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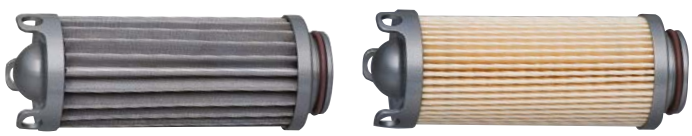

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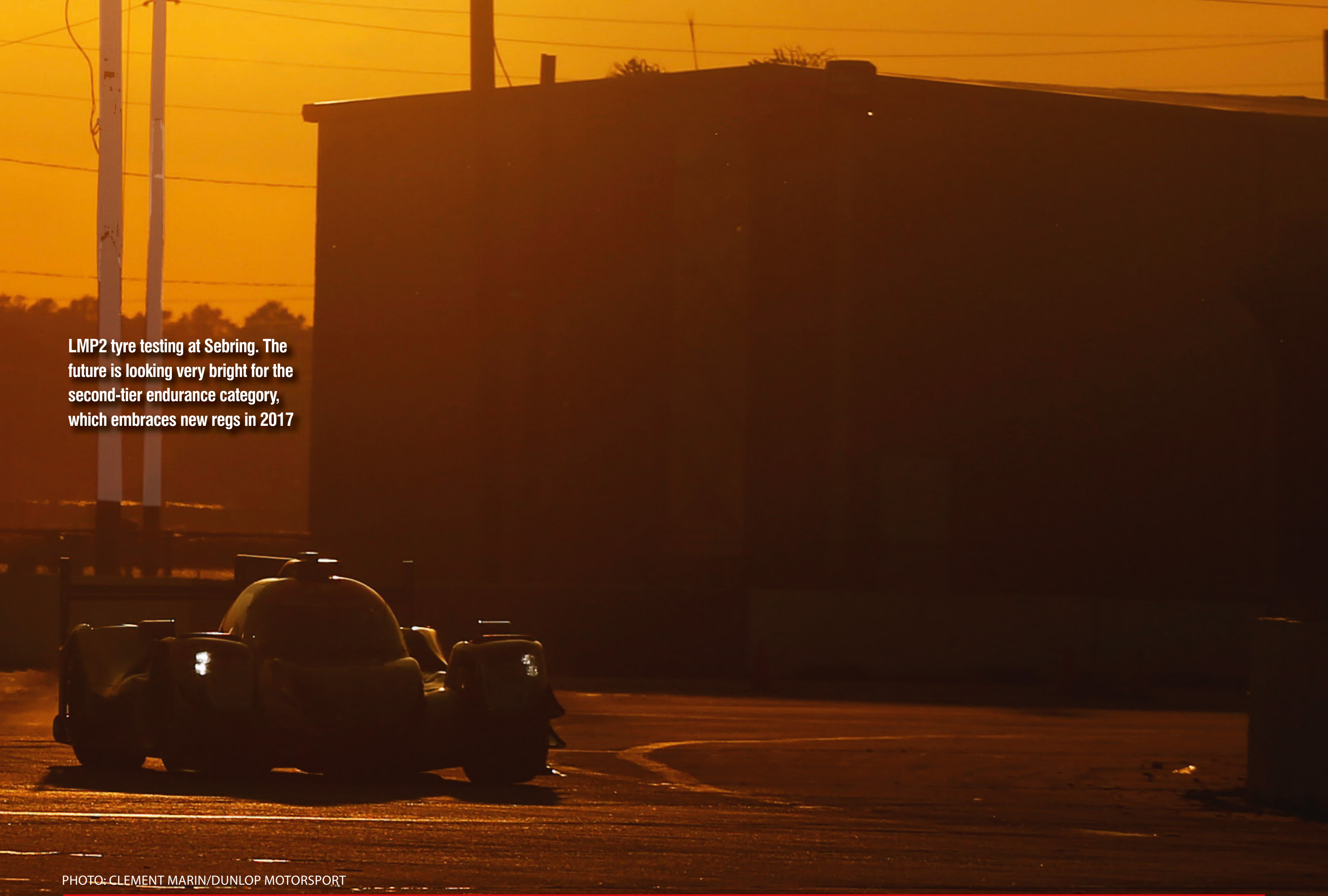

LMP2 tyre testing at Sebring. The future is looking very bright for the second-tier endurance category, which embraces new regs in 2017

PHOTO: CLEMENT MARIN/DUNLOP MOTORSPORT

Ghosts in the machine

When applying the brakes cuts the power steering just where do you lay the blame?

One of the great lies going on in the world is the triumph of technology. The reality is that the more technology comes into our lives, the more we are enchained by it.

Let's just take a small example. Once we got transistors into chips, to the tune of several million of them, we find that the simple tickling of AND and NAND gates can make inanimate objects take on a life of their own, even to the extent of seemingly having consciousness. The bad news is that this simulacrum of consciousness has an evil tinge.

The latest conspiracy of electrical gadgets bit me hard in the nether regions a short time ago. Having been dragged from another continent to flog a new racecar around a track to shake out all the bugs, together with a brace of drivers and the entire pit crew in preparation for the upcoming endurance racing season, one found oneself looking at a crash of software engineers (for surely this is the right collective noun) trying to make the CAN lines stop being CAN'T lines.

The gearbox was not speaking to the TC and the dashboard was sulking

Computer says no

There we have it, a fully fettled, fuelled and polished brand new racecar sitting in the garage while the opposition is pounding around. Many a computer was plugged in, only to find that the confusion around the Tower of Babel was a slight misunderstanding compared to the utter lack of communication between the multiplexed systems.

The engine was not speaking to the gearbox, the gearbox was not speaking to the TC and the dashboard was sulking in a corner, not talking to anyone. The fact that stepping on the brakes cut the power steering was the sort of thing not even James Joyce would dare to put into Ulysses (with Molly Bloom as an ECU), but Becket could conceivably knit it in to a coda for Vladimir and Estragon to spend more time waiting for Godot, who never comes, much like the data one is trying to collect.

Mechanical engineers tend to see all systems as something you cannot only grasp by mentally picturing it, but also as something you can grasp physically. The concept of electrons jumping gaps in silicon wafers has a little bit of a fairy tale about it, and can only be explained by imagining little green elves pushing electrons through copper wires, or by making pigs fly just because they are pink.

Well, there might be a bit of exaggeration there, but the whole concept of everything happening at a subatomic level is slightly surreal, but nothing compared to what dedicated software writers can do with code. It takes the concept of unintended consequences to a whole new level, not least because coders seem to have no inkling of what havoc they can wreak by the sheer fact that they all seem to operate in an ethereal fashion, totally unconnected to the real world.

One is only restrained from not using a baseball bat on their knees to bring them to reality by being too busy trying to distract the drivers by suddenly saying, 'Look! A squirrel!' or looking profound and muttering 'Of course! We overlooked the possibility of emulating the dashboard in a multiplex mode'.

Computers are like Old Testament gods; lots of rules and no mercy. Throw in programmers who delight in creating logical chains that always seem to end in situations where there is always an explanation for why it didn't work, but no solution to solve the problem, and you might be tempted to ask: 'Why do we have so many bells and whistles when we only want this to do one job?'

It probably can be answered by the simple observation that Voltaire once offered: 'Common sense is not so common.'

One proposes that the basic rule for programmers is that mechanical engineers are entitled to cut off a finger off the programmer's hand for each non-working piece of software, much as Yakuza members atone to the Oyabun for their mistakes. The downside of this would be that software will then be written much slower if the resulting gaggle of coders have to do it with their noses, as there would be a dearth of digits (see what I did there?).

Control-alt-delete

Lest one sounds too harsh, think about the tyranny software has brought into your life. Where most of the glitches end up being touted as a feature, not a bug, by people that should know better. By programmable steering wheels that cost more than a whole racing car did a couple of decades ago, and one is not being Luddite here, one even says *mea culpa* for opening the door to using electronics in the pursuit of a faster lap time at the very beginning of digital computing.

Lord, forgive us for that, we knew not what we had unleashed upon racing, and will atone for it by throwing ashes upon our shaved head and wearing sackcloth. Meanwhile, do not be surprised to see racing cars pulling up on the grass verges to do a control-alt-delete and reboot.

There is a standard response now that males of a certain age give when they can't answer basic questions. The usual reply is: 'You can find it out on Google.' So, the possibility that our technology, instead of empowering us, might actually reduce us and enslave us, seems to me definitely something worth thinking about.

XPB

There are now more computers than spanners at races – but have we become slaves to such technology?


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That deflated feeling

Could run-flat technology save motorsport tyre suppliers from adverse publicity?

Given the current insistence in the hierarchy of motor racing that the sport should be seen to be driving technology for road cars, the not uncommon sight of dramatic tyre failures – including in the most highly-televised global arenas such as F1 and WEC – presents the opposite image. Whatever the cause, be it debris or failure, the sight of one of these super-sophisticated machines destroying itself with a flailing tyre or spearing into the barriers at high speed because of an instant deflation is not a great endorsement of racing taking a technical lead. Especially when a good many up-market passenger cars already have run-flat tyres (RFTs) fitted.

Much of the huge development in production tyre technology such as materials, construction, tread design and compounds that has resulted from the race track is no doubt lost to the average viewer because it's not obvious. A tyre seemingly exploding is. It's not great for the tyre manufacturer either – a dramatic failure like this must surely create the wrong sort of publicity.

Flat mates

Admittedly production car run-flats have had mixed reviews among users, and the tyres have not been without their problems. Most of these have been to do with price, effects on ride quality, inability to be repaired and the like; not issues that trouble racing tyres, with the important exception of ride. However, I don't believe that there is any serious questions concerning their added safety. As most of you will know RFTs rely on a very stiff insert to the sidewall to prop up the tyre when the air pressure disappears. As sidewall deflection plays a major part in suspension characteristics (especially in F1, because the archaic 13in diameter wheels lead to a tall tyre), introduction of RFTs would create many headaches for chassis engineers. No doubt this would apply, but to a lesser extent, to the ultra-low-profile tyres common in LMP and GT cars, too.

Most likely RFTs, as well as being heavier – which is detrimental to unsprung weight – would be slower in a racing application, being less compliant. Therefore it would require the FIA to mandate that tested and proven run-flat capability was enshrined in the technical regulations. A lead time before implementation of at least two full years, possibly three I suspect, would be a necessity after consultation with the tyre manufacturers but also with the chassis constructors.

Clearly a lot more opportunity to test than is currently the case would have to be arranged; this would be costly also for the teams. But as well as the public perception, the potential to avoid a serious driver injury or even a fatality caused by heavy pieces of carcass or tread impacting the cockpit area could be as, or even more, effective than something like the Halo.

Ingenuity and innovation would be required but isn't that exactly the point of being seen to be relevant to the normal motorist and also fully in the spirit and purpose of motor racing?

I have limited knowledge of what goes into the alchemy that creates a current F1 tyre but I do scratch my head a bit when the track temperature is in the 40degC range and drivers complain that they can't get heat into their rubber (which it mostly isn't nowadays, of course).

XPB

When a tyre lets go in an F1 race there is nowhere to hide for Pirelli – so why not introduce the run-flat tyre tech seen on some road cars?

Rubber check

Only Pirelli seem to feel the need to have a strictly-regulated minimum pressure. As it is a good deal higher than the norm for racing tyres of this size and designed use, leading to reduced footprint and therefore grip, it has presumably taken away the ability to fine-tune the car set-up to run different pressures on each corner as the priority will be to always set all four to the minimum permitted. Fortunately, other tyre manufacturers in various types of racing generally set a recommended pressure range and leave it to the teams to employ good engineering common-sense so as to not overstep the safety mark. They obviously believe that there is sufficient built-in margin in their products to allow this freedom.

In fact, Pirelli's F1 programme puzzles me. The company does seem to make a mountain of matters that rival manufacturers appear to take in their stride. I fully accept that their engineers needed increased testing to accommodate the larger tyres allowed by the 2017 regulations, but their oft-expressed concerns over the greater aero loads etc that will also result from these changes indicates to me some lack of confidence in their simulation and testing tools. Higher-downforce F1 cars were run in the fairly recent past and one would think the challenge is not so great as to create such anxiety. After all, rival manufacturers' products cope okay with the extreme demands of LMP1 cars, as is the case with the very fast-cornering Japanese Super Formula machines and oval-running Indy Cars. I believe that Pirelli is capable of doing much better; that's why I'm surprised that it doesn't.

Mix and match

Taking the tyre issue further, why shouldn't F1 and other cars be allowed to fit different compounds front to rear and also across the axle, providing they are all from an allocated number and range (mix and match) as now? Nothing is as important to chassis performance as the 'four black round things', therefore it seems a bit backwards to me that one cannot optimise them according to the demands of the specific car, driver, circuit and conditions. Most tracks have more corners of one hand and sometimes include a long, high-speed corner that can soon kill one of the front tyres. Such a relaxation of the regulations could also introduce an additional strategic tool for teams to use, which might occasionally shake up the order, as we have seen in Formula 1 this year with three rather than just two configurations of compound/construction available.

Restriction for the sake of it has no purpose, I say – let the good times roll!

A tyre seemingly exploding is not great for the tyre manufacturer – a dramatic failure like this must surely create the wrong sort of publicity

Triple crown

The Mercedes F1 W07 Hybrid has made it three world championships in a row for the three-pointed star and it is now arguably the most successful F1 car of all time. But what makes the 2016 chassis such an improvement over its illustrious forebears?

By SAM COLLINS

Had it not been for an engine failure in Malaysia and a driver failure in Barcelona, the W07 Hybrid would probably have won every single grand prix in 2016

Not long after the sun had set over the desert on a Sunday evening in late November the superiority of the Mercedes F1 W07 Hybrid was graphically underlined. How? A controversy had sprung up during the Abu Dhabi Grand Prix. The leading Mercedes driver, Lewis Hamilton, had driven the closing laps of the race deliberately slowly in order to allow the cars from rival teams running in third and fourth to catch and perhaps pass the second-placed Mercedes of Nico Rosberg. Most of the media coverage following the race was focussed on whether what Hamilton had done was fair or sporting, but what they seemed to have overlooked was the fact that the only way any other car could get close to the 2016 Mercedes in this race was when its drivers drove it deliberately slowly.

Designed in-house by a team of engineers in Brackley, UK, the Mercedes F1 W07 Hybrid is the third car produced by the German marque under a set of technical regulations introduced into Formula 1 in 2014 – and it is by some margin the most potent of the three.

Family silver

From the moment images emerged of its first shakedown at a chilly Silverstone circuit in early 2016, it was clear that the W07 Hybrid was an evolutionary design, with a number of clear similarities to the W06 Hybrid which had dominated the 2015 season. 'It's difficult to have a complete revolution when the rules have stayed pretty much the same year on year,' Paddy Lowe, executive director (technical) at Mercedes AMG F1 explained at the car's public debut in Barcelona. 'We aim to make minor revolutions wherever we can, even within a small context. We may look at a completely new packaging solution or suspension concept, for instance. So, while the car may look very similar to its predecessor from the outside, as is inherent within stable regulations, underneath there are a lot of mini revolutions that make up an overall evolution for the new season.'

Quick silver

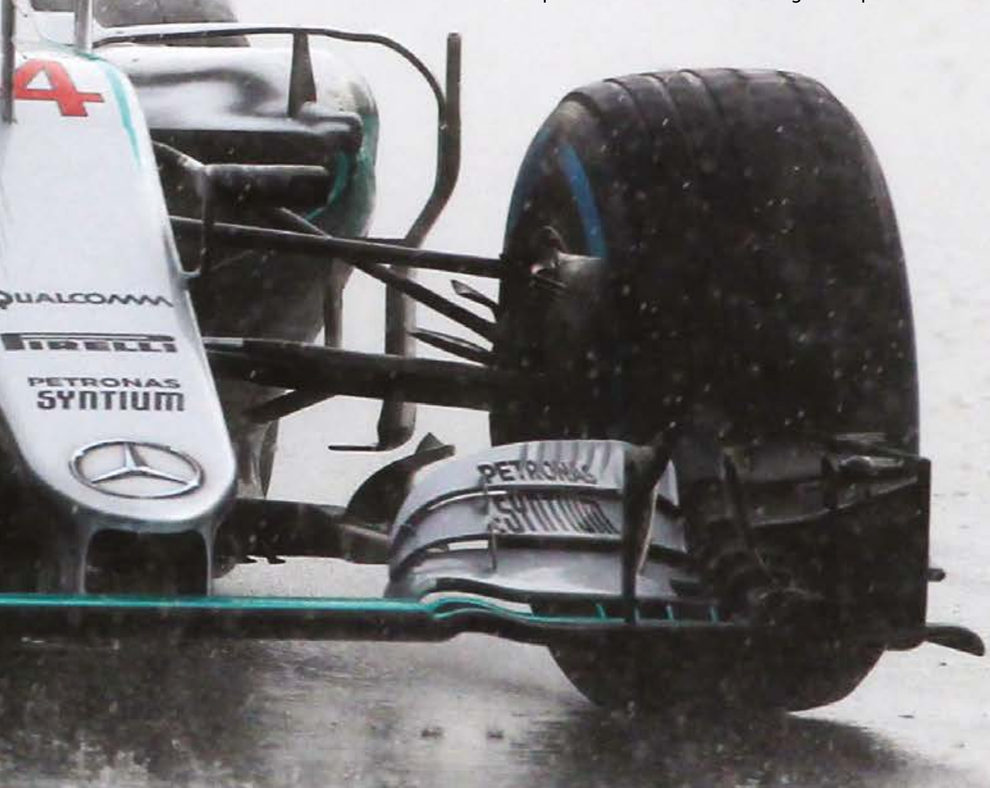
Looking back over the trio of Mercedes V6 hybrid F1 cars, the W05 (2014), W06 (2015) and the W07, Lowe feels that the two older cars are starting to look somewhat agricultural, despite the fact that they, too, were title winners, and would probably still be more than a match for most of the 2016 field. 'I guess it's all about innovation; the fascinating thing about innovation is that you don't see it coming.' Lowe says. 'It is not just about racing cars. I have just got a new phone, it's really cool, really small, shiny black package, more powerful, better camera, better screen, lots of things. I look at that and say to myself 'why didn't I have this 10 years ago?' The answer to that being that nobody had thought of a lot of the things used; they had not been invented. Invention is not always made in big dramatic moves. It's often the fine detail, the low level of advancement of progress of a design as you unlock opportunities. Using my phone as an example, perhaps they invented a much better camera receiver which was 10 years in the creation, and the camera's now moved on and that is just part of the package. The reason you had not done it before is simply that human endeavour had not gone that far. An F1 car is no different.'

Many of the lessons learned from the running of the W05 and in the development of the W06 fed in to the 2016 project. 'We make a better car each year because across a thousand different areas there are improvements, many of which are individual to a single designer,' Lowe says. 'He finds a way of making something five per cent better than he managed the previous year. How? Because he has a new platform, looks at it and thinks about it all. Perhaps he becomes aware of a new opportunity that unlocks a possibility or solves a problem he had, and that results in that improvement. It's perhaps things like someone came up with a new sensor which is half the size of the old one and that enables something else, which allows you to make something else in a totally different shape and that might save weight. It is human endeavour, lots of low level innovation and most of it usually unseen, and unappreciated.'

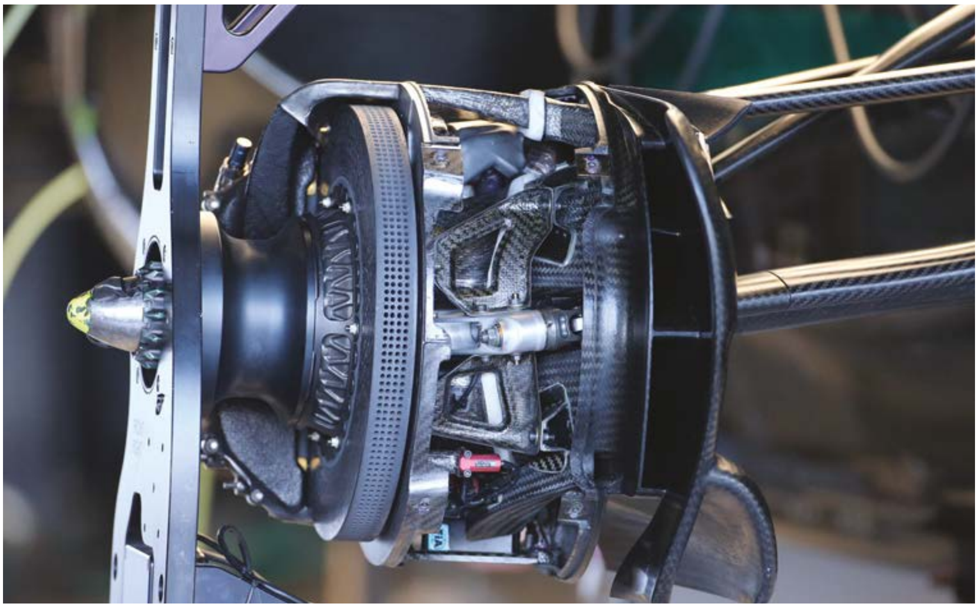
There were some areas of larger scale innovation and optimisation on the W07 which are clear to see, though. From the moment the first pictures of the car emerged one of its most distinctive characteristics was the roll hoop and

TECH SPEC

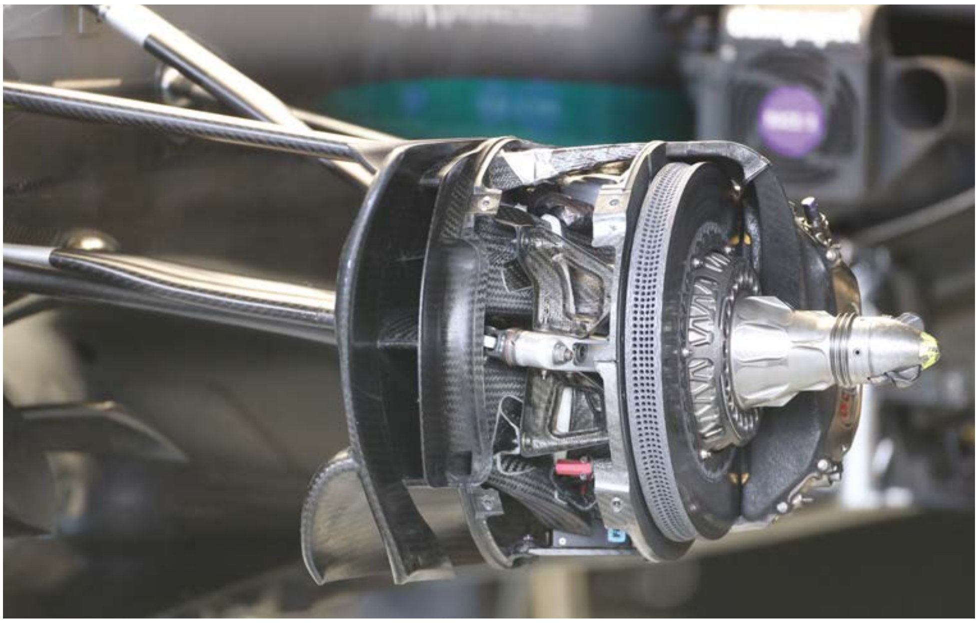
Chassis: Moulded carbon-fibre monocoque
Engine: Mercedes PU106C hybrid; 1.6-litre 90-degree V6 ICE
Gearbox: Paddle-operated 8-speed semi-automatic transmission with twin skin casing
Clutch: Multi-plate carbon fibre
Electronics: McLaren FIA standard ECU
Front suspension: Double wishbones, push-rod actuated springs and dampers, anti-roll bar
Rear suspension: Double wishbones, pull-rod actuated springs and dampers, anti-roll bar
Steering: Rack-and-pinion, power assisted
Brakes: Carbon-carbon friction material, Brembo calipers
Fuel tank: ATL Kevlar reinforced rubber bladder
Wheels: Advanti forged magnesium
Tyres: (fr/r) Pirelli 245/660 13; 325/660 13
Length: Approx 5000mm
Width: 1800mm maximum
Height: 950mm maximum
Weight: 702kg minimum



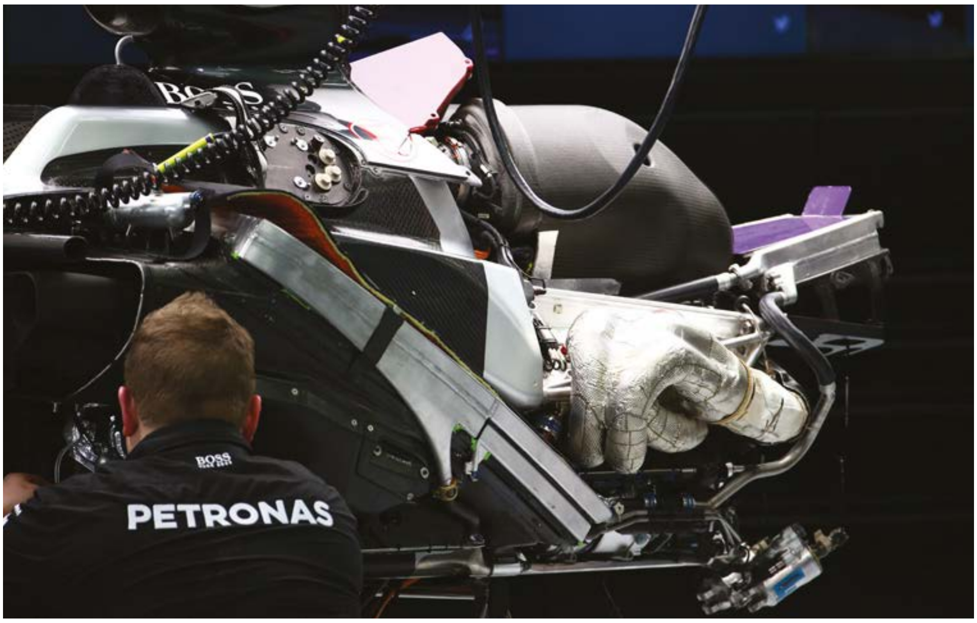
Come rain or shine the Mercedes W07 was the car to beat in 2016 winning all but two of the 21 grands prix and staking a claim to be the best F1 car ever



Detailed shot of early season front brake set-up. The Mercedes F1 W07 Hybrid uses Carbon Industrie carbon discs and pads



The front brake set-up from later in the season. The concave shape of the carbon disc edge can be seen in this picture



PU106C installation showing the MGU cooler in centre. Balancing cooling and performance was a challenge for Mercedes

airbox concept. While the older cars in the trio have a smallish and roughly triangular air inlet in the roll hoop the W07 has a much larger oval inlet. This is split into three segments separated by the legs of the roll hoop structure. The central segment feeds combustion air to the V6 engine while the two outer segments feed a heat exchanger mounted just above the bell housing; this cools both the MGU-H and the MGU-K.

'It's an evolution of the cooling concept on the car. There is more air taken in through the airbox now and that has come from the sidepods,' Lowe adds. 'I don't really know the weight results from the roll hoop change, but moving the coolers to the centre of the car is about trying to get the most work done for the minimum aero detriment.'

Cool approach

This centreline cooling approach was pioneered by the Toro Rosso team, which mounted coolers high up and in the centre of the car some time ago, though the Mercedes version is less extreme. The cooler fed by the roll hoop ducts has changed in its design a few times in the season with various versions coming and going throughout the year.

'We run at a range of circuits which have quite different requirements, whether its ambient temperature or the duty cycle on the circuit,' Lowe says. 'You not only need to get the balance with the least aerodynamic deficit, but the best performance curve for the range of circuits you need to do. For instance, you could have a great cooling package which worked brilliantly at Silverstone, but then in Malaysia it would be hugely penalising as you opened it up for a greater cooling load. So the cooling project is about trying to get a system that can be both great at Silverstone, for example, but extend itself to those much tougher circuits without killing performance. It's a fact that it will be worse in Malaysia but the game is about reducing the detriment as you increase the load.'

Custom cooling

With average speed, on-throttle time, and other circuit characteristics added to the environmental demands calculating the best package for each track is far from straightforward and it seems that the W07 has a kit of options which engineers can choose from race to race. 'We may change the cooler sizes and cores, depending on the demands,' Lowe says. 'It is the nature of the whole lap we take onto account, not just the temperature but also on the demands of the hybrid system, so some tracks place different demands on the ERS changing the cooling demands of the MGUs. The charge air cooling is another element to all of that; oil, water, ERS, charge air and hydraulics, all need cooling. Cooling is one of the trickiest aspects of a modern Formula 1 car, and finding the optimum solution for a given circuit can involve a lot of science these days and a lot of

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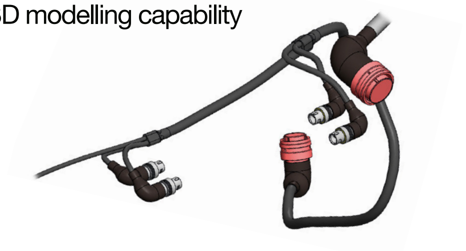

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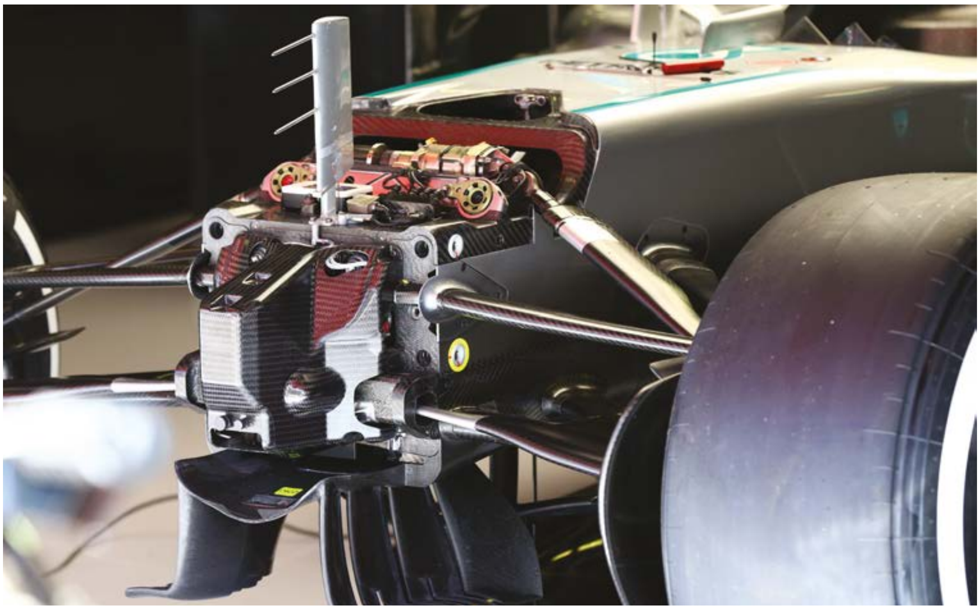
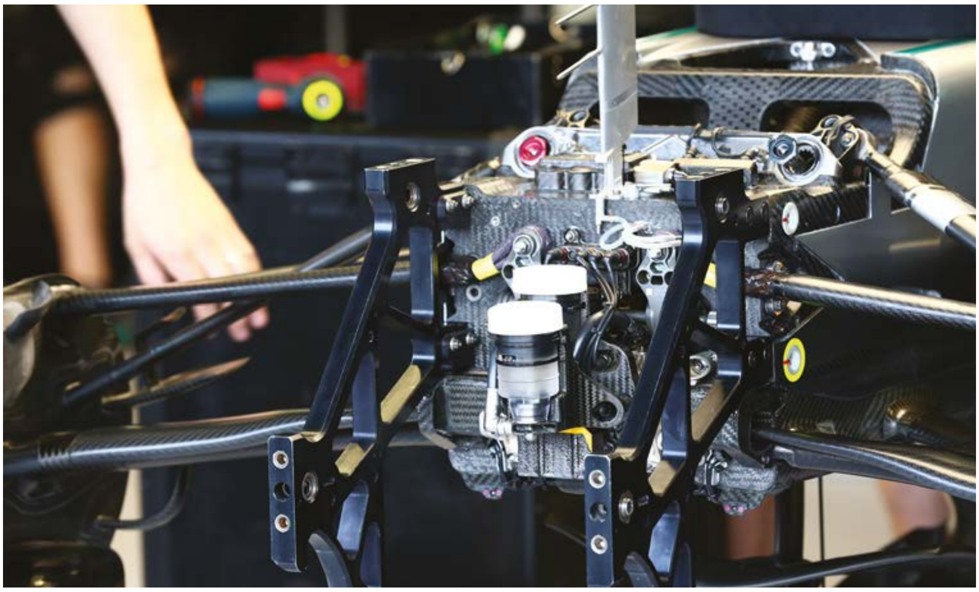
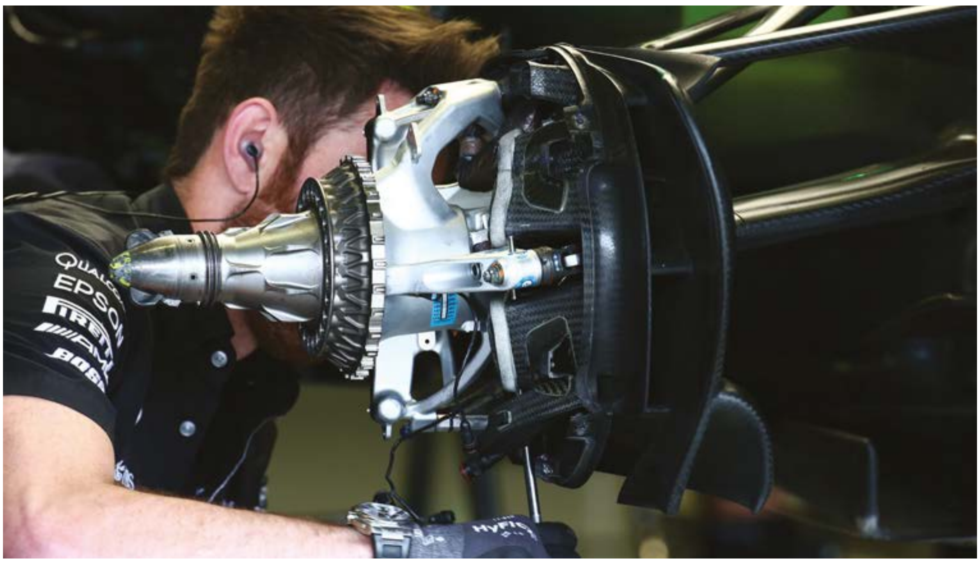


The W07 front bulkhead showing stepped design and the hydraulic third suspension element – note the cover on the front



Bulkhead with front cover removed showing master cylinders mounted line astern, for packaging reasons Mercedes says



Front upright. Suspension at the sharp end features blended lower wishbones, while the torsion bars are push rod actuated

simulation, of different parts, and a lot of lab research to get the right combinations.'

In other areas of the W07 it is clear to see that there are concepts which have carried over directly from the W05 and W06. The transmission is an example of this, with its twin skin design, the composite external casing taking most of the chassis and aerodynamic loads while the gears themselves are housed in an inner titanium skinned cassette. Yet while the concept is the same there are improvements and many small differences on each year's design, these can be seen easily enough when looking at the Force India, which uses the transmission from the W05.

Suspension tweaks

It is a similar story in terms of the suspension on the W07, where it has carried over at least in terms of concept directly from the W06 with its distinctive blended lower front wishbones. The front torsion bars are push rod actuated, while at the rear they are again pull rod actuated for aero reasons. 'In terms of the external layout, we didn't move that much really. We had some novel directions in 2014 which were further improved upon last year but for 2016 it was a lot more carry-over in those respects,' Lowe says. 'Internally I think the changes were more about packaging than how we get the same jobs done, making things lighter and smaller.'

But looking at the layout of the inboard front suspension it is clear to see that there have been some significant changes. The front bulkhead has been completely reworked on the W07 with an optional hydraulic third element utilised at some races, which has no visible springing medium, leading to some speculation that it is mounted in the sidepod. However, Lowe is reluctant to reveal too much about the operation of this third element. He says: 'The nature of the game in that area is quite continuous and has been so for the last 20 to 30 years. It is all about how to get the best out of the ride height range you want to use given the aerodynamic sensitivity of the car. FRIC was a big part of trying to optimise that until it got stopped. We continue to fine tune what we can without actually linking front to rear. We actually have various different things we can use on the front end of the car, and they come and go depending on the nature of the circuit and the fine tuning of front ride height.'

Enforced changes

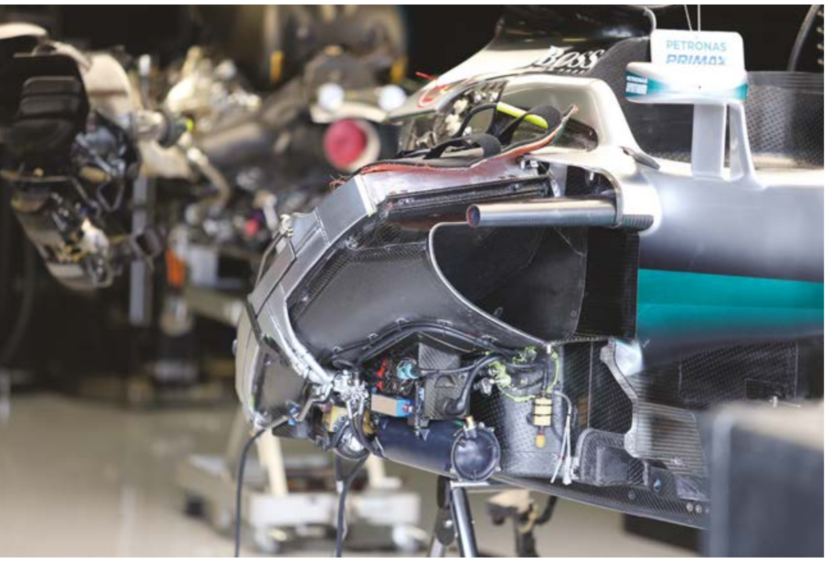
One area that had to change on the car for 2016 was the monocoque construction. It was as a result of one of only a small number of changes to the technical regulations ahead of the season, which saw the crash test requirements for cockpit sides increased and the sides themselves raised somewhat. 'When you get a

'The fascinating thing about innovation is that you don't see it coming'

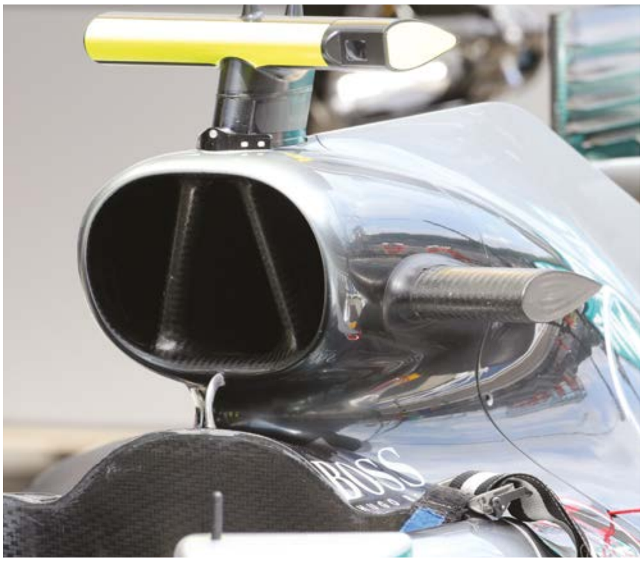

188.0
89.1
109.1
5.552
4
1:26.029
1:49.400
-0.002

Semi-automatic gearbox features a composite outer skin around a titanium inner cassette

Rear upright with brake cooling parts. Suspension at the back is pull rod design



Sidepod with bodywork and covers removed to show the coolers and the side impact structure



Outer segments of airbox supply flow to MGU cooler; the centre part air for ICE

new requirement like that everyone works hard to reduce the detriment, but in the end it's not hugely penalising, perhaps a kilogramme or so in weight,' Lowe says. 'It's more about putting the time and effort into passing the tests in the most structurally efficient manner. But it was a significant increase, and that was a good thing. It actually went so well I forgot about it.'

Silver bullet

During 2014, and in particular in 2015, Mercedes decided that it wanted to significantly improve the reliability of its car when developing the W07. Those who watched the races in 2016 may have got the impression that the team failed in this objective with some high profile issues on the car during the season. But a look in further detail reveals that in reality – at least in terms of the chassis – the W07 was notably better than either the W05 or W06. 'We are very proud of the reliability, its been really good but the season has not given that appearance,' Lowe says. 'We have had a few issues which have affected the drivers in an asymmetric way, but on the chassis side we made great progress, looking at race finishes and retirements is quite a crude measure, but looking at the detail we have, it is a fact that the reliability has increased in a solid and a measurable way.'

Had it not been for an engine failure in Malaysia and a driver failure in Barcelona the W07 Hybrid would probably have won every single grand prix in 2016, eclipsing the records held by the McLaren-Honda MP4/4 in 1988. Yet despite exhibiting a level of dominance not seen since the days of Senna and Prost, the performance level of the W07 has been overlooked by many followers of the sport. Indeed, one mass market Formula 1 publication ranked the Red Bull RB12 as the best chassis of 2016, something which clearly grates with the staff at Brackley.

'I know it was a public vote in that magazine, but it was a dubious finding,' Lowe says, adding: 'So if you asked me now what the weakest point of the 2016 Formula 1 campaign was I would say it was the press office, as they have clearly failed to communicate the superiority of our chassis to the public!'

Silver star

While Lowe's comment above is clearly light-hearted the underlying truth is right, the Mercedes was perhaps the most dominant grand prix car of the modern era. In terms of race wins it scored 19, more than any other car in a single season, and only two fewer than the Lotus 72, which had a five year competition career. It is a similar story in terms of podiums, at 33, and its 20 pole positions, both beating the records for single seasons. Of course, many might argue that the number of race wins, podiums and pole positions are higher with the 2016 car simply because there were more races in the season than ever before. But even bearing that in mind the W07's 19 wins were from 21 starts; the Lotus 72 started 75 races and won 20. In terms of pole positions the Mercedes has the highest percentage in a given season at 95.2 per

'We are very proud of the car's reliability, it's been really good, but the season has not given that appearance'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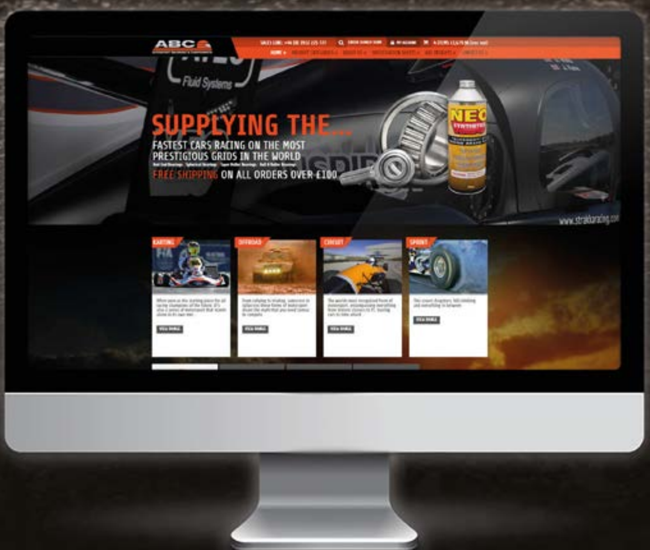
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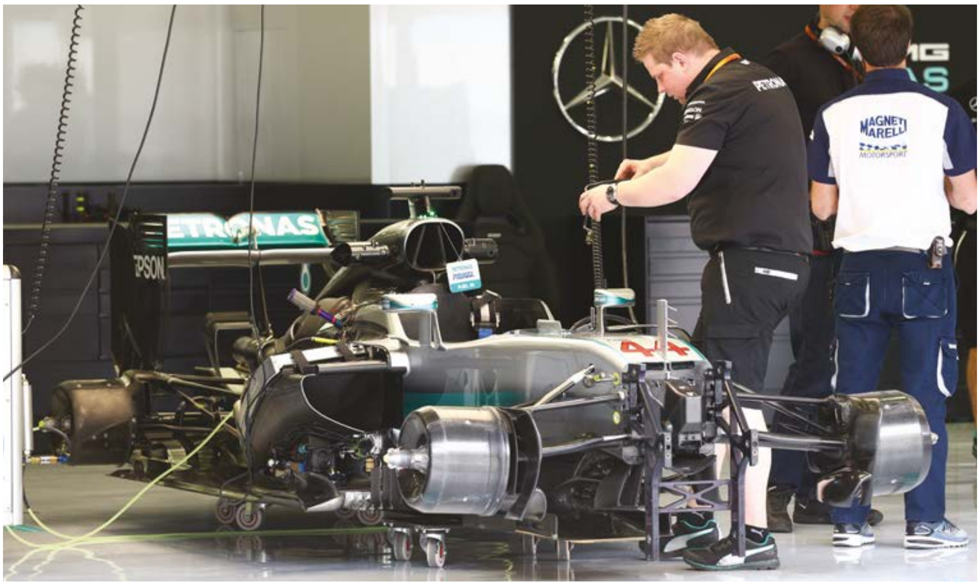

The monocoque was altered to meet new regulations but the car is very much an evolution of the W06 that came before it

cent, ahead of the 2011 Red Bull and, of course, that McLaren MP4/4 of 1988.

'If you look at our data, only in qualifying at Monaco and in the race at Singapore were we not the fastest chassis,' Lowe says. 'Everywhere else we were fastest. At some tracks where people expected certain other cars to be quick they struggled, they lacked consistency in performance, and that is about being able to optimise the car at every circuit. When it comes to underlying pace, even when power unit corrected, our chassis was the quickest and also the most consistently quickest.'

Dire starter?

No racing car is perfect, however, and the W07 had its weak points. And one of them was very public indeed. Its drivers frequently struggled to get it off the start line cleanly, and on many occasions one or both of the silver cars lost positions as the lights went out.

'That is something that has always come up as a weakness. By our numbers, though, we were the best in that area in 2015, [but] we are no longer the best on average,' Lowe admits. '[But] it's not as disastrous as people may think. It looks worse perhaps as we are always starting at the front and from there you can only go backwards. You can't make a good start and make that heroic five-place gain from pole position. Ironically, Lewis did his best start of the year in China and did make that hero start off the line which then put him straight into a shunt, another piece of bad luck for him. The variability in our race starts was far higher than we would like and that cost us a bit, but it's really not as bad as it seems. People, including our drivers, just by human nature, only really remember the bad days. Optimising race starts is a rather thankless task for those involved in it as they get a load of criticism when it goes wrong and no credit when it goes right, especially if you are starting at the front.'

The Mercedes AMG W07 Hybrid has now seen out its career as a competition car, and aside from the odd show run the chassis are now all museum pieces. Some time ago its creators turned their attention to a new set of technical regulations and the creation of the W08 Hybrid for the 2017 Formula 1 season. 'These new rules have been created in part to disrupt the status quo, in terms of the dominance of Mercedes,' Lowe says. 'So we accept that as a personal challenge to overcome. Despite the reset we are aiming to come out of the blocks with the quickest racecar again. That is what everyone has foremost in their mind in the organisation,' Lowe concludes, in what is perhaps a rather ominous warning to his rivals.

HALO effect

When the HALO frontal protection device was first displayed fitted to a car in public at Barcelona in winter testing the reaction from fans and the media was far from universally positive. Most teams, including Mercedes which was instrumental in its creation, have since trialled the concept on track. But the reaction, while more muted, has still not really been positive.

But Paddy Lowe has another take on HALO. 'Nobody has really commented about the higher cockpit sides on the cars in 2016 and complained that they can no longer see the drivers' helmets and things,' he says. 'It's why I find this stuff about HALO funny. If you drill back into the past, drivers used to go around in an open face helmet, or even none at all if you really want to go back. They would sit with the whole upper body exposed and then we have gradually year-on-year buried them with full face helmets, lower seating positions and higher cockpits. So in 2016 we buried them even more. Today, as a car goes past you would be pretty lucky to get eye contact with a driver. You now just recognise them by the colour of the helmet.

'So this trajectory we have been travelling down forever is clear then,' Lowe adds. 'We get HALO and people are saying that it's a disaster, because the sport can't survive this intrusion into its open cockpit nature. Why have people drawn the line there when we have been moving in that direction for years step-by-step?'

Mercedes executive director (technical) Paddy Lowe says HALO is a natural next step for progressing driver safety in F1


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Silver's **lining**

The power behind the glory for the Mercedes W07 came from another version of Brixworth's finest – HPP's 'new' for 2016 PU106C Hybrid

By SAM COLLINS

Since the first race of the 2014 season Formula 1 has been dominated by discussion of one thing: power units. The talk, however, was not of the exceptionally high thermal efficiency of the new units, but more often it was of how they had become the main performance differentiator. Really this discussion was, and is, more about how one manufacturer's PUs have dominated the sport under the new formula. Since the power units were introduced in 2014 there have been 59 Formula 1 World Championship races, and only eight of them have been won by cars not propelled by a Mercedes power unit.

For the 2016 season, Mercedes AMG High Performance Powertrains (HPP) in Brixworth, England created the PU106C, what it claims is an 'all new' design. The new unit is, in common with its predecessors and indeed all F1 power units, a turbocharged 1600cc V6 internal combustion engine with a 90-degree cylinder bank angle, mated to a pair of motor generator units (MGUs) and an energy store. 'It was really all new again, pretty much,' Andy Cowell, managing director of HPP says. 'That was either because of reliability issues or performance updates and the consequential changes because of that. There were a handful of changes to the units during the season, too, more for reliability than anything and more than we intended to be honest. We explored the classic elements of the combustion engine and the healthy areas of the ERS in order to gain performance and efficiency improvements.'

Crank call

While on the face of it the technical regulations would prevent this level of difference year on year with the homologation rules and token system, upgrades on the grounds of reliability are unlimited, and this is how HPP was able to again bring in a substantially new unit. Because while Mercedes PU failures were rare in 2015 they were not unknown; a crankshaft failed on one car, for example, and on top of that there were some other issues which were not obvious externally. Cowell says: 'To make a new crank, for example, if there was a change for reliability you have to consider that it is supported in the crankcase. The way the bearing loads support the crankshaft, you can end up doing changes there and that means a new crankcase, too. Besides that, the crankcase was not 100 per cent robust in 2015, there were some small cracks developing on some of them which we managed through the race season. We wanted to make changes in some of those areas to reduce the stresses and not be anxious about those things in the following year.'

Between the 'A' spec of 2014 and 'B' spec of 2015, only a few nuts and bolts were carried over, according to Cowell, and it was a similar situation with the 'C' spec for 2016, with revisions to all of the major components including the block, heads and crankshaft. Yet a quick look at the overall design and layout of the PU106C reveals that its overall concept and layout is very similar to that of both the PU106A and the B. All three feature the split turbo concept which sees the compressor mounted at the front of the block and the turbine at the rear with the MGU-H in the V of the engine linking both sides of the turbo via a common shaft.

Core aims

It is clearly the case then that the 'C' was a refinement of the 'B', but with almost nothing carried over. Cowell and his team at Brixworth had laid out some clear targets for the 'C', however, and not all of them involved changes to the five core power unit areas (ICE, MGU-K, MGU-H, Energy store and control electronics).

'The core aim is simple,' Cowell says. 'That is to get more useful work out of the available fuel energy, so in other words increase the thermal efficiency of the engine. That means more grunt, and better use of the electrical energy, so you can leave the MGU-K on for longer, making sure that the driveability is perfect. Another key aim is that at race weekends during every session we do not disturb car set-up, we do not enter the drivers' minds with thoughts regarding hiccups, glitches or worse still DNFs.'

It is the latter point that defined a related key objective in the development of the PU106C; improving the serviceability of the unit overall. 'The power unit is made up of the five elements which are restricted by the regulations in terms of their development, but there are ancillaries outside that perimeter which are not,' Cowell says. 'Pumps, a lot of the hydraulics, fuel system, all the loom and sensor boxes, all of those things; and things like changing oil, changing plugs, air filters, all of those things are unlimited.

'So if you have a faults list you tackle those things within the perimeter and make them the most robust they can be,' Cowell adds. 'The things outside the perimeter, the things you can change for the same spec at a shorter life, say 2000km, you leave those to the world of the service schedule and our component lifing system. What you don't want to do is introduce poor reliability because you're changing parts in the garage at a race. That is why if you are planning on making those changes at the circuit it must be easy to do it, so the risk of an issue when you roll out in FP1 is low. The best thing is not to need to service it at all, just build it all, break it in, pass it off, give it a bespoke calibration then send it out the door and not touch it again other than taking it in and out of the chassis and blowing the dust off now and then. That'd be Utopian, because there's always stuff to do. You just have to make it simple.'

It also seems that development in these areas in terms of improving serviceability can also bring notable performance gains. 'A lot of the pumps, oil pumps, water pumps, are only around 40 per cent efficient, so there are benefits to be had there. Some of those benefits can be a bit of a double gain, we saw that with the naturally aspirated engines. Improve the efficiency of a pump, reduce the friction and you see that energy gain on the crank, and that's energy that is not going to the radiators so Mike Elliott [head of aero] and his team can make the sidepods tighter, therefore the car goes quicker.'

While the PU106C was designed specifically for use in the Mercedes W07 chassis it was also fitted to the Force India VJM09, Williams

Since 2014 there have been 59 Formula 1 grands prix, and only eight of them have been won by racecars not propelled by a Mercedes power unit

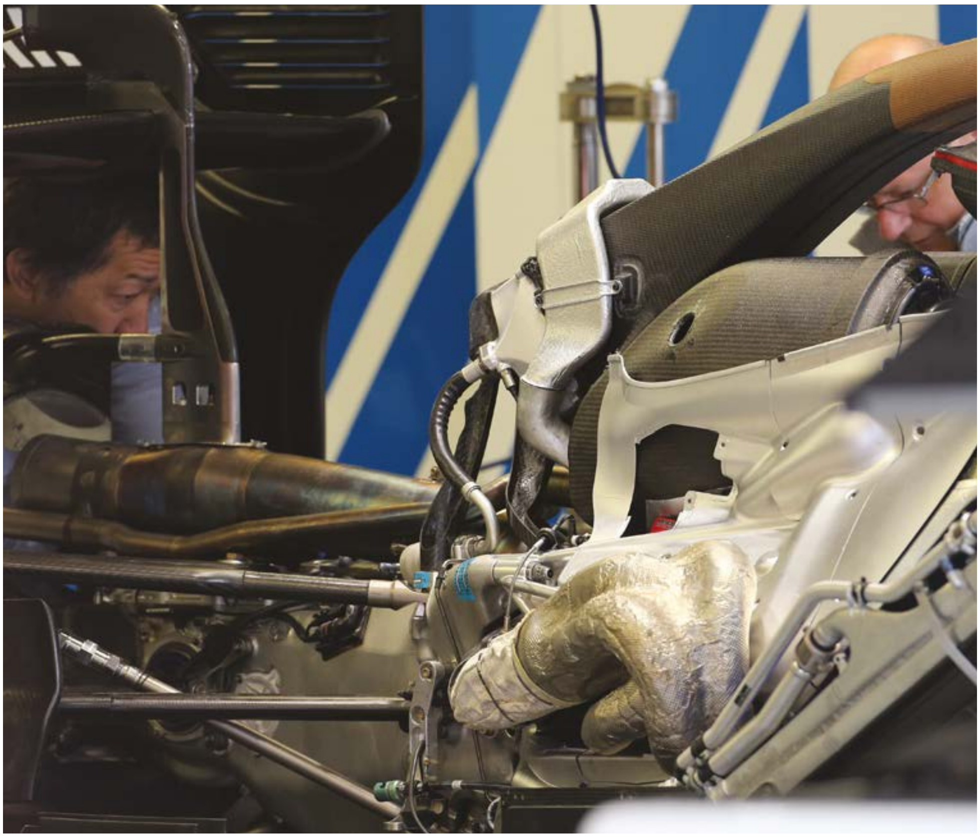
In 2016 there were some very high profile power unit failures and it's clear that this rankles with all the staff at Brixworth

FW38 and Manor MRT05, requiring a lot of dialogue with these teams. 'We try to have open relationships with the customer teams' technical directors and engineers,' Cowell says. 'They have a huge amount of experience and they all know how to make fast racing cars. If you look at the span of percentage lap time across the whole grid it's really tight; all the cars are fast. The teams all have good ideas and we try to put them all in the melting pot and sometimes those ideas are carried forward, but it is Aldo Costa [Mercedes engineering director] and his team in Brackley who come first.'

Logging off

The engine bay has remained fairly similar over the three seasons, the biggest differences being the abandoning of the compact 'log' exhausts toward the end of the 2014 season in favour of a larger and more conventional manifold design, as well as the adoption of a variable inlet system in 2015 which required a considerably larger plenum. 'There has not been a huge change in the demands in terms of packaging since these units were introduced in 2014' Cowell says. 'In 2012 and 2013 there was a journey of trying to make the unit as simple as possible to install in the car, so we didn't want the turbo to be poking out the back of the engine, we wanted it to be entirely inside the two planes created by the engine mounts. We wanted every single aspect of the ERS module to be in one unit tucked inside the cockpit and nothing significant in the sidepods. Beyond that we looked carefully at the shadow created by the monocoque and the roll hoop, drivers helmet and the protection around it. That provided a fairly standard shadow flowing backwards over the engine. That shadow has not really changed since 2014. If anything its got a bit bigger. We did a reasonable job in 2014 and we have not relaxed our ambition in regards to those surfaces.'

The PU106C, seen here installed in a Force India, powered the Mercedes W07 to 19 wins and the championship in 2016



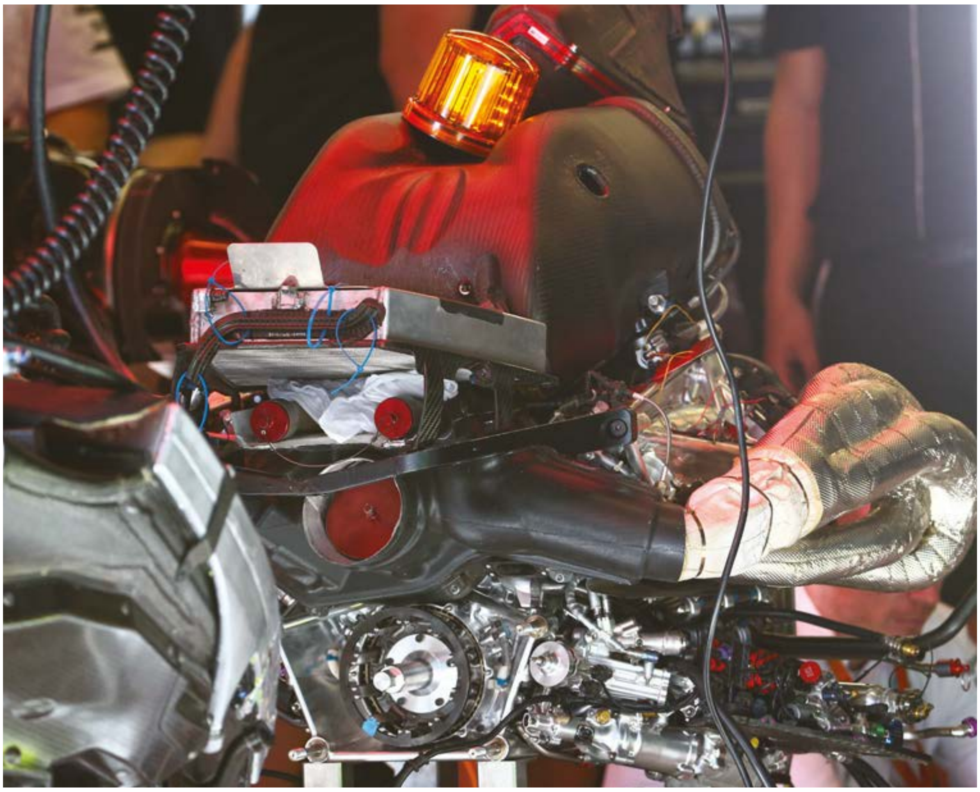
PU106C in the Manor. The engine is very similar to its predecessor yet very few parts were carried over from the 2015 unit

One-race specials

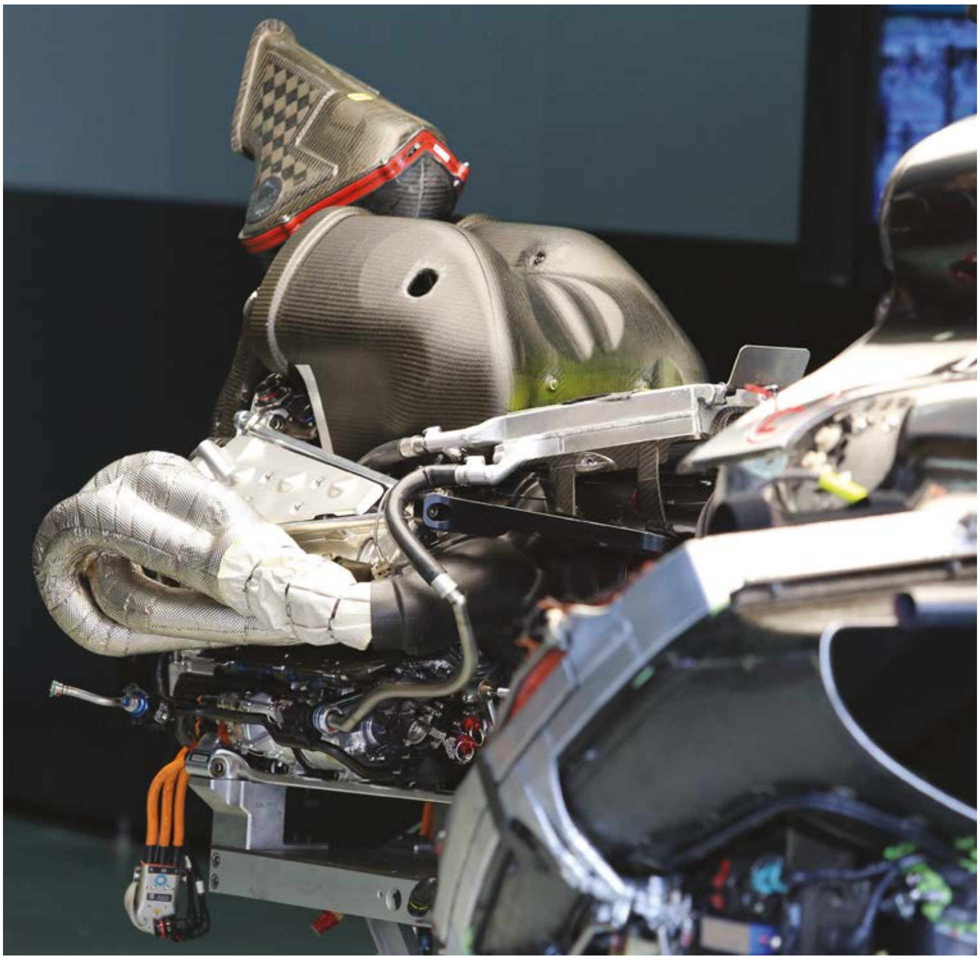
Under Formula 1's regulations each driver can use four complete power units per season without any penalty, but if the season is extended to 21 races then a fifth unit can be used. As it transpired the season did end up being 21 races long, after the calendar was finally confirmed just before the season-opening Australian Grand Prix. This additional power unit raised the intriguing possibility of a one-race special power unit, the like of which has not been seen in Formula 1 for many years. 'It is tempting to keep an engine back to use as a wildcard unit, maybe just for one race,' Cowell said shortly before the start of the season. 'Our plans were based on there being 20 races and four units, our targets are all based on that. With 21 races and five units it's possible that we could do a performance special.'

Things turned out a little different, though. 'The extension in number of units really didn't have any impact on us in terms of durability targets as we had intended to run with four units all year,' Cowell says. 'Our view was that the regulations should stay at four units for the season even if there was a 21st race, for the reasons of cost control. That is the only reason that there is a restriction on the number of power units per driver, per season. So as we had expected four units per year, we kept to that. We thought that we were in a very good condition, and indeed we completed that aim with some of our customer teams.

'The way the events of the season unfolded meant that we never really looked into the special,' Cowell adds. 'Issues we had in China and Russia with the MGU-H changed the



Rear of the PU106C. Note the clutch plates have been removed from clutch basket. The light could be to show the unit is live



The PU106C from the left side; note the cooling pipes running from cooler to the MGU-K, which is just visible in this picture

mindset quickly to the realisation that we would in fact need five turbo assemblies, and that we needed to understand why we were having issues that were coming out of the blue. Our factory resource was put into understanding those issues and maintaining and developing performance while getting on top of those reliability issues,' Cowell says.

Mission statement

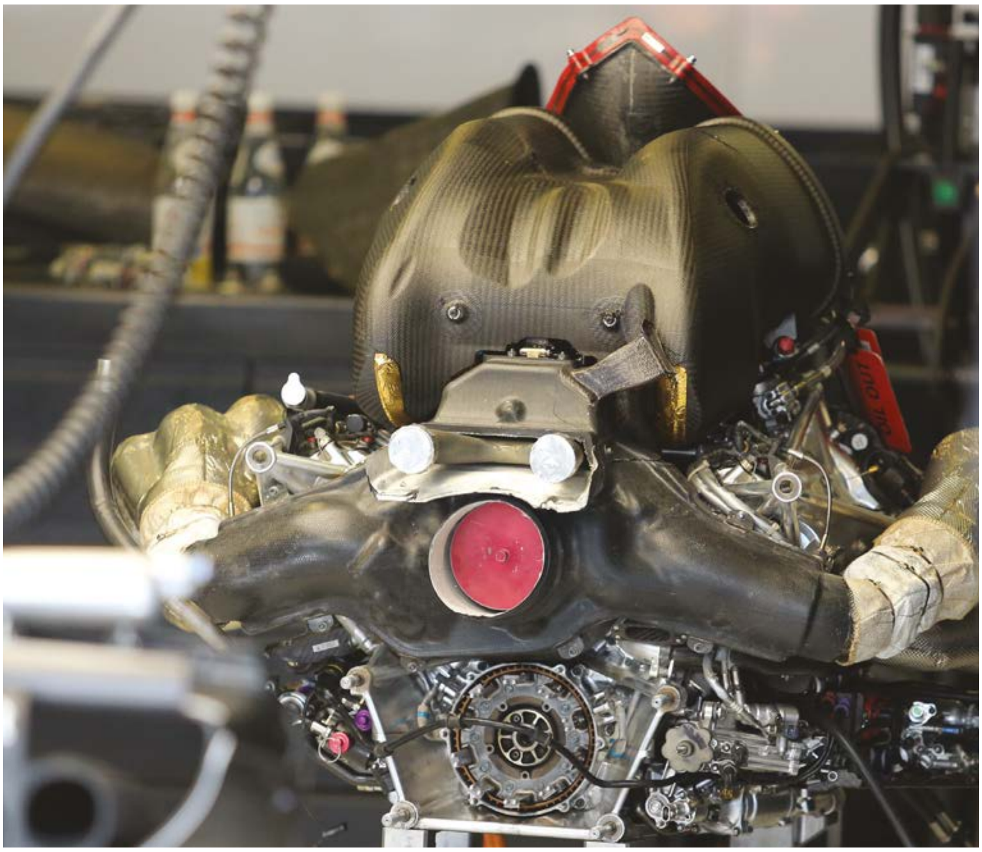
Mercedes prides itself on its reliability in F1, and as a wider company, and when you switch on any computer in HPP the company mission statement of winning both world championships without a single category 1 failure appears on the screen. But in 2016 there were some very high profile power unit failures and it's clear that this rankles with Cowell and all the staff at Brixworth. 'The first two issues occurred in the same chassis and on the same headline assembly but they were in two different areas within that assembly,' Cowell says of those MGU-H failures. 'It's frustrating, as logical scientific engineers you end up puzzled and perplexed by those things. But it has actually turned into one of those great learning experiences for all of HPP, one of those opportunities to investigate deeply, not only the specifics of the failure, but also the opportunity to look at areas across every department across the business to see where else that style of issue might impact us in other areas.'

The problems, allied to the very public bottom end failure in Malaysia, have to an extent re-doubled the efforts of HPP to avoid on track failures. 'Internally we have an expression for it; "Mr B**tard comes to town,"' Cowell reveals. 'If there is any little chink or imperfection it will not happen on a long run at the factory, it will not happen in testing, it will happen when it matters, in qualifying, then the next qualifying, and in a race when the driver has a certainty of 25 points and wrapping up the constructors' championship. That is what Mr B**tard will do, unless everyone is aware of their responsibilities from the moment they walk into the factory. That is about discipline, integrity, not only of the individual but also the department. Unless that is all in place, Mr B**tard will have you.'

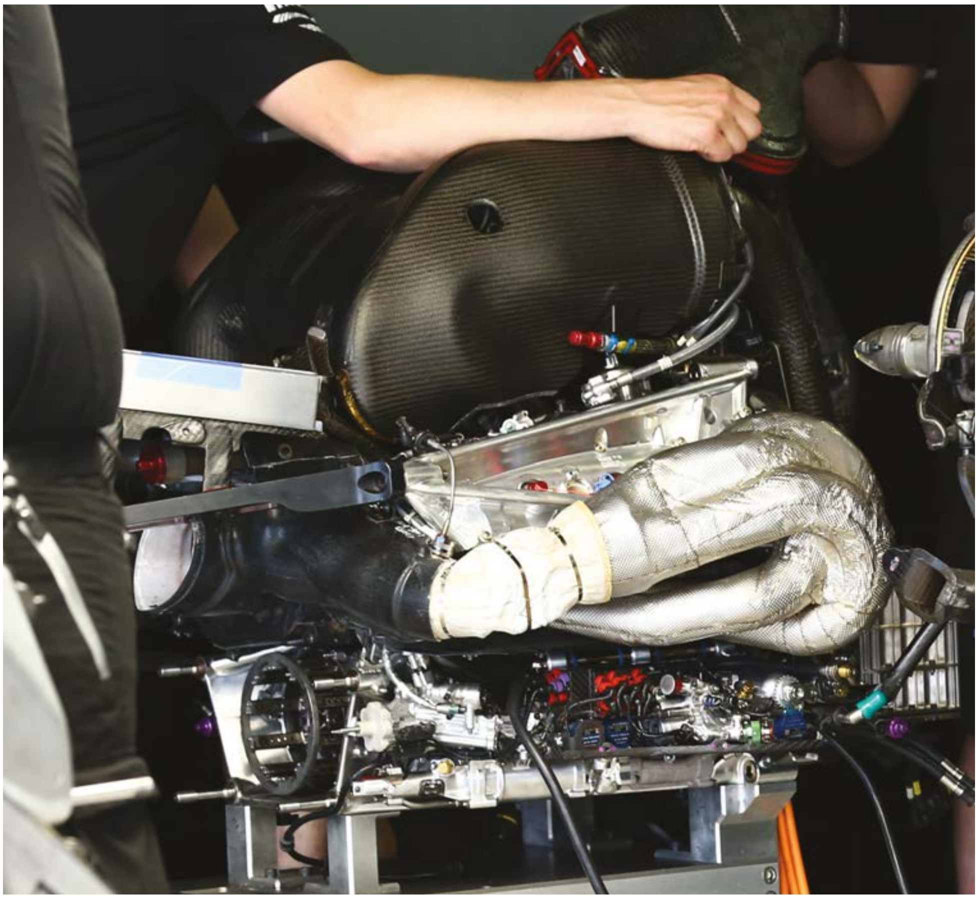
Illegitimate concerns

After the unwelcome visitor came to town in Malaysia in such spectacular fashion, it seems that the whole organisation at Brixworth had a long hard look at itself. 'Every single person in this factory has those problems firmly etched in their mind. We are fortunate this year that we had those painful experiences and have not lost either championship as a result. That's the silver lining in the cloud. It provides a great

It is clearly the case that the PU106C power unit was a refinement of the PU106B unit, but with almost nothing carried over from it



The rear face of the PU106C power unit showing the clutch housing and tailpipe stub; note the shielding around the turbine



Right side with exhaust manifold and some MOOG valves visible. More conventional manifold design was adopted in 2015

'It was tempting to keep an engine back to use as a wild card unit, maybe just for one race'

personal investigation and a way of discussing it with every department. We all had to think about what do we need to do as individuals and departments in order to ensure that we are rock solid in all areas. That goes from initial ideas to the final execution and use at the circuit, all of the steps on that long complex chain have to be absolutely robust. If there is any chink in the armour you know that it will happen at the worst possible moment,' Cowell says.

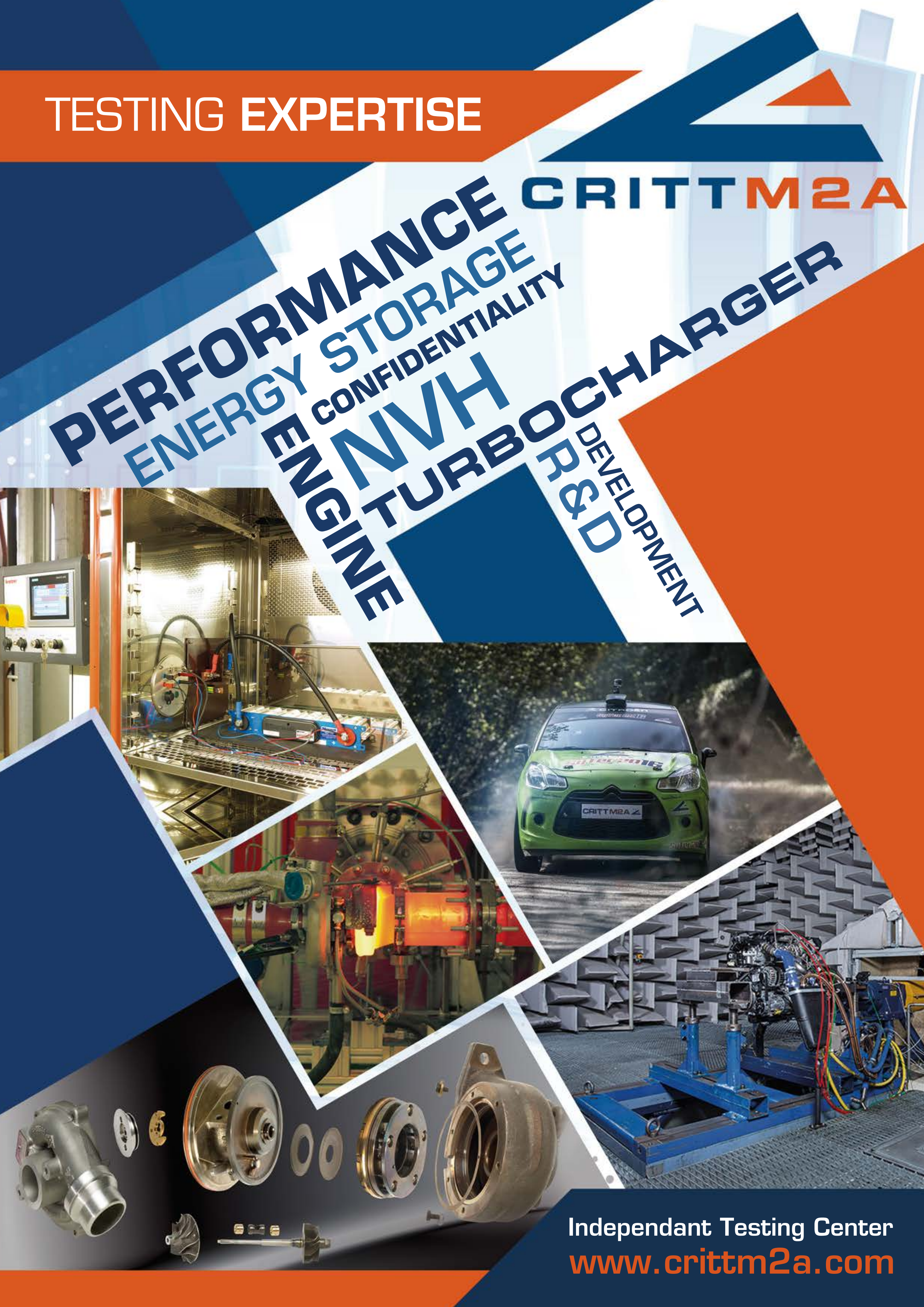
Rivals regroup

Despite that dark cloud in Malaysia, the PU106C did propel the W07 to a record breaking 19 victories in the 2016 season, but it was also becoming clear throughout the season that the power unit advantage enjoyed by Mercedes was getting ever smaller. Honda, Ferrari and Renault all made big improvements to their power units leading up to and during the season and the law of diminishing returns meant that ate into Mercedes lead at the front.

'Honda, I think, has been the best in terms of improvement through the year,' Cowell says. 'Renault made a good step in the first half of the year, Ferrari did a lot over the winter. I don't have a clue where our rivals are in terms of mass, centre of gravity or heat rejection. I think we are competitive in terms of drivability, with regards to propulsion out of the corner when we are not traction limited. I think we are still at the top of the pile, and in terms of electrical energy to keep the MGU-K on we are also still at the top of the pile.'

But while the law of diminishing returns applies quite clearly when it comes to F1 power unit development, it does not mean that the Mercedes engineers are running out of ideas. Indeed the opposite actually seems to be true. 'Really we are only limited by time, imagination and tenacity. You prioritise and it is important that you don't listen to what your opponents are saying. You have to do your own work; combustion is the first major step in the energy conversion from the fuel energy; thermal management is crucial for heat recovery in the MGU-H, you must ensure that the MGU-H itself is as efficient as possible. Compressor efficiency is critical, you want the teams to improve the charge air cooler efficiency to ensure that the air is as cool as possible to push away the knock limit. You want the control of all of that to be ever more potent so you don't end up with the MGU-K filling in little torque holes which then costs in terms of energy when you really want that energy to be used towards the end of the straight. There is a big list of things and we are working on it all,' Cowell says.

The Mercedes PU106C Hybrid will be replaced by another all new power unit for the 2017 season, one that will have to cope with the demands of a very different type of chassis designed to very different regulations – and it will also have to be a very special PU, to be as successful as the one it replaces.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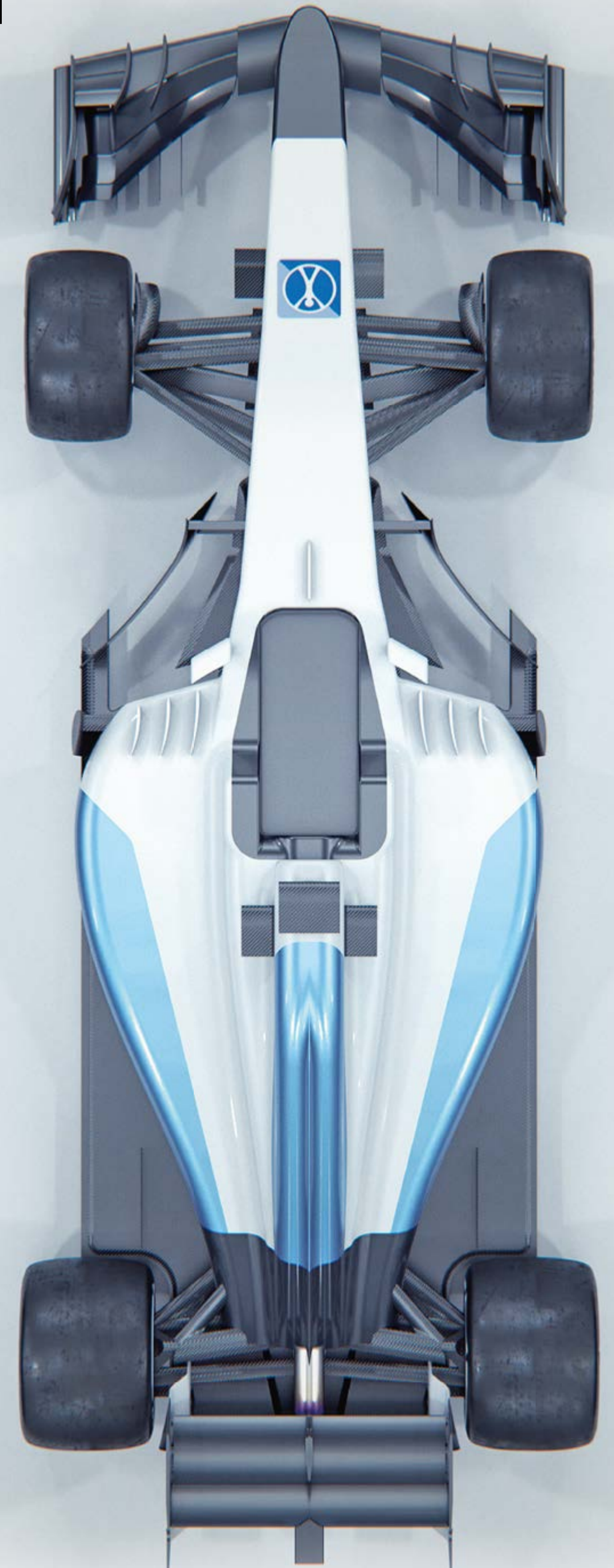
People power

The Perrinn F1-2017 might only exist in digital form but it's still a great example of what can be achieved with a very public design approach

By SAM COLLINS



The 2017 Formula 1 technical regulations have been met with some scepticism in the motorsport engineering community, but design work has continued regardless and the first fruits of that can now be revealed. Nicolas Perrin, a French motorsport engineer based in England's rugged Yorkshire Dales, has been working on his own answer to the new regulations, the Perrinn F1-2017 (the extra *n* is a deliberate branding move).

Perrin has a long history in motorsport, having worked in Formula 1 with Williams and Manor, as well as in LMP1 with Courage Competition and Pescarolo, and in 2013 he set up his own design bureau.

Unlike a typical constructor Perrinn has a collaborative design approach, with anyone qualified able to edit and develop the design of the two major projects the company is working on – a Le Mans Prototype (revealed in 2013) and this new 2017-spec Formula 1 car.

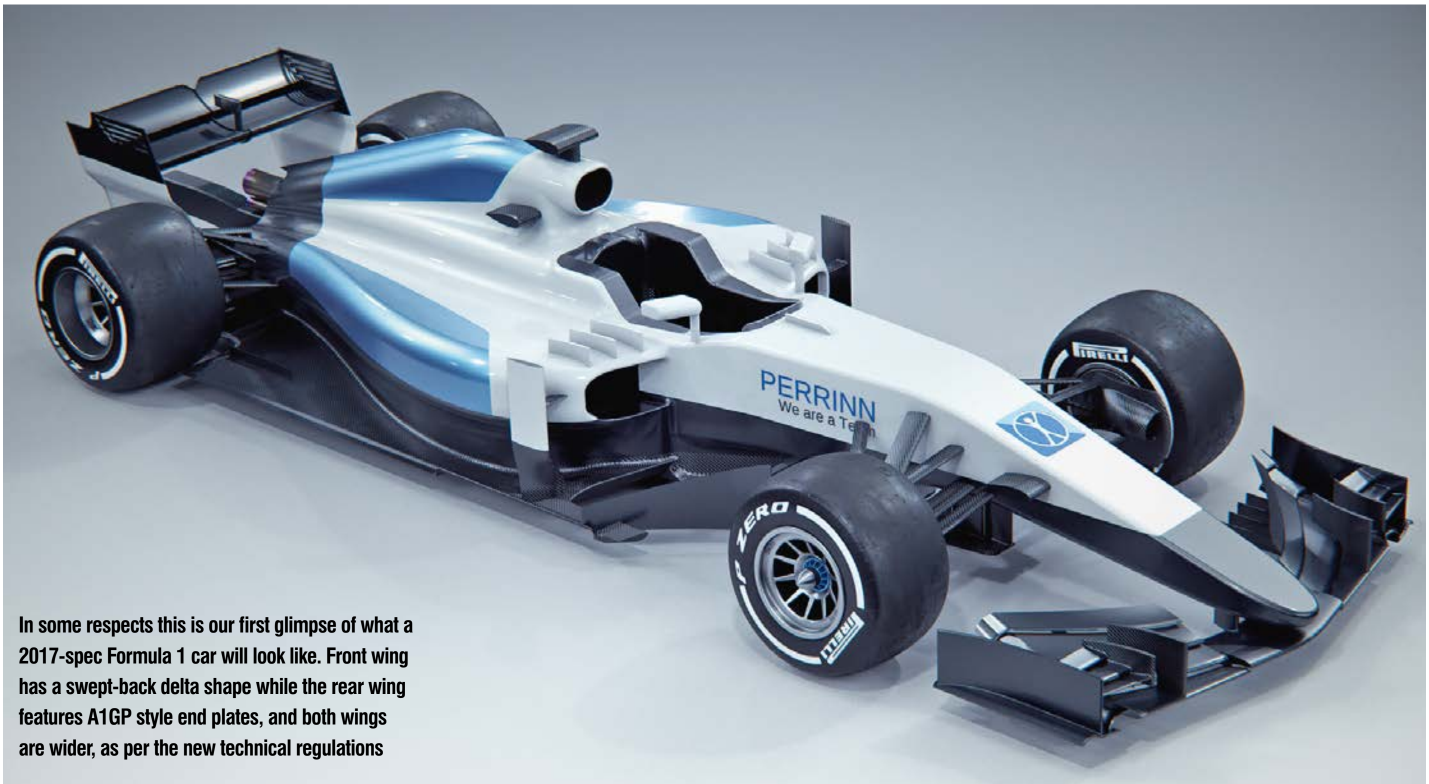
Fair share

Ownership of the Perrinn company is unconventional, too. Some crowdfunding and additional start-up funding from Perrin himself defined some of the shareholding, but those who contribute to the design and development of the products also earn shares based on their experience level and the amount of time they have dedicated to the programme.

The Perrinn F1-2017 is to some extent a publicity tool for the company, highlighting its unique approach and its capability, but its

Those who contribute to the design and development of the products also earn shares based on their experience level

Every aspect of the Perrinn design is open to public scrutiny and those who are qualified can even join in the process. But it's not just a design exercise, says the man behind the project



In some respects this is our first glimpse of what a 2017-spec Formula 1 car will look like. Front wing has a swept-back delta shape while the rear wing features A1GP style end plates, and both wings are wider, as per the new technical regulations

creator does not think this is simply a proof of concept project; he has every intention of seeing the car, or a development of it, built. 'We are committed to developing a long-term racing programme at the highest level of motorsport, be that LMP1 or Formula 1, or both,' Perrin says. 'More importantly, we are also developing a digital platform for the general public with an application and a digital currency that will carry our vision and become the main products of our organisation. These products will target a market far beyond motorsport and will be presented soon.'

A look over the available CAD drawings of the new Formula 1 car reveals a very conventional design which is clearly a gentle evolution of the 2015/2016 Perrinn F1 concept. The front suspension has a pushrod actuated torsion bar set-up and the rear has a pull rod set-up, the same general layout as every 2016 Formula 1 car and probably every 2017 car, too. 'I took the 2016 car and evolved it to the new regulations as most of the changes are dimensional, not conceptual,' Perrin says. 'As with every Perrinn car, the concept is to keep the number of design features to a minimum while focusing on optimising first-order parameters before adding more complexity when and where required. I am never looking at loopholes or hidden opportunities as it is extremely rare that these produce substantial benefit.'

The front and rear wings are wider by 150mm and 200mm respectively, while the rear wing is 150mm lower. The front wing has a swept back delta shape, more extreme than the swept wing used on the Ferrari F1-2000, while the lower and wider rear wing features end plates which sweep rearward in the style of the old A1GP Lola, but with a kink to allow adequate clearance of the rear tyres – something also seen on the Ferrari 2017 Pirelli test mule.

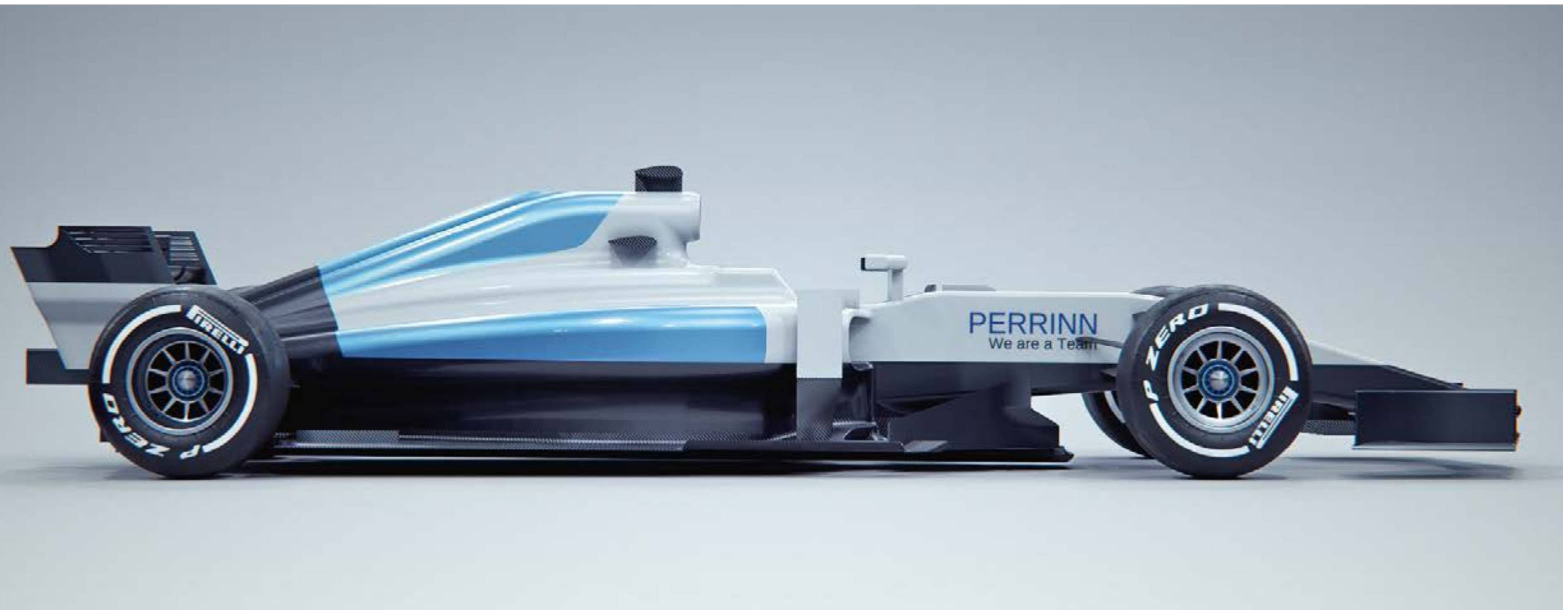
In terms of bodywork, the car is somewhat wider than the 2016 version with the widest sections around 200mm wider, though the overall shape is similar. However, the leading edges of the sidepods are also swept back and the bargeboards are notably larger.

Cool heads

One area where Perrin has decided to move away from the 2016 concept is with the cooling layout of the car, which while not yet fully developed has clearly followed the lead of Toro Rosso and Mercedes, in that it has adopted a centre-line cooling layout. 'At this stage we are not fully modelling the transmission and ERS coolers, but it is clear that it is more efficient to take cooling off the top of the car as you hurt the floor performance less than taking fresh air lower down,' Perrin says. 'It is also easier to channel the air to some of the coolers from the roll hoop. As we do not yet have a power unit partner we are taking a proportion of the total power for heat rejection data. It is a pretty good approximation at this stage.'

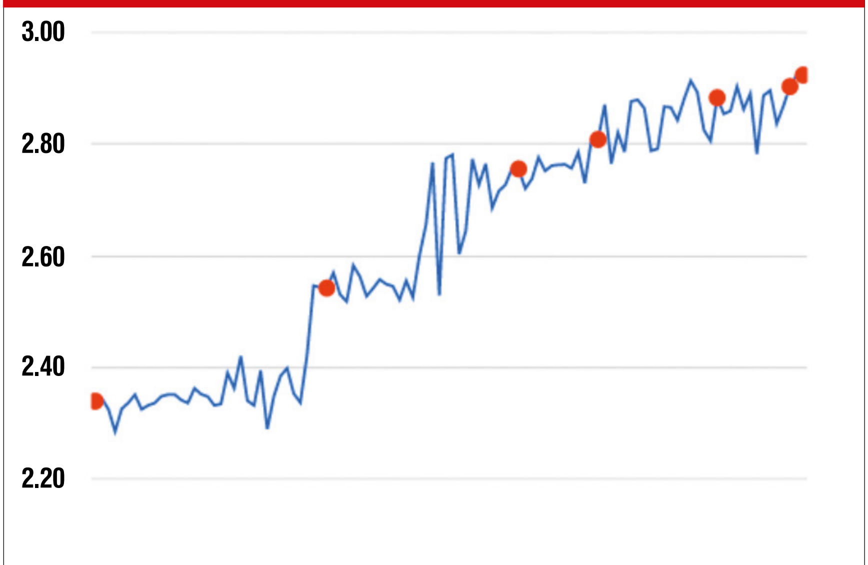
The Perrinn F1-2017 is currently primarily an aerodynamic study with CFD work now ongoing with a number of different contributors, including Perrin himself. This collaborative

Perrin has every intention of seeing the car, or a development of it, built



There is no engine or transmission modelled as yet but Perrin says he intends to design the gearbox in-house. The power unit would be supplied by a manufacturer, should the project go further

PERRIN F1-2017 development curve (L/D)



design can be tracked using an online browser based application that is called Onshape. This allows anyone to view the design and manipulate the components, and does not require any dedicated CAD software or licences.

'It is open access which means the public can read the design, but it is only written by a small number of experts,' Perrin says. 'About 10 experts have been involved in the CFD process, working closely with me and we want to reach as many people as possible and spread our values and brand which is why we are opening access to our work. Sport is very powerful for bringing people together, so we can go a step further and effectively make this team, our design team, something a bit more special. Building a car is a team experience. The internet provides services to connect with friends, or search, or do things like that, but we want to use it to create a better team of designers working from any location in the world, while allowing the public to access our design to learn or simply follow our progress. The advantage of open access is that many people can check what you're doing in real time, learn from it, and potentially even work on the project as an expert.'

The CFD work has shown notable improvement since the first configuration of the car design was tested in May 2016. 'Compared to the previous design the 2017 car has got more drag (+25 per cent) and more downforce (+40 per cent), as expected,' Perrin says.

Recent CFD runs on the Perrinn offered the following results: SCx= 1.23, SCz = 3.59, SCzF = 1.61, SCzR = 1.98, and a L/D of 2.92, the latter figure being a notable improvement over initial runs. These later CFD runs, conducted by Perrin himself, used Bramble's popular OpenFOAM software but other runs, by other users, have used Fluent and Simscale.

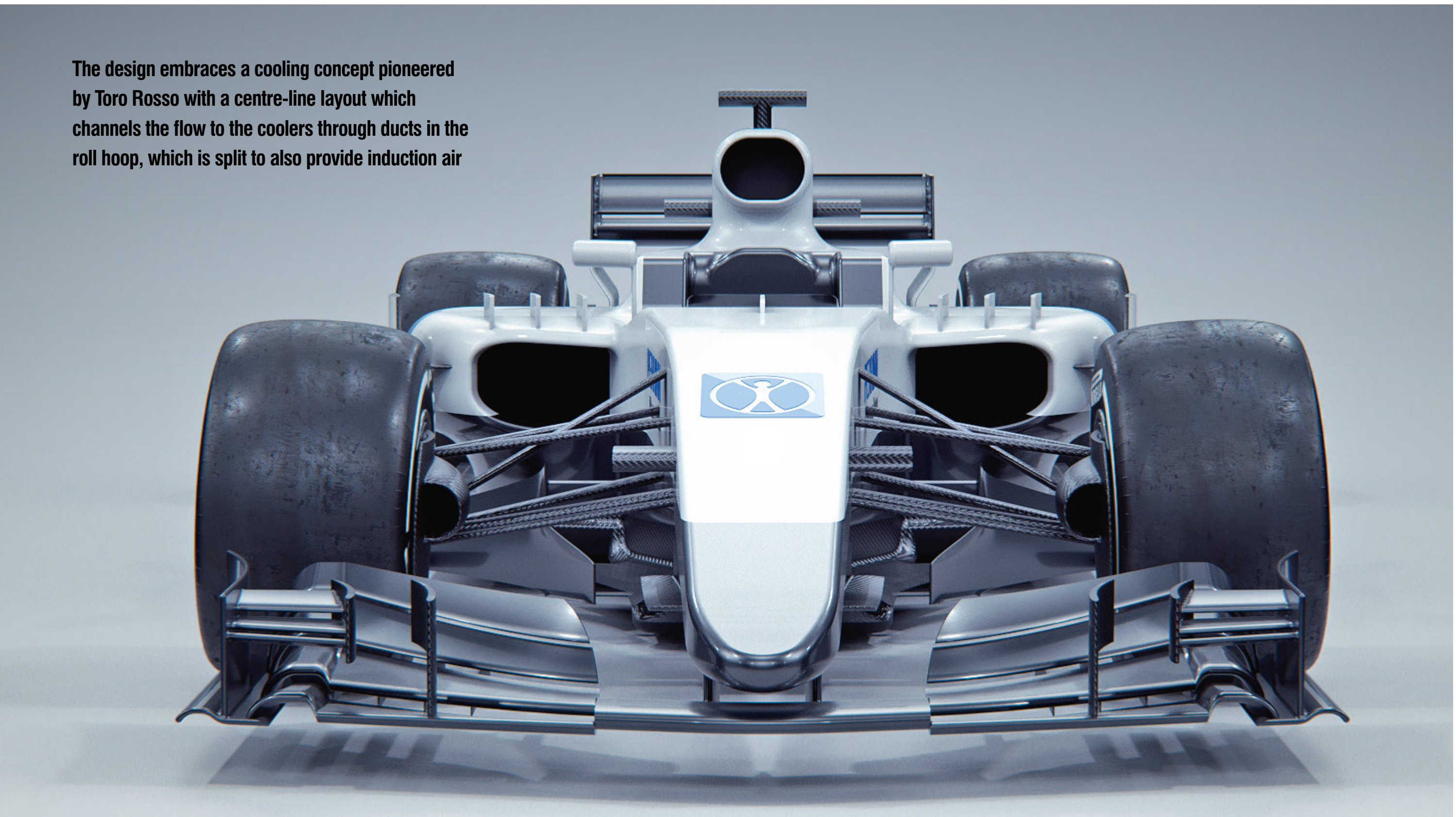
The original intention of the 2017 rule changes was quite simply to improve the show and to make the cars faster and more aggressive looking. Additionally, the cars should be harder to drive, all part of an effort to make the racing better. In 1998 Formula 1 tried to improve the show by making the cars harder to drive and overtaking easier. To try to achieve this it decided to reduce mechanical grip by introducing grooved tyres and reducing the track of the cars, so it is curious that in 2017 the sport is doing pretty much the opposite in order to largely achieve the same goals.

Regulation issues

Perrin, like many in the industry, feels that the rule changes will not achieve that goal and the work on his 2017 design reinforces the findings of Simon McBeath and Miqdad Ali in recent editions of this publication. 'I don't think that the regulations will improve overtaking, with the additional grip from the aerodynamic package and wider tyres, the braking distance will be shorter, reducing the overtaking opportunities, while the racecars will be wider and more difficult to follow, too,' he says.

Mechanical components for the Perrinn F1-2017 have not yet been fully modelled, with just a rough outline of a power unit and energy store employed as well as a general shape

'I don't think the new Formula 1 regulations will improve overtaking'



The design embraces a cooling concept pioneered by Toro Rosso with a centre-line layout which channels the flow to the coolers through ducts in the roll hoop, which is split to also provide induction air

for the transmission casing. However, while the former will have to be supplied by a manufacturer, Perrin expects the latter to be of his own design. 'I would always favour a bespoke design for better integration and freedom in terms of rear suspension layout, though at this stage we do not have to make a decision on the transmission,' he says.

Loaded question

One of the reasons that Perrin is hanging back on the development of the internal components is that there is some uncertainty over the loads which they will have to transmit. The complete tyre specifications were not finalised by Pirelli until very late in the design process and in reality the level of grip they provide allied to the increased aerodynamic forces mean that the exact loads through the car are not yet clear.

This will have a key impact on the design of not only the monocoque but also the transmission casing and the power unit itself, which on all the current Formula 1 cars is a fully stressed component. A leading F1 engine designer told us: 'The crankcase and cylinder head structure is holding the car together, so if you corner quicker the loads are higher, so we have to ensure that those structures can handle the increased loads.

'The increased full throttle time also means that there are a lot more cycles with the engine at full cylinder pressure,' the engine designer added. 'It is a big challenge to meet that so the units will have to be a lot tougher, as we do not know the exact loads it is a bit of guesswork to get it all right, and we could go under or over by about 10 per cent, which might mean we have to re-work a lot of things.'

Knowing this information, which should become clear after the initial pre-season tests at Barcelona in February, will allow the team at Perrinn to hone the mechanical design of the car. One factor those contributing to this phase of the project will look at is an increased weight limit, a result of the larger wheels and tyres. The minimum weight of the cars has increased to 722kg. It is a weight approaching that of Le Mans cars and over 120kg heavier than Formula1 cars were in 2008. The weight distribution remains fixed in a narrow window.

Reality check

In reality it seems highly unlikely that the Perrinn F1-2017 will be built, meaning that the attention must start to turn to the 2018 season, which will have largely stable regulations, although the introduction of a cockpit frontal protection system is likely. While some 2016 cars have been fitted with prototypes of the so called Halo and a number of 2017 cars were fitted with such a device in early wind tunnel developments, it is not an avenue which Perrin has yet explored. 'The Perrinn concept is one of continuous development, to always have the car designed to the latest regulations, but we haven't modelled the Halo yet as it would be wasting time to do it before the rules are written and approved,' Perrin says.

That continuous development applies not just to the Formula 1 project at Perrinn but also to its LMP1 design. This reached 'ready to manufacture' stage in 2014 with all of the mechanical components and chassis parts fully designed. While a 1:1 scale mock-up was built the final car was never constructed, despite there being some interest from teams.

Audi's withdrawal from the WEC has seen the sportscar landscape shift in recent months and the LMP1 regulations frozen, this will aid Perrinn, which has continued with its design to improve its performance, but the car is designed to accommodate a hybrid power unit rather than a combustion engine only. 'All our projects are in continuous development including the LMP1, and that remains a hybrid design. I do not understand the reason for having LMP1-L cars; for me there should be only one LMP1 category', Perrin says, before revealing that his head could be turning to the west.

'I like the DPi approach where manufacturers can develop a bodywork that carries their brand identity, it is very interesting for us and might work well with our approach,' Perrin says.

At the time of writing the Perrinn F1-2017 is actually the only clear indication as to what the new generation of Formula 1 racecars will look like. It will be interesting to compare it to the machines which roll out at the first tests in Barcelona in the coming weeks.

'The Perrinn Formula 1 car concept is one of continuous development'

Works in progress

After just two full seasons in the BTCC Power Maxed Racing has won the dream gig of a works Vauxhall deal – but now the serious business of building its Astra begins

By LEIGH O'GORMAN

Power Maxed Racing only entered the British Touring Car Championship as a team at the beginning of 2015, but the Warwickshire-based squad has been involved in the series for a number of years as a sponsor under the guise of its parent company Automotive Brands, initially with Rob Austin Racing and then Team HARD. Then, in 2014, BTC Racing sold its team including its Chevrolet Cruze to Automotive Brands, and Power Maxed Racing was thus born.

According to Power Maxed Racing's team principal, Adam Weaver, even at this early stage in the project eyes were focused on developing the team from an independent to a constructor entry. 'We had a building, we had a team manager, we had lots of resources, and two lorries,' he says. 'And I didn't need anything else other than a couple of extra people to run another car, so we bought another car and turned it into a professional racing team.'

The 2015 season was a reasonably successful one for Power Maxed Racing, with Josh Cook taking a podium and regular points finishes, propelling him to success in the Jack Sears Trophy for top rookie, and although similar results were difficult to come by in 2016,

The Vauxhall Astra road car picked up prestigious awards in 2016 and will now be on the British Touring Car Championship grid as a works entry, to be built and run by Power Maxed Racing

‘Much of the effort goes toward designing the cage and making sure it’s as light as it can possibly be’

While Vauxhall’s most recent previous involvement in the BTCC has been with privately-entered versions of its Insignia model its General Motors sister marque Opel has developed the Astra for the burgeoning TCR touring car category (above)

Weaver’s determination only grew. ‘As soon as we had bought it, it was about turning it into a dedicated professional race team. It needs to cover its costs and be successful, so that’s what we have been focusing on doing in order to attract sponsors and manufacturers, and we couldn’t be more pleased that it’s Vauxhall.’

This all came to full fruition in November, when a commercial partnership was announced between Power Maxed Racing’s parent company and Vauxhall. It is a deal that will see Automotive Brands leverage its relationships with commercial partners who operate fleets totalling over 25,000 light commercial vehicles, while also enabling Vauxhall to increase its share of this highly valued market. As part of the deal Power Maxed Racing will run a pair of Astras, based on the seventh generation K model, which was awarded the 2016 European Car of the Year.

Maxed mostly

While the move to the Astra will offer up plenty of opportunities for the team, it is not without its challenges and when asked what the most significant task will be, Weaver did not hesitate: ‘Building new cars for a start. Ultimately that’s something the people we have got here have experience in, but us as a team at Power Maxed Racing have never built new BTCC cars.’

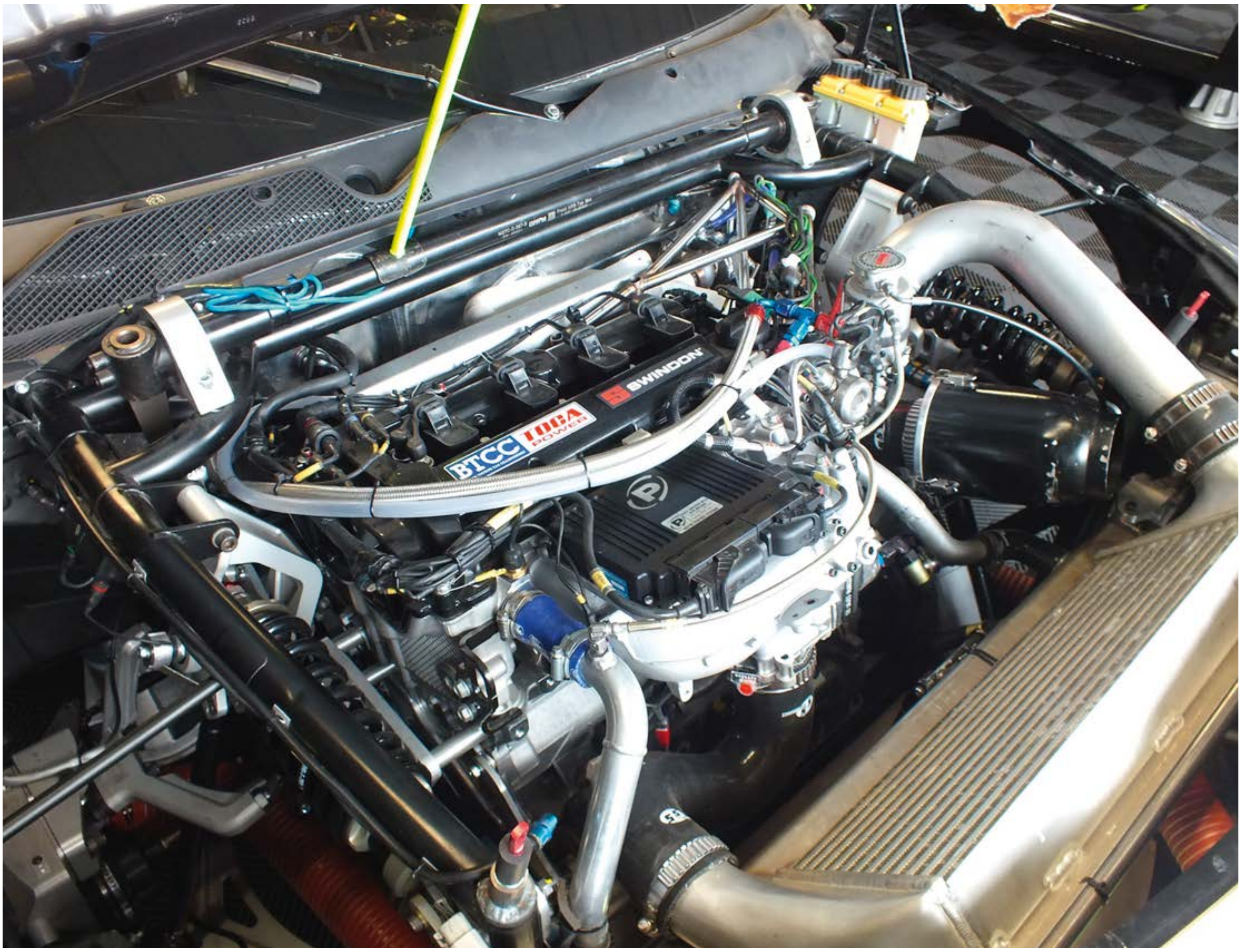
Having previously inherited the RML-built Chevrolet Cruze as an independent entry, Weaver comments that Power Maxed Racing ‘merely’ had to set the cars up and ensure they ran well, so to build one is certainly a step up. But when it comes to building racecars, the team does have experience.

‘Last year, we built three Volkswagen’s for the VW Cup, brand new Polo’s which had never been in the championship and we built those from scratch,’ Weaver says.’ Because of the regulations of the BTCC, some of the build of the BTCC shells is in some ways easier. There’s a lot more design that goes in before you start – the build of the Polos is more about drawing on the experience and scratching heads and doing it as we go along. But with the touring car regulations, the cars have all got the same front subframe and the same rear subframe, so there are many control parts that are bolt-on, so much of our effort goes towards designing the cage and making sure it can be as light as it can possibly be, that the weight is as low down as possible, and all those sorts of things.’

Astra physics

First though, the Astra, like all BTCC machines, must be adapted to NGTC (Next Generation Touring Cars) regulations for production based racecars – a set of regulations designed to reduce costs and manage levels of performance, as team manager Martin Broadhurst explains: ‘There’s a set of regulations that you can work to for the bodyshells. Everybody has a very similar roll cage layout to suit their own chassis and this fits within the regulations that are written by TOCA in what you can do and what you can’t do.’

At the time of writing, the Astra had not been put in the wind tunnel, but this does not worry the experienced Broadhurst, who is well versed in the preparation of these machines. ‘Basically we hand-pattern the bodywork –



The Power Maxed Astra will pack the Swindon Engines-built 2.0-litre turbocharged direct injection TOCA powerplant which is boosted by a turbocharger from Owen Developments

that's quite a long process, that's been going on for four weeks,' he says. 'The bodyshell is mocked up and then we hand pattern the bodywork on to a road car. The design then gets approved or rejected by TOCA, so we have had a few bits that we have had to rework.'

Broadhurst adds that until approval of the styling is received from TOCA, it is best to only hand pattern one half of the car. 'You go on and do the second half after you have approval from TOCA…until that point, there are no wind tunnel parts and there is no racecar to take to a wind tunnel.'

Vauxhall victor

There are precious few areas within the BTCC regs in which teams can freely develop the car, but in those areas that are free the nature of development will be significant. Although Broadhurst has long since earmarked where developments are likely to come in order to increase the width of the Astra, he is less keen to go into detail as to just how these areas will be developed. 'The front bumper, front fenders and rear sidepods will be different, which is what everybody does to get to maximum width. Regulations are controlled with regards to front opening and the floor. We just do what we can within those regulations.'

Weaver adds that while his team can do much to develop what they can within the rules of the game, there is little point in spending eye-watering amounts of money to do so.

'There are two ways you can do it really,' Weaver says. 'You can spend a tremendous amount of money on CFD and design work upfront, or you can draw upon the experience of the people you've got, that they've gained over all of their years, and develop a kit which you think is going to be there or thereabouts; and that's the cheapest way of doing it.

'We've got some guys with a vast amount of experience and we've basically taken that, and what we've got from learning with the Chevrolet, and developed an aerokit, almost by eye, and what we will do is take that to a wind tunnel and test that to make sure that we haven't got it too far wrong,' Weaver says. 'You can invest hundreds of thousands of pounds in design work on CFD to design the aero upfront, but the way that most teams will do it is this way, and then take it to a wind tunnel.'

When it comes to the Astra's wheelbase, Broadhurst is also slightly less forthcoming, acknowledging that while it will change slightly, he is not in a position to discuss it quite yet. However, Weaver admits that the wheelbase is likely to be similar to that engineered for the Honda Civic Type-R currently run by Team Dynamics and Simpson Racing.

Maxed power

As per the regulations, the engine is a 2.0-litre turbocharged direct injection engine with fly by wire throttle control. While teams are allowed to run engines sourced from their manufacturer's family of engines, the Astra will run the TOCA powerplant. In an effort to maintain low costs, TOCA-branded engines are built and tuned by Swindon Engines and according to Weaver, 'the block [upon which the TOCA engine is based] is purchased from Vauxhall.' The BTCC's

'As a team Power Maxed Racing has never built new BTCC cars'

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MADE IN ENGLAND

‘We really have run it like a works operation from day one’

spec-part turbocharger is produced by Owen Developments and the intercooler is from Australian cooling company PWR.

The full front subframe is designed by RML and incorporates the suspension, brakes, transmission and the engine location – and is attached to specified roll cage locations. As with all entries in the BTCC, Power Maxed Racing will run a 6-speed sequential gearbox and differential as provided by Xtrac, while the carbon clutch and braking systems will be delivered by AP Racing. The drivetrain layout must be as per the base vehicle, so this racecar will be front-wheel-drive.

The suspension is a multi-adjustable wishbone unit with SPA Penske coilover dampers. However, there is a little room for manoeuvre here. ‘We can change springs, we can put whatever springs we want in, and the way that the dampers are built, and whatever seals and pressures are in the dampers is down to us. The uprights are controlled parts, so your front and rear subframes, uprights and dampers, are all control parts,’ Weaver says.

Weighing in

Where Power Maxed Racing may have some extra room to play is with weight. The BTCC weight limit is 1280kg and Broadhurst admits that the team is working hard to ensure the Astra hits that mark. ‘We’re working hard on it at the minute. The championship runs to a minimum weight, and we will run to that.’

Weaver acquired a factory for Power Maxed Racing several months after the team initially came into being, allowing the engineers to not just build the new cars, but also to strip them back and refit them after each meeting. ‘We took on an 8000sq.ft unit, which was over the road from our traditional business.

‘We kitted this out. We put mezzanine floors in and created a fabrication room. We have got plasma cutters, compressors, all types of equipment and machinery and airlines all around the building. We have created a very professional environment to go in to. A few things will change during the time we actually build the racecars, but we have always ran both cars like a works team. We are meticulous when it comes to the preparation of the car, with a massive amount of set-up.’

The works

Emphasising just how professional the organisation is, Weaver says: ‘After every race meeting we take part in the racecars are stripped back to just the seat, roll cage and the wiring loom. The engine comes out, the front subframe comes out, the rear subframe comes out; we inspect it all for cracks, looking for things that may have been bent or warped. We rebuild the entire gearbox, crack test the gears, we measure and shim the clutches, and we measure the driveshafts to see whether they’ve bent through the number of rotations. There is a massive amount of work that goes into this operation.’

Thereafter each car is rebuilt and taken to a local airfield for a shakedown. ‘We really have ran it like a works operation from day one,’ Weaver says. ‘Hopefully, now we will be able to afford to do more tests and when we are at those tests we will be able to afford many more sets of new tyres, and that is the only thing that is really going to change.’

Should all go as planned Broadhurst believes the Astra should be ready for testing by the middle of February, with Weaver adding that the second car should be ready two weeks after that. However, the team’s taking nothing for granted and realises it cannot control some factors: ‘We’ve got quite a challenge on our hands to build two cars ready for the start of next season, but it is something that we are very confident that we will be able to deliver. Our aims are subject to weather. It really is pointless going testing in bad weather and very cold weather, so as long as the weather is okay, we will be out testing at the very end of February and certainly in March,’ Weaver says.

Astra la vista

There is little doubt that Power Maxed Racing is a race team with plenty of ambition, and as it enters its third season in the BTCC, the tie-up with Vauxhall may be what makes that ambition a reality. But Weaver is not getting ahead of himself and has set some reasonable goals for the year ahead. ‘We want to get on the podium. We’d certainly like to bring back the Jack Sears Trophy to our team. We won it with Josh [Cook] in our first year and we’d like it back in our third year.’ With young talent like Senna Proctor on board, this is certainly an achievable aim.

TECH SPEC

Vauxhall Astra BTCC

Engine: TOCA-BTCC unbranded engine, tuned by Swindon Engines; 350bhp 2-litre turbocharged direct-injection with fly by wire throttle control; Owen Developments turbocharger and PWR intercooler

Drivetrain: Xtrac 6 speed sequential-shift gearbox and differential; AP Racing carbon clutch; front-wheel-drive

Chassis: RML-designed full front and rear subframes incorporating suspension, brakes, transmission and engine location that attaches to specified roll cage locations.

Suspension: Multi-adjustable double wishbone suspension with SPA Penske coilover dampers front and rear

Steering: hydraulic power steering

Clutch and brakes: AP Racing

Bodyshell: Equalised width of 1890mm; spec front aerodynamic device incorporating flat floor, apertures for radiator, brake cooling ducts, intercooler and side exits; spec rear wing profile; stylised front and rear wheel-arch extensions

Fuel tank: 80-litre ATL fuel tank

Back on the world stage

The WRC might have lost VW but in its place comes another automotive giant in the shape of the returning Toyota – *Racecar* was on hand when it unveiled its new Yaris rally car

By MARTIN SHARP

Mid-December 2016. In the tumultuous wake of Volkswagen Motorsport's shock departure from the FIA World Rally Championship at the end of the 2016 season, Toyota Gazoo Racing (TGR) officially unveiled its brand-new World Rally Car, the second team to do so; two weeks after Hyundai Motorsport launched its 2017 specification i20 coupe WRC.

The first result of VW's pull-out was one of its former drivers, Jari-Matti Latvala, signing to drive the new Toyota Yaris WRC in 2017's top-level rallying series. Having been involved in testing the 2017 VW Polo R WRC during its development, Latvala has a good understanding of the latest generation of top rally cars, and indeed before the launch had already had a brief opportunity to drive the new Toyota, joining his new team mate Juho Hanninen for a test in Corsica, then for a week on French asphalt near Toulouse immediately before the car's launch.

Latvala did not want to go into a detailed comparison between the 2017 Volkswagen Polo R WRC and the Yaris WRC, but he did say: 'The feeling with the Toyota is totally different to the Polo and more like when I drove Ford Fiesta [RS] WRCs.'

TGR's Team Principal is four-time World Rally Champion Tommi Makinen and the team's headquarters are based in his home town of Puuppola near Jyvaskyla, the headquarter town of Rally Finland. No surprise, then, at the all-Finnish driver line-up – which also includes Esapekka Lappi, who joins the Toyota team as its team as test driver.

Heading the engineering team is Tom Fowler. He was Mikko Hirvonen's event engineer for many years at M-Sport, later becoming involved in testing and car development with the M-Sport engineering team. He has now been with Toyota Gazoo Racing for the full 18 months, since the team was set up. It was a small group of people initially, but the team has now grown to more than 100-strong, with more than 10 nationalities represented. Extended premises are currently under build in Puuppola – photographs show an uncanny similarity to M-Sport's Dovenby Hall pile in Cumbria.

'It was a completely white sheet of paper when we started,' Fowler says. 'Nothing at all. But we started from where we, together as a team, wanted to be.'

United nations

The Yaris WRC's engine is designed and built in Germany by Cologne-based Toyota Motorsport Group (TMG), which collaborates with Finland and Japan. The event engines in 2017 will continue to be rebuilt and maintained in Cologne.

With a unique machined cast aluminium alloy cylinder block, similar to rival 2017 WRC units, the Yaris WRC engine is of 1600cc unique 'Global' design: in-line 4-cylinder direct injection petrol with the 2017 regulation 36mm diameter inlet air restrictor. Official outputs are quoted as over 380PS (374.8bhp) and over 45Nm (33.2lbf.ft); bore and stroke are 83.8mm and 72.5mm respectively.

The FIA ensured greater power output by increasing the turbocharger inlet restrictor diameter from 33mm to 36mm, but the 2.5bar absolute maximum boost pressure regulation of yore remains. The latter means the maximum torque produced by a new WRC engine will not change significantly from that of a 2016 engine. Fowler says: 'The increase in power means that we and the rest of the teams are running

With the majority of WRC rallies being held on loose surfaces much of the testing of the all-new Toyota Yaris has been focussed on optimising the gravel set-up

The parameters controlling the diff must rely on wheel speeds, which do not correlate to ground speed on gravel

The machined cast aluminium alloy cylinder block engine. The in-line 4-cylinder direct injection petrol unit makes 375bhp and over 420Nm of torque

Aerodynamic development started on this test Yaris WRC, even to the extent of weaponising the door mirror mounts

The extensive rear wing and overall aero treatment has elicited comments that the car could double as an aircraft carrier

peak power at higher rpm and that comes with challenges in terms of making sure that the throttle response is what the driver wants, and I think it's fairly obvious to say that when you're running at higher rpm with more power it's more difficult, but it's the same for everybody.'

Return to power

When asked about throttle operation with the revised power curve, Latvala says: 'Yes [it's more difficult], because now you don't have so much torque [comparatively] [as] in old World Rally Cars and it was easy to apply the throttle. It is the same for both the [2017] Polo and the Yaris; it's just that on some events you have to be careful with the tyres. If we think about the '16 cars for instance, on tarmac you would never really kill the tyres, but now I can see, with the aero pushing the car more down – if you fight and you understeer, you kill your tyres a lot quicker.'

Fowler admits this is an area in which the team has had to work very hard indeed, but the solution is: 'Many different things, but then once you have the system that's variable you can then map it to each driver.'

The new World Rally Car technical regulations for 2017 aim to enhance the championship's top tier by regulating more macho-looking cars which are also faster, with larger aerodynamic addenda than previously allowed – the rear spoiler can now be some 50mm higher and 55mm wider than it was before, but its profile is fixed.

The rear wing can now overhang the body by an extra 30mm, while the front bumper can protrude 60mm more. The rear diffuser, to maximum permitted dimensions, now has a free shape and can stick out 50mm more than the rear bumper. Toyota has certainly embraced these regulations – to the extent of also adding obvious aero tweaks to the external door mirror mounts. The Yaris WRC's extensive rear wing and overall aero treatment has elicited comment that the car could double as an aircraft carrier.

Splitter difference

Most difficult aerodynamically with a rally car is achieving a good front-to-rear balance. A front splitter is allowed within specified maximum dimensions, but this frontal device is arguably the most vulnerable aero part of a rally car when blasting through stages. However, the new rules now allow multi-layer carbon composites to be used on bodywork. Splitters built to the 2017 regs can therefore be more robust and the aerodynamic balance of the car will likely be maintained over more kilometres of stages before this deteriorates.

Fowler says: 'Previous composite regulations were very tight; that's been opened up. Even with the change in those regulations, making those components last has not been easy...we've done a hell of a lot of work in that area, but we had choices from the beginning; whether you use all the possible benefits that you can from

‘I think our biggest challenge as a team was the time frame’

the aerodynamics, which would result in some components that are liable to damage. But with the way rallying has been going it's no longer really an endurance event; it's a sprint; it comes down to split-seconds, so if you design a car saying; "Oh we shouldn't do that because it might fall off", then you're not going to have the performance that you need. Our target from the beginning was to maximise what we could, then attempt to make it work, then we'd back-step until we could [make it work], and that's where we ended up here.

'I think if you look at all the homologations of all the cars,' Fowler adds. 'Taking the front bumpers into account everyone has pretty much ended up with a similar solution, which is not a result of copying because everyone's been kind-of camouflaged-up and trying various options and you don't know which bumper was the final one until very, very late, so I think it's just that everyone's done their research and they've come to the same, similar, place.'

The previous World Rally Car generation had passive mechanical front and rear differentials, but no centre diff. Of course, the results were some transmission wind-up and the need for drivers to set the cars up as they threw them in to bends. The new rules not only allow a centre differential, but this can also be equipped with actively controlled slip-limiting technology, in a similar way to that of the second-to-last generation of WRCs. Evidently, improved chassis comportment will result, which will be enhanced with the extra 55mm of allowed car width, to 1875mm, which means a wider track.

Slide rules

The Yaris WRC's transmission was developed by Xtrac, bespoke to the car over the period from when TGR was first established in 2015. The rules over active centre diffs have changed in that ground speed sensors are now prohibited, meaning the parameters controlling the diff must rely on wheel speeds, which of course do not correlate to ground speed on gravel. But Fowler explains that while using wheel speeds to control the diff is difficult, there is enough information available to do the job.

Also, a relaxation in front suspension pick-up point restrictions means wheel travel will increase and for sure in 2017 the speeds and the stability in the corners will also increase, but the centre diff and increased downforce from the new aerodynamics may well result in cars which look more as if they are cornering on rails than they did before.

The team decided to plump for Bos dampers, and from the beginning of the Yaris WRC testing programme in April many different gravel damper specifications have evolved. 'We have something that's very close to what we intend to use for the first gravel rallies next year,' says Fowler. 'But for sure that development will continue right up until the pre-event tests for those events, that's normal. The internals of the damper are free in the homologation so it's one area where it's wise for teams to push very hard, because you can basically change it on a rally by rally basis.'

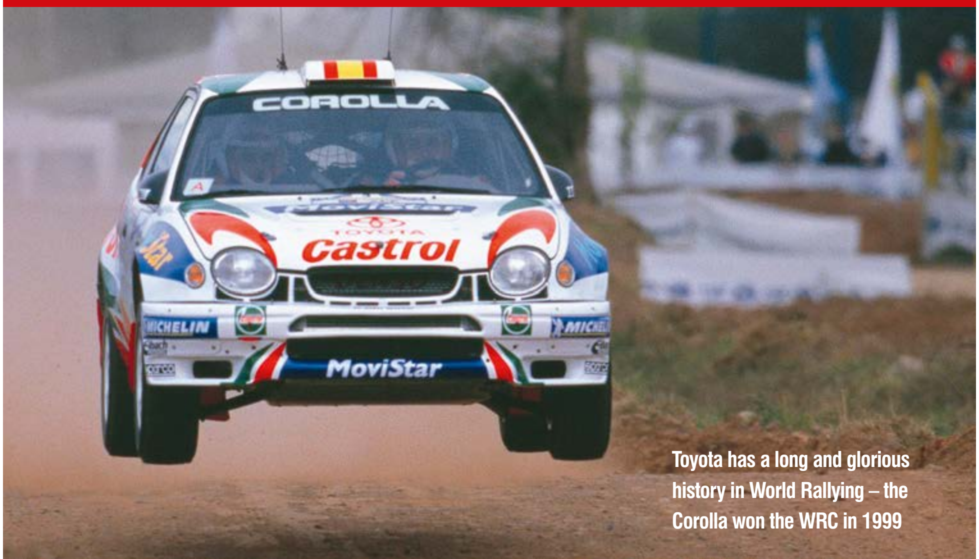
The brake system is water-cooled, but the manufacturer has not yet been disclosed – but it is not Brembo, nor AP Racing.

Gravel rash

The majority of WRC rallies are gravel, so it is sensible to make the development of a gravel spec car the priority. Fowler: 'Our main aim at the beginning was to get as quickly as possible the gravel car running and we produced the first test cars, which don't largely represent [visually] what was launched. But they were pretty similar, so we used those first prototypes to launch an extensive test programme on gravel. The tarmac car went testing this October just gone, which in the scheme of this is quite late in the year … In terms of priorities we really had to make sure the gravel car was right before we got too deeply into the tarmac [specification].

Fowler also tells us that moving to a new team can provide opportunities to explore areas which were not 'big pictures' in previous teams. He is reticent to be drawn on details

Previously on Toyota WRC …



Toyota has a long and glorious history in World Rallying – the Corolla won the WRC in 1999

A return to the World Rally Championship in 2017 is an important landmark for Toyota, a Japanese company with such a strong WRC heritage.

Its successful rallying past is essentially due to the tenacity of one man: Ove Andersson. Beginning in 1972, during the oil crisis, as a private team running on behalf of the manufacturer, the early days were lean. Then Hannu Mikkola won the 1976 1000 Lakes in a 1.6-litre Corolla.

Toyota Team Europe (TTE) was born that year and moved from a Swedish farmhouse to workshops in Brussels. The team would have preferred to field the Corolla, but Toyota insisted on the Celica sportscar for marketing reasons.

TTE then moved to Cologne in 1979 and by 1982 Bjorn Waldegard had scored the team's first WRC win in New Zealand. Group B arrived in the same year and by 1983 the rugged rear-drive Celica Twin Cam Turbo was born. Uncompetitive on European sprint rallies, its real success came on the rough African events.

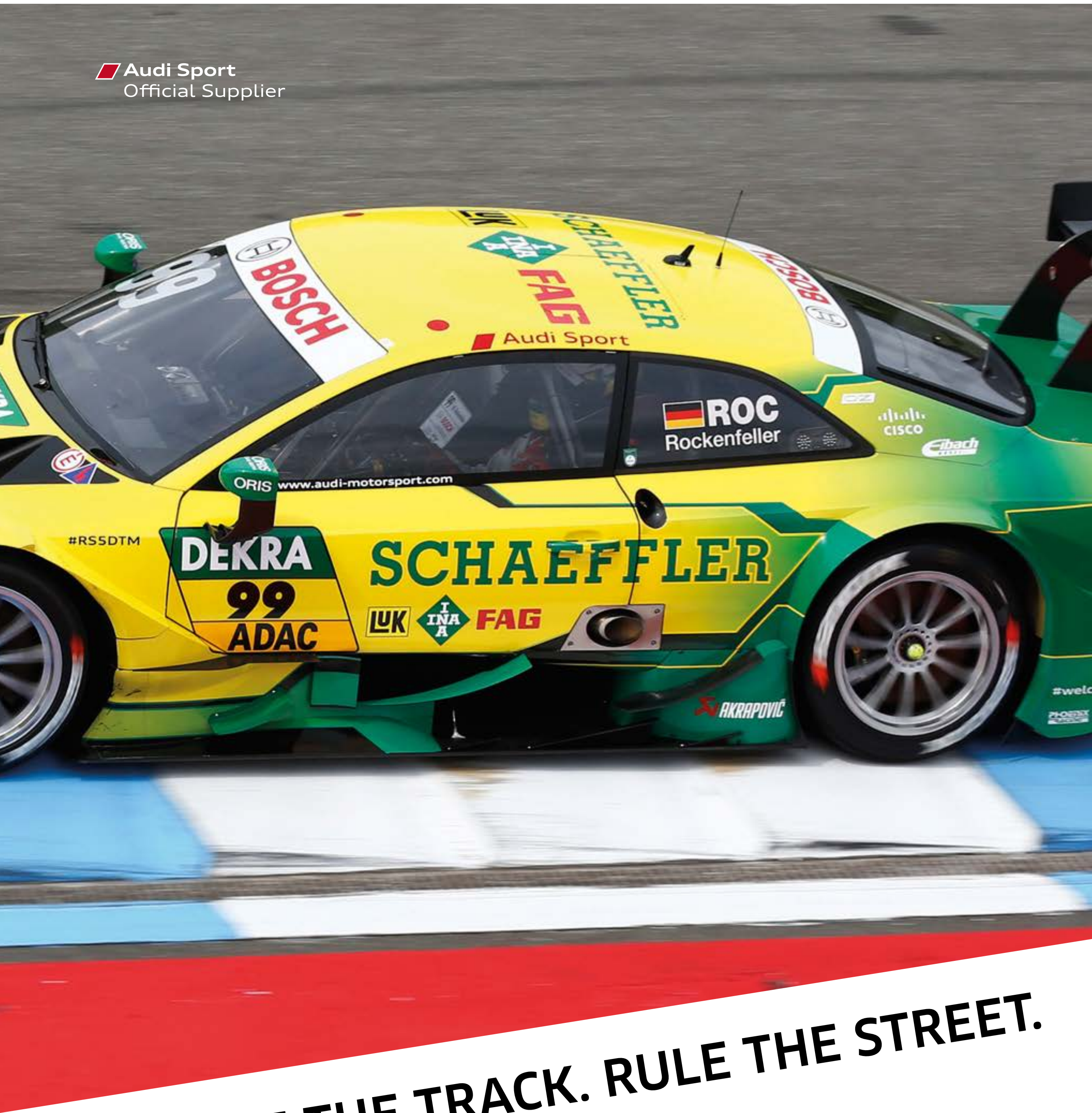
Sleeker Celica

When Group B came to a premature end TTE was left to hastily press the Supra into action as a stop-gap. But then Toyota agreed to produce a four-wheel-drive car. By 1988 the Group A ST165 Celica GT-4 was capable of pushing its rivals; and drivers' and manufacturers' championships soon came TTE's way.

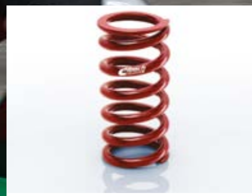
ST165 became ST185, then finally the infamous ST205. By then the Celica was too big, but still Japan insisted it was used as the rally car. To be competitive against Ford and its two Japanese rivals from Subaru and Mitsubishi; somewhere, somehow, within the TTE organisation the decision was made to develop an ingenious, beautifully made yet near-inconspicuously illegal turbocharger inlet restrictor. This was soon discovered and the ensuing scandal saw official Toyota entries banned for the 1996 WRC season.

Against all odds Ove Andersson convinced Toyota to stick with the sport – and managed to get approval to use the Corolla for the first time. The World Rally Car rules helped here, as a specialised 4x4 base production car was not required. So Corolla WRC was born: TTE won the 1999 Manufacturers' Championship with it.

Then the Toyota Formula 1 rumours proved to be true, and it was no more official rallying for Toyota...until 2017.



IMPERIAL RANGE



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New regulations allow plenty of freedom in diffuser design while it can now protrude beyond the bumper by 50mm. Rear wing is dramatic, just as the new rules intended

but does admit that one area is the chassis: 'I think everyone has a target of wheel travel … It comes down to what you do with your damper installation. In principle, wheel travel was one of our targets.' And he confirms that the target was to *optimise* the amounts of travel, not necessarily to aim for the highest numbers.

Safety measures

As mentioned, WR cars can now be built to a maximum width of 1875mm, which enables improved side impact crash safety for crews – a welcome development for cars cornering arguably faster than ever before in rallies.

Following the tragic deaths of Michael Park and Mark Lovell and Roger Freeman through accidents involving impacting tree trunks with the sides of their rally cars the FIA Institute set up a research study into the vulnerability of crews under such circumstances. The study involved Prodrive Subaru and the UK's Cranfield University and resulted in regulations mandating a minimum of 60 litres of deformable foam in each World Rally Car door, and a wide raft of other stipulations.

The latest 2017 wider body allowances allow this minimum foam volume per door to be increased to 95 litres, which, together with extra deformable protection outside the standard door skin position, improves energy management by some 20 per cent.

These side impact body measures were the final items to be included in the new regulations and their increased weight forced the FIA to revise upwards its initial intention to aid the performance increase through a reduction in minimum weight of 25kg to 1175kg to a reduction of 10kg, so the final regulated minimum weight is of the new cars is 1190kg.

Fowler says that the Yaris WRC bodyshells are all built in-house at Puppola, as is the assembly of specialist supplied equipment. He also tells us that for every event each TGR driver will have a spare car: 'Because you can't come from event to event to event without a rotation. Obviously, it's rallying; things can happen and we might need to build an extra car, if there were an accident or whatever,' he says.

Split time

'I've been involved in the development of rally cars before,' Fowler adds. 'I know the challenges, and I know it's very, very difficult, and I think our biggest challenge as a team was the time frame, just getting to where we needed to be in, well we says a year and a half, but obviously in reality we had to set a lot of things up before we even had a car, so it's been a very short period.'

A short period in which a great deal has happened in the WRC, including VW walking away. The question now is can Toyota step in to the power vacuum Volkswagen has left at the top of World Rallying?

'With the new aero pushing the car down more, if you fight and you understeer you will kill your tyres a lot quicker'

TECH SPEC

Toyota Yaris WRC

Engine: 1600cc turbocharged. Bore/stroke: 83.8x72.5mm Power: 380bhp. Torque: 42Nm

Gearbox: 6-speed sequential hydraulic shift

Differentials: Active centre, mechanical on the front and rear

Clutch: Double-plate

Suspension: MacPherson struts, Bos dampers

Brakes: 300mm/370mm discs, four-piston calipers (gravel/asphalt) undisclosed supplier

Steering: Hydraulic rack and pinion

Wheels: 7x15-inch/8x18-inch (gravel/asphalt)

Dimensions: Length 4085mm; Width 1875mm; Wheelbase 2511mm

Weight: 1190kg

Delta Force

The Lancia Delta S4 was arguably the most extreme machine of world rallying's craziest period – so strap yourself in tight as *Racecar* looks back on the definitive car of the legendary Group B era

By WOUTER MELISSEN

It was blisteringly fast straight out of the box and lapped Lancia's 2.2km test track a full four seconds faster than the 037

The Group B era of rallying, which ran from 1982 until 1986, was the last opportunity for engineers to create a virtually no-holds-barred racing car. The only real restriction was the minimum homologation requirement of 200 road cars. While the spirit of the regulations may have suggested that a rally version was then created from the road cars, few people – the rule makers probably included – were surprised that manufacturers instead then produced 200 road going versions of whatever rallying contraption their engineers had created.

Manufacturers could then homologate the evolution version, which was effectively the rallying derivative of which a further 20 had to be built. Arguably, the most extreme of these Group B machines was the Lancia Delta S4, which debuted with a one-two victory on the 1985 RAC Lombard rally. Replacing the 037, the Delta was actually the second Lancia Group B car, making the Italian company the only manufacturer to produce distinctly different rally cars in this short period.

Delta's alpha

Developed by in-house specialist Abarth, the Lancia 037 had also been the first rally car built to Group B regulations. For commercial reasons only, it loosely resembled the Montecarlo production car. Underneath the silhouette carbon-fibre composite skin, it combined the Montecarlo centre monocoque with purpose-built front and rear tubular subframes.

The 037 was powered by a mid-mounted (longitudinally as opposed to transversely in the Montecarlo) 4-cylinder engine that was equipped with a volumetric supercharger. This was unusual at a time when the exhaust-driven turbocharger was the preferred forced induction method. Lancia and Abarth already had vast turbocharger experience with the 4-cylinder engined Group 5 and Group 6 cars they raced during the 037 development. But it was actually this experience, particularly of the low-end lag, that prompted the engineers to fit the 037 with a supercharger instead – for the grunt that rallying required at low revs.

Quattro battle

Once the run of the slightly tamer road cars had been completed, the Lancia 037 made its debut halfway through the 1982 season. Its chief rival was the Audi Quattro, which had been developed to the stricter Group 4 regulations and had introduced all-wheel-drive to rallying.

Once the bugs had been ironed out, the Lancia 037 started to dominate, winning five of the eight World Championship rallies it competed in during the 1983 season. Particularly on solid surface rallies, it could easily overcome the disadvantages of its rear-wheel-drive only configuration, thanks to its much lower weight and superb handling compared to the production-based Quattro, which throughout its career never came close to the minimum weight stipulated in the regulations. But even before the 037 started its domination, Lancia had already recognised that this advantage was not going to last and in April of 1983 started the development of what was known internally as the 038, but would become better known as the Delta S4. Yet Lancia would be beaten to the punch by Peugeot, with its mid-engined, all-wheel-drive 205 T16, which was announced early in 1983 but did not compete until 1984.

Delta good hand

The Lancia and Abarth engineers virtually started from scratch, as only some elements of the suspension design were carried over from the 037. Designed as a competition car from the ground up, the Delta S4 was built around a spaceframe constructed from chrome-molybdenum steel tubes. All four corners were fitted with double wishbones and coil springs. At the front, the suspension sported single telescopic hydraulic shock absorbers while twins were fitted at the rear. As in the 037, the engine was installed longitudinally but it was also turned around 180 degrees to allow for the gearbox and, crucially, the transfer case to be mounted centrally. The gearbox was a Hewland-sourced 5-speed manual.

Hewland also helped develop the four-wheel-drive system, which consisted of a Ferguson viscous coupling with an epicyclic centre differential. The power transfer could be adjusted from 25/75 front/rear to 40/60. On both the front and rear axles a ZF limited slip differential was used. The slip could be adjusted and was normally set at 25 per cent at the front and 40 per cent at the rear.

Twinning ways

While providing excellent low-end power, the supercharged 037 engine was found to be a little lacking at the high end of the rev range. To fix that problem, while retaining sufficient drive out of the corners, the Lancia engineers decided to equip the all-new S4 engine with both a supercharger and a turbocharger. The sequential system saw the air run through the large KKK turbo, then through the first intercooler before it reached the supercharger. Low in the rev range, the supercharger was engaged, while from 5000rpm it was bypassed. The air was then fed through a second intercooler before reaching the intake plenum. With this set-up the supercharger could provide all the power needed at the low end when the turbines were still spooling up, and yet the engine suffered none of the power loss at high revs usually associated with superchargers. The system may sound elaborate but it worked remarkably well and during its rallying career the S4 rarely suffered an engine-related failure.

The 4-cylinder engine itself was also brand new. Both the block and the head were constructed from lightweight aluminium alloys.

The 1759cc 4-cylinder powerplant was brand new and both the block and the head were constructed from lightweight aluminium alloys. The head featured twin overhead camshafts

The engine made use of a supercharger and a turbocharger, the former for negating the turbo lag out of corners, the latter for high end revs at full chuff

While the aero was rudimentary, with up to 550bhp on tap at high boost settings the large chin spoiler was vital for keeping the nose down at high speed. The light cluster possibly helped too!

A carbon-fibre composite body ensured the S4 tipped the scales as close to the minimum weight as possible. C-pillar scoops fed air to intake and intercoolers

The head featured twin overhead camshafts, which were driven from the crankshaft by a belt. The displacement was relatively modest at 1759cc, which was equivalent to just under 2.5 litres, taking into account the 1.4 equivalency factor for forced induction engines. This was important as the only parity measure in the regulations was a sliding scale for the minimum weight based on the size of the engine. For the Delta S4's 2- to 2.5-litre category the minimum weight was set at 890kg.

S4 success

Despite its modest size, the twincharged 4-cylinder produced a healthy 420bhp while running at a very safe 2.4bar of boost. At higher boost levels, it could produce as much as 550bhp. This was quite an improvement over the 350bhp figure quoted for the supercharged, 2.1-litre engine fitted in the 037.

To ensure the S4 tipped the scales as close to the minimum weight as possible, it was clothed in a carbon-fibre composite body. Its design was vaguely reminiscent of the newly introduced front-engine, front-wheel-drive Lancia Delta road car. The nose boasted a deep chin spoiler to keep it on the ground at high speeds while a wing was mounted at the edge of the roofline. Large scoops mounted on the C-pillars fed the air intake and the two intercoolers with fresh air. The high mounted radiator had its intake on the roof, just behind the passenger compartment.

Despite boasting the twincharging and all-wheel-drive systems, the purpose-built S4 did in fact manage to meet its target weight, usually running at around 900kg in tarmac trim. By comparison, the Audi Quattro used in 1985 weighed as much as 1200kg, even though its limit was set at just 960kg. The Delta S4's weight was distributed 45/55 between the front and rear axles respectively.

Before the end of 1984, the first Delta S4 was ready for testing. It was blisteringly fast straight out of the box and lapped Lancia's 2.2km test track a full four seconds faster than the 037. Even on gravel, the car could accelerate to 100km/h in just over two seconds. Henri Toivonen was the first of the Lancia drivers to get a taste of the peculiarities of the four-wheel-drive system, and while the S4 was not as prone to understeer as the Audi Quattro, it was not quite as easy to drive on turn-in as the 037 it replaced, or even the 4wd Peugeot 205.

What the S4 did have over the 205, with the latter's transversely mounted engine, was a much better left to right weight balance. Heavier on the right hand side, the Peugeot was a particular handful over jumps. Some of this was cured by the introduction of the Evo 2 version halfway through the 1985 season, which saw many of the ancillaries moved to the left. Despite the changes, the difference between the left and right hand side remained at at least 50kg by the time the S4 appeared on the scene.

But homologation proved a much bigger issue for the S4, and would postpone the competition debut of the new Lancia to the very end of the 1985 season. The *Stradale* road version, which featured a complete interior and

The Lancia engineers decided to equip the all-new Group B Delta S4's engine with both a supercharger and a turbocharger

Suspension was double wishbones and coil springs with single telescopic hydraulic shock absorbers at the front while twins were fitted at rear. Little was carried over from the 037

The S4 was built around a spaceframe constructed from chrome-molybdenum steel tubes. Cockpit looks simple 30 years on but these were far from simple cars to drive

de-tuned version of the revolutionary engine, simply proved more complicated to build. But the Delta S4 finally received its homologation on November 1 1985. Even this was only achieved by building the 20 'evolution', rally specification cars first with the promise of constructing the remaining 200 road cars within a year. It is believed Lancia actually only built around 100 cars, which were reportedly inspected before and after lunch with the chassis tags replaced in the meantime to suggest 200 were actually built. Of these 100 cars, it's believed Lancia sold only around 70 to avoid any potential liability issues with this rather extreme machine.

The homologation issues meant that the new Delta S4 could only compete in a single round of the 1985 World Championship; the Lombard RAC Rally. Seven of the previous 11 rounds had been won by the Peugeot 205, four of these by the second evolution of the compact French car. Lancia entered a pair of Martini-liveried S4s for Henri Toivonen and Markku Alen. The two Finns promptly finished first and second on the UK round.

Toivonen carried his form to the 1986 season-opening Monte Carlo Rally. Despite incurring some damage when his S4 was hit by a spectator on a road section, he won the rally comfortably. Peugeot's Juha Kankkunen then won the Swedish Rally after Toivonen suffered a rare engine issue. The stage was thus set for a battle of epic proportions between Peugeot and Lancia, but Group B rallying then had a reality check when a Ford RS200 veered off course in the Portuguese Rally, killing three spectators.

B's sting

Disaster struck again at the Tour de Corse, the fifth round of the championship. Henri Toivonen and co-driver Sergio Cresto held a massive, three-minute lead, having won 12 of the previous 17 stages in Corsica, when they left the road at high speed. The car went over a steep drop and then hit the base of a tree. If the impact had not already killed Toivonen and Cresto, the subsequent fire did. This was fuelled by the high-octane fuel placed in tanks under the seats, and also by the many lightweight magnesium alloy parts in the car.

In the wake of the tragedies FISA president Jean-Marie Balestre announced that Group B would be cancelled at the end of 1986 and that no further evolutions of the cars would be homologated. The World Championship did continue and Miki Biassion and Markku Alen would go on to win a further three rallies between them using the Delta S4. But Peugeot and Kankkunen ended the tragic season as World Champions. Along with Group B, Balestre also cancelled the proposed Group S that was aimed to replace Group B later in the decade.

The Group S regulations had even more lenient homologation requirements but did limit engine performance to around 350bhp. Lancia did offer a sneak peak of what was to come with a pair of show cars that were built around a carbon-fibre monocoque and featured an even more ingenious 4-cylinder engine. Known as the *Triflux*, it featured crossed exhaust and intake ports on either side of the block. The exhaust ports on either side of the engine fed their own, relatively small turbocharger. At low revolutions one of these turbos was shut off, forcing all the air through one turbo, allowing it to spin up much faster. Electronically controlled differentials were also under development to further cure the turn-in problems of the four-wheel-drive system. The first 'ECV' car also boasted carbon-fibre composite propshafts and wheels. The car then evolved into the ECV2, which featured a much rounder body. Neither incarnation of Lancia's proposed Group S car ever turned a wheel in anger.

Still revered today, the Group B cars, and in particular the Delta S4, remain as the fastest and most sophisticated rally cars ever built. We can only imagine what the Group S cars might have been capable of. The safety of all involved, however, was paramount for the survival of the sport in the long run, so Balestre's impulse to ban these mighty machines was and still is more than understandable. From 1987 Group A was the top rally category and Lancia continued at the forefront of rallying for several more seasons with its far more docile, yet equally effective, production-based Delta HF Integrale.

The nose had a deep chin spoiler to keep it on the ground at high speeds while a wing was mounted at the edge of the roofline

The 215 from Monte Carlo

The car seen on these pages (apart from the opening shot) is Chassis 215, which first saw action during the 1986 Monte Carlo, where it was entered for Henri Toivonen and navigator Sergio Cresto. They won the rally in convincing fashion despite incurring slight damage. It then served as a back-up car in several rallies for a succession of drivers but was never campaigned again by the works team.

In 1988 it re-appeared in the European Autocross Championship and the following year it was driven to the title in that series by Italian driver Illide Romagna.

With its contemporary racing career over, it was then sold to a Japanese collector and returned to its Monte Carlo-winning livery. It was subsequently acquired by a discerning British enthusiast who has since only driven this beautifully-preserved machine in demonstration runs. When we photographed the car the hugely sophisticated machine started on the button, but sadly poor weather conditions meant we could not take it very far.


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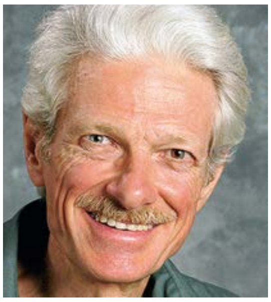


Rear wheel lock-ups while trail braking

There's more than one way to smoke a rear tyre on corner entry

QUESTION

I just read the January issue's *Consultant* on the proportioning valve. My analysis leads to what may be a slightly different conclusion. Let me lay out the logic and see what you think.

In straight-line braking with a correctly set proportioning valve the rear brakes do not lock. When the pedal is released the forward weight transfer stops giving the rear wheels more potential traction. Consequently, even though the rear pressure does not fall until the front drops below the rear, the rear wheels are not at risk of locking.

What happens in trail braking? Here one needs to set another parameter which is that the driver is following a constant radius. Given this caveat the conclusion should be the same. If the inside rear did not lock with the brakes on it should not lock with brake release as the inside rear tyre has not lost traction capacity.

Looking at another possibility: If the driver lifts off the brakes at the very same instant as he turns is it possible the rear brakes release slowly enough that the inside rear locks ever so briefly due to the hysteresis (the front brakes released while the car was going straight but the rears did not release until the car was turning)? Possible, I suppose, but one would need to look at real data to see if the lag time is sufficient to produce this effect.

It most likely the inside rear lock-up often seen on front-drive (and occasionally rear-drive) cars is related either to option 1; that the driver is late releasing the brake pedal, or option 2; that the driver is doing what he wants or needs to do and having the inside rear lock briefly as it unloads is of no consequence.

THE CONSULTANT

Yes, having the inside rear lock momentarily isn't necessarily a problem. I don't think last month's questioner meant to suggest that either. If we imagine a car cornering at a constant radius with the brakes applied, and the brakes gradually being released, I agree that if the inside rear is not locked before brake release then it will not lock during brake release even if at first only the front brake force is diminishing. This will also be true if we hold the car at a fixed lateral acceleration, which implies decreasing the turn radius in proportion to the square of the speed.

However, neither of these is what actually happens in trail braking, or at least neither of them is supposed to be what happens. When trail braking is done correctly, the car is not on a constant radius with the brakes applied, and then held on that radius as the brakes are gradually released, nor is it held at constant lateral acceleration. The objective is to transition from straight-line limit braking (maximum rearward acceleration) to pure cornering (maximum lateral acceleration) in such a manner that the car is kept at the edge of its traction circle/ellipse/perimeter throughout the entire process. This means that the driver has to feed steering in as he releases the brakes, keeping the tyres working to the limit of their capability the whole time. Neither lateral acceleration nor rearward acceleration is constant. Lateral acceleration is coming in as rearward acceleration is going out. The vector sum of the two is close to constant. This isn't easy to do perfectly.

There isn't one correct rate to feed in steering and release the brakes

Trail brake trade off

We can feed the steering in more quickly, and the braking out more quickly, or we can have more braking and less cornering if we wish. If we're keeping the car at the limit, this choice will affect our line. To brake harder, we must accept a larger turning radius. If our turn radius is larger early, it will have to be tighter later in the turn. This implies an earlier apex/tangent point/clipping point, and slower exit speed: an in fast/out slow line.

Conversely, we can have a tighter turn radius early, and a larger turn radius late. This will give higher exit speed. However, that implies less braking during turn-in. That means we have to be at a lower speed when we begin feeding in steering. That in turn means we have to begin our straight-line braking earlier, and accept a longer segment time for the last part of the straight and first part of the turn; an in slow/out fast line.

This in slow/out fast line is generally preferred any time the turn is followed by a straight of significant length. This is sometimes called a 'type one' turn. Even if the turn has straights before and after, here exit speed is worth more than entry speed, because speed we have at the start of a straight carries all the way to our cut-off point near the end.

When the turn has a straight before it but another turn immediately after it, then that's called a type two turn. For that, an in fast/out slow line makes sense, because we can't put better exit speed to use.

Differing approaches

The point here that relates to inside rear lockup is that there isn't just one correct rate to feed the steering in and release the brakes. It depends on the situation, and in some cases there can be rational arguments for different approaches. Theoretically, there's a correct lateral acceleration for any rearward acceleration, but there will be variances in what combination the driver actually uses. Additionally, cars will differ in how much rear lateral load transfer they generate for a given lateral acceleration.

In any case, if the rear tyres are close to the limit of adhesion in straight-line braking and then the driver begins releasing the brakes and feeding in steering, and at least initially rear brake torque does not diminish, what happens will depend on whether the increasing lateral load transfer unloads the inside rear more than the decreasing longitudinal load transfer loads it. And this can go either way.

Brief rear wheel lock-ups, as on the second of these two touring cars, are a natural characteristic of front-wheel-drive racecars

Playing the weighting game

What's the ideal front-rear weight distribution for a rear-wheel-drive racer?

QUESTION

Some friends and I have been debating a question. Ignoring any effects from aerodynamics, polar moment of inertia, or packaging (front-engine, front/mid-engine, mid-engine etc.), what would be the ideal front-to-rear weight distribution for a rear-wheel-drive asphalt racecar?

Some feel it would be the oft-quoted 50/50 per cent, while I suspect it might be closer to 45/55 per cent or so, to better benefit the acceleration and the braking.

Assume tyre widths are free and can be adjusted front to rear as needed. Any input would be greatly appreciated.

THE CONSULTANT

We can definitely agree that weight distribution needs to be roughly appropriate for the tyre size distribution.

If we don't have rules constraining tyre dimensions, then someone else is bound to. Assuming we can get whatever tyre we want, generally packaging constraints set the limits. If that's the case, then generally the rear tyres can be bigger than the fronts, simply because they don't have to steer the car.

If our only concern is to maximise lateral acceleration at constant speed, as on a skid pad, we theoretically want the weight distribution to be proportional to tyre size, and we also want load transfer at each end to be proportional to weight distribution and tyre size. For example, if the car has 40 per cent front, then 40 per cent of the tyre size should be there, and 40 per cent of the total load transfer should occur there.

We then have identical lateral inequality of tyre loading front and rear in percentile terms, so we should be making equally good use of the front and rear tyre pairs.

Track specific

However, in most forms of racing we are not purely concerned with maximising steady-state cornering speed. We also need to maximise forward and rearward acceleration. How important this is compared to steady-state lateral acceleration depends on the track design. If it's a stop-and-go track – significant straights connected by tight, short-duration turns – then it becomes very important to be able to brake well and put the power down well, and less important to have good steady-state cornering. If it's a momentum track – few real straights, the car almost always cornering, modest speed changes – then steady-state cornering takes precedence.

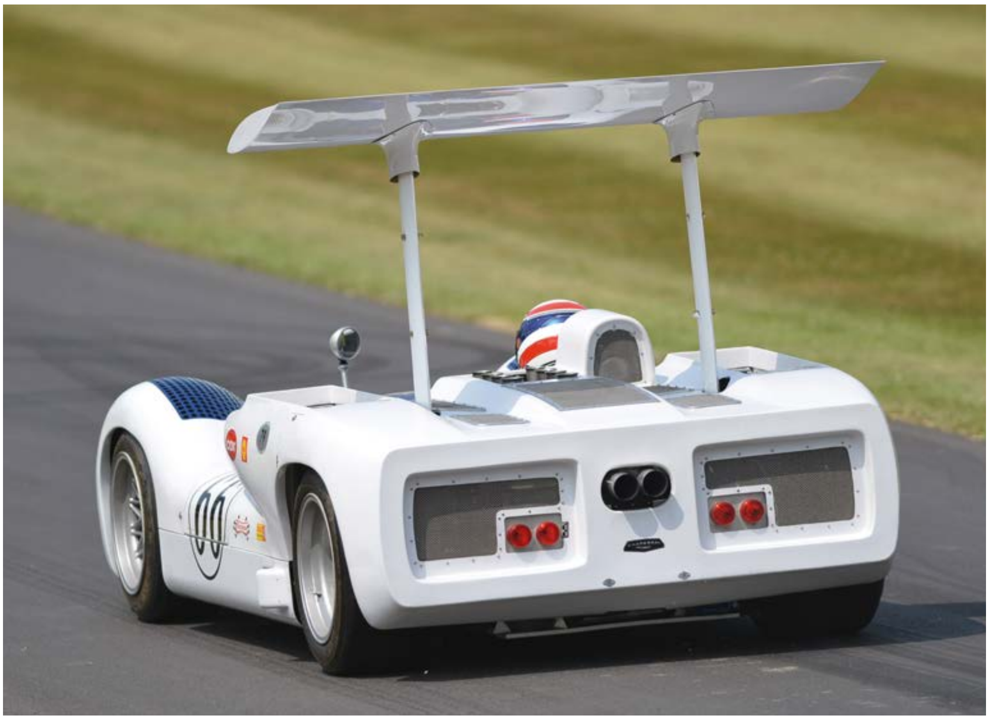
With rear-wheel-drive, we want the car as tail-heavy as possible for best forward acceleration, at least up to the point where the car becomes wheelstand limited. We also want it tail-heavy for best braking. Up to a point, we can compensate by using more front brake, but there are packaging limits to front brake size, and also endurance limits to how much stopping power we can get from front brakes of a given size.

Even for a momentum track there is no penalty to having the car as tail-heavy as tyre size constraints dictate, and having lateral load transfer proportional to weight distribution, as already noted. But to improve longitudinal acceleration capability, there is a strong case for making the car even more tail-heavy, and increasing the percentage of load transfer occurring at the front to get the desired understeer gradient. This will then compromise steady-state cornering in favour of better braking and propulsion.

Even for a momentum type of track there is no penalty in having a rear-wheel-drive racecar as tail-heavy as tyre size constraints dictate

Tail weight constraints

In most cases, there will be various constraints limiting how tail-heavy we can make the car. The Chaparral 2E, for example, had all major components behind the driver, including the radiators. The car reportedly had close to two thirds of its weight on the rear tyres. That could only have been increased by lengthening the wheelbase or by adopting a layout with the engine behind the rear axle. At some point, the penalties in vehicle size, transient handling characteristics, or something else will set a practical limit to how tail-heavy it can be.



The Chaparral 2E had close to two thirds of its weight on the rear tyres, with all the main components behind the driver

CONTACT

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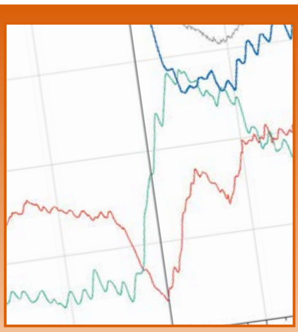


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

Customising codes for data systems

How using Simulink to auto-generate code for specific devices can be a powerful weapon in the arsenal of a racecar data engineer

Most data and control systems come pre-loaded with embedded software that allows them to perform the tasks needed for the racing environment. In the majority of installations, the base algorithms allow teams and manufacturers to achieve the performance they want when they want. There are, however, sometimes software constraints that don't quite match up with specific needs or hardware. When these instances come up, the traditional solution was to task the manufacturer of the control or logging hardware to make a change to the embedded code. This would often mean long lead times and, of course, there would be an additional cost involved.

Allowing a customer access to generate embedded code can be quite tricky as it involves allowing access to software development at a very high level, and there is also the complicated issue of intellectual property within said software.

But it is a well-known practice to generate embedded code for hardware devices using model based design tools such as Mathworks' Simulink, and this solution has been around in racing for some time. By creating a software tool-chain that allows embedded code to be generated by the customer, it is possible to allow much more specific and tailored functions to run on hardware already available

Allowing custom code to exist on control systems can lead to some interesting problems. For example, if the code has full access to the core input output function of a device it is possible to execute a set of commands that can be dangerous. For this reason, some auto-code enabled platforms implement the custom code at a specific level of hardware functionality so that all normal safety precautions are already taken care of. This means the custom code sits at the same level of any other applets that are already on the device, such as switches, CAN functions, and other basic functions, as is shown in **Figure 1**.

When custom code is being used on hardware, there are two stages where an interaction takes place. The model is first generated in Simulink, and then the model is compiled with code that runs on the hardware. An example of this software development process is shown in **Figure 2**. In many cases it will not be the same people interacting with the two steps, so it's important to allow the Simulink based code to interact

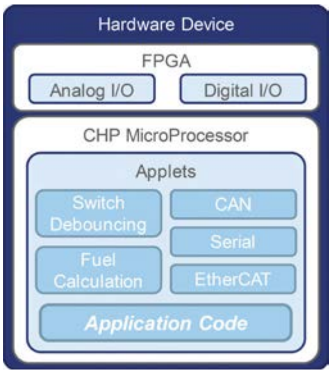


Figure 1: Embedded code structure; the custom code sits at this level

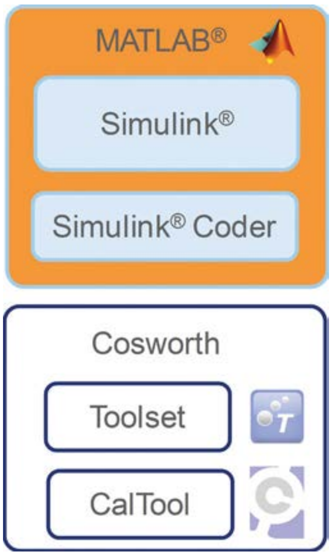


Figure 2: This shows fluid interaction between the Matlab environment and the Cosworth configuration tools

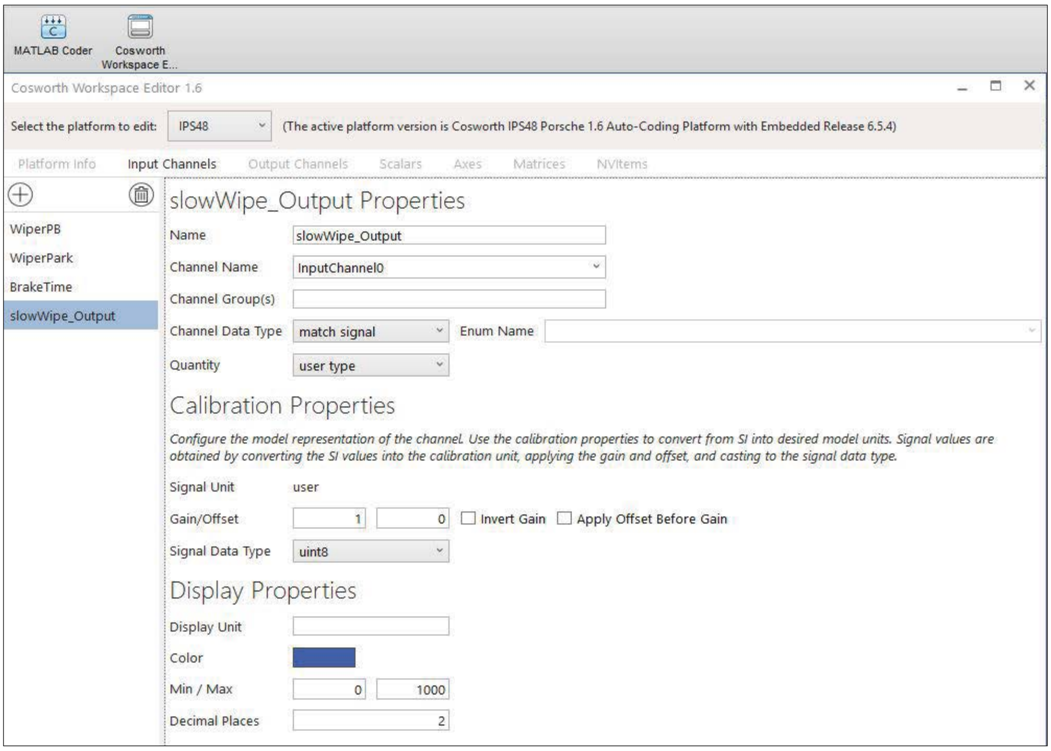
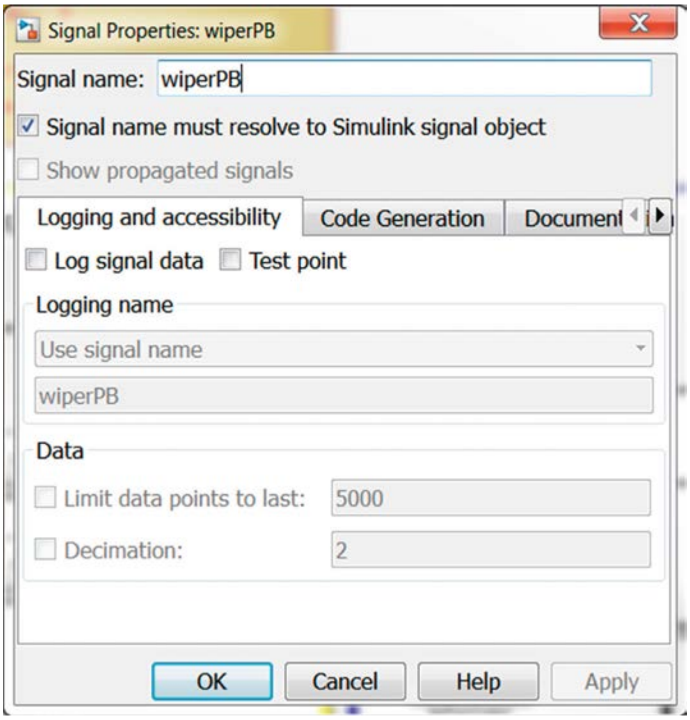


Figure 3: Here's an example of the workspace for configuring the channel properties within the Matlab environment

It is possible to execute a set of commands that can be dangerous

This creates a stable and well-known platform to run the car from



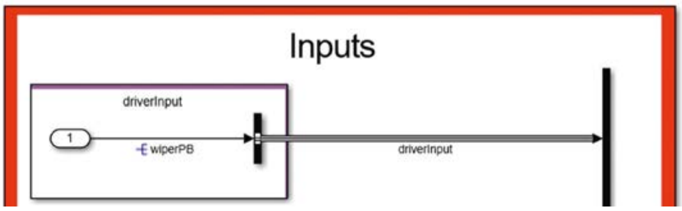


Figure 4: Simulink model example showing the input channel allocation

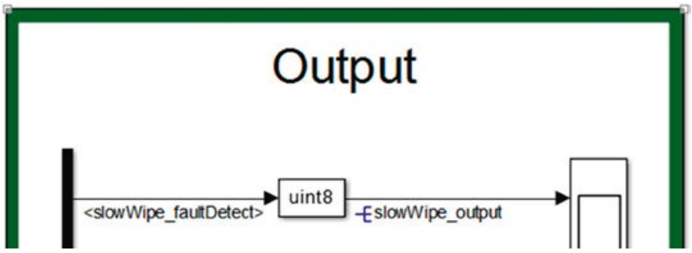


Figure 5: This nicely illustrates the output section of the Simulink model

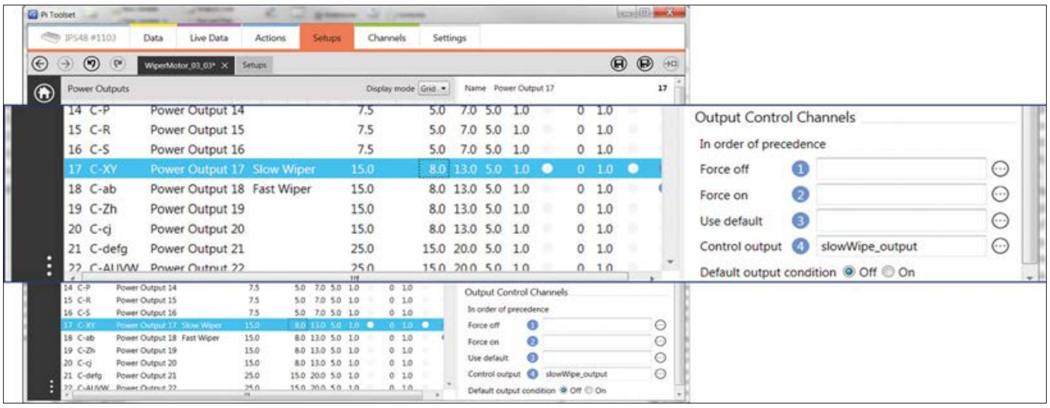


Figure 6: An example of the Simulink channel assigned as the output control

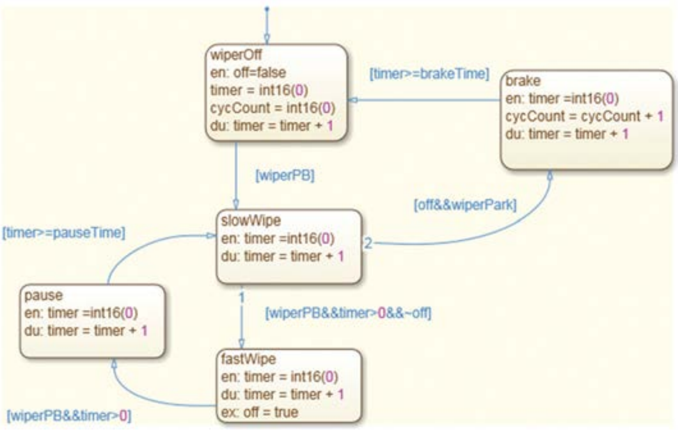


Figure 7: Stateflow diagram for wiper controls shows intuitive representation

with the standard configuration software. This creates a stable and well-known platform to run the racecar from, with added flexibility of custom generated code.

In order to facilitate the generation of embedded code from a Simulink mode, a workspace is needed within the Simulink environment, such as that shown in **Figure 3**. This workspace allows the user to configure channel properties in the exact same way as they would in the configuration tool, providing continuity in the whole tool-chain.

Looking inside the Simulink model, the input and output names are then easy to use and require no further definition. The input names could be maths channels, CAN channels or direct inputs. The choice of which to use all depends on how the end user needs to interact with the model. The model could therefore be made completely self-sufficient with no interaction needed if all the input channels are generated by the hardware. **Figure 4** shows an example of model adaptation to utilise defined input channels.

When using auto-generated embedded code the end user will need to know what channels the model outputs in order to use them. It then becomes very easy, such as in **Figure 5** for example, to assign this channel to control an output function. This would be exactly the same as if a maths channel was used.

Once the model is complete and a code file is generated, a given channel can be allocated within the hardware manufacturer's bespoke software. In this manner, interfacing with user-written code is consistent with the pre-loaded code package. **Figure 6** provides an example of the final step for output channel selection, where the user output channel is selected for control of hardware features.

Code read

Using Simulink to generate embedded code for devices also means it can be easier to present a visualisation of how a particular state machine functions.

Further, it is possible to reuse models, blocks or Stateflow machines that are known to work well. Because Simulink is a visual programming language, complex control algorithms, such as a wiper state flow shown in **Figure 7**, are represented in an intuitive manner.

Using the custom workspace in Simulink also means that the same model can be used on different target devices, which speeds up deployment and means the same model or strategy could be use on multiple different racecars independent of hardware specifications.

Using Simulink to auto generate code for specific devices is an exceptionally powerful tool in the arsenal of any race team or manufacturer. The flexibility and simplicity it offers makes it the preferred method for custom embedded code development.

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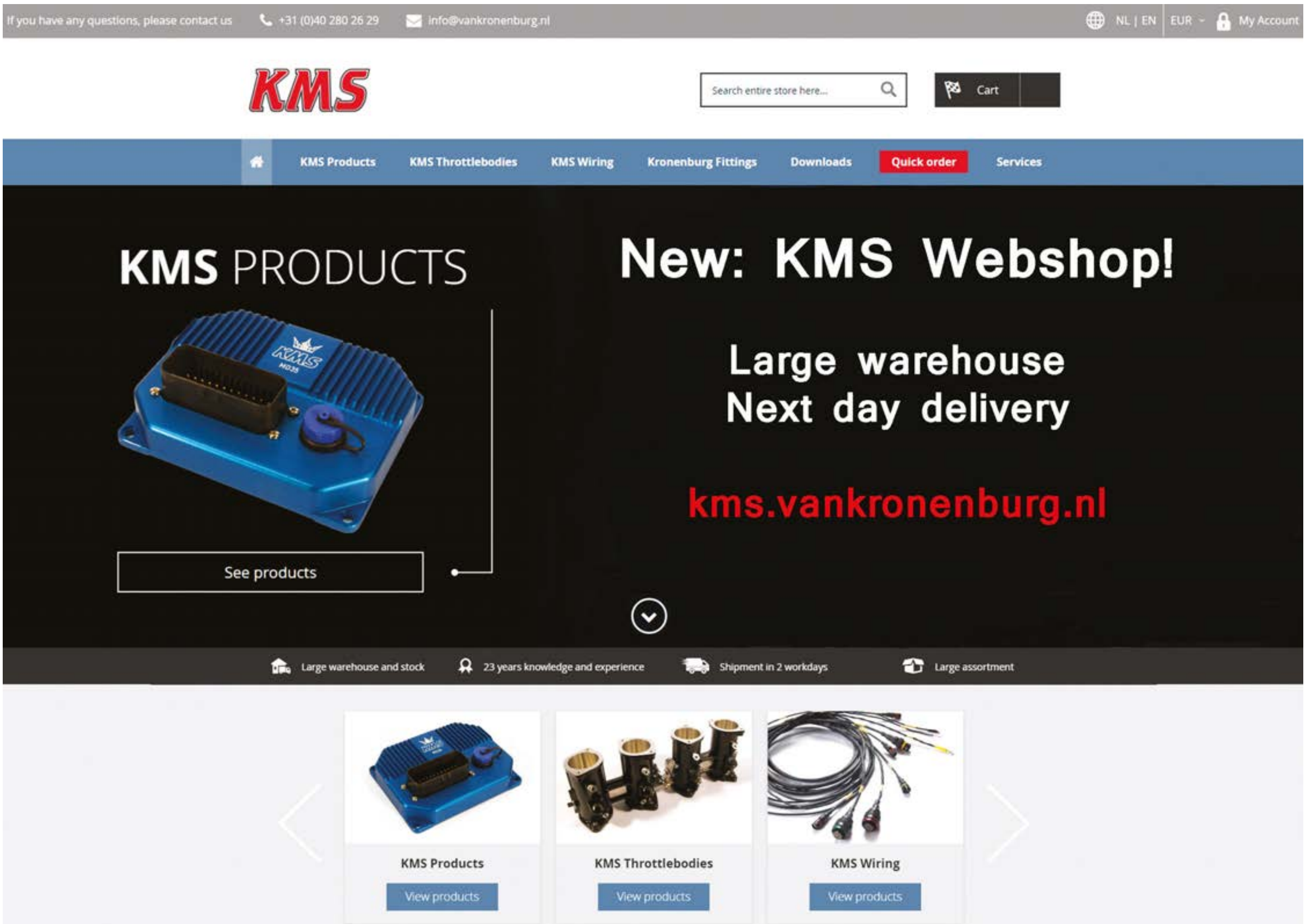
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Reducing the drag on a Formula Ford

Our quest to shave speed-sapping drag from a Swift SC92F continues

The Swift SC92F that continues under the MIRA full-scale wind tunnel spotlight this month hails from the formula's 25th year, exactly halfway through its existence. And if one thought that the designers would have whittled drag down to an absolute minimum during that first 25 years, well, our findings from this session indicated otherwise. In our December issue we used flow visualisation methods to examine where there were potential sources of further drag reduction and in January's issue we saw how four per cent was shaved off the drag by reducing the radiator inlet and outlet apertures. This month the quest for further drag reductions continues.

Table 1 shows the baseline aerodynamic data at the start of the session, and also after the runs reported last month. Coefficients multiplied by frontal area are used; these values are directly proportional to the measured aerodynamic forces (at any speed) and also eliminate any errors in the 'bare' coefficients arising from the estimation of frontal area. With a raft of additional changes made following last month's cooling duct modifications we'll tabulate all the remaining results and highlight those that yielded most benefit. **Table 2** shows the changes to the coefficients from subsequent modifications as 'Δ' or 'delta' values, expressed in counts (1 count = a coefficient change of 0.001).

The baseline data shows that the Swift, the author's hillclimb mount, had moderate drag and also generated lift, which was concentrated at the front. Following reductions in cooling duct inlet and exit areas the drag was reduced by around four per cent and, although it was not being targeted, lift was reduced by nearly 10 per cent.

Configurations 9 to 12 in **Table 2** were essentially one experiment to

Table 1: The baseline data on the Swift SC92F

	CD.A	CL.A	CLf.A	CLr.A
Baseline	0.495	0.175	0.140	0.035
After cooling duct mods	0.475	0.158	0.131	0.028

Table 2: The remaining configuration changes, results shown as Δ values in counts

Config.	Description	CD	CL	CLf	CLr
9	Tape gills on engine cover	+1	-1	-1	0
10	Tape over two thirds of engine inlet	-1	-2	-2	+1
11	Fully tape over engine inlet	+1	-1	-1	0
12	Tape fairing over engine inlet	-6	-1	-2	+1
13	Tape over NACA ducts in engine cover	+2	+1	+1	-1
14	Tape body gaps around exhaust headers	0	+3	+2	+1
15	Fit fairings behind roll hoop	-14	+2	-2	+4
16	Tape nose and other gaps	-1	-1	+1	-2
17	Fit exhaust fairing	+1	-2	-2	0
18	Fit front upper suspension mount fairings	-3	+1	+2	-1
19	Blend rear pushrod fairings to trailing edge of engine cover	+2	+2	+1	+1
20	Fit mirror vortex generators	-1	-2	-1	-1
21	Remove mirrors (illegal)	-16	+7	+6	+2
22	Raise rear ride height 5mm	+5	-3	-5	+2
23	Fit engine cover vortex generators	+2	0	+1	-1
24	Remove tyre trip strips	-3	+63	+30	+32

The writer's Swift SC92F Formula Ford 1600 undergoing its drag study in the MIRA tunnel

The object of one of our experiments was to find out if the engine inlet duct created drag

Taping directly over the Swift's inlet duct actually made no difference to the drag

A fairing placed over the engine inlet made a useful difference, but would be impractical


These roll hoop fairings were one of the most beneficial modifications of the session

A fairing positioned ahead of the exhaust actually seemed to cause a small drag increase


Shaped foam suspension mount fairings provided some help in reducing the drag

determine the engine inlet duct's drag. Partially and totally taping it over made little difference, suggesting the drag from air entering the duct was the same as the drag from bluffly taping over it. But fixing a shaped fairing over the duct effectively simulated removing the duct altogether, and produced six counts (one per cent) of drag reduction, indicative of the overall drag from the scoop (clearly then the engine must be allowed to inhale from elsewhere, hopefully with less drag accruing).

Configuration 13, taping over the NACA ducts on each side of the engine cover, caused a small but surprising drag increase, while equally surprising was the lack of drag reduction from partially taping over the large hole around the exhaust headers (config 14). However, having shown the roll hoop as disruptive to flow using the smoke plume, configuration 15's roll hoop fairings gave a satisfying 2.4 per cent drag reduction. These met the 90cm maximum height rule, and their tapered shape clearly tidied up some of the hoop's wake. Taping over panel gaps around the nose and engine cover (config 16) may have yielded a tiny drag benefit, while a fairing ahead of the exhaust (config 17) probably caused a small drag increase.

Suspension mounting fairings worked on the Spectrum FF tested in 2007 and, as configuration 18 shows, shaped foam pieces based on the NACA 0024 symmetrical aerofoil profile worked here, too, yielding another 0.5 per cent drag reduction.

Wool tufts on the engine cover aft of the pushrod rocker fairings had shown flow separation, so blending these fairings to the engine cover's trailing edge was expected to yield a small drag improvement. Instead, as configuration 19's results show, a small drag increase occurred, even though the wool tufts showed the flow was tidier.

The smoke plume also revealed the mirrors' wakes in December's issue. Could the size of that wake, and hence the mirrors' drag, be


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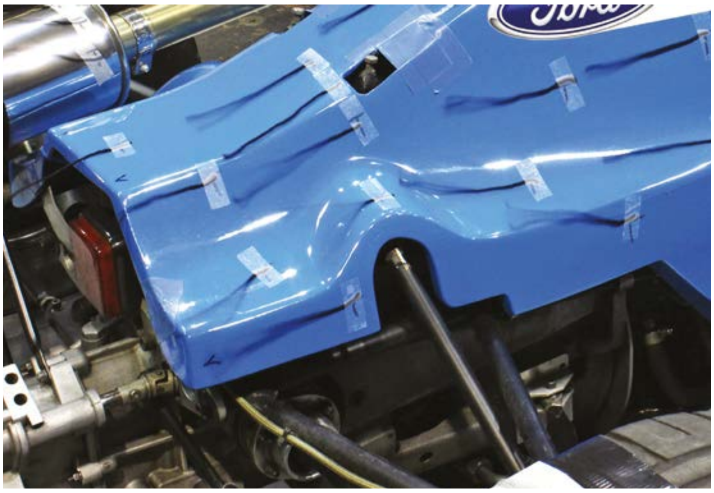
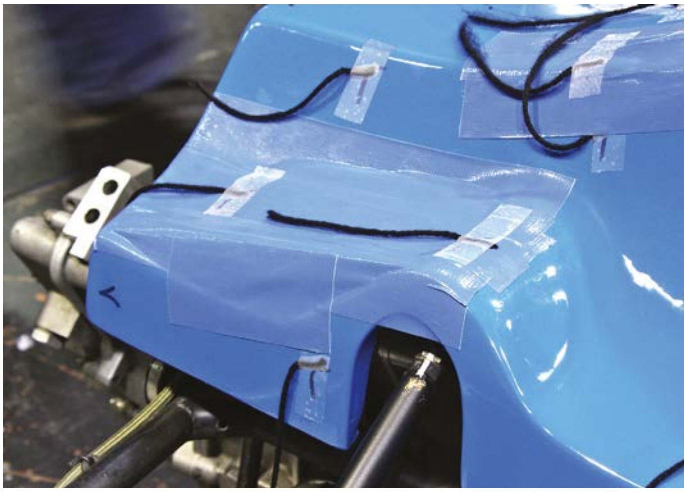


The flow was seen to be separating at the top of the pushrod rocker fairings when wool tufts were taped to the Swift to check the airflow over this crucial area of the racecar's bodywork



It was hoped that blending the pushrod rocker fairings to the engine cover's trailing edge would reduce drag but a small increase occurred, despite those tidy-looking wool tufts

Vortex generators on the engine cover and lower flanks were aimed at reducing the car's wake but actually added some drag

Small vortex generators were fitted on the car's mirrors with the object of reducing the size of their wake

reduced? Small vortex generators were applied to the upper and lower trailing edges of each mirror in an attempt to induce downwash and upwash to thin the mirror wakes.

Configuration 20's result shows there may have been a very small drag reduction here. However, configuration 21, in which the mirrors were completely removed from the racecar, provided the biggest single drag reduction of the entire session, with some 2.7 per cent. But this is one modification that the rules do not permit, even if this particular car competes in hillclimbing!

Increasing chassis rake on the Spectrum FF produced a modest but useful drag reduction, so the Swift's rear ride height was raised by 5mm (configuration 22). Curiously drag increased by 0.9 per cent, so this was another avenue that was closed to further exploration.

Note that lift was slightly reduced by the chassis rake increase, as is normally seen with this particular adjustment.

Finally, another idea – like the mirror vortex generators was borrowed from Koike, M., Nagayoshi, T., and Hamamoto, N. in *Research on aerodynamic drag reduction by vortex generators* – was to place 10mm x 20mm vortex generators (VGs) around the engine cover and lower sides of the car.

This was an attempt to induce downwash and inwash at the rear of the car to reduce the size of the wake, which is essentially what those Japanese researchers did to reduce the drag of a Mitsubishi Evo (though only very slightly, by six counts).

Clearly the results of configuration 23 show that the idea, as it is implemented here, did not work and succeeded only in adding two counts of drag. Perhaps taking a ball end mill bit and dimpling the entire body surface like a golf ball would yield more benefit? But then, what size dimples would you have to use to make this work?

The cumulative effect of all the beneficial modifications made in this session amounted to a drag reduction of 7.7 per cent, which is actually equivalent to 3.2bhp at 100mph. And who wouldn't want another 3bhp plus from their nominally 105bhp Formula Ford 1600 Kent engine?

There was one other thing we wanted to try but run out of time, and that was a reduction in the frontal area of the Swift by narrowing the sidepods. Next month we will start a new aerodynamic project.

CONTACT

Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk.
In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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Black art

The first group test of the LMP2 cars at Sebring gave *Racecar* the chance to gain a rare insight into the world of tyre testing

By ANDREW COTTON

Talk to any racing engineer and they will tell you that tyre development is a 'black art'. Ultimately, racecars are set up to manage the one part of the car that is in contact with the road, which is effectively a living organism that degrades with wear. Tyre management and development is critical to not only improving the performance, but also the life of the tyre.

The FIA World Endurance Championship has mandated a reduction in the number of tyres that can be used over a race weekend, both in LMP1 and in GTE (see sidebar), forcing teams to double stint their tyres more regularly. With testing limited, this means that pre-season the work has to be methodical and accurate, with clear trends visible to enable improvement through the season where permitted. Dunlop invited *Racecar Engineering* to its first test with the 2017 LMP2 cars, which was its first sight of the new machinery for 2017.

Present at the P2 test were ORECA, Dallara and Ligier. The IMSA test at Daytona a few short hours away was compulsory for the Daytona Prototype International cars, and with a late delivery time this was the only place that the Riley Multimatic could run. Dunlop's partner team, Aston Martin, was also on hand at Sebring to prepare for the new GTE regulations that will demand more double stinting and fewer new tyres for the 2017 season.

The Sebring Raceway in central Florida provides an ideal basis for the test. It is cheaper to rent than many circuits in Europe, the weather is pretty much guaranteed to be good and consistent from morning until sunset,

ORECA brought its brand new LMP2 car to the test and ran its own programme alongside that of Dunlop in preparation for the new season

It is possible to gather a lot of different information very quickly at Sebring, and to test for a wide variety of tracks

Rebellion brought new tyre blankets to Sebring to replace the ovens that are more traditional in endurance racing. It wanted to use the test to establish the warm up times for the new season

and the circuit offers a variety of surfaces on which data can be collected. Even with shipping and flights, the cost of the Sebring test is comparable to a European venue, which, in December, might not provide the stable weather so sought after for testing purposes.

Success story

Dunlop had a successful season in 2016. In the World Endurance Championship its first season as technical partner to Aston Martin yielded titles for both drivers and team, while in the European Le Mans Series the top seven teams ran Dunlop rubber. The company also contested the VLN series, which has open tyre regulations for GT3 cars, and has single-tyre supply deals with categories such as the British Touring Car Championship. Now it is looking to prove that the success in the 2016 WEC was no accident, and that it has a clear direction forwards to improve its product still further. To this end, and with the help of American company OptimumG, Dunlop is now far more involved in the technical set up of the car, as well as using its own tyre modelling software to improve both structure and compound.

The new season will see a dramatic change with the LMP2 cars and so a new baseline for the tyre manufacturers to work with. Four chassis manufacturers were selected by the FIA to provide cars for the 2017 season. These new cars have different characteristics to the 2016 cars, including an anticipated higher top speed

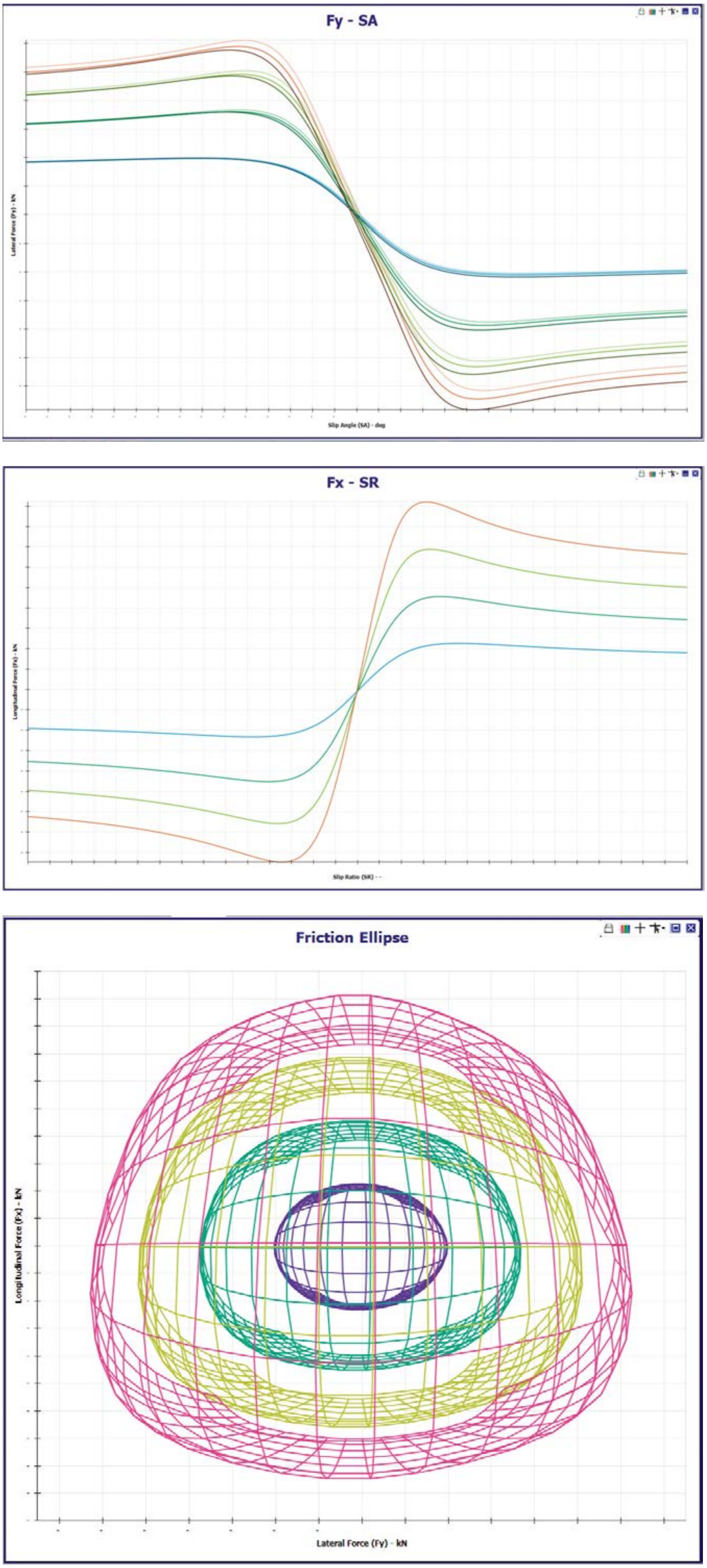
New Dallara spent the first day completing set-up work, with Jan Lammers at the wheel, before the tyre testing programme began the next day. It is one of four manufacturers allowed to build cars for new LMP2

Pipo Derani was on hand to test the new Ligier LMP2. Lap times were not distributed amongst the teams to prevent any direct comparisons between them as this was really about testing the rubber rather than the cars

Dunlop uses HH Timing at tracks to help it and its teams with strategy, and also for post-race tyre analysis

at Le Mans, and more downforce. But the drive to prevent tyre development continues.

Three models of tyre are permitted for the season, with two declared by the 'prologue' pre-season test, held on April 1/2 at Monza, just two weeks ahead of the opening round at Silverstone. A third may be declared later in the season. By agreement, Dunlop and Michelin are permitted to ask for each other's tyre post race and check that it is, in fact, one of the three models nominated. In the GTE category, however, there is a proposed limit of two or



Slip angle, slip ratio and friction ellipse graph from OptimumTire from OptimumG. This software package allows Dunlop's engineers to perform very advanced tyre data analysis, visualisation, and model fitting

three models (this has yet to be confirmed), plus one 'joker' specification.

For Dunlop, the work started early, with modelling of the new cars and a prediction for what tyre characteristics would be necessary for the season. While Dunlop does not supply tyres to cars that race at Sebring (the Daytona Prototype International cars run on Continental tyres), the Florida circuit was selected for a week in the run-up to Christmas due to its constant temperature range and the fact it has the most abrasive tarmac alongside very smooth concrete, so it's possible to gather a lot of different information very quickly, and to test for a wide variety of tracks.

Test aims

'This week we are looking at 2017, and a change of regulation in LMP2 and we are looking at two different things,' says Sebastien Montet, R&D Director at Dunlop Motorsport. 'In LMP2, we are focussing more on the car side, and on understanding how the three different chassis will impact the tyre performance, because they all run the same tyres [as each other], while in GT the car is the same but we have to change the tyre to fit the regulations. We will look at things differently.

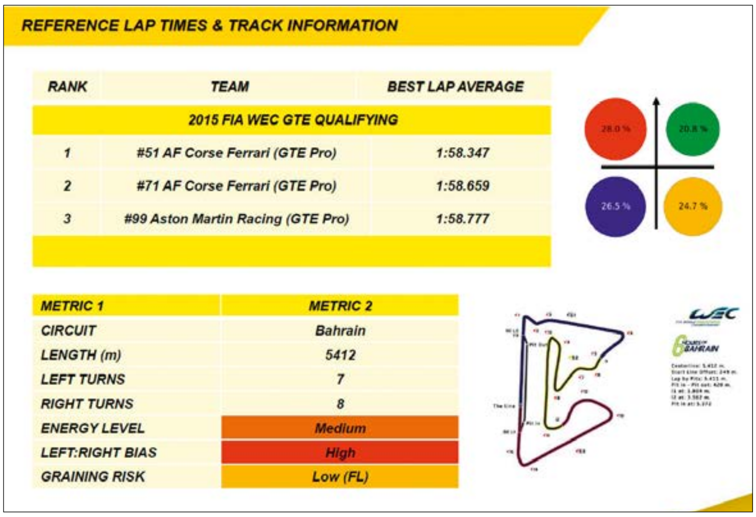
'From a track point of view we have looked at a track characterisation system, which for every car that we work with, we calculate the level of energy, which is generated by the track and its configuration,' Montet adds.

In preparation for the tests, Dunlop also operates seven-post rig testing as part of the evaluation tests. This helps to make sure that what the company sees on the F&M (force and moment) testing can also match to the cars' damper spring set-up that has been seen in simulation. The Multimatic rig has played a major part in Dunlop's development process over the past eight years.

OptimumG

Since Dunlop first started to work with BMW in the American Le Mans Series in 2009, it partnered with data specialists OptimumG in order to develop its software and deliver a more consistent approach to its tyre development. Multiple titles were won and representatives of OptimumG are now embedded not only within Dunlop, but also within the teams themselves on Dunlop's behalf, to help set the cars up so as to make the tyres work.

'We use software to look at all parameters, including tyre dynamics, camber and things like kinematics,' says Kevin Marion, Vehicle Dynamics Engineer at OptimumG, who works with Aston Martin. 'We look at it all in simulation so we can look at tyre fitting, kinematic study, lap time simulations and look at every parameter of the car, such as power, downforce and so on, and then the track attitude, dynamic camber, kinematics, geometries … The full package to how we can set the car to the tyres.



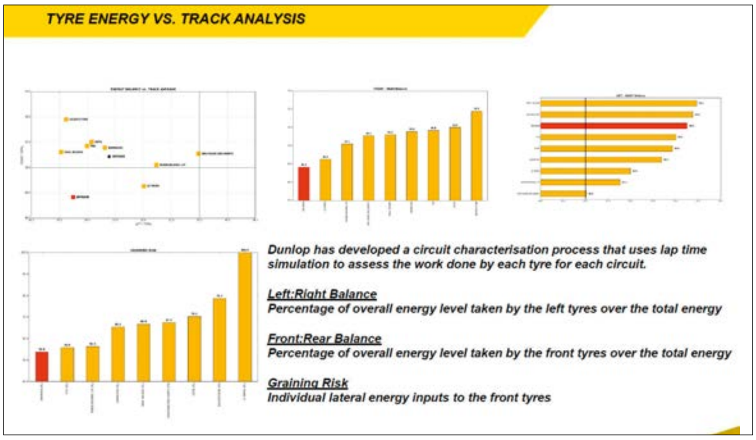
REFERENCE LAP TIMES & TRACK INFORMATION

RANK	TEAM	BEST LAP AVERAGE
	2015 FIA WEC GTE QUALIFYING	
1	#51 AF Corse Ferrari (GTE Pro)	1:58.347
2	#71 AF Corse Ferrari (GTE Pro)	1:58.659
3	#99 Aston Martin Racing (GTE Pro)	1:58.777

METRIC 1	METRIC 2
CIRCUIT	Bahrain
LENGTH (m)	5412
LEFT TURNS	7
RIGHT TURNS	8
ENERGY LEVEL	Medium
LEFT:RIGHT BIAS	High
GRAINING RISK	Low (FL)

Dunlop pre-event report give all the info teams will need. This page shows previous year's lap times, the circuit averages and the way the energy is distributed to each corner of the racecar

Sebring's challenging Turn 1 is bumpy, slippery and fast, and is a true test for both the tyre and the racecar set-up. Every one of the new LMP2s adopted this inside-front lifting attitude around this particular corner on the first day of the test



TYRE ENERGY VS. TRACK ANALYSIS

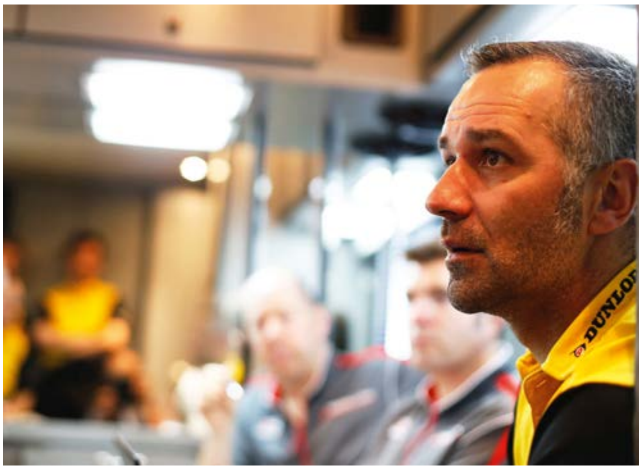
Dunlop has developed a circuit characterisation process that uses lap time simulation to assess the work done by each tyre for each circuit.

Left:Right Balance
Percentage of overall energy level taken by the left tyres over the total energy

Front:Rear Balance
Percentage of overall energy level taken by the front tyres over the total energy

Graining Risk
Individual lateral energy inputs to the front tyres

This page of the pre-event report show the overview of the WEC tracks for the season and where they rank in overall circuit energy, plus the graining risk compared to the other tracks



Dunlop Motorsport's R&D director Sebastien Montet in the pre-test briefing with Rebellion. The former P1 team ran the brand new ORECA during the five-day test

We can do our process and understand before the test what is going on.'

Pre-test, the tyres are tested on a flat track machine that can monitor the tyre before it is taken to a track. 'We use a flat track machine as opposed to a drum, and the tyre is fitted to the machine and we change the speed, pressures, everything live,' says Marion. 'It is a six-axis machine that measures the moments of the tyre. We fit a model to the data, which is a steady state model for the moment and we can overlay and compare grip, load sensitivity, camber sensitivity, and pressure sensitivity, every parameter of the tyre and what is its influence. There are a few key parameters such as corner exit, peak grip, and we have a good understanding of what they will do in vehicle performance and balance, and then we put it into a matrix, and define our solutions including balance, stability, response from the steering and so on, and we use a tyre model to do this.

Mathematical model

'The next step is to fit a mathematical model,' Marion adds. 'After every short run, the driver will have a rating sheet of warm up, what the front likes, what the rear likes, high-speed stability, degradation from the start to the finish and so on. This is then fed into the computer and if it matches, then we are confident that the testing went as we expected.'

New challenge

With completely new machinery in LMP2, the process was a little more complicated than in GTE. While the track could be mapped, the racecars were pretty much unknown, although Dunlop had worked with the British Rebellion team and the German ByKolles team in LMP1 in 2016, and so had an understanding of the downforce levels for this year.

How each car used the tyre, however, could be completely different. Therefore, Dunlop started with a development of its successful LMP2 tyre from 2016 as a baseline and worked from there. As part of the preparation for the new season, Dunlop tested at Sebring in July, 2016, with a Ligier tuned up to 600bhp to give the company the best chance of choosing the right direction for the new tyres.

'Every product is different and will be treated differently,' says Montet. 'With all the success through the years, the first thing that we did is to work from the existing P2 tyre. We tried to already learn from where we were in 2016 to improve on specific areas already for 2017 with a new optimised rear tyre and with a new size front to match the regulation and the same kind of construction compound, and then some iteration to create a preliminary spec, which we then released to the teams to use during the development of their cars.

Learning curve

'It is all about finding stability in the development,' Montet adds. 'You are going to have something which is 90 per cent of what we will have in 2017, but for the test [at Sebring], we need to explore several things. We need to understand the level of aero of those cars, what impact that has on compound, on construction, lateral and vertical loads, which change the behaviour of the tyre.

'Then, we also needed to understand the tyre warm up process, the double stint where you have to run the stiffer side of the compound, which by definition means that the tyres will be harder to warm up,' Montet

'There are a few key parameters such as corner exit and peak grip'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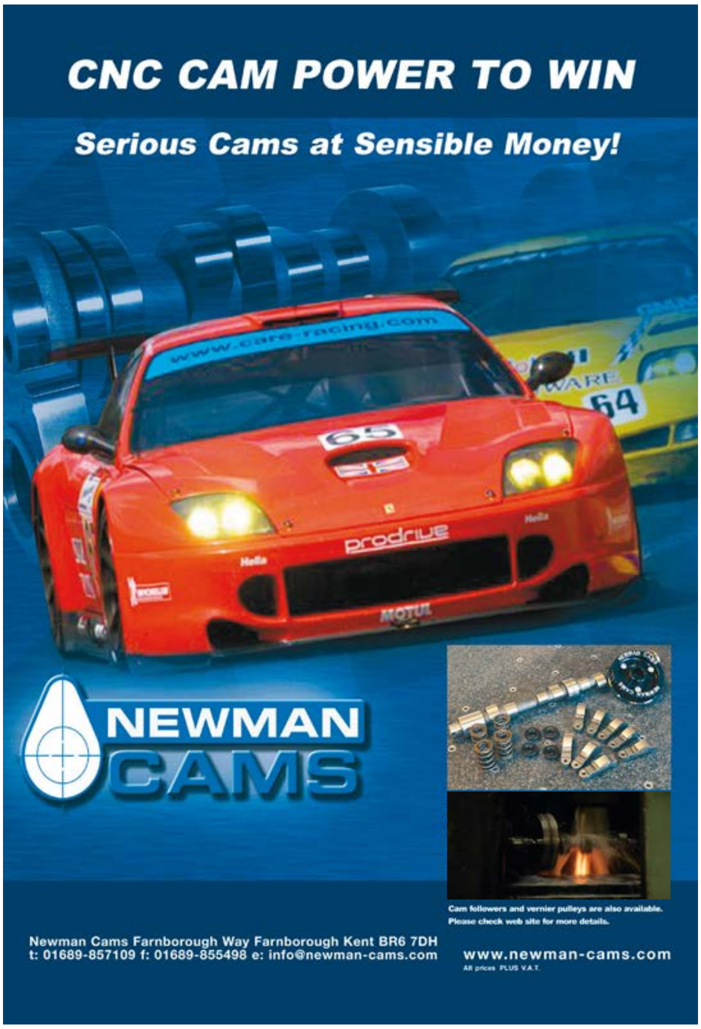
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While the track could be mapped, the cars were pretty much unknown

says. 'We are really trying to get this triangle of consistency, warm up, and the aerodynamic impact on the tyre construction.

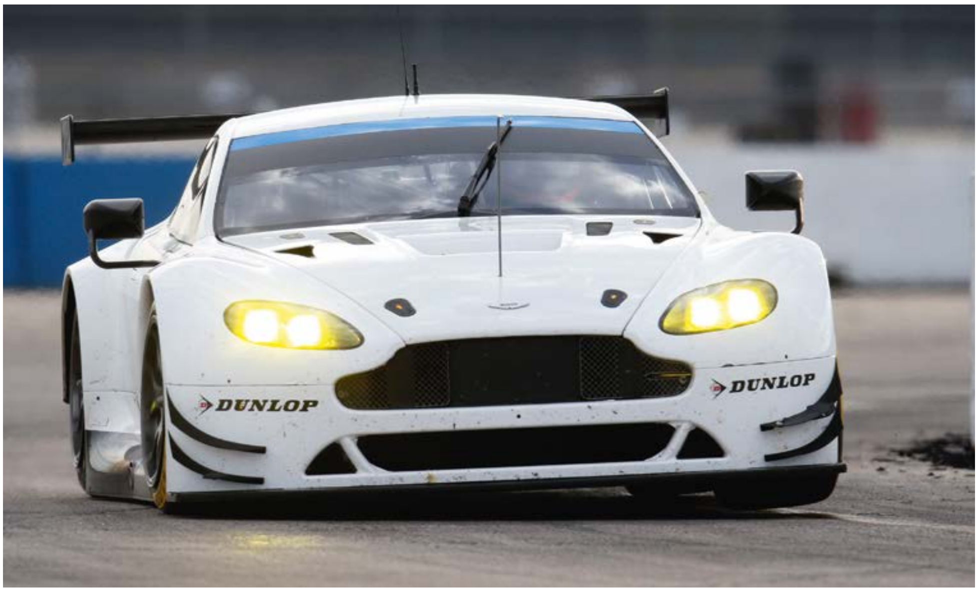
'For LMP2, we try to look at everything because we knew that the baseline from the old P2 was pretty good. We had something that was good, and so we fine-tune around it. If you come here with brand new concepts, we would not want to race them next year. If the regulation would allow we would run the tyres at the end of the year, but in LMP2 with the new regulation it was not possible for 2017.'

The link up with OptimumG not only helps before a test and running live data during the races, but it also speeds up the post race analysis. 'We generate a data pack that we will give to Aston Martin. We run the simulation on our side, and we know where the set up will go for every type of tyre,' says Montet.

'Before, you would throw the tyres on from spec one to ten, put it into the car, run it for seven laps; the driver will give his comment, the lap time will speak for itself, and we will miss out on some good specs,' Montet adds.

'For some specs the potential was there, but not exploited on the day with the car set-up whereas running the simulations, we know that spec A on the set-up as it is, is okay, but for spec B, you may need to change the ride-height, camber, or other variables. We try to do that to optimise the solution for the tyre, based on the simulation, [this way] we save the time, and we have more options.

'For the drivers it is important because they can feel the difference in the tyres, and the progress, and you discover the car as much as



PHOTOGRAPHY: CLEMENT MARIN/DUNLOP MOTORSPORT

It was not all LMP2 at Sebring, Aston Martin was also there with drivers Nicki Thiim and Jonny Adam. The regulations for GTE will change for 2017 to reduce the number of specifications of tyre and also the number of tyres allowed per event

Kevin Marion is the Vehicle Dynamics engineer at OptimumG and works with Aston Martin Racing

The programme

Set up day on Sunday saw the Dunlop team unload 1000 tyres in preparation for the test, mark them up and prepare the schedule for each of the cars.

Using a bar-coding system, the engineers know which tyre compound and construction they are dealing with for each set, and purposefully keep that private from the teams. The tyres are then put into sets, but great care is taken to ensure that each model of car goes out on different tyres, to prevent teams locking horns in terms of outright pace. T1, therefore, will be the first compound and construction used for each of the manufacturers, but they will be different for each car, and even the teams will not be told which is which.

After unloading and checking, each tyre is hand cut to the canvas. While in the tyre mould, cuts (TWIs, tread wear indicators) are deliberately made into the tyre as a wear gauge, the hand cutting ensures that the hole goes to the canvas to ensure wear can be accurately measured. This is done with the development tyres only, so as to ensure that all the necessary data is gathered before the spec is released for production.

It's not a race

Meetings are held with the teams to ensure that they know not to try to compete with another car. Although teams can time each other around the lap, and Dunlop can map each car through its GPS system, the idea is not to compete, particularly with such new cars. In order to create as stable a platform as possible, the cars are given two sets of tyres to set up a good balance before the test programme begins, and are run on full tanks.

They then are given a test programme, that includes short runs of seven laps on each of the tyre sets, and in addition to the data gathered from the systems within the car, the drivers are given a data sheet and asked to mark out of 10 parameters such as balance, front end and rear end grip and peak grip.

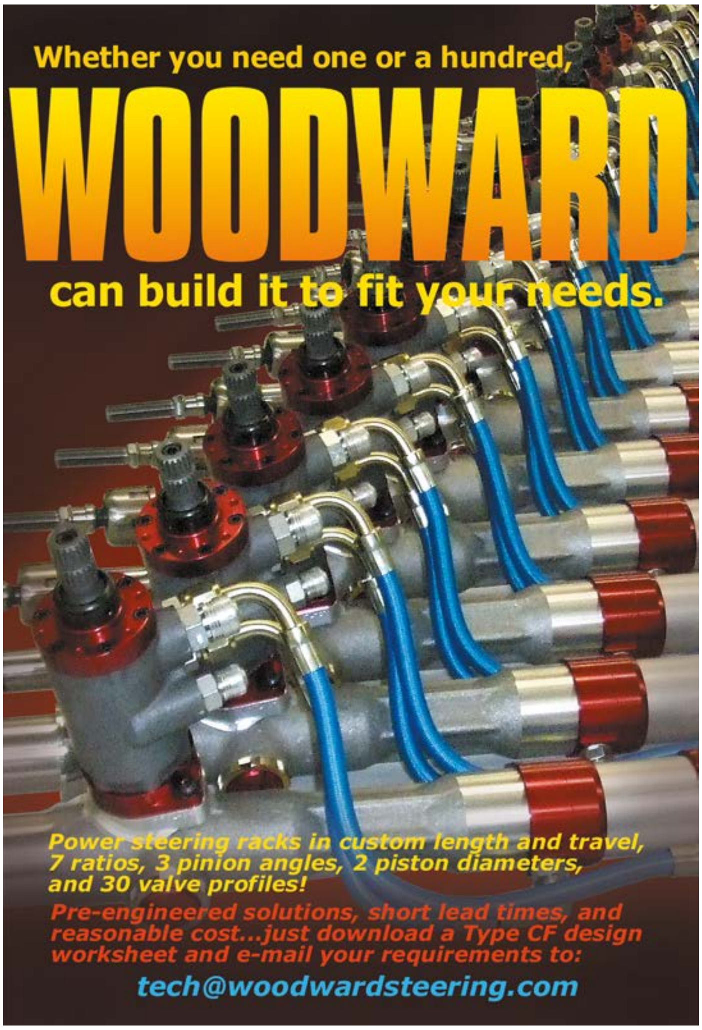
'The cars complete short runs on Monday and Tuesday, and then on Wednesday we sit in front of the computers looking at all the data, and try to understand how to build up on Thursday and Friday when we do the long runs,' says Montet.

Thanks to the simulation packages produced in advance of the test, car set-up is also considered between the runs, including ride-height changes that may be necessary to make the tyres work. 'We may need to change the car set-up to be able to physically run it,' says Montet. 'The idea is to look at the data on all three chassis, and rebuild our test programme.

We have a programme for the short runs, but not for the long ones. We have the different options of tyres. It could be that all the three chassis will be on spec one, two, three, four, because they are clearly the best, but it could be that one chassis prefers one spec and another a different one. We need to be sure that when we leave on Friday night, we have a solution that works on all three chassis.'

Once these have been established, the team will then retire to base and begin the build process ahead of another test in Aragon, Spain, early in the new year. There, customers will be invited to try out the 2017 range of tyres for themselves before the racing starts in earnest.

Any dramatic changes that are required can still be made, but the idea is to finish the winter test with a clear picture of what will be required throughout the 2017 season.



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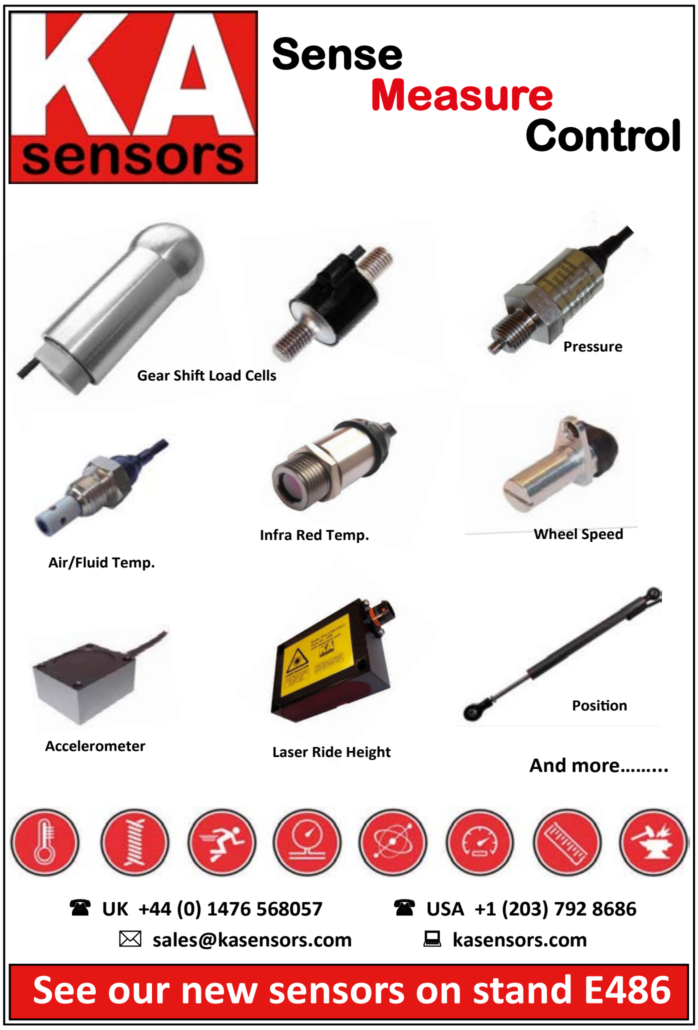

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Drivers fill out a form that rates 10 parameters of tyre performance including the balance and the front and rear end grip and peak grip. Here Nicolas Lapierre completes his comments after his run on the fourth set

the tyre when you do that so it is key to do it, and you understand whether or not the tyre has the potential. If there was one negative comment, you don't discard it. This small extra work that you do preparing the event is work that you don't have to do afterwards. You don't have to question the data. With all the megabytes of data, if you have to go through it in detail, it will take two or three weeks and time is always against us. At least we know that we can read the data with confidence because we have done most of the work with it. The post processing is made better, and has much more quality.'

Understanding data

With so many data channels on the racecar, up to 60 measuring sensors, collecting the data is actually not that difficult. It is analysing it and acting on it that makes it valuable.

'Obviously you can generate megabytes of data, but that is where the processing comes in and that is where OptimumG has come in, creating some KPIs,' says Montet. 'The whole idea is that when you run 10 to 12 specs, and maybe 50 to 60 channels, and you multiply that by the number of tyres, the number of corners in one lap, you have so much data in the engineering field, and what do you do when you look at that? It is unreadable, so you extract the KPIs and you can tailor those to low speed corners, medium speed corners, high speed corners, entry, mid-corner, exit or whatever you want, and depending on where we feel the gap is or where we need to improve based on the driver feedback, we focus on the KPIs and focus on that and run the comparison there. The KPI is usually one number, with a calculation behind it.'

Passing the test

Applying a more mathematical approach to the system of development may seem to be obvious, but Dunlop's successes clearly indicate that the route it has chosen is a very productive one. Ultimately, the results in the 2017 season will show whether or not it has given them the competitive edge in the WEC and ELMS. Either way, though, the team at Dunlop knows that regardless of the results, its understanding of the tyres has improved dramatically.

GTE tyre wars

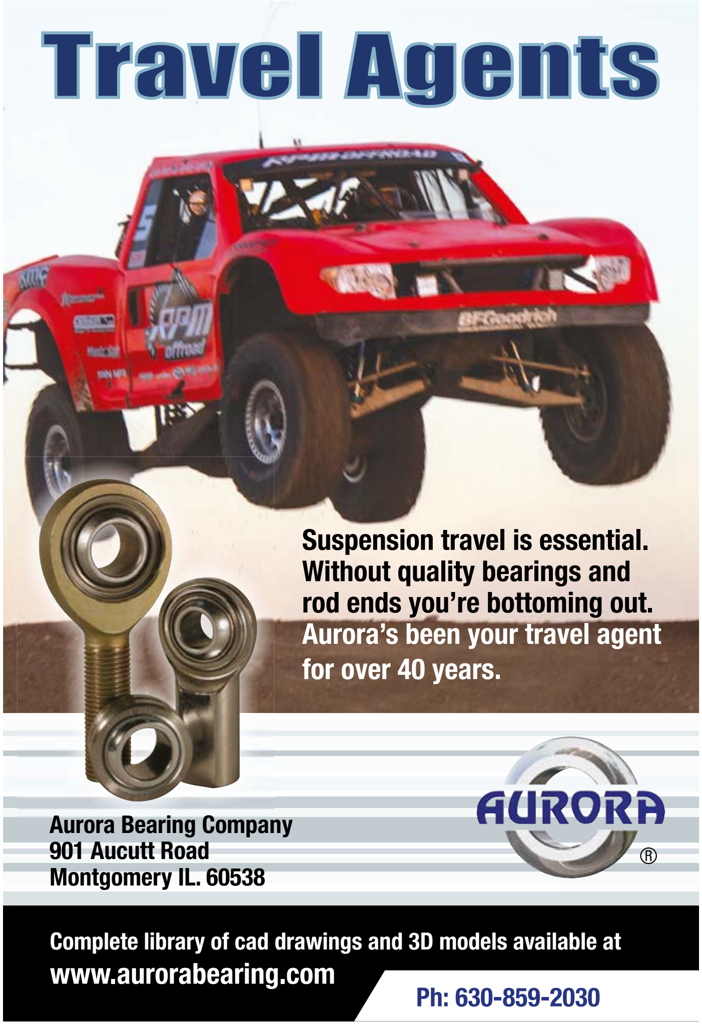
The World Endurance Championship was thrown into something of disarray in 2016 as Dunlop and Michelin engaged in a perceived tyre war, the former having signed a deal with Aston Martin to develop its GTE tyre. The company started with its first specification, that saw it through the first three races, including Le Mans, and then brought a new rear profile tyre to Mexico, and then a new front to match it. There was a new compound range in Austin, and then another new specification in Bahrain.

Falling outside the scope of the Balance of Performance, this meant a whole new area of performance that could disadvantage the runners on one tyre brand and has led to questions being asked at the FIA as to how to fix it.

A development tyre may not necessarily bring the performance that it is designed to do, and Dunlop's rivals believe that the rate of development will slow in the future and that it is natural to make so many changes in such a new partnership, but the FIA has reacted by limiting the number of tyres next season to prevent a war raging.

Details are still sketchy; there is no confirmed number of tyres and, in reality, no information of how the FIA will police it. In LMP2, Dunlop and Michelin are responsible for monitoring each other's customer tyres through an agreed system of swapping tyres post-race. However, LMP2 is not a tyre development category, and so there is limited confidentiality in the tyres anyway.

However, for the GTE category, there is no such restriction, and so it is unlikely that Michelin or Dunlop would be willing to share their data. It is therefore down to the FIA to monitor the situation, and this could turn out to be both expensive and complicated.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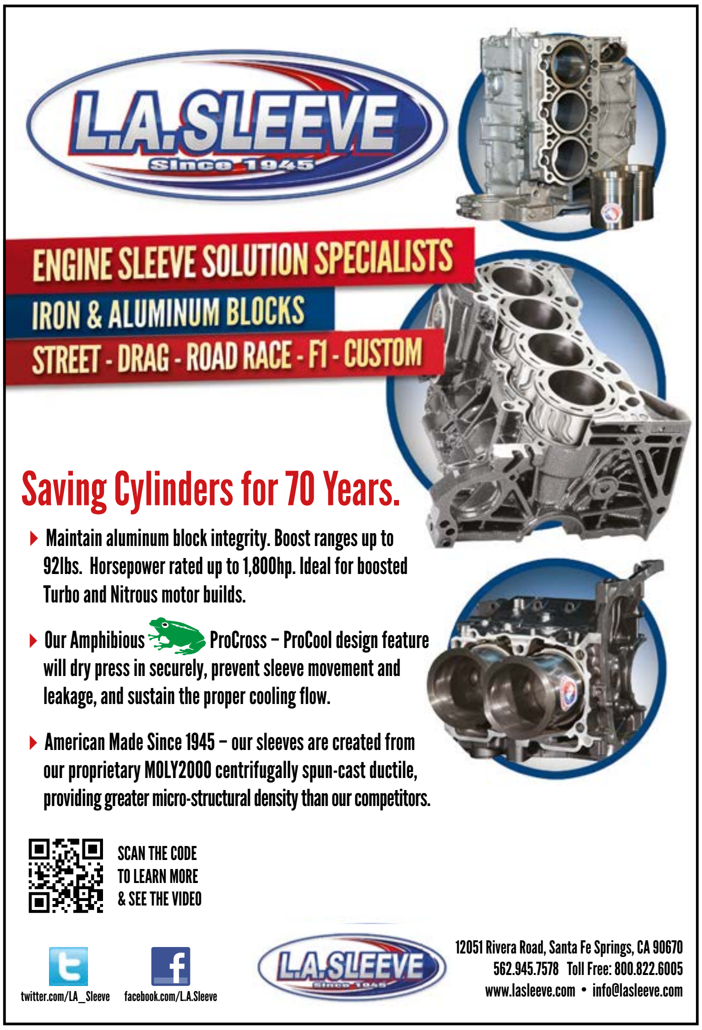
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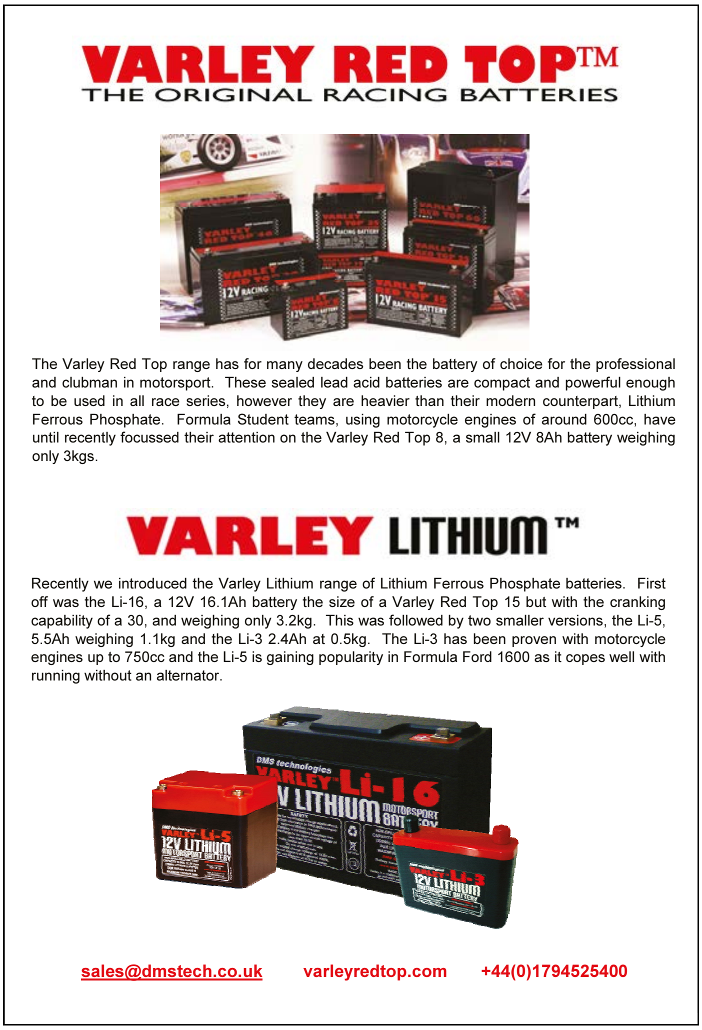
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Scaling down

Can't afford a session on a chassis rig to check a racecar's torsional stiffness? Why not use some bathroom scales? In part one of our new mini series we reveal some tricks of the trade

By RICARDO DIVILA

Kinematics and compliance rigs (K&C) are an ideal way to check over a car's chassis without running it on the race track

K&C rig time is expensive and they are often used by manufacturers (this belongs to Toyota) but there are other solutions

Most budding racecar designers and race engineers benefit from a vast range of software and information on the nuts and bolts of their calling these days.

You can bypass multi-million dollar wind-tunnels and work with CFD, some of it open source, while simulation programs can allow you to see your design running around the track and have a fairly good analysis of the track performance design parameters you have chosen – but don't forget the cardinal rule is GIGO (if you put 'garbage in' you get 'garbage out'), and so make sure your inputs are right.

FEA analysis can help you stress out the components of the same design and theoretically find the weak spots and correct them even before you build it. And computer programs can allow you to plot your suspension characteristics to your satisfaction with four-wheel 3D geometry computation.

However, at some point it will be informative to find out if all the virtual information you have produced is correct, information that can only be checked out in real life. You can, of course, have access to the track, for real life performance, the lap time you produce being the fundamental parameter. But when the new racecar produces non-anticipated results how do you validate your calculations and sims and then find where the problem is? There are K&C (kinematics & compliance) rigs, but they tend to be expensive, and most of them are in intensive use, so it is difficult to find slots to measure your car – even if you are working for a manufacturer. Here we will look at other solutions.

Torsional stiffness

For racecar handling response, one of the primordial requirements is torsional stiffness. This is what gives a racecar a quick response when changes in direction are asked of it through the steering, chiefly by having your

For racecar handling response, one of the primordial requirements is torsional stiffness. This is what gives a racecar a quick reaction

Comparisons are only valid when measured on the same rig and with strict procedures. Even this will give you a drift of about two per cent

contact patch receiving the car's load transfer without any lag or hysteresis.

On a circular skid pad, torsional stiffness (within reasonable bounds and assuming you are comparing like with like) will not be an issue in steady state, providing you optimise all cambers and toe, being only dependent on your CG height, track width, mass and pad radius. A flexible flyer will generate the same Lateral *g* as an infinitely rigid car, providing that when all the compliances are taken up your cambers and the roll couples are the same.

Transient response will have more definite requirements. Remember a racecar is seldom in a steady state; it is either braking, accelerating or turning; sometimes all three at the same time (to skewer all you wise guys out there, you can be braking while turning in and accelerating, to have the exhaust blow your diffuser).

Measuring stiffness

You can measure your chassis stiffness with a simple tool, made by constraining the chassis at a suitable point, such as the rear damper pickups, or in the case of a stressed engine at the engine pickups, then having a roller under the front of the chassis and a long lever attached to the front spring perches.

The mass applied to the end of the lever and a ruler measuring the distance from the tip of the lever to the ground will give you the angle it is being twisted through and the torque applied. Then, *bingo*, you have your chassis stiffness. A three-metre beam and your own weight can give you 225kg/m of torque. Remember to allow for beam deflection if you are on the heavy side, or convince a couple of team mates to increase the mass, which in this case could be as much as 300kgs or 900kg/m, and also remember that part of the deflection you are measuring is the beam itself – which will not be there when the car is on track, we hope.

Using constraint

The photos on page 82 illustrate another way of measuring your deflection, which is possibly more accurate than the ruler off a beam. This is measuring the tub stiffness and engine/gearbox/rear suspension unit, but the system is imposing an artificial constraint on the chassis. Rollers under the chassis allow the chassis to twist along its natural twist axis, not the case here, where the front pivot restrains it, and the method of fixing the rear suspension is also introducing an artificial constraint to the system, which will make the whole unit stiffer.

There can be found online an excellent SAE paper from Clemson University that outlines the requirements for twist tests, on a more

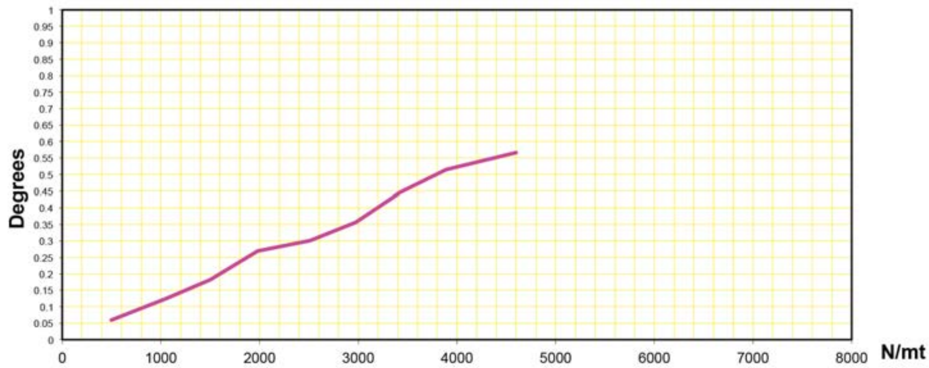
Figure 1: Torque test of a Lola B02/50

❑ Chassis only
❑ Chassis + rear

Rear info:
Gear box n° Km:
Engine n° Km:
Side pressure **RH** **LH**

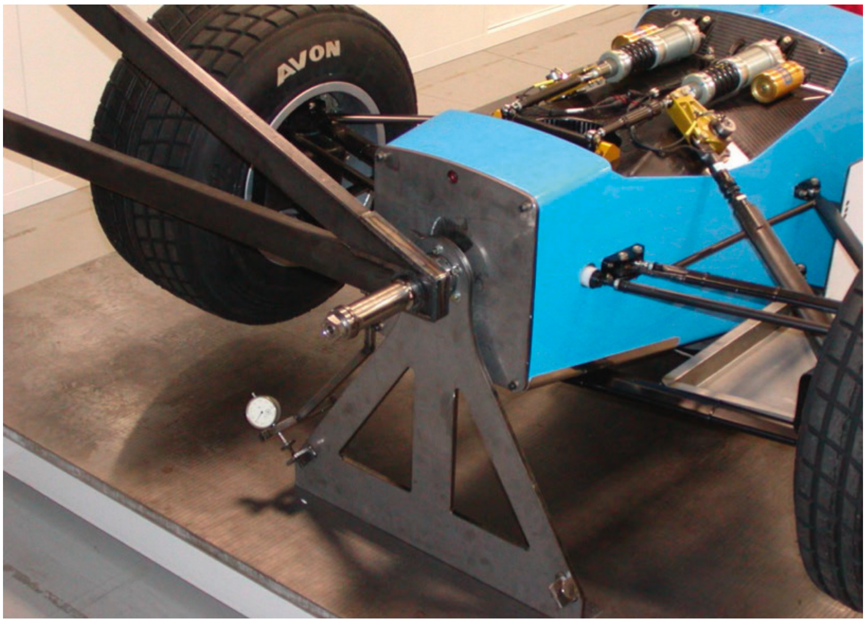
Air temp. 15°C
Note: We zero the gauges considering the lever weight (Kg 11.66)
After the test at N/mt 3890 the gauges came back to 0.8mm not 0

N/mt	Kg/ weight	value in mmmm/mt		ANGLE°	N/mt/deg
500	25	0.521.04	0.05959	8391	
1050	52.5	1.08	2.16	0.12376	8484
1502	75.1	1.59	3.18	0.18220	8244
1980	99	2.35	4.7	0.26929	7353
2514	125.7	2.63	5.26	0.30137	8342
2974	148.7	3.11	6.22	0.35638	8345
3424	171.2	3.89	7.78	0.44575	7681
3890	194.5	4.49	8.98	0.51450	7561
4600	230	4.94	9.88	0.56606	8126
5000	250		0	0.00000	

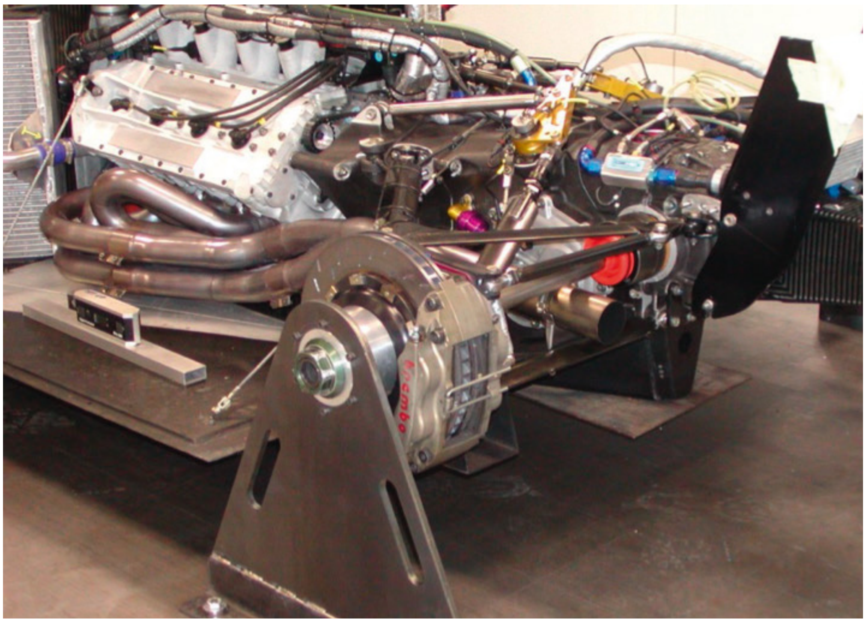


You can measure your chassis stiffness with a simple tool such as this, which constrains the chassis at a suitable point

This is a more sophisticated approach to checking the torsional stiffness of a racecar, this time applied to a Lola B02/50



The front pivot restrains the car and the method of fixing the rear is also introducing an artificial constraint



Possibly more accurate than the beam; measuring the tub stiffness and engine/gearbox/rear suspension unit

elaborate rig. It can be downloaded from http://bit.ly/2gjY01A. For some results generated by the sort of twist outlned above, see **Figure 1.**

As methods for measuring differ considerably, if you don't know how the figures you are given are arrived at, always take with a pinch of salt figures from other sources. Comparisons are only valid when measured on the same rig, and with strict procedures. Even this will give you a drift of approximately two per cent in the best of cases.

The wider the base, the more accurate the measurement, but alternatively a pair of dial gauges applied directly to the chassis will eliminate any deviation of measure through rig compliance. Do not even trust the floor. I have had cases where sufficient torque was applied to lift the floor slightly, and then throw the readings out.

Furthermore, beware of parallax error, as your reading of the dial gauge can be out depending on which angle your eyesight is relative to the dial face (of course, this does not apply to a digital readout, but there are other problems associated with these).

Stiffness losses

Chassis stiffness is not equivalent to contact patch stiffness. What the racecar responds to is the weight transfer at the contact patch, and racecars can have massively stiff chassis only to lose this through the suspension mountings, or even from the chassis to engine, or engine to gearbox, the connections, not to speak of bearing pack or upright stiffness.

Table 1 illustrates some examples of Formula 1 cars measured, with the breakdown of losses . It can be seen that the introduction of aluminium honeycomb in 1983, and the passage to a full carbon honeycomb chassis, increased the chassis torsional stiffness, but effectively wheel to wheel it did not improve it. This is either because of a different engine with less stiffness, losses through engine mounts, or suspension detail design.

The 320 per cent gain in seven years of chassis stiffness gave sensibly the same values at the contact patch. The improvement in aerodynamics and engine power made up for this, but nevertheless illustrates how detail design can bring down your efficiency. Maybe the most telling point is that the earlier car won a world championship, but latter ones didn't, until the matter was recognised.

So how do you go about all this without a $750,000 kinematics and chassis rig?

Wheel-to-wheel check

As a first step to check wheel-to-wheel torsional rigidity, you only need a set of corner weight scales, a series of plate shims, solid set-up wheels and some dummy dampers. If you do not have set-up wheels available you can use a set of rims without tyres, or if that proves too difficult, you can even sit the car on its discs.

The wider the base, the more accurate the measurement, but alternatively a pair of dial gauges applied to the chassis will eliminate any deviation of measure through rig compliance

If you do not have dummy dampers you can shim the damper shaft with packers, or take out the spring and use half a tube held in place with a tie rap or jubilee clip, the target being to eliminate any movement due to the spring.

Alas, the corner weight scales are non-negotiable; you will need them to get the weight. At a pinch, common or garden variety grain scales will do, but it makes life a lot more complicated. The other solution, in this digital age, and one which I have used, consists in acquiring a set of bathroom scales. These usually go up to 180kg each with a 0.1kg readout and will amply cover a Formula SAE car at 230kgs. To find out what range scales you will need to use for your particular car consider it must be able to measure your total front weight (or rear in the case of front-wheel-drive cars), as you will load one side till you lift the other wheel (and you can remove all surplus weight not connected to chassis rigidity, such as bodywork panels, liquids, batteries, wings, etc, even engines and gearboxes if not part of the structure, further increasing your range for a given set of scales).

A bonus is that you have a set of corner weight scales for as little as £30 (or US$38 at time of writing) if you acquire four Salter Magnified Display Scales, easily found on Amazon, which copes with 180kg each. Just a search on Google will bring a plethora of other available scales to suit your budget, such as a PCR-3115 300kg/100g LCD Display Digital Weighing Postal Scale for Logistics that also does tare weights for 36 euros.

Solid wheels

The reason for solid wheels is to make measuring more precise, as we are endeavouring to measure some high values of load and the deflection of the tyres will make measurement more compliant. As an example,

When a racecar is on the track being driven at the limit it will often be braking and turning at the same time and will rarely be in a steady state

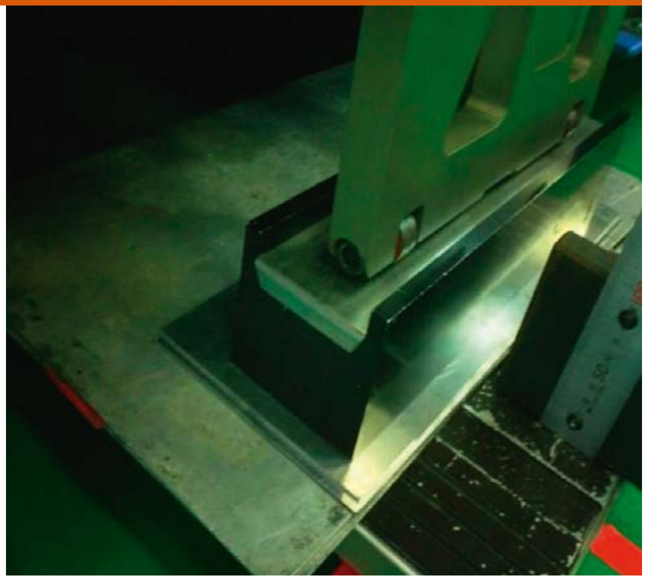
Scales are a fundamental part of chassis set-up at all levels but they need not be prohibitively expensive items to buy

Table 1: Examples of Formula 1 cars measured, with the breakdown of losses

Vehicle and Type	Chassi to axle rate ratio %	Overall Torsion Axle to Axle				Chassis Torsional Stiffness				Engine+Gearbox Torsional Stiffness		Total
		(kN*m/rad)	Nm/degree	kgmF /deg	lbsf.ft /deg	(kN*m/rad)	(N*m/deg)	kgmF /deg	lbsf.ft /deg	(kN*m/rad)		(kN*m/rad)
1982 (F1) Aluminium Tub	78.0%	400.6	6991	713	5154.5	513.7	156469	15950	115365.8	1834.4		401.3
1983 (F1) Honeycomb Tub	65.0%	397.6	6939	707	5116.2	611.5	186261	18987	137332.3	1136.3	(Engine change)	397.5
1984 (F1) Carbon Tub	39.2%	324.7	5667	578	4178.3	828.7	252427	25732	186116.7	0.0	0	0.0
1985 (F1) Carbon Tub	41.8%	309.5	5402	551	3982.9	741.0	225723	23010	166427.9	0.0	0	0.0
1988 (F1) Carbon tub	30.3%	502.1	8763	893	6461.0	1657.2	504819	51460	372207.6	0.0	0	0.0
1989 (F1) Carbon tub	38.7%	395.2	6897	703	5085.2	1020.3	310791	31681	229148.8	0.0	0	0.0

Figure 2: Procedure – car on set-up plate

Set-up on scales on solid set up wheels. Front and rear bars are disconnected Spring damper unit is disconnected, replaced by solid strut dummy dampers. Car lifted on jack. Corner weight scales zeroed. Car set on scales. Corner weights noted. Car lifted on jack. Front right shimmed with ally sheet of measured thickness, in this case 2mm



Shims under dummy wheel. Corner weights noted. Car lifted on jack. Front right shimmed with ally sheet of measured thickness, in this case 4mm. Corner weights noted. Car lifted on jack. Front right shimmed with ally sheet of measured thickness in this case 8mm. Corner weights noted. (Make sure all scales register weight; if one scale reads zero it means a wheel is off ground and your equation will become meaningless). Car lifted on jack. Front right shims out, back to zero condition. Corner weights residuals noted. Procedure repeated for front left, rear right, then rear left.

doing corner weights with dummy wheels can give almost twice the corner weight offsets compared to measurements taken on race wheels, for the wheel rate with dummy wheels are only the spring rate at the wheel, whereas with road wheels it is = 1/(1/Spring rate at wheel+1/Tyre spring rate)

Make sure that you are using the spring rate at wheel correctly. It will be the spring rate motion ratio. MRs are not used for twist tests, though. As there is a natural confusion between the motion ratio and the velocity ratio just use the definition: MR = spring movement/ wheel movement. Keep in mind the scales will have a tolerance, so include in your calculations the range your end values can have, this will be your margin of error, and in stiff cars can be quite large. For the procedure see **Figure 2**.

You will note if you plot this out that the initial slack in all your bearings and joints can then ramp up and the car seems to stiffen, this is a clue in itself to the losses in linkages. The less of this you have, the better will be the response in change of direction, and the drift from a right hand twist to a left hand twist can point you to some discrepancy in the chassis.

If you have values that decrease with the torque applied, that is usually generated by the added accuracy on the high end. Even the residuals should come back to reasonable values; lightly oiling the plates ensures there is no hysteresis or stiction as the car is settled on them. If residuals are still high it could indicate that at a given load the play in, say, your studs or dowels between the engine and gearbox (again in the case of a stressed engine assembly) are taking a set under load. After running the car for a while, any fretting at the joints will show where it is happening.

Measurements and results

Taking shim thickness divided by tread gives us angle of twist. Note, shim thickness is very critical. Angles measured are very small. Stiffness being force/angle, make sure the sheets are measured stacked up and individually to verify stack height. You will seldom exceed eight to 10mm of twist on an average track. If you have more, you have a banana on your hands, and good luck with that!

Ex = 8mm/1985mm = 0.00403 arc tan or 0.2030913730188 degrees of twist

8.1mm/1985mm = 0.00408 art an or 0.233800119972 degrees of twist

For a given torque, say 850kgm giving approximately 8mm twist on one axle that 0.1 difference in measurement will give you 3724.33 kgm/deg with 8mm and 3678.36 kgm/deg for 8.1mm, so plus or minus values will vary by 1.25 per cent (or 2.5 per cent total drift).

At smaller angles of twist, values are even more affected, so the stiffer the chassis the more critical will be the measurement. As a comparison, always use maximum twist. Weight drift on scales is not that critical, plus or minus 1kg will be 1/450 in this particular case.

This simple way of measuring twist can be used for a baseline, and a further measurements check for any modifications you make. For a deeper analysis of where you are having movement, you can put a bar across the car at different stations and measure the deflections, but as you progressively get nearer your constraint, the more accurate you will have to be, as with shortening the torque tube the smaller the angle you are measuring.

We will continue this series next month with a closer look at torsion testing with more elaborate rigs, and then venture into a cheap and handy way to measure other parameters a K&C rig does, like toe and camber stiffness under braking or lateral forces, and how to chase where any deflection is occurring. You will have to invest around US$150 for the materials, But that's still much cheaper than a K&C rig.

One last thing. I cannot emphasise enough the need for rigorous checking of your measurements and procedures, lest you be led astray by numerical dispersion. As I always says, better no data than bad data.

The scales will have a tolerance, so include in your calculations the range your end values can have, this will be your margin of error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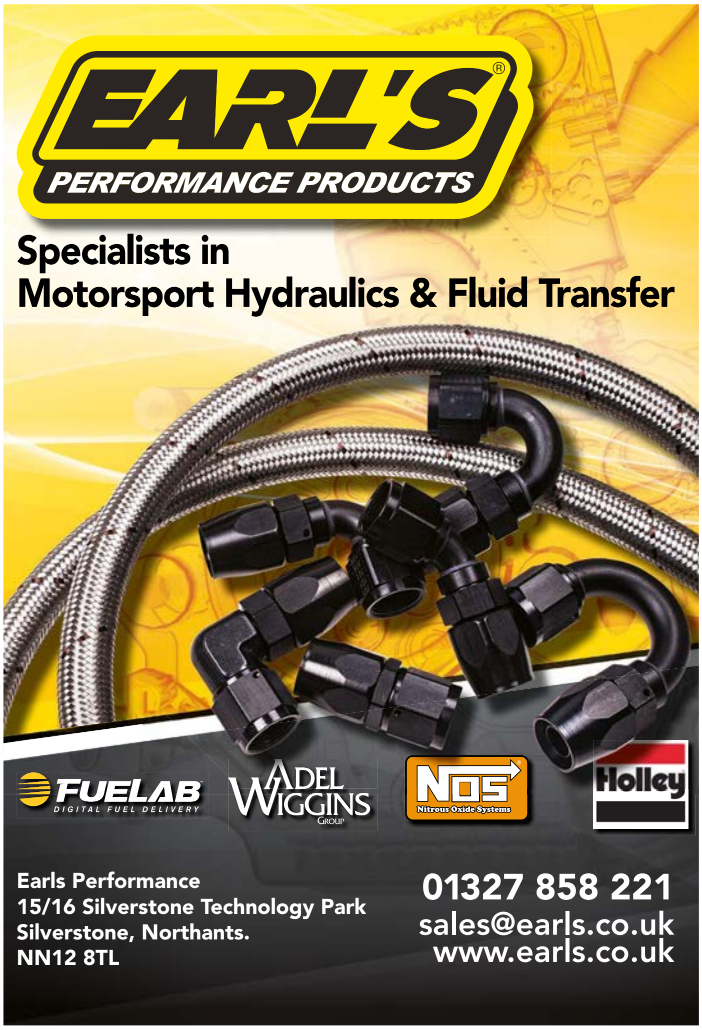
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Charging **bull**

Ever wondered what would happen if you stuffed an electric motor or a KERS system into a Lamborghini GT3 racecar? *Racecar's* simulation wizard has worked his mathematical magic on this very scenario

By DANNY NOWLAN

A Lamborghini GT3 car in 2012, similar to the Bathurst 12 Hours car our numbers man has based his electric power and KERS study on

The hot topic of debate in racing is in which direction do we take the sport. In particular, the focus on green racing has led to the introduction of KERS in LMP1 and Formula 1 and the emergence of Formula E. While these are necessary and important steps a key question has been lost. Is this of real engineering benefit and, more importantly, will it make racecars quicker? We will be exploring this question in depth in this article, which is on the application of electrics and KERS to a GT3 category racecar.

To narrow down this study we'll be focussing on a contender for the Bathurst 12 Hours. Note the keyword: *contender*. One of the problems with motorsport is, due to the challenges we are facing, the regulatory bodies are grasping at anything to keep it relevant. However, this takes away from motorsport a key goal, and that is our aim to go as fast as possible. Everything flows from this and we are losing this at our peril. So, with this as our perspective, let's examine where electrics and KERS come into the picture.

To this end we'll be using the Lamborghini LP 560 GT3 racer as our baseline car. This is a car I have been closely involved with. In 2012 I was the data/performance engineer for the Consolidated Chemical LP 560 entry in the Bathurst 12 Hours and some specifics for the racecar are shown in **Table 1**. This will appropriately frame our discussion as we consider what the options look like.

To kick off this discussion let's consider what an all-electric option looks like. To this end we need to review what a typical lap looks like, and so a typical lap is presented in **Figure 1**.

As discussed in one of my earlier articles on electric propulsion, what we really need to determine here is the time on brakes and time under full throttle. The data for this, from the lap in **Figure 1**, is shown in **Table 2**.

We now need to put in some of the specific electric numbers. The electric motor we will use is the Remy HHV–250 motor. We will also base our cells around Thunder Power Rampage 7700mAh 65C cells. The relevant parameters for all this are presented in **Table 3**.

Given the peak power of the motor is 305kW we will need to run an AWD configuration. This will bring us to our peak power configuration of 380kW. Let's now crunch the numbers. Firstly,

We need to determine the time on the brakes and time under full throttle

Table 1: Car specifics LP 560 GT3

Parameter	Value
Mass	1300kg
Peak power	380kW
Time for a stint	45 minutes

Table 2: Specifics from the Bathurst lap for electric analysis

Parameter	Time
Time under full throttle	82.6s
Time under part throttle (50%)	13.46s
Time under full braking	28.5s

Table 3: The parameters of the electric powertrain

Parameter	Value
Remy HHV 250 peak power	305kW
Motor operating voltage	650V
Cell weight	0.2kg
Regen' Power	150kW
Cell operating voltage	3.5V

let's establish the currents under power and regeneration. For acceleration we have **Equation 1**. For regeneration, we have **Equation 2**.

Now that we have established the acceleration and regen' parameters, we now need to calculate the Ah used over the lap. Crunching the numbers we have **Equation 3**. We now need to calculate what we need from the battery pack and this is the critical point of this discussion. Given that we'll be running 20 laps over a 45 minute stint we'll need at least 253Ah of capacity. So the number of cells we'll need is shown with **Equation 4**. You don't need to be a rocket scientist to figure out a pack mass of 1264.8 kg is simply not practical.

Tesla option?

As an interesting aside the Tesla Model S 85kWh battery pack weighs in at 540kg and has 7104 cells, so is this an option? To answer this question we need to crunch some basic numbers. The Model S has engine options that range from 285kW right through to the 568kW option. Given the HH 250V has a base power of 305kW it's a pretty fair estimate that this motor and the Tesla motor would be running similar voltages. So calculating the Ah we have **Equation 5**. That is about half the capacity of what we need. That, coupled with the practicalities of getting a 540kg battery in and out of a car every 30 minutes, means an all electric contender for the Bathurst 12 Hours is simply not practical. That said, I'd love for Tesla to prove me wrong and its boss Elon Musk just might be crazy enough to do it.

However, while the all-electric option for a GT3 contender isn't practical, we now have the mathematical basis to nail down what a KERS electric option would look like. From our earlier analysis we can charge about 1.82Ah per lap. So revisiting **Equation 4** and using a 3300mAh Thunder Power pack (the cells weigh in at 80g)

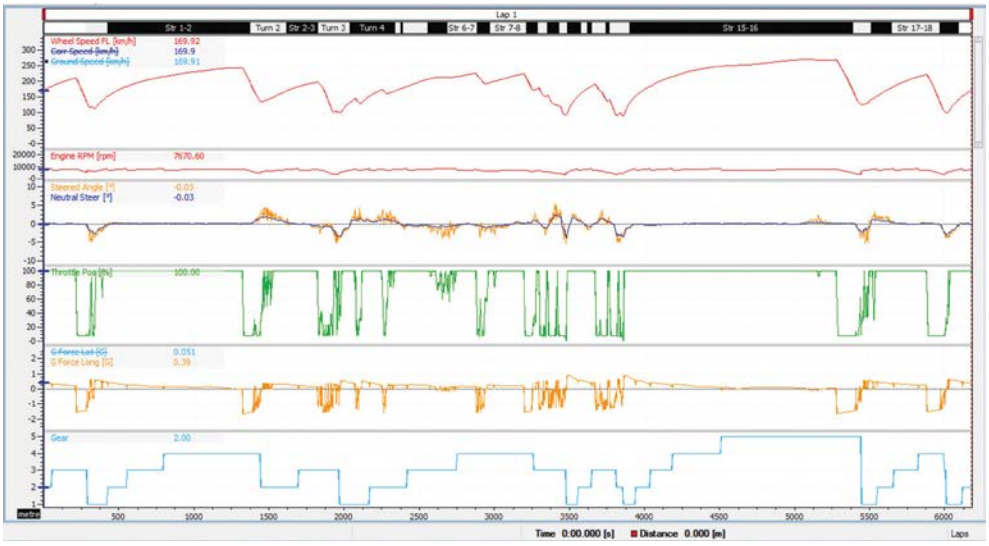

Figure 1: A typical lap from the legendary Mount Panorama circuit in Bathurst, the base track for our electric Lambo study

EQUATIONS

EQUATION 1

$$P = V \cdot I$$

$$I = \frac{P}{V} = \frac{380000}{650} = 584A$$

EQUATION 2

$$P = V \cdot I$$

$$I = \frac{P}{V} = \frac{150000}{650} = 230A$$

EQUATION 3

$$Ah_{DISCHARGE} = \frac{t_{FT}}{3600} \cdot I_{DISCHARGE} + \frac{t_{PT}}{3600} \cdot 0.5 \cdot I_{DISCHARGE}$$

$$= \frac{82.6}{3600} \cdot 584 + \frac{13.46}{3600} \cdot 0.5 \cdot 584$$

$$= 14.5Ah$$

$$Ah_{CHARGE} = \frac{t_{Charge}}{3600} \cdot I_{CHARGE}$$

$$= \frac{28.54}{3600} \cdot 230$$

$$= 1.82Ah$$

$$Ah_{LAP} = Ah_{DISCHARGE} - Ah_{CHARGE}$$

$$= 14.5Ah - 1.82Ah$$

$$= 12.68Ah$$

EQUATION 4

$$No\_of\_cells = \frac{V_T}{V_{CELL}} \cdot \frac{Ah_{TOT}}{Ah_{CELL}} = \frac{650}{3.5} \cdot \frac{260}{7.7} = 6324$$

$$Pack\_mass = No\_of\_cells \cdot m_{CELL} = 6324 \cdot 0.2 = 1264.8kg$$

EQUATION 5

$$Ah = \frac{Wh}{V} = \frac{85000}{650} = 130.77Ah$$

EQUATION 6

$$No\_of\_cells = \frac{V_T}{V_{CELL}} \cdot \frac{Ah_{TOT}}{Ah_{CELL}} = \frac{650}{3.5} \cdot 1 = 186$$

$$Pack\_mass = No\_of\_cells \cdot m_{CELL} = 186 \cdot 0.08 = 14.88kg$$

While the all-electric option for a GT3 isn't practical we now have the mathematical basis to nail down what a KERS option would look like

Table 4: KERS parameters

Parameter	Value
Discharge limit	300kW
Charge limit	150kW
Charge limit	2MJ
KERS weight	60kg

EQUATIONS

EQUATION 7

$$P = F \cdot v = 2 \times 9.8 \times 100 \times 109 / 3.6 = 59.3kW$$

we have **Equation 6**. So this means to store the energy charge for a lap we would need a battery pack that weighs about 15kg. By the time you install cooling and battery protection this might jump to 20kg. Also, the Remy HHV motor weighs in at 43kg. So tacking on a KERS system to a rwd car would incur a weight penalty of 63kg.

It is now time to put some serious numbers into this so let's investigate using the ChassisSim KERS feature. For the purpose of this investigation we are using the parameters in **Table 4**. Also, for brevity we selected discharging down the start finish straight. The results were a dead heat with a lap time of 2:04.95s.

However, the overlays of the data show a very different story, as shown in **Figure 2**. The non KERS baseline is coloured and the black is the KERS lap. Due to the fact the start finish straight is short at Bathurst this has skewed the C-Time plot. However, the impact is completely obvious. Not surprisingly we do pay a corner speed and end straight speed penalty for the KERS system. This averaged about 0.2-0.3 km/h per corner and we where down 1 to 2km/h going down Conrod straight. However, with the KERS engaged with a 300kW discharge the results down the start finish straight are incredibly stark. Going into Turn 1 without KERS the end speed is 211km/h. With the KERS on this jumps to 251.4km/h. This is a push to pass you can not defend against. Also, unlike DRS, this is a legitimate push to pass that can be optimised!

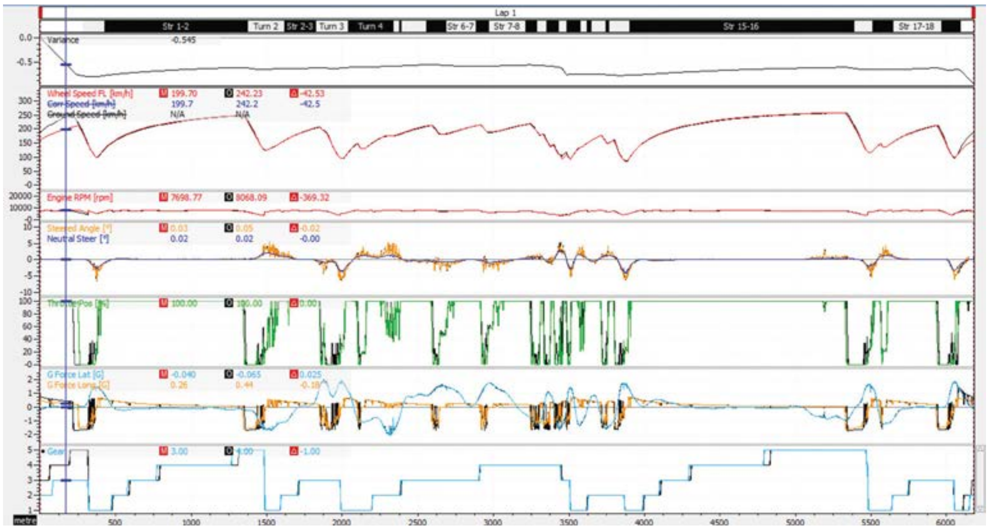

Figure 2: KERS fitted car versus Non-KERS at Bathurst. The non-KERS baseline is coloured while black trace is the KERS lap

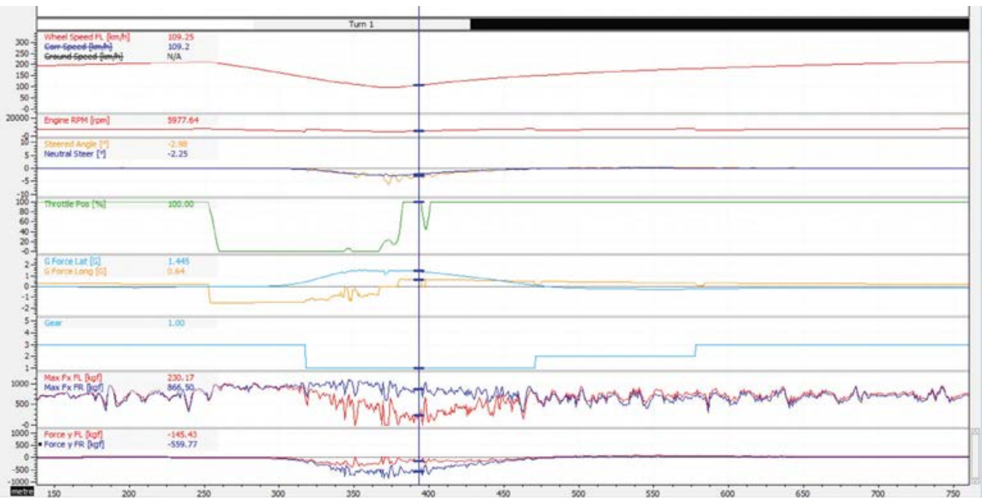

Figure 3: Available front tyre forces for the KERS car in Turn 1 at Bathurst. The key traces to observe here are the bottom two

KERS and effect

The other thing to keep in mind in this analysis is we haven't optimised it yet. I've literally tacked this on to the existing car. I haven't even played with the brake bias, let alone optimising where on the circuit we have used this. Just imagine this unleashed climbing up the mountain or going down the mountain on Conrod straight. Also, if the KERS system is designed into the car from day one I would wager the weight penalty could be appropriately minimised. And with the battery pack that can store 4.28MJ of energy you have plenty of options. Just imagine the effect this can have when you have complete liberty of where to use it.

There is one interesting spin off from this and this comes from looking at the front tyre forces, shown in **Figure 3**. The key traces to observe are the bottom two where we see max longitudinal tyre force plotted against lateral force. I'd like to bring your attention to where the cursor lies. There is a differential force of 100kgf on the inside front and 200kgf on the outside front. Strictly speaking to calculate the available force I should do a traction circle calculation. I'm actually going to go off the minimum forces because I am deliberately doing this to be conservative. So to estimate the engine power we could apply we have **Equation 7**.

KERS potential

To put this in perspective **Equation 7** represents 15.6 per cent of the base 380kW. Most engine builders would sell their souls to the Devil to get this kind of improvement. Also, we're applying this at the wrong end. Can you imagine the implications of this being incorporated in an AWD platform such as the Nissan R35 GTR?

In closing then, applying KERS and electric technology to a GT3 racecar is far from a fool's errand. While the all-electric option was not feasible the KERS electric option is not just viable in a technically open formula, you'd be mad not to consider it. The deltas on the start finish straight speed of over 40km/h meant this is an option to consider very seriously. Also the loss in corner speed was not an onerous one. It also has the potential to add in exciting racing because in a wheel to wheel battle you will never fully anticipate where the KERS will be discharged.

Yet what is really striking in our study is that we have just tacked this on to an existing car with no optimisation. Just imagine the impact on the racecar when this technology is deliberately designed in from day one.

It is of little surprise to me that both McLaren and Porsche have incorporated these sort of systems into their latest hypercar offerings and, frankly speaking, we in motorsport would be mad not to follow their lead.

INTERVIEW – Nick Wirth

Wirthwhile endeavour

The founder of Wirth Research tells us how its CFD tech has helped build better drones, fridges and trucks – and why Formula 1 might be in for a shock in 2017

By MIKE BRESLIN

XPB

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'I think 2017 is going to be a huge challenge, unlike any which the Formula 1 teams have faced to date'

With the diversification that has become a fact of life for many motorsport engineering concerns these days there surely must come a point where one amongst them suddenly steps back and says; 'Heh, we're not racers anymore!' Which begs the question: when does a motorsport company cease to be a motorsport company?

Take an operation like Wirth Research (WR), for instance. WR was set up in 2003 by former Simtek F1 boss and Benetton chief designer Nick Wirth. The company's most recent high profile motorsport programme has been working as a technical partner to Honda Performance Development (HPD), developing a series of successful Acura LMPs and more latterly the Honda aero kit for IndyCar. But with LMP2 construction now restricted, and aero kits frozen, it suddenly has a little less racing work on its plate.

But that's not to say WR's relationship with HPD is at an end, and Nick Wirth says there are a number of ongoing projects which he is 'not at liberty to talk about right now'. He will, however, talk about the fascinating spin-off work the firm has been involved in, and how that is also, in fact, making WR a better motorsport operation. 'It's amazing how our technology, which was purely developed in the fire of competition, is really being pushed forward by the work we are doing in so many other areas, which is then feeding back into our motorsport experience,' Wirth says. 'For example, we made a major breakthrough in our CFD work, which came as a result of our understanding of the very complicated flow around skyscrapers. In solving that particular problem we realised that it could be applicable to the type of flow we have around racecars, and it moved our whole racecar programme forward.'

Fridge racers

Beyond skyscrapers WR has developed an aero kit for trucks for leading UK haulier Eddie Stobart and is heavily involved in unmanned aerial vehicle (UAV) technology, working with Lockheed Martin, and also helping to develop hydrogen-powered mapping drones for Japanese company Deryl.

Each of these projects had their own challenges, as did a job for supermarket chain Marks and Spencer, where the brief was to stop cold air escaping from open refrigerated display cabinets. 'They sent us a cabinet, and we built a very sophisticated CFD model of it. We spent a year working on it, trying to stop the digital cold air falling out with no success whatsoever. So then I decided to throw the most sophisticated CFD technology we know at it. We did a type of simulation that is extremely expensive and extremely time consuming. And that set in motion us inventing a device which made a dramatic difference. This invention, called an Ecoblade, saved 29 per cent of the energy when you bolted it on,' Wirth says.

That's just one example of how WR's motorsport-developed CFD has been put to good use in the outside world. But in motorsport itself Wirth's relationship with CFD, and what he likes to call 'design in the digital domain', has become something of a trademark, but that does not mean he doesn't recognise its limitations. 'People think I'm a CFD or simulation obsessive, and maybe they're right, to an extent. But, simulation without validation is nothing. It's irrelevant. And where we are so fortunate is, by our own efforts and our own process, and the dedication of the people at this company, we are in a unique position to have this unbelievably powerful CFD weapon. And the difference is it has been continually validated from the day we started work on it back in 2004. [We have been] trying to transition away from scale wind tunnel development to a digital only method; but validated for scale, validated on the track, validated in full scale wind tunnels. That is the difference.'

Digital domain

Wirth does not see total digital design being with us anytime soon, either. 'There are areas where it is very difficult to get complete confidence. You need to keep validating to check what is right and what is wrong. We are not at a level of perfection, by any stretch of the imagination. And anyone who says they are is simply not understanding what they are doing.'

Wirth's last spell in F1 was as technical director with Virgin Racing (now Manor) in 2010. It was widely reported then that all the aero was done on CFD. 'The bottom line is the very best CFD simulations take an enormous amount of time,' Wirth says. 'It is simply faster to use one of these amazing, precise, facilities as used by the top F1 teams. But that technology simply was not available to us at Virgin Racing. We did not have access or the funds to be able to develop 50 to 60 per cent scale models, or have a massive high quality wind tunnel with one of these steel

XPB

belts, and if you are forced to use a lower fidelity wind tunnel, or a smaller scale, then you're better off using CFD.'

Wirth actually thinks that the restrictions placed on CFD in Formula 1 right now is a sad state of affairs, but while he keeps an eye on F1 he says he has no deep knowledge of next year's new aero package. The new larger tyres, however, are another matter altogether. 'I have experience of what happens when you make a dramatic change with regards to the tyres. Some years ago I came up with the crazy idea of improving the performance of an LMP1 car [the Acura ARX-02a of 2009] by exploiting a loophole in the regulations; that we could put the gigantic rear tyres that came out of the diesel era of LMP1 and use that tyre size on all four wheels. This was a huge challenge, and if you think you have a lot of discussion about tyres in F1 at the moment, well 2017 is going to be dominated by people trying to figure out how to turn these gigantic tyres on.'

This will be particularly so in the wet, Wirth says. 'I'm interested to see how much aquaplaning goes on with these new tyres. I'm not sure everybody has thought everything through, and I think that it's going to be an amazing challenge, unlike any which the Formula 1 teams have faced to date.'

Rallycross dynamics

But for Wirth the challenge that has really grabbed his interest right now is a rallycross project for a client he cannot name. 'The challenge of developing tyre models that can accurately reproduce gravel and tarmac in a single lap. We're making great progress on the dynamic modelling of cars with three differentials, and dealing with jumps, and it's just fascinating.'

Yet Wirth admits that it is non-motorsport projects, particularly the UAVs, which are the bulk of WR's work right now. So, back to the question we came in with: is WR still a motorsport company? 'Absolutely. It's my first love. It's the first love of most of the staff here. We enjoy expressing ourselves in competition; and all of the interesting and diverse work we are doing outside of motorsport has come as a result of us testing ourselves, and pushing ourselves, and having our methods validated on the grandest stage of all, which is in competition. And we will never forget that, and we want to continue in competitive motorsport in the long term.'

In 2009 Wirth prescribed big rubber for the front of the Acura ARX-02a – the experience has led him to believe that F1 teams will struggle with the new tyre regulations coming in for 2017

RACE MOVES

XPB

Motorsport marketing guru **Zak Brown** is the new executive director of the McLaren Technology Group. His appointment came soon after **Ron Dennis,** the former chairman and CEO of the McLaren Group, stepped down. Former race driver Brown (45) took up his new position in early December and is now in charge of marketing and racing at McLaren.

Sammy Johns has joined NASCAR operation Richard Childress Racing (RCR) as its new operations director. He will report to **Dr Eric Warren**, the director of competition at the Welcome, North Carolina-based organisation. Johns, a former NASCAR crew chief, comes to RCR from Richard Petty Motorsports, where he was vice president of operations.

Speedway Motorsports Inc. has promoted **Greg Walter** to executive vice president of Charlotte Motor Speedway. Walter has worked at the US track operating organisation for the past 17 years after an earlier career in the media.

Greg Hahn has stepped down as boss of New Zealand-based Supercars outfit Super Black Racing. There had been speculation over the team's future in the premier Australian motorsport category after owner **Tony Lentino** died in July, and soon after Hahn's departure it was announced that Super Black Racing had sold its Racing Entitlement Contract to Tim Blanchard Racing.

Steve Harris, the Area 4 representative on the Sports Car Club of America board, has died at the age of 65. Harris was a steward, an SCCA racing competitor, and a long-time member of the club.

Marcus Merideth has been appointed to fill the remainder of the SCCA board of directors Area 4 term. Merideth previously served as Area 4 director from 2009 until 2011 and has held numerous volunteer positions with the SCCA. He replaces **Steve Harris** (see above).

Tom Milner is now the manager at Panoz Racing. Milner, whose Prototype Technology Group developed the Panoz Abruzzi model into an ALMS GT2-spec racecar in 2011, started work for the Georgia-based operation in November. He has been tasked with turning the Panoz Avezzano into a GT4 racer for the north American market.

NASCAR and its track-operating arm International Speedway Corporation (ISC) has named **Christopher Davis**, a veteran FBI executive and risk management expert, as managing director and chief security officer. Davis has now taken up the leadership of the NASCAR and ISC security strategies.

Former CART and IndyCar driver **Adrian Fernandez** has taken on the driver management role for fellow Mexican **Esteban Gutierrez**. Gutierrez was previously represented by Formula 1 driver management veteran **Didier Coton**, who has now elected to step back into a consultancy role.

NASCAR Xfinity crew chief **Kevin Meendering** was suspended from the Homestead-Miami Speedway round of the series after the JR Motorsports No.1 Chevrolet he tends was found to be running with two wheel lug nuts improperly secured at the Phoenix race. Meendering was also fined $10,000 for the infraction.

Joshua de Wit, a student at the University of Sussex in the UK, has won the prestigious Autocar-Courland Next Generation Award for 2016. The second-year mechanical engineering student scooped the prize thanks to an original idea of his which focussed on stacked graphene batteries, a design with the objective of improving sustainability in electric vehicles.

Frazer Madder, who was the long-time clerk of the course at British Hill Climb Championship venue Doune, in Scotland – and also one of the original members of the Scottish Motorsport Marshals Club – has died.

Obituary Paul Rosche

Legendary BMW engineer and technical boss Paul Rosche has died at the age of 82.

Rosche worked for the German manufacturer for 42 years, specialising in developing race engines that propelled BMW to success in F1, touring cars and sportscars – not forgetting Formula 2, where its F2 engine scored over 150 race wins.

XPB

Former BMW engine builder and motorsport chief Paul Rosche was with the German car manufacturer for 42 years

Munich-born Rosche joined BMW from university in 1957 and because of his skill in calculating cam profiles he began to specialise in this area, earning the nickname 'Nocken-Paul' (Camshaft Paul). His first race engine success came with the 2-litre turbo unit that won the European Touring Car Championship in 1969 and in 1975 he led the development of the straight-six that powered the M1. He then went on to design the powerplant for the legendary first generation BMW M3.

But he will be mostly remembered for the outlandish turbocharged BMW F1 units of the 1980s. When Rosche was asked just how powerful these engines were he reportedly said they were around 1400bhp, but that BMW did not know for sure as the dyno didn't go beyond 1300bhp.

In the 1990s Rosche also tasted success with the 6-litre V12 engine that won the Le Mans 24 Hours twice, powering the McLaren F1 in 1995 and then the BMW V12 LMR sports prototype in 1999.

By this time Rosche was BMW's technical director, and managing director for BMW Motorsport, helping lay the foundations for BMW's return to F1 in 2000 before he retired from the company at the end of 1999, having been at BMW for all of his working life.

Paul Rosche 1934 - 2016

RACE MOVES – continued

XPB

Formula 1 doctor and coach **Dr Aki Hintsa**, best known for his work with McLaren, has died aged 58. The Finn was a specialist in orthopaedic and trauma surgery. He joined McLaren in 1998, becoming physician and chief medical officer during an 11-year spell at the F1 team. Hintsa had been fighting cancer in the latter months of 2016 and his last appearance at a grand prix was at the Italian race at Monza in September.

Former *Autosport* editor and motorsport magazine publisher **Peter Foubister** has died at the age of 63. Among his many achievements are the launching of *F1 Racing*, and taking the lead in the creation of the Autosport Awards. More recently he was motoring secretary at the Royal Automobile Club in London.

Aston Martin has appointed **Maximilian Szwaj** as its new vice president and chief technical officer. He joins Aston Martin from Maserati and Ferrari, where he served as head of Innovation and Body Engineering. Szwaj has spent more than 25 years in the automotive industry and he has also held management positions at BMW and Porsche.

NASCAR has indefinitely suspended **Ryan D Hess** for his third violation of its strict substance abuse policy. Hess, who has worked with BK Racing in the Sprint Cup in 2016, was first suspended in August 2012, when he was with MacDonald Motorsports in the Xfinity Series

Former Supercars entrants **Ross** and **Jimmy Stone**, who ran the ultra-successful Stone Brothers Racing (SBR) concern before it became Erebus at the end of 2012, have been inducted in to the Supercars Hall of Fame. SBR won three Supercars Championships, took 41 race wins and 27 pole positions, plus a Bathurst 1000 victory, during its time in the premier Australian motorsport category.

Historic race engine specialist Peter May Engineering has merged with Midland Classic Restorations with the managing director of the latter, **Dominic Moody**, taking over the reins of both concerns. **Peter May**, the founder of his eponymous firm, will continue to work within the business in the short term before retiring in March 2017. The two companies already share premises in Worcestershire in the UK.

NASCAR's season-closing National Motorsports Press Association's (NMPA) Myers Brothers Awards in Las Vegas went very well for Hendrick Motorsports with the Mahle Clevite Engine Builder of the Year Award going to **Scott Vester** (Hendrick Engines); the Mechanix Wear Most Valuable Pit Crew Award to its No.48 car team; the Moog Steering and Suspension Problem Solver of the Year Award to **Alan Gustafson** (the crew chief on the No.24 Hendrick Motorsports car); and the Champion Crew Chief Award going to No.48's **Chad Knaus**.

NASCAR has reinstated crew member **Michael Casto** after he successfully completed its Road to Recovery Program. Casto was working as a crew member on Stewart-Haas Racing's No. 4 racecar when he was suspended after the Watkins Glen round of the Sprint Cup in August for violating the governing body's substance abuse policy.

◆ Moving to a great new job in motorsport and want the world to know about it? Or has your motorsport company recently taken on an exciting new prospect? Then email with your information to **Mike Breslin** at **mike@bresmedia.co.uk**

Infiniti and beyond for successful Engineering Academy recruits

The seven winners of the 2016 Infiniti Engineering Academy have been announced and they have now started their placements with both Infiniti and the Renault Formula 1 team.

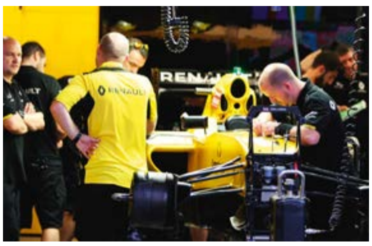
Initially selected from more than 4000 hopefuls, the university students and budding young engineering talents who are the regional winners are: Caitlin Bunt (24, USA), Felix Lamy (21, Canada), Alexandros Palaiologos (24, Mexico), Riccardo Manfredini (24, Europe), Xuezi Li (23, China), Shihab Solaiman (23, UAE) and Jaden Partridge (21, Asia-Oceania).

Their 12-month placement, split between Infiniti automotive and the Renault Formula 1 team, includes accommodation, access to an Infiniti Q30 company car, and a full salary.

They have now relocated to the UK and are sharing two Academy houses near the work placements; at the Infiniti Technical Centre in Cranfield and the Renault Sport Formula 1 team in Enstone.

Tommaso Volpe, global director at Infiniti Motorsport, said: 'With Formula 1 more relevant to the automotive industry than ever and our Academy engineers at the cutting edge of both automotive and motorsport engineering, we are perfectly placed to explore, understand and encourage the crossover of technology between our two companies and disciplines. The Academy engineers will meet monthly, alongside their mentors, to share the freshest thinking and brightest ideas between the two industries.'

There is now also an extra element to the 12-month placements, with the chance for one of the seven winners to secure an engineering place with the Renault F1 operation at the first race of the 2017 season in Melbourne in March.



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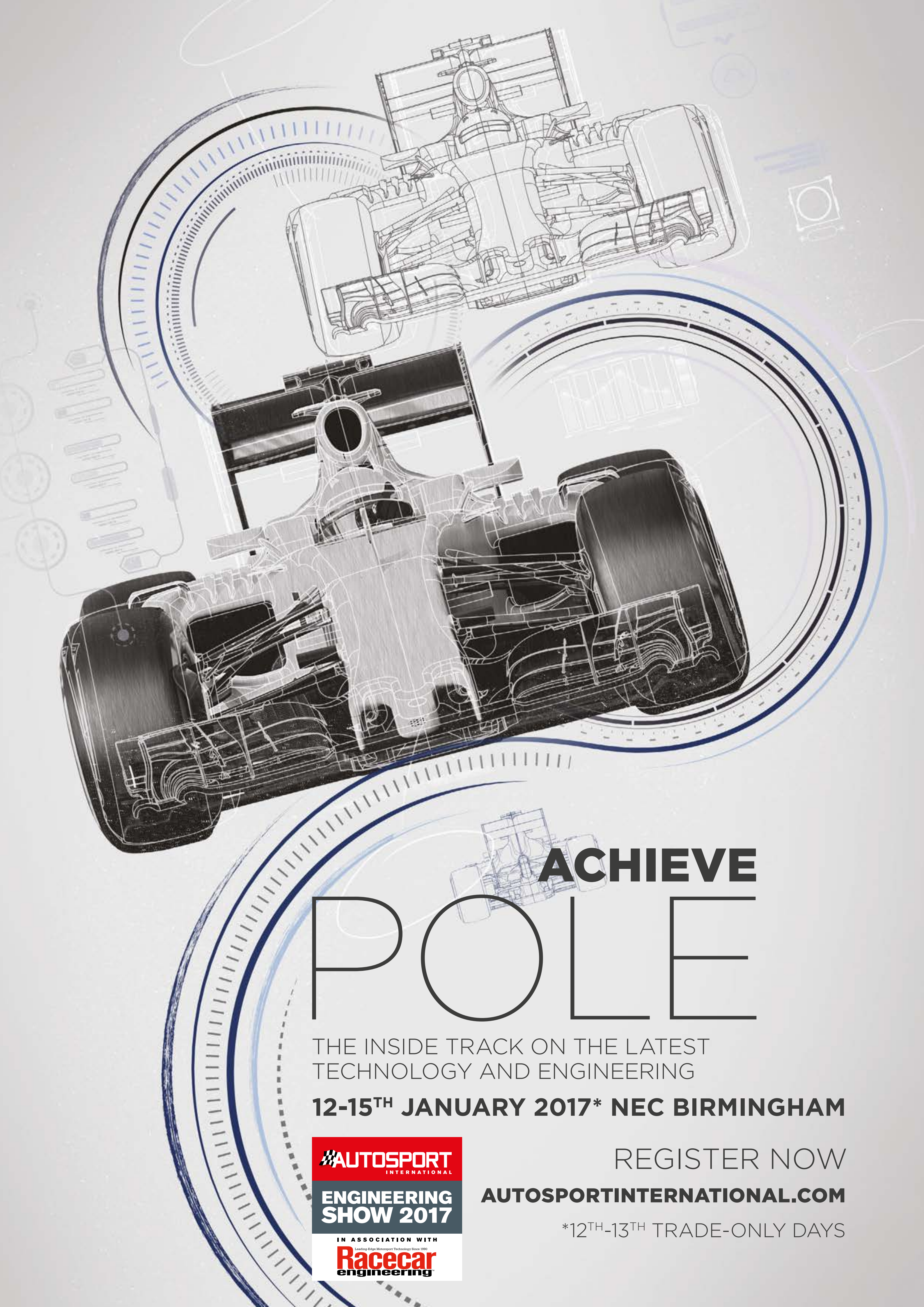
One of the seven Academy winners will work with Renault F1 at the Australian GP in 2017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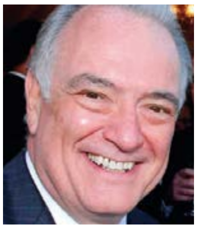

Electrical circuits

Why the motorsport industry is ideally placed to plug in to an electric future

The power of motorsport technology development was demonstrated by the choice of Audi to highlight diesel in LMP1. I think out of its experience has come a realisation across the world of OEMs, that if you engage correctly with motorsport it will accelerate and enthuse people, and even the most odd powertrain choice, as diesel was considered, will be popular.

This is an interesting benefit. It shows that motorsport is powerful at change. Now we are entering a position where OEMs have never been faced with more rapid change, and they have no clue what we as consumers will use in future. It is easy to assume that it will be electric, but in the interim – if there is one – hybrid solutions with ever increasingly efficient ICEs, is on the doorstep. If you think of transferring that into motorsport, then we are superb at making the ICE more efficient, and we are very good now at collecting energy from anywhere and utilising it.

You could see in the next five years that we could be great demonstrators of a real sea change in giving the ICE a future, and getting the public used to the idea that you can have the mix, compared to just choosing battery power, which could be limited by the capacity of the batteries.

Assault on battery

It has just been announced by the British government and the automotive industry in the UK, that the ability to manufacture new and innovative batteries is a core capability that will be invested in heavily in Motorsport Valley. Ever smaller, ever lighter, small capacity batteries, that is, and hundreds of millions of pounds will be put into the UK, and in the middle of Motorsport Valley. I am pretty sure that our innovative motorsport guys will move towards the front of powerful, lightweight batteries, as there is good reason to do so.

For instance, karting has a future if it goes silent. The part of society that complains about them being noisy quite suddenly is silenced. At the moment electric karts are being used just in corporate karting, but tracks are being built with recharging points, and that is an indicator of change.

Another sector that is crying out for electric power is rallying, in particular rallycross, although the trend really started with Pikes Peak. The fact is our Latvian friend (the Drive eO PP03, see *Racecar* V25N8, August 2015) blew them out of the water out of the box. I know the throwaway line is that it was to do with the altitude, but you still have go round the corners and not fall off the mountain. So I am not too sure why rallying has not moved a whole lot faster in the direction of electric power.

The question of return on investment is a question of fan engagement. If you can capture more fans, and get a following for your new technology, then you get a good ROI. I am hoping that OEMs will realise that with motorsport, as they go on the journey of new technologies, they will draw in a new fan base. The younger group are obviously early adopters of this explosion of new technology. That affects the age group of the fan, and therefore will bring in sponsors. The ICE, I am afraid, just doesn't grab them in the way it used to, but if they enjoy drone racing, and that gets going in a couple of years, there is scope to tap that and turn it into proper racing and give ROI to investors.

There will be a need for prototype short-run battery manufacturers

XPB

With their high-revving two-stroke engines karts have a hard time from the noise police – so might quieter electric power units be ideal for the future?

Get connected

OEM brands face a global problem to cope with these changing methods of powertrain. You cannot fragment a global industry that is as massive as automotive is, so they are going to face their own internal challenges. They are well aware that younger people are not taking up driving as they used to, or buying cars as they used to, so they have to respond. It is a very exciting time.

It is said that it takes seven years from concept to final car, so they have to make a decision. You can't deny that electric will be the powertrain of choice because of that. But is it the powertrain of the future? I don't know. We will certainly get hybrids between now and in 10 years, and we will get an increase in electric high performance powertrains. We are experts in motorsport in collecting vast amounts of data in harsh environments, shove it through our systems and we can produce an answer very fast, before the car comes around on the next lap. That makes our technologists in motorsport perfect for the world of connected vehicles. The next 10 years could be about the connectivity of vehicles, rather than autonomous vehicles, and that can be quite cool. We will be able to gather the information and do something with it in performance terms, but in terms of new ownership in F1, you can entertain your fans with it at home and on the track, which is useful for the connected vehicle world. We don't know if we will get full autonomy in 10 years, because even in the automotive world it is still in its early stages, but will it play a part?

Our companies will. It will be a hugely wealthy period for motorsport companies that are willing to embrace new sectors. They have capabilities that they might not have even realised are going to be in demand. I say 'capability' rather than 'product', because when you are dealing with something as innovative as we are, then it is taking your capability to a company, and saying that 'we have the capability to do this', rather than saying 'we have a product'.

Electric dreams

I am excited by the investment being made in the UK in resolving the challenge of the range of an electric car. We are right at the core of this. Once there is a breakthrough in battery technology because of these investments, I think it could be possible to do Le Mans on four swaps of a battery. At that moment in time, can you imagine how that success would popularise electric power to the masses, in the same way as Audi at Le Mans did with diesel? It would be a demonstration of how far that technology had moved on.

There is a fabulous opportunity, there is specifically going to be a need for prototype short-run battery manufacturers. Williams has done it already [with Formula E], but this is ideal for you in motorsport. It is not beyond the realm of possibilities that you will be at the world centre of battery technology. But it is the manufacturer of the cell being close to the manufacturer of the battery that is probably key to acceleration of innovation.

We need to have a big investment in the UK to make cells, which can then be turned into prototypes. Once we find Motorsport Valley companies in close proximity to this source, they are going to be using this technology.

AUTOSPORT INTERNATIONAL
ENGINEERING SHOW 2017
IN ASSOCIATION WITH Racecar engineering

The season starts here

The first big date on the motorsport calender is the Autosport International Show, which is the perfect place to start the 2017 racing season. Here are a few reasons why you and your business need to be there

The world of motorsport is entering into a significant period of change, especially with the wholesale rule changes governing Formula 1 and the World Rally Championship which are set to come into place in 2017. New regulations mean teams must now find new solutions to meet them, while at the same time developing ever-more innovative ways to gain that all-important competitive advantage.

Autosport International and Autosport Engineering in partnership with *Racecar Engineering* remains the first place to witness these brand new developments ahead of the new season. The world's leading suppliers and buyers of cutting edge motorsport technology such as AP Racing, Xtrac, Hewland Engineering, Eibach, Young Calibration and Mazak will be exhibiting – on these pages we've highlighted some businesses to look out for at ASI.

For over a quarter of a century Autosport Engineering has cemented its position as the foremost platform for the global motorsport industry to unite under one roof, and *Racecar Engineering* has been an integral part since the beginning. Exhibitors from 21 different nations will attend Europe's biggest and best motorsport and precision engineering trade show. But what sets Autosport Engineering apart from other events is the range of networking activities available to all business professionals throughout the two trade-only days. For 2017, the organisers have created an all-new space within Autosport Engineering for buyers and suppliers of motorsport technology to meet and discuss new opportunities and to provide the necessary platform where companies can further their own business interests both nationally and internationally.

This new business hub already complements the MIA International Business Lounge and numerous workshops running across all four days of the ASI show, in providing unrivalled networking opportunities for exhibitors and professionals from the industry.

AUTOSPORT INTERNATIONAL
12-15 JANUARY 2017

PUBLIC OPENING TIMES:
Saturday: 9:00am to 6:00pm
Sunday: 9:00am to 6:00pm

TRADE TICKETS (12-13 January)

TRADE	Advance price	Door price
Adult	£28	£30
MSA members	£23	£25
BRSCC members	Free	Free

Tickets do not include access to LAA (Live Action Arena), which is sold separately at £11 (advance and on-site)
Each ticket includes a Trade Directory (value £10), collectable on the day.

STUDENTS

Ticket type	Trade days (12 and 13 January)	Public days (14 and 15 January)
Student 1 day entry pass	£28	-
Student 1 day entry pass + LAA	£33	-
Tutor 1 day entry pass	£28	-
Tutor 1 day entry pass + LAA	£33	-

How to book
Trade Days.
To register visit www.autosportinternational.com
or call 0844 335 1109
(BRSCC Members should contact the BRSCC directly)

CONSUMER TICKETS

	Adult	Child (6-15yrs)
Standard	£35pp	£23pp

Electric GT (Hall 6 Stand 6250)

Electric GT will have its modified Tesla Model S P85+ race machine on display at the show and visitors are in for a further treat as this first-ever fully electric GT racecar will also make a number of dynamic appearances within the Live Action Arena; the first chance to see it in action.

With eight drivers already announced, a number of the new 'Electric Heroes' will be presented at Autosport International. The 2017 Electric GT Championship will consist of 20 international drivers, both male and female, racing for 10 professional teams.

Each team will race in identical race-prepared Tesla Model S racecar equipped with the latest OMP safety equipment and running on bespoke Pirelli tyres.

The series will visit seven classic European circuits in its inaugural season, including Paul Ricard, Barcelona, Assen, Estoril and the Nurburgring, before staging three non-championship races in the Americas.

Electric GT's Tesla S P85+ car is to perform in front of the public for the first time at ASI's Live Action Arena

Yamazaki Mazak (Hall 9 Stand E1240)

Yamazaki Mazak's new 5-Axis multi-tasking, latest generation machine debuts at Autosport Engineering in January.

Mazak has a long history of supporting Autosport Engineering and supplying CNC machine tools to the global motorsport sector, most notably in Formula 1.

As well as providing machine tools to the Renault and Mercedes F1 teams, Mazak is also the official supplier of CNC machine tools to the McLaren Honda Formula 1 operation.

Mazak will be exhibiting its new state-of-the-art VARIAXIS j-500/5X 5-axis machining centre, which combines a compact footprint with the ability to offer simultaneous 5-axis machining across multiple surfaces, making it ideal for automotive applications involving volume, small batch, or prototype work.

The VARIAXIS j-500/5X delivers high accuracy and productivity from a wide B-axis spectrum of rotation (+90-degree to -120-degree). Outstanding accuracy is guaranteed by its high rigidity structure, Mazak tells us, which utilises linear roller guides on all linear axes and roller gear cam on both rotary axes.

Most importantly, the VARIAXIS is equipped with SmoothX, the 5-axis version of Mazak's SMOOTH Technology, the world's fastest CNC.

SmoothX includes a 19in touchscreen control panel, and has the capability to deliver vastly improved machining, from programming and cycle times through to automation integration, data collection and ergonomics.

Mazak is a world leader in motorsport engineering CNC tools

Gearing up for the new racing season: there's nowhere quite like ASI for getting to the very heart of motorsport engineering

Young Calibration (Hall 9 Stand 232)

Young Calibration returns to Autosport Engineering in 2017.

It provides UKAS accredited (Lab 0604) calibration services and thermal fluid component testing to customers around the globe. As its name implies, it is a young, vibrant and professional company employing leading edge technologies throughout the laboratory. It has knowledge and experience of flow calibration, air velocity, thermal testing and component cleanliness.

The West Sussex-based firm also brings news that it will continue its laboratory expansion with the opening of a new Durability Test Laboratory. The facility provides pre-production validation, prototype development and type approval testing for electro-mechancial and thermal fluid components utilised within the internal combustion engine.

Young also has a 24-hour emergency call-out facility, which enables high priority production line problems to be addressed with immediate attention and with minimal disruption to the ongoing production.

The team has presently completed projects and rectification solutions for; identification of leaks, component performance issues, casting porosity, assembly misalignment and component cleanliness issues. Working with engine sizes from 25cc to 80-litre displacement, the facility covers all major automotive, traction, motorsport and marine applications.

Testing facilities are available at Young Calibration for thermal cycling, pressure cycling, burst, leak, altitude, corrosion, vibration, ageing, SWAAT, bump, hot soak, cold soak, pump performance, smart coolant drives, flow, pressure and temperature characterisation on component cleanliness and particle analysis.

ASI Q&A: Lifeline's Jim Morris

Following the successful introduction of the Lifeline Zero 3620 fire suppression system, the company has launched the new Zero 3620 Firemarshal, a further development of the original system, designed to meet the increase in demand as more categories are required to use systems approved to the FIA 8865 suppression standard. Autosport International caught up with Lifeline's managing director Jim Morris, ahead of January's show at the NEC, Birmingham.

ASI: *Where is Lifeline right now?*

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

ASI: *Why is the introduction of the FIA's new fire suppression standard so significant?*

JM: As we know, the FIA are duty bound to ensure that motorsport is as safe as it can be, and so they review their safety rules and standards regularly. With the latest introduction, they have increased the required levels once again, and it is up to us in the industry to make sure we meet it. This can be a challenge both technically and financially, but I commend them for taking this approach to try to be ahead of the game rather than wait for a significant incident to occur and introduce new standards afterwards.

ASI: *How far ranging are these new FIA safety standards?*

JM: What the FIA have done is, in effect, bring WRC levels of safety standards down across the other categories in rallying such as R5, Super 2000 RGT and T1 Cross Country vehicles in 2017. This potentially means that competitors in these series are faced with significant cost increases, unless there are cost-effective systems available that still comply to the new standards. This is the reason why we have collaborated closely with the FIA to produce the Zero 3620 Firemarshal system, which is the first system to be FIA-approved to meet the new standards, but at a significant cost reduction compared to our WRC spec Zero 3620 system.

ASI: *Why does Lifeline make such a commitment to achieve this?*

JM: Well, my father used to race and I compete myself as well, and so there is a long history with competing, and knowing what it is like as a competitor out there. We all want to enjoy our racing safely, and so we would never compromise on quality, but at the same time, it is crucial that costs are being kept under control as much as possible, and so we are committed to meeting that challenge. I suppose we could just not care and simply sell our WRC spec system, but that is not the way we like to do things.

ASI: *What does Lifeline see as the main benefit from exhibiting at ASI?*

JM: ASI is very much the showcase of the year. It is crucial for us to meet our customers and keep them up to date with the latest safety developments. Bringing our Firemarshal system to the show was a priority for us from the start and we look forward to showing it to the show visitors.

Working in the sunshine

It was strange to be in 27degC temperatures just over a week before Christmas, watching racing cars in the Florida sunshine, but then racing is hardly ever a normal lifestyle. First of all *Racecar Engineering* attended the Dunlop tyre test programme with the European-spec LMP2 cars from Dallara, ORECA and Ligier, and with the GTE Aston Martin that has to adapt to new-for-2017 regulations. On Wednesday morning with a day to kill, I then drove two and a half hours north to Daytona to see the DPI cars in action for the first time. The two tests were illuminating.

Sitting on a wall outside Turn 1 at Sebring, I timed Stephane Sarrazin in the Rebellion-run ORECA at 1m47.6s, already comfortably faster than last year's pole position time for the Sebring race (on Continental tyres), which was hardly unexpected – after two days of running with the four cars, there was some rubber on the track (although not as much as during a race weekend), the temperatures were dropping into the evening, and the track temp was high, the LMP2 cars have around an extra 100bhp compared to last year, more efficient aero and are new. What was surprising was that he set the time in a seat that didn't fit properly, and so was effectively driving one-handed.

Then, on to Daytona, where the cars were reported to be lapping around 1m36s, already faster than the record despite IMSA's watchful eye on the balance of performance. Yet the sandbag grand prix was on in all of its glory, with teams and drivers openly admitting that they couldn't go any slower if they tried. With just limited running on the opening day of the IMSA test, the Cadillac Dallara was accidentally the fastest, just as the driver was sorting out whether or not his seat fitted.

The sandbag grand prix was on in all of its glory, with drivers admitting they couldn't go any slower if they tried

There is a certain buzz about these cars on both sides of the Atlantic. Despite the electronic issues that plagued the racecars in both of these initial tests, they are clearly quicker straight out of the box than anyone had any right to expect. Suddenly Gibson's prediction of 325km/h in a straight line at Le Mans (set-up permitting) sounds about right.

There is a lot of back-slapping going on at the moment and it looks to be deserved. At this point, there has to be a caveat. The cars have only just started to run (Dallara hadn't completed any night running ahead of the Sebring test, for example, and the Riley was not there at all. Also, the final testing for items such as brake pads had not yet been finalised, so none of the Daytona Prototype International cars were running in homologated format) so reliability at the first race of the year, the Daytona 24 hours, could be suspect. The first race for the Daytona Prototype cars, in 2003, saw the GT class Porsche winning the Florida race overall, for example, and it may be that these racecars won't be robust enough for this tough debut. Teams are, apparently, already looking at the garage and consider that the race will be won or lost in there, rather than out on the race track.

However, for now, not only are the cars fast, but they look good too and, in the US certainly, there is a sound business case for manufacturers to get involved. Manufacturers are looking for cheap wins, and none can be cheaper than racing in DPI. At stake is the North American Endurance Cup title, including the Daytona 24 hours, Sebring 12 hours, the Watkins Glen 6 hours and the Petit Le Mans, a 1000-mile race at Road Atlanta in October. For a manufacturer, it has to buy a ready-sorted car, develop and install an engine (probably the most complicated/expensive bit of the whole process), develop bodywork and present it for homologation to IMSA. That, plus a running budget of between $2m to $2.5m per year (IMSA's estimate). A manufacturer could have a four-year programme for less than $15m-$20m, then, and go for some of the biggest wins in American sportscar racing. That's a big market for Volkswagen, Bentley, Ferrari, Porsche, Nissan, Toyota … the list is actually pretty long, and organisers are confident that at least one more manufacturer will come in 2018, and there are up to five more that are starting to take active notice. It doesn't even need to be with a factory team – that would fit with Ferrari's Clienti Corse model and it has done that before, with the Ferrari 333 SP, as has Porsche in the 956/962 era.

It would be interesting, although admittedly not that informative at this point, to look at who was in the original meeting at Daytona on January 27 2015 when the outline proposal for LMP2 was put together. The full list of manufacturers in attendance reads: Bentley, VW, Ford, Riley & Scott, Mazda, General Motors, Coyote Cars, Wirth Research, Engine Development, Multimatic, Lamborghini, Dallara, Nissan, ORECA, OnRoak, HPD. Rumours of the others are easy to start, and I am sure that they will quickly be put to bed. But there is no doubt these new cars have sparked the imagination. And so they should - they are running at LMP1 2012 pace at Sebring. That's something to celebrate!

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