

run out of the manufacturer's Stoke plant in Coventry and all the team employed by Peugeot Sport.

One year on and the still spiralling costs accounted for half of the remaining manufacturers, Renault, Volvo and Nissan. The latter showed just how brutal manufacturer decisions can be, quitting directly after winning the 1999 championship. That left just Honda, Vauxhall and Ford, each adding to their costs by running three cars, while a class B of 'super production' cars was added to bolster the shrinking grids.



ABOVE The tight tolerances involved in the design of cars during the hedonistic days of Super Touring belonged in an F1 factory rather than a domestic series – quite literally, as outfits like Williams F1 built cars for Renault

NEW DIRECTION

BTCC management had seen what was coming, however, and had in May 1999 announced new technical regulations for 2001. The cars that became 'BTC-T' had more aggressive bodywork but no carbon fibre-festooned interiors. They used specification alloy wheels in place of the highly expensive forged aluminium rims of the Super Tourers, while a host of common components included the transmission, brakes, clutches, engine electronics and double-wishbone suspension. Cost savings were put at 40 per cent overall, 92 per cent on certain parts.

Yet throughout this era, and a subsequent switch to Super 2000-spec machinery, the BTCC continued to have a love-hate relationship with manufacturers. While the domestic series appeared healthy, Gow and his technical director Peter Riches could see familiar problems looming: as the car giants fought ever more keenly to win on the world stage, costs were inevitably rising and trickling down to national level. ▶

GPRM/BTCC

BELOW & INSET Part of the success of the NGTC is the process undertaken to equalise cars before they reach the track. Here the prototype Toyota Avensis is in the wind tunnel. Back in the Super Touring era, inset, even the boot catches were fashioned to have a beneficial aero influence

Hal Ridge

As touring car followers will know, their solution, the Next Generation Touring Car (NGTC),has since proven a major success. The category's key ingredients are a combination of spec parts, equalised aerodynamics and use of either a TOCA official engine or an OEM equivalent with its performance matched to the TOCA unit. The impressive list of suppliers – AP Racing, ATL, Carless Fuel, Cosworth, Dunlop, Lifeline, Owen Developments, Penske, PWR, RML, Swindon Engines, Rimstock and Xtrac – all work closely with the series organisers and teams.

Today NGTC cars are generally considered to be quite expensive to build but significantly less costly to run than previous formulae. They also boast high residual values. The very first car built, a Toyota Avensis demonstrated by James Thompson in 2010, was driven at two rounds in 2016 by Tony Gilham. The shell of Jake Hill's 2016 Avensis was built as long ago as 2011. Its running gear is new, however, as at the end of the 2013 season previous owner Cicely Racing stripped out the official components, suspension, drivetrain and such like, and installed them in a Mercedes A-Class chassis that Adam Morgan has campaigned since.

Today's BTCC boasts a full grid of 32 cars, its size limited only by circuit licences. And crucially, the majority of those cars ▶

What's in it for them?

SUBARU arrived in the BTCC in 2016 as a full-blown manufacturer entry, with four Levorg estates built and run by Team BMR in a deal brokered to a large extent by multiple champion Jason Plato. But what advantage does Subaru gain from entering the BTCC as a manufacturer, rather than simply letting BMR build the cars from shells and run them as independents? As with BMW, the answer is control of marketing.

BELOW Subaru is one of the new wave of manufacturers finding marketing value in the series

Ebrey/BTCC

"We have a rallying pedigree, we've won the World Championship, ticked all the boxes – we wanted to do something that would promote the current and next generation of cars," says Subaru managing director Paul Tunnicliffe. "The STi that we rallied was part of our history; the future is about estates and SUVs.

"We needed to have a little more control over the programme than just selling the team some shells – the first choice for a team wanting to run a Subaru would probably be an STi, but that doesn't suit our marketing aims whereas the Levorg does. It is very much the future of Subaru."

Tunnicliffe even admits that the operation is not technically a factory-supported team: "We've come to a gentleman's arrangement that I'm sure the team finds very beneficial. But in return we get great exposure, with the best team and the best drivers."

And the presence in the championship is having an unexpected marketing benefit. "Interestingly we are seeing overall brand awareness, and the STi sales have benefitted as much as those of the Levorg – the Subaru owners are reappearing at race meetings in numbers, having not been there since the rallying days." RT

ABOVE & BELOW The move to specified components from trusted suppliers, like AP Racing (above) and Cosworth, has controlled costs in the NGTC era

are independent, not manufacturer entries. Due to the effectiveness of the NGTC regulations, the independents have equally as high a chance of victory as any manufacturer team. In the final meeting of the 2016 season Subaru manufacturer squad Team BMR almost snatched the title with its Levorg, debuting that year. But exactly 12 months earlier BMR had come equally close to title glory, running a squad of privateer Volkswagen CCs.

Series Director Gow succinctly summed up the way NGTC works when he told Race Tech that required budgets for NGTC can be 10 per cent of what was needed in the Super Touring years. If a manufacturer really wants to win, the only areas it can throw money at are the salaries of its drivers and the size of its hospitality awning. "There's nothing they can spend to make the car go quicker; it's good old-fashioned engineering and racing," he adds.

THE MANUFACTURERS RETURN

So having been through two new formulas without attracting the manufacturer interest it formerly enjoyed, the BTCC now boasts a stable technical package that does not need such interest – yet the 2017 season will see the most manufacturer entries since the Super Touring era. The five manufacturer teams are two more than in 2016, yet still comprise less than half of the overall field.

The two newcomers, BMW and Vauxhall, appear to be taking very different views of the series.

BMW has effectively been in the series with West Surrey Racing for 10 years. WSR has flown the BMW flag as an independent, winning the drivers' title with Colin Turkington in 2009 and 2014. Several independent teams' titles were also secured until WSR was declared a constructor for 2015 and took the manufacturer/constructor prize in 2016. So why does BMW now desire a full works involvement, for the first time since 1996?

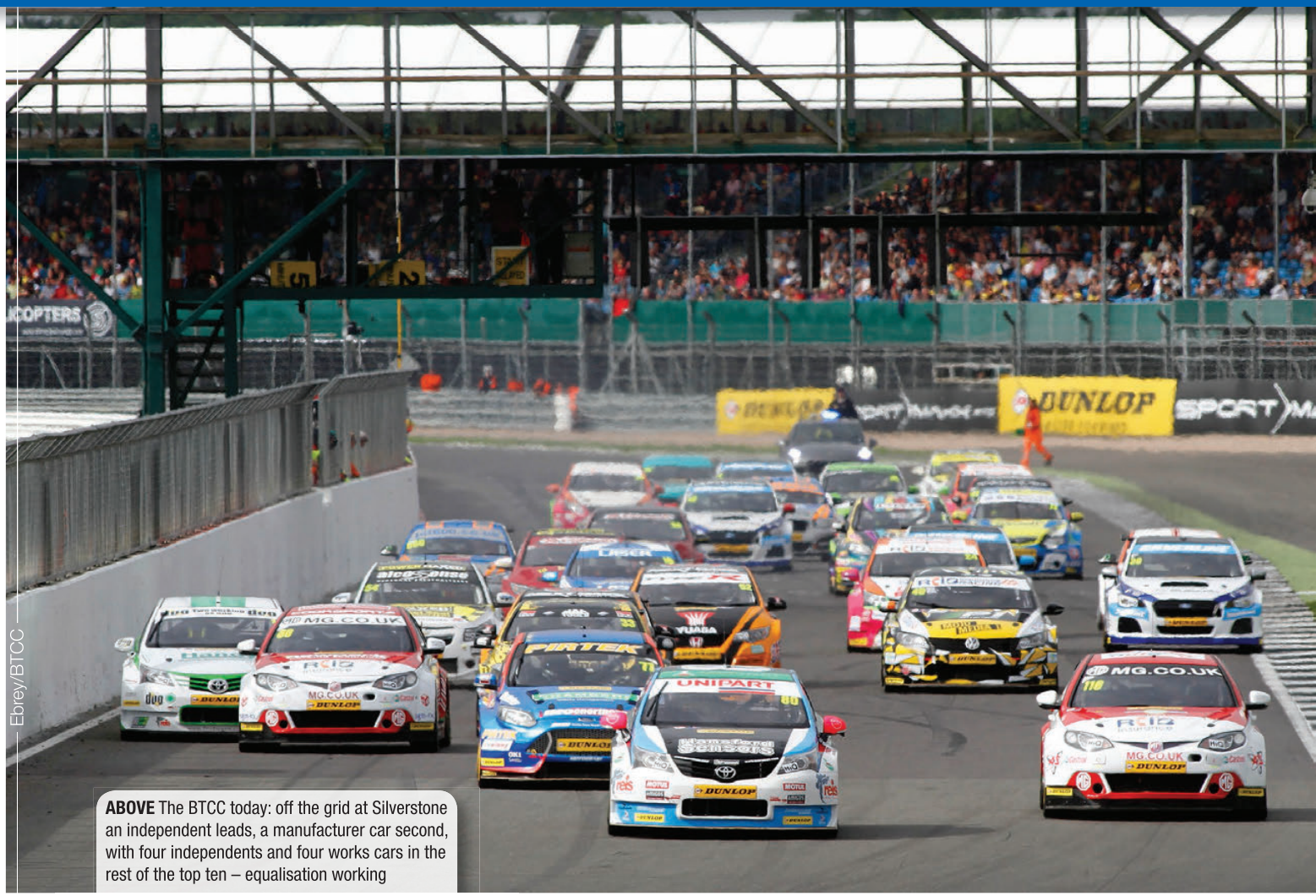
"Primarily because we wanted to have a little more responsibility for how we market the results that Dick and the team are achieving," BMW UK MD Graham Grieve told Race Tech at the launch of the 2017 car.

"Dick has been really lucky over the years with some really good sponsors but we wanted to step in this year as BMW UK, just to maximise the team's chance of winning the drivers' championship.

"Previously it was a lot more direct (BMW) motorsport involvement – this time it is a local activity. We've put financial support behind it to make the engine development happen, but it is very much West Surrey Racing's design, their car, and they have shown over the years an amazing competence to deliver fantastic results."

WSR team head Dick Bennetts does not anticipate full manufacturer status making any difference to the day-to-day running of his team. "I've always run the team like a manufacturer – you always have to have the right amount of people and I probably overspend each year as the engineering comes out," Bennetts says.

"If you give the drivers the best opportunities then you should win – manufacturer status ▶



Ebrey/BTCC

ABOVE The BTCC today: off the grid at Silverstone an independent leads, a manufacturer car second, with four independents and four works cars in the rest of the top ten – equalisation working

Two sides to the manufacturer coin

A MANUFACTURER deciding to use the BTCC for its marketing can get it badly wrong, as was demonstrated only two seasons ago by Infiniti.

The basis was a project dubbed 'Support Our Paras Racing', set up by Derek Palmer, a Scotsman behind many motorsports programmes over the years. Working with the official Parachute Regiment charity, the team aimed to include several injured paratroopers among its ranks, with the long-term aim of propelling one of them to a BTCC driving role.

The laudable project proposed using the Infiniti Q50 as the basis of the BTCC race cars but rather than Infiniti simply supplying the shells to the team, at some point it was agreed that an entry into the manufacturers' championship would be made – and to the outside world the complexion of the team changed.

All involved possibly underestimated just how big a challenge the BTCC represented. Only one of the cars was completed in time for the opening round and being untested it struggled. A further car was built for the second meeting at Donington – driver Richard Hawken did not trouble the top 20 in any of the three races, while team leader Derek Palmer Jnr's day ended with retirement in race one. Hawken was replaced by former F1 driver Martin Donnelly for the next round at Thruxton and the best of six results was a 17th place.

Ebrey/BTCC

ABOVE Even bringing in the F1 experience of Martin Donnelly failed to save Infiniti's short-lived works BTCC programme

Had this been a privateer team running Infiniti cars, such struggles would not have garnered headlines, more likely support and appreciation of its charity aims. But as it was a manufacturer entry, the image was of a major car brand running at the back instead of fighting with Honda, BMW and MG at the sharp end of the grid.

Inevitably, Infiniti took what appeared to be the most effective means of damage-limitation, and pulled its manufacturer backing after the Thruxton races. The team was forced to scale back to one car and by mid-season had lost its second TOCA entrants licence. Palmer Jnr soldiered on to the end of the season, the best result a 15th place at Snetterton, and despite regular rumours of a revival the team has not been seen in the series since. RT

puts a bit more pressure on us but the drivers always drive the best they can so it shouldn't make a lot of difference."

The other newcomer, Vauxhall, appears to be taking a much more backseat stance. The entry for PowerMaxed Racing in the manufacturers' championship is an element of a fleet deal between PMR parent company Automotive Brands and Vauxhall, which has seen latest specification Astra shells delivered to the team to form their 2017 race cars.

Vauxhall personnel spoken to by Race Tech insist that the entry is not a works team and maintain that Vauxhall will not return to the BTCC as a full-blown manufacturer while the brand's marketing centres on the UK's international football squads.

Honda, however, is more than happy going into its eighth season as a full works effort with Team Dynamics, and like BMW sees the series as important to getting its message out. "'Racing plays a large part in the DNA of Honda, it runs through the veins of everyone in the business," the brand's Karen Parry says.

"The BTCC is a fabulous and engaging form of motorsport: it's accessible, it's also great for families and shows us racing our 'showroom cars'. We're massively proud of our touring car team and we're looking forward to the season."

> *"The only areas a manufacturer can throw money at are the salaries of its drivers and the size of its hospitality awning"*

Gow, meanwhile, sees the increasing manufacturer involvement as only good news for the series, opening it up to marketing levels it cannot reach by itself, and no longer carrying the boom-and-bust risks of the 1990s.

"Manufacturers leverage their involvement and investment in the championship in ways in which we could never reach the public," Gow says. "The marketing and PR they carry out around their involvement does nothing but add tremendous publicity to the BTCC – that's the most important aspect by a long shot, it keeps on putting the BTCC in front of a public that might not be exposed to it otherwise."

He would be happy for more manufacturers to join the BTCC: "The difference is manufacturers today can't influence the technical regulations and the costs to the teams. That's a good thing, and good for the manufacturers too. Manufacturer involvement in motorsport and particularly touring car racing has changed dramatically from what it was. Then it was an engineering exercise; today it's a sponsorship exercise."

So the manufacturers in the BTCC are happy and the BTCC is happy to have them – they have nothing like the clout they enjoyed in the 1990s, but the financial investment required of them is also nowhere near as challenging to justify. And if every competing manufacturer withdrew tomorrow, their BTCC representative teams would likely be able to continue as independents, due to the level of cost control established. "The teams running with manufacturers were independents before; they could easily be so again," Gow says. "A team can design, build and run a car at the highest level with or without manufacturer involvement."

The BTCC appears to have achieved the Holy Grail: it is today a self-regenerating racing series. RT

Ebrey/BTCC

ABOVE BMW's return as a manufacturer has added to the buzz around this year's series

FLYING START

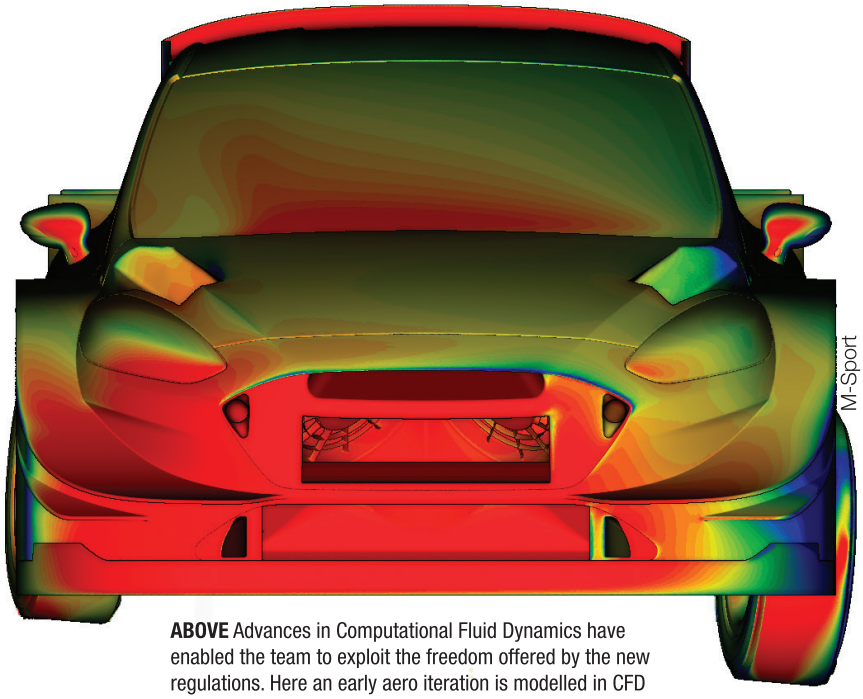
The might of the Citroen, Hyundai and Toyota works squads currently trail their only regular non-factory WRC rival. **Hal Ridge** talks to M-Sport's head of rally engineering to find out why

BRITISH firm M-Sport has a habit of achieving success with new cars created in the Lake District for FIA World Rally Championship competition. Its new Fiesta WRC, conceived to take on the might of works teams from Citroen, Hyundai and Toyota, continues that tradition. Despite what's been branded the most fiercely competitive series in years, as we closed for press the Fiesta topped the drivers' and manufacturers' standings.

Much hype has accompanied the new WRC regulations, which take the cars closer to the glory years of the Group B era than they have been for some time. More power is extracted from the 1600 cc engines and they are armed with significantly more aerodynamic aids. Crucially, greater thought has also been given to the safety of crews, particularly in the event of side-impact accidents.

The Fiesta is not a wholesale redesign, however. While most aspects are totally new, generally it's a case of optimising every single area of the concept using knowledge gained since 2011. "The latest evolution of the previous car was implemented from Portugal 2015, so we had a reasonable base," explains Chris Williams, head of rally engineering, who has been at M-Sport since the beginning of the firm's Ford WRC contract in '97. "There are changes that are quite fundamental on the architecture side, and when you go for a new homologation you're allowed to change everything. It's a full new car, which gives you the chance to optimise – to look at everything again.

"It's fair to say that pretty much every part has changed in some way. Where over the last few years we've been looking at things and finding benefits, but not significant enough to warrant the use of a homologation joker [each manufacturer can implement three engine and three chassis jokers through the year], a lot of small development parts have been parked because there have been other things with higher gain to use instead. Here we've been able to incorporate all of those."



M-Sport

ABOVE Advances in Computational Fluid Dynamics have enabled the team to exploit the freedom offered by the new regulations. Here an early aero iteration is modelled in CFD

The chassis utilises new regulations that allow for suspension pickup points (onto each of which the T45 steel rollcage is linked to increase structural integrity) to be moved further from their standard location. But unlike the World Rallycross Focus RS RX that M-Sport collaborated with Ford Performance to create for 2016 (which uses double-wishbone suspension), WRC cars remain restricted to using a McPherson damper arrangement all-round, with lower A-arm. The dampers on the Fiesta are angled back to achieve positive castor, increasing high speed stability and camber gain to improve cornering. M-Sport has used its long running partnership with Reiger to develop its

WRC/Red Bull

ABOVE The aerodynamics of the new Fiesta WRC are given a thorough workout in Mexico

> *"At the last minute we were fighting over gurneys, what things should be and how they should be defined and calculated"*

external reservoir dampers for 2017.

"It's much more open on the pick-up points now, which is good," says Williams. "We've been working with Reiger on trying to optimise mass, so we've been exploring things like aluminium strut bodies. We've learned a lot over the last few years and there are places we can go to improve yet. The headache with dampers is that there are an awful lot of variables. The easily adjustable things are the velocity of the damping, high speed and low speed, rebound and adjustable bump stops, but there is our own innovation inside that you cannot see."

Adjustable anti-roll bars are used front and rear, along with a power-assisted high ratio (12:1) steering rack (with one and a half turns lock-to-lock). M-Sport's billet aluminium uprights are designed in-house at its Cockermouth base, but the machining is outsourced, and Williams is coy about the amount of suspension travel the 2017 version of the Fiesta has.

"We hit a point with the 2015-2016 car where we have more than enough. I'm not quite sure what our competitors are doing, but we have an awful lot," he says. M-Sport hasn't homologated specific 'architectural' differences into the Fiesta for different tarmac and gravel events, where for the different surfaces, alterations are around damper stiffness, wheel and brake size, increased under-body protection for the rougher events, and to the cooling package.

The new generation WRC car's behaviour is also affected by the implementation of an active centre differential. Fully active WRC cars were outlawed in 2005, but for ▶

ABOVE This line up demonstrates how the manufacturers have converged on similar aero solutions
M-Sport

2017 a hydraulically-operated centre diff is permitted. It's controlled using data from front and rear axle slip, speed, throttle position and brake position, with variable map options for the driver. Ultimately, the centre diff controls the amount of lock between the front and rear axles, where passive (mechanical) diffs are used.

"A centre diff on its own is not a massive change, but you have more control over the handling in different scenarios. There was generally inherent understeer before with a fixed centre diff, so you have a lot more control now," says Williams. "With this kind of technology on many road cars, it's crazy not to have it in world rallying. We're not in the days of free active diffs though, where there was a lot more control over vehicle dynamics."

REVERSE TORQUE

The use of the active diff also increases reliability. "A lot of the peak torques are actually reverse torque, so you can iron out the peaks. It helps with durability, which is good," he says. The new Fiesta also has brand new driveshafts and CVs, not only because cars are longer and wider under the 2017 regulations, but to find gains too: "We've followed some different architecture. We needed to design new shafts anyway, and that allows you review and optimise."

Braking is provided by Brembo four-pot monoblock callipers. The increase in power and grip, both mechanical and aerodynamic, means brakes need to be more efficient than previously. Disc size for asphalt events has been increased from 355 mm to 370 mm (with a minimum and maximum thickness of 30-32 mm) but the increase in size also makes for a rise in heat retention. To avoid this, ducting from the front bumper and rear quarter intakes feed air to the brakes – water-cooled braking was disregarded in favour of airflow after work with Brembo.

While 370 mm discs are mandatory on the front (on tarmac), teams in the WRC vary between 320 and 355 mm on the rear (housed within magnesium 8 x 18" wheels). On gravel, disc size remains at 300 mm as before (under 7 x 15" rims) with a minimum thickness of 25.4 mm and maximum of 28 mm. Where there are less heavy braking areas on gravel rallies compared to asphalt, lighter discs are used, and the ceramic pads are of a softer compound. According to Brembo engineers, tarmac rallies in Corsica and Germany are the hardest on the brakes, while the toughest gravel rallies are in Argentina, Italy and Mexico.

"We're allowed larger brakes on tarmac. We've homologated a variety because depending on the rally, we run a different braking package," says Williams. "We've worked very hard with Brembo and they've ▶

ABOVE Power and aero gains have been accompanied by a major push to improve side impact protection for the crew. The extra padding can clearly be seen here on the co-driver's door

ABOVE The design team have worked with Reiger to explore avenues like aluminium strut bodies in a bid to reduce mass

M-Sport

been very good to us with brake callipers. We've made good improvements over where we were."

At the other end of the drivetrain from the brakes, M-Sport has switched transmission for its 2017 WRC programme. Having previously used Xtrac, the six-speed sequential gearbox in the new car is from Ricardo. "It's a whole new transmission for us, and we chose it for a few reasons," confirms Williams. "We wanted to go somewhere different to what others were using, and implement ideas that we had that we didn't want shared. Going to a different manufacturer was the only real option to make sure 100% that there is no crossover." Like its competitors, the Fiesta uses a hydraulically-operated paddle shift, the championship having previously reverted to a manual change from 2011 to the end of 2014.

Between the transversally-mounted transmission and engine is an AP Racing multi-disc clutch. The power extracted from the 1.6-litre, four-cylinder, 16v direct injection EcoBoost engine for 2017 is one of the key talking points of the new-look WRC. Cars boast an increase of around 80 horsepower to 380, and approximately 450 nm torque, restricted to a maximum of 8,500 rpm.

Since 2015, M-Sport has been building its engines in-house, having previously used units from French firm Pipo. "The engine is an evolution on what we've used before. We've made a step forward, but we're learning all the time," notes Williams. "If you get the chance to optimise like we have for this year, you look at the whole engine package again. We had a few more ideas and innovations that we wanted to apply." The current Fiesta engine has a bore of 83.0 mm (84.0 mm is the maximum in the regulations) with a stroke of 73.9 mm.

Williams believes that having used the 1.6-litre powerplant since 2011, advances are now marginal: "All the gains are through efficiency and optimisation. I don't think there are any fundamentally big gains out there to be had with this type of engine. We're just looking to optimise and hunting for horsepower here and there. The engine is definitely more difficult to drive (this year), but we have a reasonably flat torque curve."

For 2017, the WRC's manufacturers have agreed on a single turbo, a Garratt Honeywell, through the rally technical working group. As part of the power increase, turbo restrictor size has increased from 33 mm to 36 mm. "The turbo has to be homologated on a list that everybody ▶

2017 Ford Fiesta WRC Spec List

Bodyshell	M-Sport	**Transmission**	Ricardo
Engine	M-Sport	**Clutch**	AP Racing
Radiator	PWR	**Brakes**	Brembo
Intercooler	PWR	**Dampers**	Reiger
Turbo	Garratt	**Springs**	Eibach
Management	Cosworth	**Fuel tank**	ATL
Dash	Cosworth	**Wheels**	OZ Racing
Steering wheel	Sparco	**Tyres**	Michelin
Harnesses	Sparco	**Fuel**	Carless*
Seat	Sparco		
Steering rack	M-Sport		

*FIA World Rally Championship control fuel

can use," he explains. "We [the TWG] originally opted for two different turbos and two different suppliers that could be used. But then, every time we did an evolution everybody would have to revert and test both turbos again, and the advantages are small. We've agreed on one supplier and one turbo that everybody uses." The maximum boost permitted remains at 2.5 bar, while the 2017 Fiesta continues M-Sport's use of Cosworth electronics for engine management and chassis and engine data acquisition.

The water radiator and intercooler sit at the front of the engine bay, fed by air through apertures in the front bumper. "The cooling package has changed for this year, in concept and philosophy," Williams reveals. "There was a regulation that limited ducting and the position of fans, which was lifted. It's opened up new areas that we've been in the past, that the door had been closed on."

It's that opening of the regulations that includes ducting to the brakes and cooling package that has made for arguably the biggest change in 2017 WRC cars. For the first time since the Group B era (that ended in 1986), WRC machines now have a significant amount of aerodynamic devices. Rules allow for a 55 mm width increase, additional overhangs front (by an extra 60 mm) and rear (an extra 30 mm), aero devices can be placed ahead of the front wheels and a rear diffuser can protrude up to 50 mm behind the bumper.

> *"Everybody's been developing in secret but you can see where we've found the same solutions"*

AERO BATTLE BEGINS

The Fiesta, like most of its rivals, has two diveplanes per side on the front bumper, but the Ford also has a turning vane below the diveplanes on both sides. At the rear, two diveplanes in front of the aggressive arches sandwich a duct for the rear brake cooling. Behind the front and rear wheels, louvers are housed in the arches, similar to those seen on the Focus World RX car.

"In the past [FIA regulations] limited it so much that cars had few appreciable aerodynamic features that actually made a significant difference. It was all small stuff that gave a very small effect, but now you have proper aerodynamic cars with proper effect," explains Williams. "It's something new in the modern era, certainly.

"We've been discussing [in the TWG] since early 2015 about what areas could be opened up in aerodynamics, although the regulations were not fixed for quite a period of time; in fact, they were not fully fixed until September of last year. At the last minute we were fighting over gurneys, what things should be and how they should be defined and calculated. But, we knew early on what the potential could be, and each manufacturer was looking at where we could explore that, where the limitations were, what was feasible within the regulations and fed it back.

"Quite a few amendments were made on what was permitted, rather than having an open rule book to do whatever you want. There are a few rules to avoid people spending huge amounts of time, effort and ▶

WRC/Red Bull

ABOVE A Ford driver hasn't won the WRC crown since 1981 but Ogier's victory in Monte Carlo, the team's first win for five seasons, threw down the gauntlet to the rest of the field

M-Sport

ABOVE R&D collaboration with Lazer Lamps has resulted in the use of LED technology that is lighter, uses less power, offers better contrast to drivers and has aero benefits

money in wind tunnels."

The traditional way of testing for aerodynamic gains is in the wind tunnel, but M-Sport's Fiesta has never seen such a thing. Such are the advances in Computational Fluid Dynamics (CFD) modelling that the Fiesta was designed on computer. And, it's in that area where engineers in the sport have benefitted with the recent technological advancements.

CFD BREAKTHROUGH

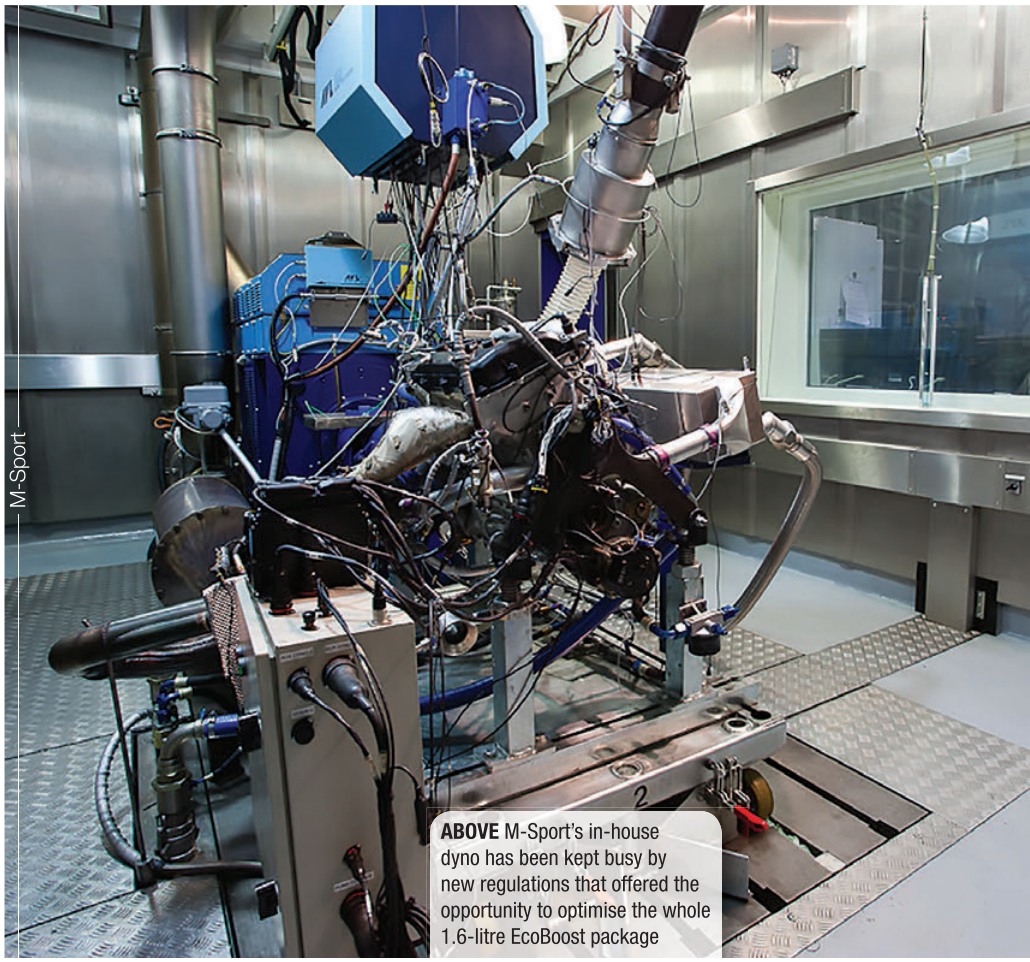
While a wind tunnel is ideal for smooth tarmac surfaces, it's near impossible to create the undulations of a rally stage, especially with a rally car that has significantly greater yaw angles (up to between 10 and 15 degrees in a WRC car) than a circuit racing machine. "We had good experience from previous CFD programmes and reasonable confidence," says Williams. "We also didn't really have the budget to spend weeks in tunnels with scale models. Simulating different environments is the breakthrough that's coming more and more. Once people gain confidence in the model techniques and there's good validation, you're not constrained to steady state."

M-Sport has current experience of aerodynamics outside rallying, in GT3 racing with its Bentley project, and in World Rallycross with the Focus RS RX, but Williams says there is no crossover with the current car and any of its other programmes: "It's a whole different ballgame; we couldn't carry over anything because it's not relevant. You have to look at it as a complete package, with both environment and car."

Having homologated its car for 2017, Williams doesn't expect that M-Sport will change the aero this season, and says the biggest challenges have been to ensure the car works in all environments. "We have the opportunity to change things with homologation jokers through the year, but the intention is not to. You've got to have an aerodynamic package that is robust in its operation, so over a wide range of yaw and pitch angles you don't have any significant drops or sudden changes. You can't optimise it for a very specific area and forget about other transient changes, or you could have a car that is extremely difficult to drive."

Since imagery was released of the 2017 test cars, there has been speculation that the aerodynamic efficiency of the machines would be minimal on gravel, something Williams refutes: "They are surprisingly effective, and one of the keys to the whole thing is how durable you can make your aero package because if you start losing parts, you could be quickly at quite a high performance disadvantage. At the design stage there is an approached risk and I think you see that across all of the cars. Some do not look that dramatic, although there are some fairly sound aerodynamics on them, right through to the ones that look fairly extreme and you see some quite interesting features. It is a risk; you don't know when you're designing it if you can get it to live. The key is to find a compromise."

Williams also says that similarities in the four new WRC cars for 2017 are reassuring. "Some have explored different areas but for sure there is an awful lot of commonality," he notes. "Everybody's been developing in secret but you can see where we've found the same solutions, albeit that some of them ▶


M-Sport

ABOVE M-Sport's in-house dyno has been kept busy by new regulations that offered the opportunity to optimise the whole 1.6-litre EcoBoost package

ABOVE & BELOW The arches, flick-ups, louvres, diffuser and rear wing form a distinctive aerodynamics package

WRC/Red Bull

are implemented in a slightly different way. That gives you confidence in your studies and analysis. There are a couple of wacky things here and there, but unless I'm wrong, I don't see any game-changers."

Of the four new cars, the Fiesta's double-plane rear spoiler and lower diffuser are among the more modest. As a diffuser is angled to balance downforce front-to-rear, the fact that the Fiesta's is a relatively shallow angle suggests the front end is suitably efficient to not require anything greater.

Among the 'wackier' elements on the 2017 cars are the dual-element wing-come-wing mirrors on Toyota's Yaris, that wouldn't look out of place on a Formula 1 car. Williams has doubts about the gains in such areas: "I don't see an advantage really. Or, it's very small because they maybe initially had a different design, but by regulation were perhaps forced to tone it down somewhat and what was left is more aesthetics than actual performance, but I don't know."

Adjacent to the performance advances this year, safety in WRC cars has improved too, specifically surrounding side-impact protection. An increased amount of foam is required between the side of the car and the crew, and strengthened sills. Originally, the sills were proposed to be extended and foam-filled too, but following concerns that the extensions could block the door in the event of an accident, the sills on all cars have been reinforced with additional steel, inside the door, to give less opportunity of blocking the opening.

POLE-SIDE IMPACT

"It's all to improve the side-impact protection, specifically to what is known as pole-side impact, i.e. when you hit an immovable structure like a tree around the centre of gravity of the car, on a lateral collision," says Williams. "Those types of impacts are quite difficult to dissipate the energy from, and over the years that has seen the most fatalities by a long way. It's approximately 300 mm from outer skin of the car to the crew, which is not a lot. If you hit forward or rear of the COG, the car tends to rotate around the pole, but if you get it close to the COG, the acceleration and the intrusion into the cockpit is high.

"In 2016 we had side impact protection foam and specific 8862 seats. Now, there is more foam of a mandated thickness between the outer point of the car and the seat. There's a minimum thickness (240 mm) and volume from the seat to the door skin. To achieve this, many cars have a layer of foam on the outside of the door skin and a composite cover. The Fiesta for example has about 55 mm of foam on the outside of the door, and just looks a bit fat around the waist." Additionally, for safety and weight saving (for 2017 the minimum weight has been reduced by 10 kg to 1190 kg) the side windows are polycarbonate, but the windscreen is glass laminate, bespoke to the car.

Unlike the manufacturer-owned and run teams in the WRC, M-Sport is achieving its current success despite significant limitations. That momentum is driven by the passion of the management, which rubs off on the employees. That was more than evident in the video published before Christmas where MD Malcolm Wilson announced to his staff, in the workshop, that they had signed four-time world champion Sebastien Ogier for 2017, following VW's departure from the sport. Across the design and development of the project, just 12 designers and five engineers were involved on the chassis, transmission and electronics, and not all of those were permanent.

"By combining 20-odd years of M-Sport's experience and new ideas, designers and engineers, it's brought together a very small, passionate team that work some very long hours because we really think that we can hold our own against the bigger, more funded teams," says Williams, proudly.

Having Ogier as the spearhead this year is clearly of benefit to the British squad, but Elfyn Evans' and Ott Tanank's speed and consistency in the opening three rounds is also proving that the Fiesta is fundamentally a very solid proposition. "When Sebastien first drove the car he wanted to change some things, but mainly setup. We knew then that the car was okay," recalls Williams.

"Seb coming was a morale boost, but in terms of technological advancement, the philosophies we've followed are our own. We've done our best over the two years of this project and the pressure is on now. We know we should be able to win, we should be at the front."

Despite winning back-to-back manufacturers' titles in 2006 and 07, M-Sport is yet to win a drivers' world championship. A Ford hasn't won a drivers' WRC title since Ari Vatanen steered an Escort RS1800 to success in 1981. The 2017 Fiesta WRC could be the car to re-write history. RT

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BLACK MAGIC

Much time is spent tyre testing, but what is involved and what does it actually mean? **William Kimberley** went to Aragon in Spain with Dunlop to find out

EVERYONE knows about tyre testing: teams go off to various circuits armed with a lorry load of tyres and test them, usually before the season gets underway. All the other components of the car are tested, so why shouldn't the tyres? The problem is that because they are made of that elastic rubbery stuff that changes shape and distorts at the drop of a hat, they are virtually impossible to simulate. The only way to get positive feedback is to reduce the variables and simply go pounding round the track.

After decades of providing racing tyres, Dunlop has got its test procedure down to a fine art. Nothing is left to chance, everything is recorded and analysed and consistency is the name of the game.

Before the tyres and teams reach any circuit, whether for testing or to race, there is a huge amount of work that goes on in the background analysing both construction and compounds. The logistics side of the business is an industry all to itself. From its plant in Hanau, Germany, Dunlop will produce something like 18,000 tyres for the cars competing in the World Endurance Championship, comprising slicks, intermediates and wets, which will be ferried around the world to different circuits. Of these, less than 10,000 will actually be used.

When it comes to this year's Le Mans 24 Hours, Dunlop will be servicing 30 cars, its biggest grid for very many years. It will be taking 80 staff including management, technicians, designers, compound engineers and 36 fitters. The latter, the guys on the ground, will be split into three groups of 12, of whom 24 will be on duty at any one time. The Dunlop pitlane engineer will stay with 'their' team or teams for the duration of the race.

According to Paul Bryant, Dunlop's international event manager, when it comes to managing the tyres for the long haul races in WEC and the European Le Mans Series, something like 2,100 are shipped from Germany to Mexico in five containers. After the race, one container filled with used tyres will return to Hanau while the other four will make their way overland to the Circuit of the Americas in Austin, Texas. They will be joined by another three containers that will be air freighted in from Germany. After the race, all seven containers return to Hanau. The same process is then repeated for the races in Japan and China.

ANALYSING THE TRACK

On arrival at the track, the technicians start the process of measuring, recording and analysing the surface, taking into account things like the curve radiance, rumble strips and any dips and bumps.

"Because we are performing tyre tests we like it to be as scientific as possible so that we get a good understanding of what we are doing and the interaction between the drivers and the cars and the tyres," says Mike McGregor who is responsible for testing and track support. "We measure the surface and look at any changes to see how it affects tyre wear." ▶

BELOW The cars racked up over 20,000 kilometres between them at Aragon, the equivalent distance of four Le Mans 24 Hours races

All photos: Dunlop Motorsport

Why Aragon?

BELOW Aragon's demanding characteristics make it an excellent venue for tyre testing

MEASURING 4.929 km, Dunlop favours testing at the Spanish circuit for a number of reasons. Apart from the better weather, there is a high-speed section that allows speeds to reach around 330 km/h, the upper limits seen at Le Mans.

Where it's very different is that the loading and energy level of this track are much higher, so giving almost the hardest scenario in terms of what load is being put into the tyres. "This circuit is very demanding on the tyres and is a great place to test them," says senior engineer Vincent van Goor. In its 'aero' configuration Aragon also has some similarities to the Nordschleife.

"As you come off the back straight you have a very tight high-speed left-hand corner like the Parabolica at Monza," says Mike McGregor, who is responsible for testing and track support. "We race on a multitude of tracks and over the year we have certain things we need to improve upon at certain types of track. At Sebring, for example, there are 37 different surfaces around the track so we have to understand that and see where those changes come in to make sure that we are accurate in the data acquisition.

"We segregate what we can learn from each of the tracks and take that to our next tests. When we look at our mid-season tests, we look at what circuits we're going to visit in the rest of the season and also what information we need for the following year for tyre development in terms of load and cornering.

"We race at extremely different circuits. Mexico is more like a street circuit, where you need to be soft on compounds; but at places like Fuji, which is very hard on traction, you need to be more aggressive. We try to understand how that works with the rear tyres to make sure we get the most benefit out of them.

"It means that when we look at the development through the season we might see we need to concentrate more on mid-corner, corner entry or corner exit on a circuit that's got more abrasion or long radius corners like the Parabolica." RT

Tyre simulation and data analysis

COLORADO company OptimumG has been working with Dunlop Motorsport since the end of 2008 with the Rahal BMW M3 in the American Le Mans Series and with the Schnitzer car in WEC, then in LMP2, GTE and VLN.

"I think we have helped Dunlop make substantial performance gains on their competitors," says OptimumG president and founder Claude Rouelle. "I firmly believe that Dunlop creates better tyres than its competitors, but the main advantage that OptimumG engineers provide to the Dunlop teams is expertise on tyre exploitation thanks to simulation and data analysis.

"Designing tyres' construction and compound – tell me about 'black magic' – is an incredibly difficult job. That's not our business. Explaining what the tyre needs and how to exploit it is what we do. By making the vehicle dynamics interface between car and tyre, we help Dunlop to design tyres for a given car and/or we help the teams to get the most of given tyres.

"The beginning of our collaboration started with a seminar in Birmingham in the summer of 2008 when I quickly discovered that Dunlop Motorsport operations director, Jean Felix Bazelin, and then technical director, Emmanuel Robinet, as well as key Dunlop engineers shared the same vision as OptimumG staff about the car-tyre performance interdependence. How could you design a tyre if you don't understand the car? How can you design the ideal suspension kinematics and choose the weight distribution and the aero balance in the car design phase and springs, anti-roll bars and damper setup in the development phase if you do not understand the tyres?

"Since 2008 that collaboration has been an engineering and a communication success. We challenge each other in a respectful way and that helped them make better tyres and us to design and exploit better testing methodologies as well as better simulation and data analysis tools. At the end the Dunlop customer is the winner.

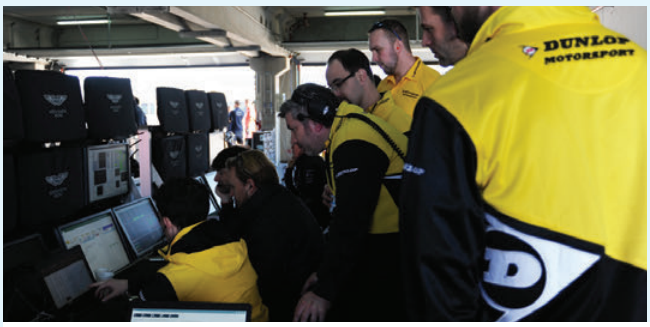
"Before and during the racing season we perform in-lab extensive tyre testing. We use Calspan and Sova motion flat track tyre test bench quite often. We measure and characterise each tyre force and moment sensitivities to slip angle, slip ratio, vertical load, camber, pressure, speed, temperature, heat cycles and wear.

"From the tyre test data we create a tyre model with OptimumTire that includes transient and thermal analysis and we then use the model in OptimumDynamics, our vehicle dynamics simulation. We use the criteria of grip, balance, control and stability on entry and at the limit to quantify which car design and setup parameters will influence the car behaviour either on generic tests or on track replay.

"We do not know for sure what the car setup should exactly be – a week before the race we don't know the air and track temperatures, the wind speed and direction and so on, but we can advise the team on a good basic car setup. Moreover, we give them direction on under and oversteer issues to adjust the car setup depending on the objective (data analysis) and subjective (driver comments) information collected at the track during or between test sessions.

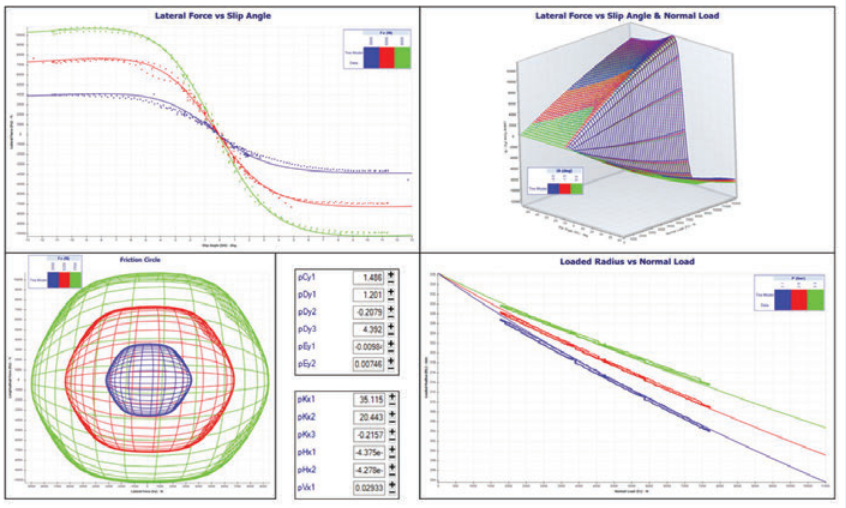
"I think one of the advantages that OptimumG provides is that the engineers who oversee the simulation and data analysis tools are also the ones who go on the race track and help the Dunlop team. We have been performing that work for over eight years with Dunlop on many different circuits with many different cars and drivers. We have now lots of data that help us refine the tyre design/in-lab test/modelling/simulation/on track test/data analysis loop. That's what is helping Dunlop design better tyres and increase the car performance quicker – and to know why.

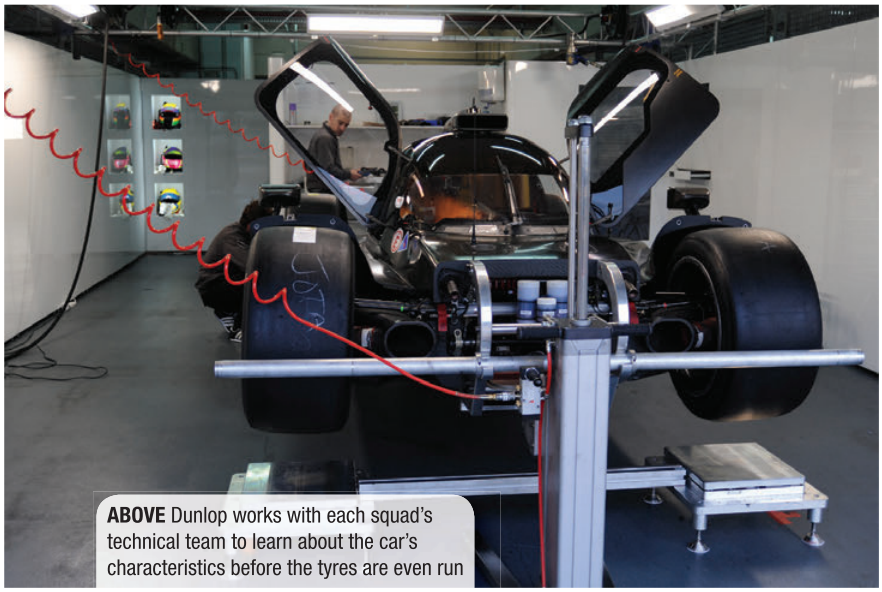
"The success of this collaboration depends also on the quality of the communication with the car manufacturer and the team. Optimum results can only be achieved when the two sides are prepared to share their most secret and sensitive data. There's always a little resistance for teams to share their car design, but the reality is that the teams are the ones that benefit the most from our advice." RT



LEFT Extensive tyre test data has improved tyre modelling

BELOW OptimumTire software allows a huge amount of tyre test data to be converted into usable mathematical models for simulation





ABOVE Dunlop works with each squad's technical team to learn about the car's characteristics before the tyres are even run

A key component is the driver, but being human beings, their feedback can be inconsistent and varied. To try and overcome this, Dunlop has a rigorous method of getting them to put down their thoughts on a data sheet before they can even talk to their engineers, let alone other drivers.

"It's never easy with drivers because each one is different," says McGregor. "We have a set schedule for a test programme and when the car is on its in-lap we like them to push as much as possible so that we can record the data as they come into the pitlane. They give their feedback as to whether the car has more under or oversteer, aspects of traction and braking, overall stability and grip and then we give them a rating sheet in which they rate different areas from 1 to 10. We don't allow them to communicate with anyone beforehand so that they can concentrate on their ratings as their feedback has to be accurate and the data we record is precise.

"Drivers like our test driver Daniel Serra, who has done a great deal of development work, can even rate things down to 0.5. One of the reasons we have a development driver not necessarily linked to the programme is that drivers tend to concentrate on the car whereas we need to understand different cars. With LMP2 and ELMS this year there are four different chassis and we need to understand how each one works with the tyres, so one of the reasons for having Daniel is to remove that variability.

> *"The speed increase is massive and downforce levels have increased by up to 40%, giving higher loads on the tyres"*

BELOW Aston Martin spent time adapting the tyre and car set-up for the change in regulations which restricts tyre use for the GTE class this year

"We use the ratings all the way through to score the tyres and sit down with the driver afterwards and go over the ratings with him. Prior to that, even before we start testing, we work with the team's technical guys to learn about the car's characteristics before we run the tyres. It means that we can really make sure that if, for example, we change the vertical stiffness of the front tyre, we've already pre-empted that in terms of the ride height or have advised the engineers so that if there's improved grip, it hasn't been influenced by the aerodynamics or anything else, but it's because we've improved the tyre in that area. They're the things we try and separate.

"We work with different race teams to try and get specific information that can help us understand whether the warm up is better, where any inconsistency has improved or if there's a better braking performance that we put into a matrix. However, at the same time, we have to take the driver out of that equation and do it with car data, which is where the KPI – key performance indicators – comes in.

"We are running different KPIs with the car data to see how we can help driver feedback and the balance of the car to improve setup information. Is the driver braking in the same place each time and if it's different, is it because the tyre is performing better? We need to take into account everything such as the brake pressure, the steering angle, the throttle position. If we look at all of those ▶

matrix together we've got to try and make sure that the driver is being consistent and we get the correct information.

"In endurance racing, consistency is key and as we proved at Le Mans last year, the drivers were still putting in as fast a lap on their fifth stint as they were on their first. Then we start to build more about the handling, braking, turn-in response, change of direction, high-speed stability and traction, all data points that we need to understand.

"Building on from that we try to make sure that the information we get matches the race weekend. So we also have another data sheet in which the parameters are exactly the same but are based on practice sessions with different compounds and different combinations in a race weekend to understand the tyres. To match that information for tyre development we use the rating sheet that gives us the same information.

"We're trying to find new ways of supporting the teams that can make it much easier to transfer data, making it more accurate, so we are rolling out new software this year that will run live at all the race tracks. The track engineer will be based in the garage next door to the data and tyre engineers and will be constantly inputting back data from all the drivers.

"It's run live so that when I'm in the main office we're looking at that data to see if we can help them in any way. Straight after every session we can also provide the teams with a summary report to help us know what we need to target for the next session in a weekend. We are also looking at introducing a Bluetooth system to speed up the whole process and support teams better."

Tyre spec feels the freeze

THE tyre manufacturers must declare to the FIA a maximum of three tyre specifications for each model of car entered in LMGTE Pro and LMGTE Am for the full season. However, the three LMGTE Pro specifications can be different from those of LMGTE Am for each model of car.

Two specifications must be submitted at least 15 days before the first event and a further additional one can be declared at least 15 days before Le Mans. These three specifications are then frozen for the duration of the season unless the manufacturer changes model.

ABOVE & BELOW LMP2 presents a huge challenge with all-new tyres and all-new cars. Progress was made with each team with nine Ligier, ORECA and Dallara cars attending

2018 STARTS HERE

To prepare for this season, Dunlop tyre tests had already covered over 10,000 km on development tyres. Work has also started on 2018. The LMP2 front tyre has increased by about 25 mm to be 685 mm but the rear remains the same despite the extra power. Key goals for this year include: the durability of the tyres to meet the requirements of the more powerful and higher downforce 2017 cars; optimise the combined loading capabilities of both the front and rear tyres; and maximise wet grip and consistency to widen the operating window for wet and intermediate tyres. With the class allowing a free choice of tyre manufacturer, Dunlop is also keen to retain its leadership in LMP2.

"We started testing in Bahrain straight after the last race of the season with the new cars coming into LMP2 and so tested with multiple manufacturers," says McGregor. "From there we went on to Sebring with three of the LMP2 manufacturers as well as with Aston Martin. Then it was Valencia and then a major wet test at the start of February at Paul Ricard with the LMP2 and GT ▶

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ABOVE Two new-for-2017 Ferrari F488 GTEs were present for the test

VLN and the Nordschleife

ALSO taking advantage of the Dunlop test session at Aragon were three VLN teams: Phoenix Audi with its R8 GT3, BMW Walkenhorst with its BMW M6 GT3 and the SCG Glickenhaus, which looks like an LMP2 car but is road legal. The challenge for them and Dunlop this year is that there are potential new regulations coming into force that could stipulate 'customer tyres'. With this in mind, the main goal has been to work to meet the teams' requirements at the Nordschleife.

The special requirements of this demanding circuit include tyres that can work in extreme conditions from 2°C in the wet up to 60°C track temperatures in the summer. It means that tyre durability is extremely important and they must have a wide operating window to be able to cover the varying conditions without additional pit stops.

"The Nordschleife has many parts that are unique to it with loading situations that can go up to 10,000 Nm and peak loading of 50,000 Nm depending on the situation per wheel," says Bernd Seehafer, technical project leader motorsport EMEA. "It therefore makes it quite demanding on the tyres and needs to be the focus of tyre development. There are also variable weather conditions from ice in May to snow in March and also Sahara conditions." RT

BELOW BMW Walkenhorst was among those teams with an eye firmly on tyre changes for the Nordschleife

manufacturers. It also included VLN cars."

"We gained a great deal of knowledge and experience from last year's LMP1 development that we captured in this year's LMP2 tyre package," says Vincent van Goor, senior engineer, racing car tyres development with reference to Prototypes. "We have performed extensive FEA modelling to improve the shape of the tyre, leading to both the front and rear sets having a new shape to improve wear and consistency. In addition, we also wanted to improve the combined – lateral and longitudinal or braking and turning in – loading of the tyres compared to last year that is based on feedback from the team."

By the time of the Aragon test session in March, 500 development tyres had been tested with more than 40 specifications considered.

"We now have four chassis manufacturers – Dallara, Ligier, ORECA and Riley – with two being new to the series and all four chassis being new so we have to learn how to get the best out of the tyres for each one," says Goor. "The engine from Gibson Technology is also new and is 100 hp more powerful which leads to an increased top speed of around 340 km/h and reduced lap times accordingly compared to the 300-310 km/h of last year's cars. Even the LMP1-L cars last year were only capable of around 320 km/h, so the speed increase is massive.

"On top of that, the downforce levels have also increased by up to 40% so that at its maximum it's three times the car's weight and consequently higher loads on the tyres. This year is therefore a big ▶

BELOW Dunlop's future goal is to increase tyres' intelligence to the point that they are feeding back real-time information to teams and drivers

> *"Consistency is the name of the game"*

challenge to get a good tyre package which works consistently well in terms of durability and performance."

"One of the biggest things for us now with endurance racing at the Nürburgring and the Le Mans 24 Hours is operating windows," says McGregor. "We try to look for the widest operating window. When it comes to strategies it's all about having the optimum tyre on the car at the right time but at the same time not having to change tyres all the time as the weather and temperatures change and trying to pre-empt that."

Enhanced RFID technology

AT the Aragon test, where something like 2,500 tyres were being put through their paces, work was also ongoing on a refinement of the RFID that is used in the British Touring Car Championship.

"Dunlop is designing a new version that's smaller and lighter than the one that's been used in the BTCC for the last eight years," says James Bailey, Dunlop's marketing and communications director. "A radio frequency tag – an electronic barcode – is inserted into the tyre's sidewall as it's being moulded ,which is paired with a chip on the car so we always know what four tyres are on the car.

"By programming it with the length of the circuit, it helps the technicians know the precise distance every tyre has done and the reason it's important in the BTCC is that in that series over a race weekend the rules say that the teams can only use 16 tyres. A race weekend includes three free practice sessions, qualifying and three races so the teams have to consider how they are going to use brand new and used tyres throughout the weekend.

"Prior to this system being introduced, the BTCC scrutineers used to have to write down the barcode number manually. So it's not just about providing a tyre but about providing a good service for our partners. Not only is it more efficient, it also provides far more data."

The system was first tested with truck tyres. Similar technology is harnessed in NASCAR with the Goodyear brand. It's not yet compulsory in WEC but is being trialled. RT

BELOW The company's innovative RFID technology (Radio Frequency Identification), launched in BTCC at the beginning of the decade, has been replaced by an all new system trialled at Aragon

Dunlop wants to maintain the successful partnership is started last year with Aston Martin Racing which saw the team win two GTE Pro titles. "The contract with Aston Martin was not signed until the beginning of March last year which led to a lot of development work to get the tyres ready in time for the season, but the team still won the teams' and drivers' championships," says Stefan Nasello, Dunlop's man responsible for R&D tyre vehicle mechanics and race engineering, GT. "The work with Aston Martin was exceptional and we became part of the team, discussing race strategy and so on. In addition to that we did a lot of development work before the season to surpass the competitors. Now we are concentrating on the season ahead to provide the best tyres for the team, which is what is going on here at Aragon.

"The new regulations for this year [see sidebar] have seen a reduction in the number of tyres to four sets for a six-hour race and there is a limit on the number of tyre specifications, preventing in-season development. It means that we have to cover different track layouts, track surfaces and weather conditions with just three tyre specifications.

"Le Mans provides an additional challenge being a part street course, so the track surface is very different from GP circuits while it's also subject to a diverse range of weather conditions. Altogether we've tested more than 300 tyres to define tyre specifications for this season and to train drivers on tyre management." RT

ARE YOU SITTING SAFELY?

From touring cars and rallycross, to drag racing and historics, Racetech seats are playing a role in the never-ending quest for improved safety

NEXT year will be the 20th anniversary of New Zealand company Racetech (no relation) producing the 8855-1999 FIA Standard homologated race seat. Since then it has produced hundreds of specialist race seats that are used the world over, by thousands of teams and drivers.

Over the years it has worked with the FIA on various development and testing projects. Its team is regularly consulted by national motorsport organisations regarding appropriate technical standards and improved safety within race cars.

Never resting on its heels, the company has continued to develop seats that can be safely used in motorsport. Managing director David Black has even helped write the 8862 standard, which particularly features an upper back mount connecting the seat to the car's roll protection structure. This concept was originally developed in 2002 for the Dodge Viper race project by the late Dr John Melvin, a much admired independent racing safety consultant to the FIA, Indy Racing League and NASCAR.

The company has been recently very successful in supplying its seats to circuit racing teams and has experienced the largest growth while it has also supplied a number of FIA approved 8862-2009 seats to World Rallycross teams. This includes supplying the championship-winning Mattias Ekström Audi S1.

"We have seen our seat involved in some high G accidents where the driver has, through a combination of safety items incorporated into the car, literally walked away," says Black. "In a direct side impact into a tyre barrier at Hockenheim, a GT3 driver survived a 75G impact. The combination of a Racetech seat, Impaxx300 energy absorbent door foam and an extremely strong, well designed car allowed the driver to survive with very little injury."

Racetech's collaboration with Cobra seats has been a positive move, allowing it to supply its seats to teams competing in the British Touring Car Championship. FIA 8862 seats were mandated for last season and after a hectic pre-season every team was supplied and were operational for the media day.

"We can safely say that they have been well received and the hustle and rubbing that goes on in that series has put quite a few of the seats to the test," notes Black. "I have had comments from most of the drivers that it has been a very positive step forward in the safety of the cars.

"For the forthcoming season we have gained an even bigger share of the BTCC grid with Racetech seats being fitted to the works Vauxhall Astras prepared by Martin Broadhurst and Power Maxed Racing. Again this was another championship that was won using one of our seats."

The next area of growth has been in the drag car market: "We have supplied seats through our dealer Andy Robinson Racecars in the UK. He is the MSA Pro Mod champion for the fifth time. He also builds cars and roll-over protection for all disciplines. This is great for us as he can integrate the seat at the design stage. He then has a jig shell for each of the four sizes of our seats, which can be used at the build stage, reducing the risk of damaging the seat during installation. As he is building the rollcage it is simple for him to optimise the position for the backmount that is integral with our seats."

> *"The hustle and rubbing that goes on in the BTCC has put quite a few of the seats to the test"*

Another area of growth has come in the classic arena. The boom in companies producing very high quality saloon cars for racing at Goodwood events and Silverstone Classic – and the good sense in allowing them to incorporate up to date safety features in the car – has seen the constructors take advantage of fitting Racetech's FIA8855-1999 seats, primarily the carbon/Kevlar RT9119HR.

"This is the lightest seat that we produce with a shell weight of 4.4 kg and a total weight of 6.4 kg," says Black. "With the increase in the capabilities of these cars and the fact that most are driven by gentlemen who have to go to work on Monday to pay for the pleasure, safety is a real issue. It's also the wives and partners who want to look out for their safety as well." RT

ABOVE The 129 series has improved safety but also offered drivers a better 'feel' in series like the BTCC

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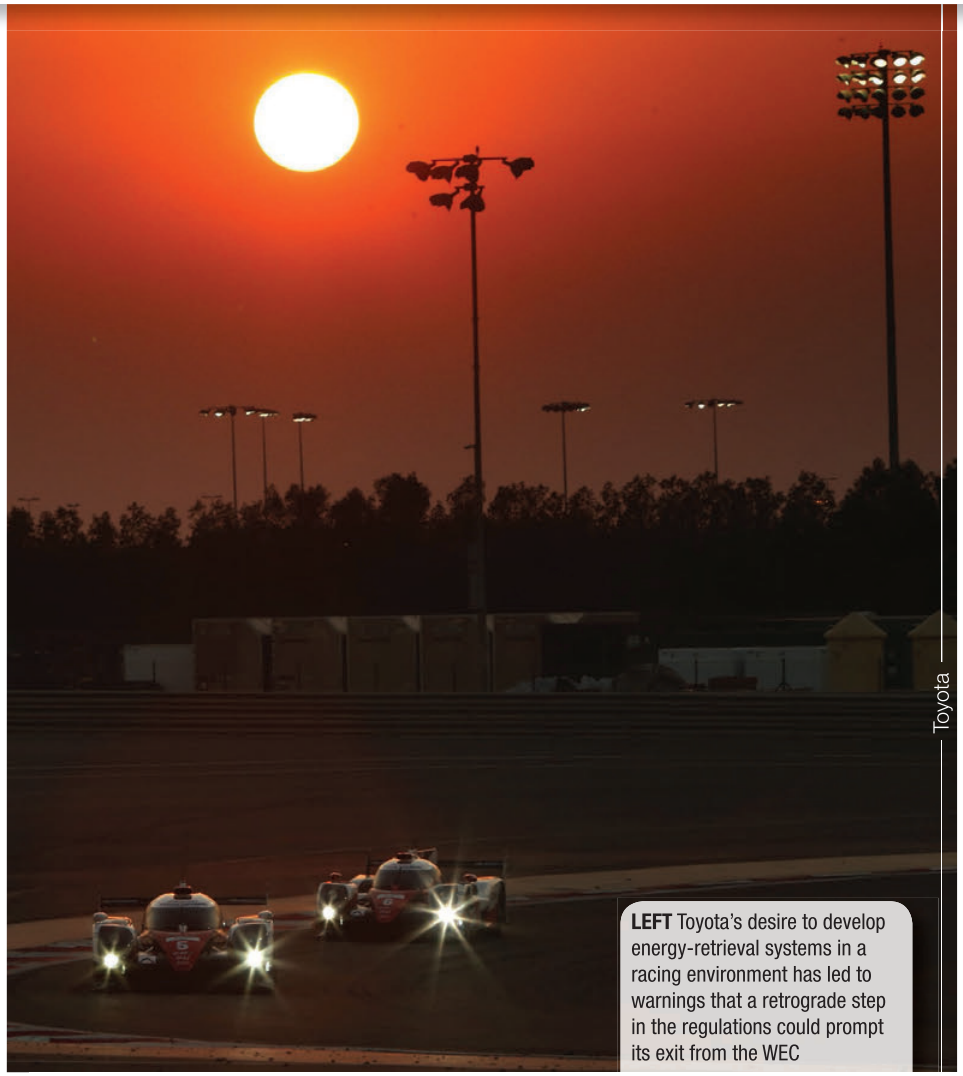

Toyota

LEFT Toyota's desire to develop energy-retrieval systems in a racing environment has led to warnings that a retrograde step in the regulations could prompt its exit from the WEC

A 'DUMB' DECISION?

The World Endurance Championship is at a crossroads, caught between warnings not to dumb down its level of technology and fears that costs are too high. **Sergio Rinland** has a suggestion

I **READ** with concern the suggestion a few weeks ago that, if there was any attempt to dumb down the current level of technology, Toyota would withdraw from the World Endurance Championship. If this happened, it would transform it into a 'one-horse race'.

We have written in this column on several occasions about the need to shape the WEC rules to make it attractive to others to participate, with a chance of being competitive, other than the rich OEMs.

The current rules were designed to encourage the highest level of energy recovery by penalizing the cars with the lowest energy recovery or the non-hybrid cars. These have, with the present format, no chance of competing with Porsche or Toyota, even on paper.

The withdrawal of Audi and downscaling of Rebellion sent shockwaves through the governing bodies. They reacted by freezing the current rules until 2019 and started discussing the reduction of the level of technology in order to cut costs. A knee-jerk reaction, perhaps?

If teams or manufacturers have money to spend, they will, despite what the rule-makers wish. There will be no exception this time round. Ten years ago you could be competitive in LMP1 with 10% of today's budgets. Yes, the technology level was lower, but there is not public knowledge of how much Audi and Peugeot spent to develop the diesel powerplants. Nevertheless, on paper, you could still be competitive with a petrol-engined car. This is not the case today.

The conundrum for the FIA, and more so the Automobile Club de l'Ouest (ACO), is how to balance technology deployment with the cost of participation and opportunity for success. It's not an easy task. But it has been shown by the current rules that the FIA and ACO have the tools and means to balance technologies to 'design' a status quo, so it should be possible to 'design' a set of rules so everybody has a chance and the best will win.

They won't be able to avoid the fact that a big OEM spends whatever they feel is an appropriate level to win and still have a good return on investment, be that marketing or R&D. If Peugeot believe they can succeed with a non-hybrid car, let them try. If Toyota wants to develop hybrid technologies and prove it's the way to go, let them try, and let the best one win.

In the same way as the automotive industry, where at the moment there is no winner in terms of what technology is best (even though Tesla is showing a possible direction!), motorsport and in particular endurance racing should allow competitors to develop what they think is best. They could spend as much as they want developing winning or dead end technologies: only time will tell.

At the same time, if smaller outfits want to participate with the most economical solution and have a chance, they should also be able to compete. That way, Toyota will be happy, Peugeot will come and privateers will still venture in. How can a set of rules be created to accommodate these needs? We have said it here before: regulate the outcomes, not how to achieve them.

What are the outcomes which affect most racecar performance? Power, downforce, weight and available energy. How to get these? It will be up to the competitors. As someone once said, 'Don't tell a kid what they cannot do, because he/she will do exactly that!' And we are all kids at heart, after all. RT

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