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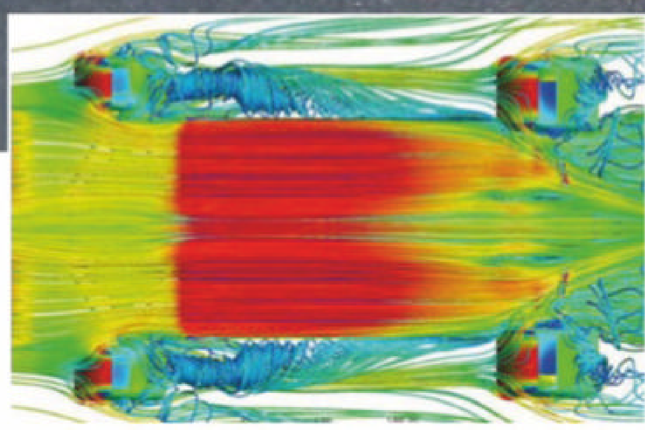

Simon McBeath

Formula 1's ground effect era gets the CFD treatment


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Wing envy? Whether the new F1 aero rules will spice up the show has yet to be seen, but this bird at Melbourne doesn't seem so impressed. Turn to page 8 for our aerodynamic insight


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Freight expectations

Why Brexit could lead to huge complications when it comes to taking racecars abroad

My thoughts on politics tend to be scathing, so I usually keep them to myself. It's not so much of the politicians, venal banalities that they are, but more the voters themselves. After all, they are the ones that vote the scoundrels in, and so they shouldn't really complain about the outcomes.

This column is being written before one of the votes that could determine how and where the UK will align itself with Brexit, One of the multiple outcomes of all this could take us back to an increase of the paperwork that will be needed to take racecars, equipment and crew to whatever venue they will perform at. This has only dawned latterly on me, as for a considerable time travel within Europe had been seamless and bother free and the same went for goods. Now visas for the UK might be needed again, and likewise European visas, for Brits.

Border hostilities

The grim business of having to plunge yourself into Kafka-world only happened when getting visas to places like China or some benighted country where one would race, or even just pass through, such as the United States. In fact, my dealings with that country always seem to include acrimony, especially from the days when we had GPs in Mexico or Canada, but had to transit through the land of the free and the brave.

The transit lounge concept, where people just changing planes is a minor happening, seemed absent in the US. You had to go through immigration, where usually my retort to being asked why I was coming to that country tended to devolve into one of my rants: 'I don't want to come here, I have no intention of living here, and I don't know how you all think this place is the best place in the world to be in, I'm just forced to do it because of your moronic insistence, I do so on my way to other, better, places'. The thought that this is possibly something that I will have to consider while coming to the UK still seems surreal.

I now travel on a French passport, as I had not bothered to claim a UK passport despite having an English mother and being married to an Englishwoman; this was simply because the Brazilian passport I had used had been quite adequate for most travelling before fears about mass migration loomed on the horizon.

After working for two years in Italy, upon return to the UK after a gap of three months without visiting it, I was surprised when the immigration officer questioned my reason for entrance into the UK, as I had been a resident for over 10 years by then. It seemed being absent for that period of time meant I would have to apply for it again, it being now null and void. 'New regulations, sir.'

Worse still, when inquiries were made on how to obtain a British passport it seems that being married to one Brit and the offspring of another wasn't enough, and to add insult to injury, my residency for all those previous years would be ignored and I would have to wait for seven years, as a resident, to then be eligible to apply.

Moving racecars and equipment from country to country is a complex task, but it could get a whole lot worse for British teams if there's a hard Brexit

The serendipitous circumstances that eventually led me to being a French resident and in the fullness of time a citizen is one of the better outcomes of all that bureaucracy.

Shipping forecast

But these personal problems are small beer when compared to the hassles that could now return for race teams. Anyone who was based in the UK, or, anywhere else on the continent, still has allergic reactions when the 'ATA carnet' is mentioned.

This was a workaround for customs, where at the beginning of the year the teams would deposit a hefty bankers draft for the material that would be going in and out of countries, considerably easing movement. The carnet, a large, multiple-page booklet, had pages that had to be filled in for the relevant customs port, and stamped in to the country and stamped out on exit. Turn up back in the UK with any of the stamps missing and it meant you would forfeit your bankers draft for the relevant equipment when they were returned at the end of year. You had multiple carnets, for the rolling chassis, for the engines, the tools and the other equipment, and it was an exceedingly boring chore to sort it all out. Bureaucracy was even worse then than today, as nothing was computerised. The sight of the officers sitting in a dusty paper strewn office only missed the goose quills and parchment to look like a scene from Dickens.

Budget smuggler

At the end of the year there was always a day of reckoning looming, as from bitter experience the lack of one stamp, say in exiting Eastern Ruritania, even if all the subsequent pages were okay and it all had been stamped back into the UK, could lead to months of arguing the case to avoid the forfeiture. To quote Karl Marx: 'For the bureaucrat, the world is a mere object to be manipulated by him.'

As we were using engines prepared by Novamotor in Italy, we had used Italian teams with the same motive power, when convenient, to take them back for rebuilds in their truck, avoiding the added logistical problems of having to take them ourselves. Them not exposing their wallets to the sanctions was the flaw in this method. We found out, by having multiple entries or exits missing on separate carnets, that my Italian mates sometimes didn't bother.

This eventually led to a desperate attempt to collect the stamps on future occasions by having engines in the boot of the car hidden in oversized suitcases on other trips going out, and then stamping the carnets to square them coming back. Not always successfully. Thus does racing inevitably lead to a life of crime. Being a smuggler had not been included in my career planning.

And in case this seems to be something minor that is just part of business, consider that one of the biggest problems we had in actually designing and building an F1 car in Brazil was the fight to get parts out of customs to fit on to the cars. All reducing to the old cliche: 'Be careful of what you wish for, it might become true'.

One of the biggest problems we had in designing and building a Formula 1 car in Brazil was the fight to get parts out of customs

Aiming high, hitting Lowe

Does Williams need to completely rethink its approach to running a Formula 1 team?

Only those of a *schadenfreude* disposition can have enjoyed the very public fall from grace suffered by Williams technical director, Paddy Lowe, an engineer with a high reputation and considerable experience at the forefront of Formula 1 (see page 96).

Lowe is not the first to go as part of Williams' recent adoption of professional football club habits and its frequent hiring and firing of managers. Even so, it is difficult to understand how an F1 car can be conceived these days that is more than two whole seconds off the front-of-the-grid pace. Especially when it has one of the best power units. This is despite all the previous design and engineering data and digital simulation technology available, and the wealth of information that Lowe must have accumulated while at Mercedes and brought with him to Williams.

Human resource

Lowe's situation rather illustrates that it's one thing to forge a formidable reputation when part of a highly talented and superbly resourced engineering team; it's quite another to live up to this when the surroundings are less favourable. Taking on the responsibility for the overall role can be a stretch too far without the support of a high-level engineering design and production structure, one that is up to speed with contemporary thinking, as was the case in his previous positions. So much depends on having management skills – of people and processes – and the ability to identify the really key design directions and control their implementation. And to do this on time too, because if you start on the back foot, you'll likely stay there.

I suspect that the failure to meet the first-car delivery target has affected performance even more than the subsequent testing time lost. It's not unusual, when time is fast running out, to start cutting corners. Strict design and manufacturing validation processes can be a victim when panic sets in. Just one weak link in the complex assembly of components that creates an F1 racing car can create no end of misleading handling problems. Effort that would ideally be spent on optimising certain aspects of the concept – especially in the aero department – right up to the latest deadline, if swept aside purely in order to get the car on track, will certainly compromise its full potential.

More concerning is that it's now being said that a fundamental design fault exists – the same reason for poor performance given last year. This begs the inevitable question; was nothing learned from this? Given the restrictive Formula 1 regulations which dictate so many parameters, even down to front/rear weight distribution, what can be so wrong that it can't be at least partially fixed?

An understanding of how to work the tyres to best advantage is possibly the trickiest knowledge to gain. With Pirelli's offerings this is super-critical and without having successfully analysed what is needed to achieve this, no amount of fettling will get the result needed. As long as big changes such as wheelbase and rake-angle or a complete re-design of the aero concept are not required, if this breakthrough is achieved at least a useful amount of improvement should then be found fairly quickly. Enough surely to bring the car towards the midfield pack from which the FW42 is currently so sadly and humiliatingly distanced.

XPB

The Williams FW42 struggled in Melbourne and the team now believes it has a fundamental design issue. It said the very same of its 2018 racecar

Frank speaking

These woes also highlight, I suspect, a deeper issue. The Williams family speaks passionately of its pride in being an independent constructor, making almost everything in-house. Fine though this determination is, it is only sustainable if it works. On good authority, I understand that much of the Grove team's design and engineering assets are in fact behind the times, such has been the huge upscaling of technology in Formula 1 in the last few years. Better perhaps to spend money on upgrading these tools than on large pay-offs to sacked engineers? Pride can be a good thing, but it needs to be paired with pragmatism.

Reaching out

Pride before a fall is a well-known saying, for good reason. Other than McLaren and Renault, all the F1 teams ahead of Williams (which means all the teams) benefit from some level of collaboration with the big three outfits, whether just purchasing transmissions, such as Racing Point from Mercedes, or a hefty chunk of the whole car, like Haas from Ferrari. Now, I don't much like this trend any more than Sir Frank or Claire Williams because it can be the thin end of the wedge leading to a semi-spec formula, which in my opinion would be disastrous for F1. Nonetheless, that's the way things are and there's little point of swimming against the tide in such an unsentimental and unsympathetic environment. If the regulations permit off-loading substantial high R&D spend onto a wealthier and much more competitive outfit, freeing up one's own resources to concentrate on areas of the car design that will reap greater benefit, then you're just sticking your head in the sand if you ignore the opportunity. Results are what matter, especially when the viability of the whole organisation is at stake.

Contrary, no doubt, to the views of the majority, unless the 2021 regulations (still awaiting publication at the time of writing) seriously even-out the distribution of money among the constructors, I can see an argument for actually taking this practical solution even further. Why not allow any two Formula 1 teams which lack the finances of manufacturer-backed competitors to collaborate even more closely – *but only with each other* – on the research, data share, design and construction of certain elements of their cars? Why not share the same monocoque, for instance, this almost being defined by the technical regulations anyway?

Division of responsibility and resources together with eliminating duplication greatly reduces costs and could quickly bring these entrants much closer in performance to the big guys. Almost like creating a virtual budget.

I suspect that the failure to meet the first-car delivery target has affected performance even more than the subsequent testing time that was lost

Air warfare

The new-for-2019 Formula 1 technical regulations have been met with a variety of fascinating and sometimes conflicting aerodynamic approaches, but which of the teams has found the optimum solution?

By GEMMA HATTON

There has been a lot of hype surrounding the start of the 2019 F1 season, and for good reason. Forgetting the 12 driver swaps, the three rookies and the change of power unit for Red Bull, there has also been a new set of technical regulations that have been specifically designed to spice up on-track action. But how can changing the dimensions of aerodynamic components equate to better racing?

We have all watched eagerly as F1 drivers on the charge hunt down their next victim to overtake. Yet when they get to within a second or two of the car in front they almost seem to quite suddenly switch to cruise control, never quite dipping under the one-second gap to gain the benefit of DRS, leaving the team frustrated, and the viewers disappointed.

In an effort to reduce controllability of the front tyre wake, which should help increase the potential for overtaking, wider and more simple front wings are the order of the day for 2019

Of course, this cruise control effect is actually a result of the hot, turbulent wake coming off the car in front. As air flows over the wings, tyres and all the other aerodynamic devices of a Formula 1 car, it loses energy and slows down. Low velocity flow leads to turbulence and by the time the airflow has worked its way downstream of the car, it has transformed into a hot, unsteady mess that the car behind has to drive through. Therefore, the pursuing car always experiences a performance loss compared to the car in front, which is why it slows down. Add to this the hot wake overheating the brakes and increasing tyre degradation and it's a wonder we see any overtaking in F1 at all.

Thankfully, Formula 1 and the FIA have recognised this and have worked with top aerodynamicists to rewrite the rules and change the behaviour of this turbulent wake. 'The aim of all the FIA's research has been to reduce the turbulence that the following car has to drive through, by making sure that the wake is as high as possible,' explains Arron Melvin, principal aerodynamicist at Haas F1 team. 'They feel that they can achieve that by reducing the amount of outwash the front wings generate.'

Outwash washout

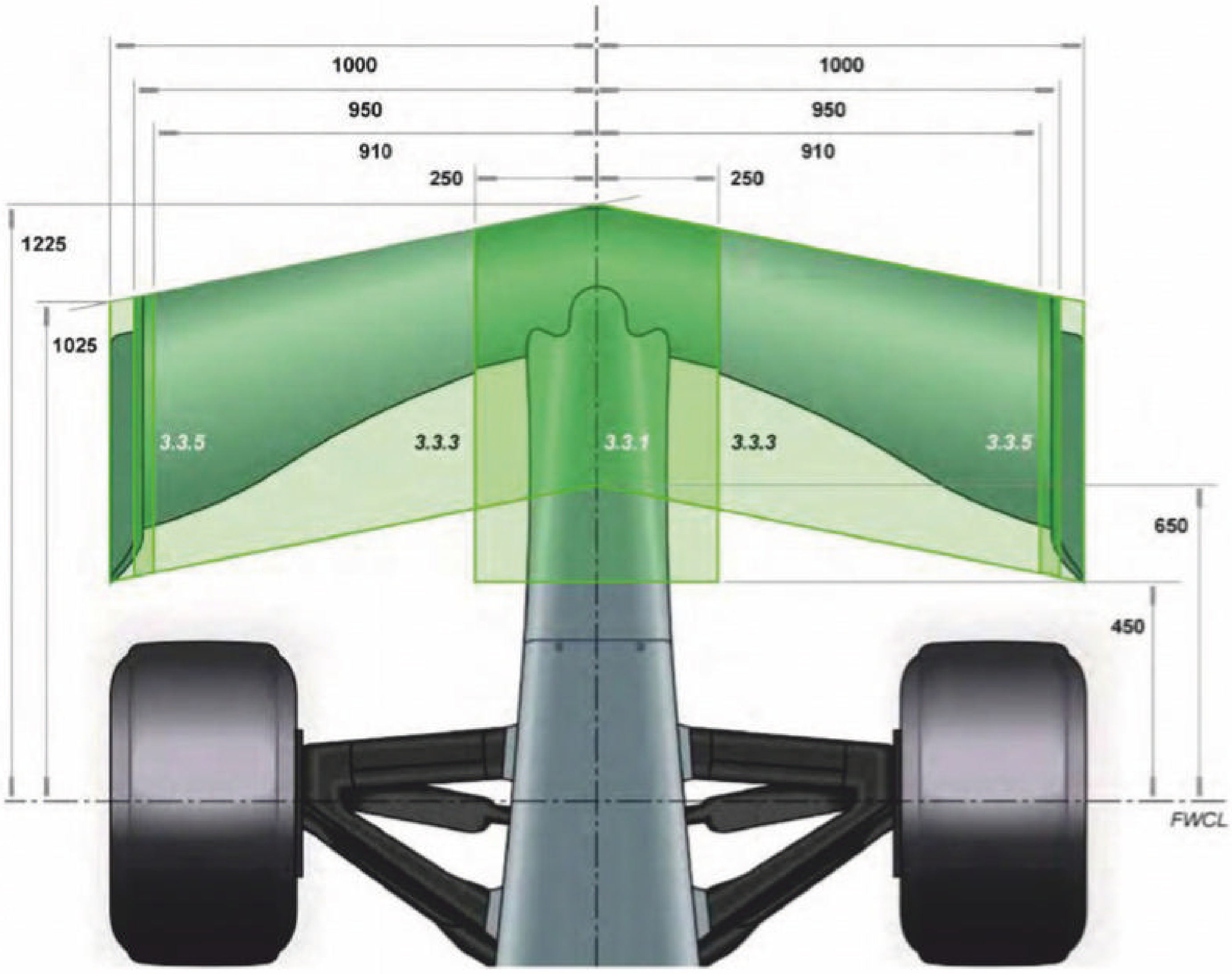
Outwash has been another buzzword for 2019 but what does it actually mean? 'Tyres create a lot of aerodynamic chaos behind them; they generate a nasty wake of low energy chaotic air and if you allow that to fall on your own car then it damages its ability to generate downforce,' says James Allison, technical director at Mercedes. 'So, every year since 2009 we've been developing techniques to take the wake of this tyre and throw it away from the car, as far away as we can. The main agents of throwing that wake outboard is the front wing, front brake ducts and the bargeboards behind. Sadly, if this airflow doesn't fall on your own car, it winds up on the car behind you and makes it much harder for that car to then follow.'

To try and improve the racing, the F1 teams themselves voted to change the regulations to limit their ability to control the tyre wake. 'Outwash is just a particular method of reducing and manipulating the front tyre wake, namely moving it away from the car,' highlights Melvin. 'Imagine a teardrop-shaped 3D wake behind the tyre. By changing the outwash we are just trying to move the wake more outboard of the car, so it's not that we don't create the wake, we just change the point at which the flow separates which essentially rotates the wake. For us, we want to push it out, [and] the challenge is to push it out along its height, but we no longer have the devices up high on the front wing to help us achieve that.'

Although these rules might not be a revolution, they have already induced enough variability to spice up the 2019 Formula 1 season

As the front wing is the main device teams use to direct the tyre wake away from the racecar, this is the area that has seen the most changes. Compared to 2018, the front wing length has increased by 25mm, while the overall width has extended by 200mm, matching the full 2m width of the car. With the end-plates now 100mm further outboard, less effort is needed to turn the airflow around the tyre, and so the complex array of winglets that used to sit on the outboard section of the wing are now gone. Furthermore, the end-plates have been simplified and the wing can only feature five closed main elements, two strakes, the necessary brackets and a fairing for the tyre temperature IR sensor.

Designing the front wing is a balancing act between generating downforce and generating outwash, and this year's regulation changes have altered this balance, leading to a variety



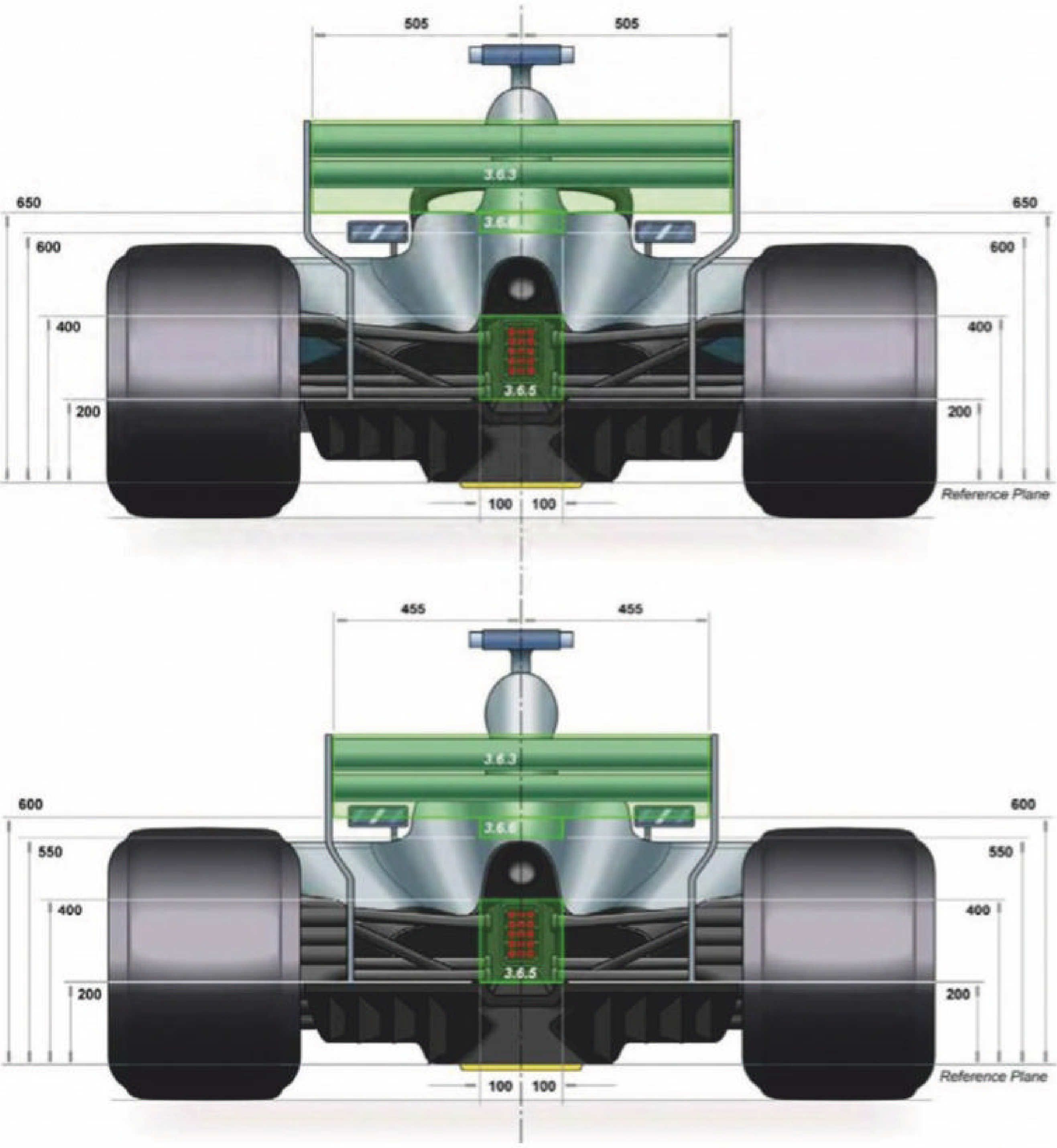
Designing the front wing is a balancing act between generating downforce and producing outwash

of approaches up and down the Formula 1 pit lane. 'There is quite a divergence in front wing design, as there are at least two or three different approaches,' says Jody Egginton, the technical director at Scuderia Toro Rosso. 'Some teams are loading the outboard section of the front wing very differently to others, by focusing on outboard loading rather than just generating outwash. I think the front wing is one area that is going to see rapid development but also the bargeboards, forward floor and brake ducts as teams try to get outwash as well as the Y250 vortices and the front inboard tyre jet where you want, the development is just going to be ongoing really.'

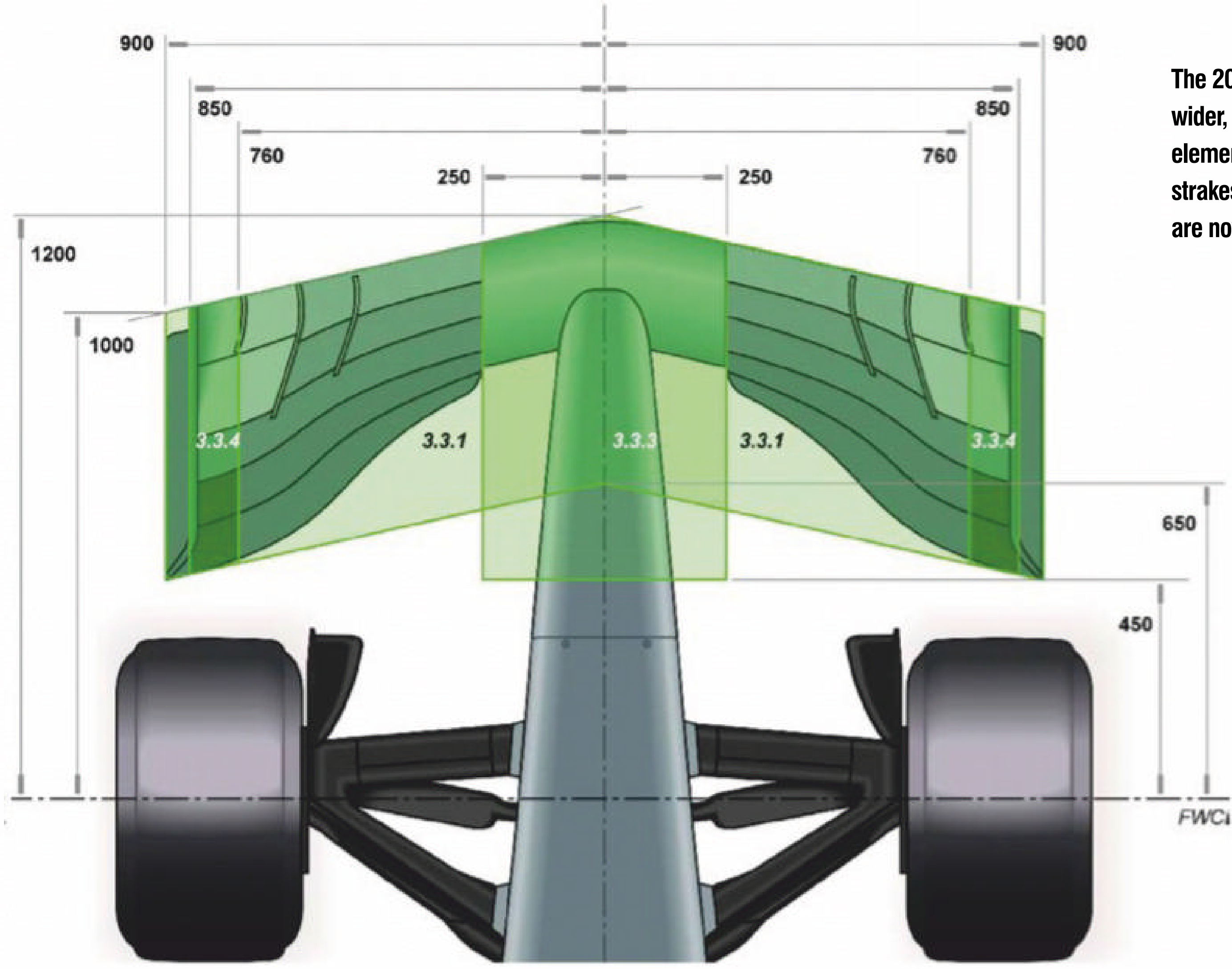
Differing approaches

There are three approaches to this year's front wings. The first is an unloaded front wing, as seen on the Alfa Romeo and the Ferrari, where the height of the five main elements is much shorter at the end-plate and dramatically increases in height towards the nose. This reduces the wing's ability to generate downforce, as there is less flap area in front of the tyre, but it does help to promote outwash.

At the other end of the scale are the likes of Mercedes and Red Bull which have chosen



For 2019 (top) the rear wing has increased in height by 50mm and is now 100mm wider and deeper than 2018 (bottom)



The 2019 front wings (facing page far left) are now 100mm wider, 25mm deeper and have had all the outboard elements banned. Only five closed main elements – two strakes, brackets and a mounting for the tyre IR sensor – are now permitted. The 2018 wing is shown on the near left

a 'loaded' design. Here, the height of the main elements are at a maximum at the end-plate and slightly reduce or remain consistent towards the nose. This maximises the amount of downforce generated, but reduces outwash.

The third and final approach is halfway between the previous two, with more conservative transitions in height between the outboard and inboard sections of the wing. These approaches all aim to manipulate the height of the separation point on the tyre, and therefore the characteristics of the tyre wake. It is also interesting to note the higher throat area of the Mercedes front wing, where the lower element elevates up to the end-plate, leaving a large area for air to flow under the wing.

Lame duct

Another method teams use to direct the tyre wake away from their racecar is by utilising the front brake duct. 'The flow from the inboard to the outboard side of the wheel through the brake duct or upright is a very powerful mechanism,' explains Melvin. 'We know it's a powerful mechanism because we had much more freedom in the past so we have an idea of what can be achieved. The flow coming through the wheel helps steer the tyre wake wide, it's less about local drag and more about steering of the wake. Now the challenge is the new rules, and what we can do within those new constraints to achieve a powerful flow turning, that we know is worth it.'

'The flow from the inboard to the outboard side of the wheel through the brake duct or upright is a very powerful mechanism'

Unfortunately for the teams, these restrictions are fairly dramatic. Only a single aperture is now permitted that 'must be constructed such that no point on the periphery of the aperture is more than 50mm from any other point on the periphery of the aperture.' All the complex turning vanes that surrounded the brake ducts of 2018 are now banned and any apertures where the suspension legs, uprights or brackets meet the duct must be sealed so that no air can flow through them.

But with the outwash effect of the front wing so restricted, it is even more important to develop the brake duct to try and recover this, despite the new rules. Therefore, it is not surprising to find that teams have exploited a 5mm gap between the wheel rim and the duct. 'The new rules fundamentally use a smooth, teardrop-shaped duct, but there is a 5mm offset from the wheel rim, where we can take a very small span of this non-smooth shape. All the teams have taken advantage of this,' says Melvin.

Another area of interest is wheel rims, and following controversies last year it seems that this will continue to be a topic of discussion for 2019. Wheel rims not only provide a mount for the tyres to be fitted to, but they also encompass the discs, pads and calipers of the braking system. With some of these components hitting maximum temperatures of 1000degC or more, the wheel rim has to not only withstand these large fluctuations in temperature, but also be designed to manage this heat transfer between the brakes and the wheel rim. This is why teams have been constantly evolving the intricacies of their wheel rim designs to try and control the wheel rim temperature to either warm up their brakes and tyres or cool them down through dissipating as much heat to the surrounding air as possible.

'Obviously there is heat transfer from the brakes and depending on where we are with the rim, air and carcass temperature, we

To try and improve the racing the Formula 1 teams themselves voted to change the regulations to limit their ability to control the tyre wake

‘There is quite a divergence in front wing design on the 2019 F1 cars, there are at least two or three different approaches’

will decide how we want to distribute that heat transfer and that has been the trick for quite a number of years now,’ Egginton says. ‘Everyone has been trying to get smarter at ensuring that that heat transfer is under control and doing what they want. It’s no secret that people have been developing wheel rims to increase surface area by knurling and other features and it’s all part of the same challenge; to improve the control of rim temperature, air temperature and carcass temperature.’

With the 2019 rules heavily restricting the amount of air that can be blown through the wheels, dissipating the heat from the brakes could be a major challenge, which is why we are seeing a change in wheel rim designs compared to last year. However, this heat could also be used to help with tyre warm up.

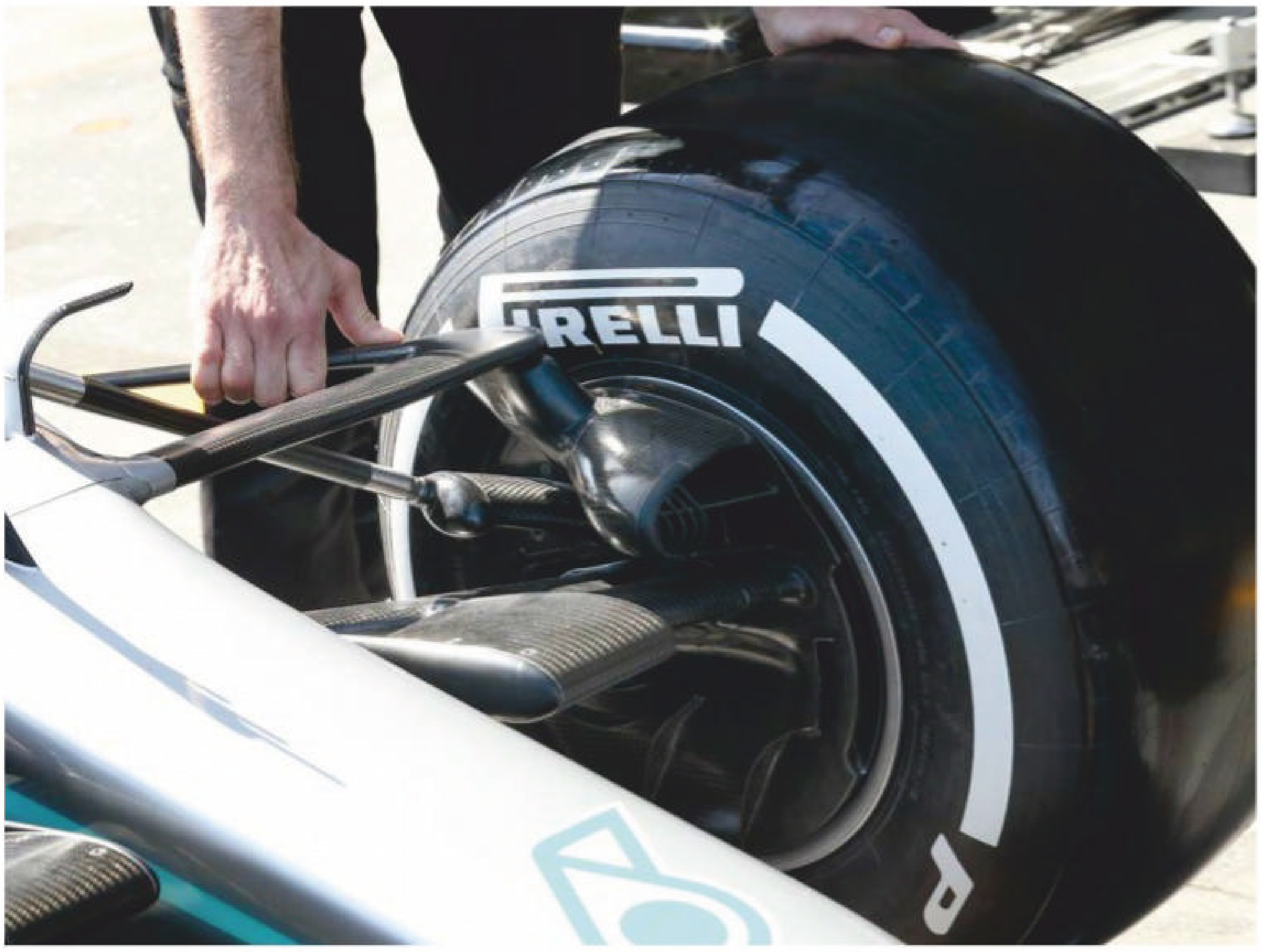
‘We’ve been using similar brake technology for a number of years now and the operating range is fairly well known. Once you’ve got a handle on that, you want to make best use of that heat energy to optimise your tyres,’ says Egginton. ‘Ultimately, getting the tyre to the carcass temperature we want is what decides how much heat transfer we apply. So, if we’re struggling to get a front tyre into the working range we would typically try to make use of the brake temperature heat transfer to the rim [and then] to the tyre. Now that could involve running the rim at a higher temp than you would do if you had no warm up issues.

‘In all honesty we have operating limits for all materials and designs but within that we want enough options to be able to put the tyre where we want it,’ Egginton adds. ‘Typically, everything is tyre driven but you wouldn’t take a huge risk on the brakes in order to try and achieve a tyre target. I think if we have 10 conversations [about wheel rim temperature] eight of them would be to improve tyre performance and two would be to improve brake performance, because we understand the brakes quite well, whereas the tyres are variable week on week, circuit to circuit.’

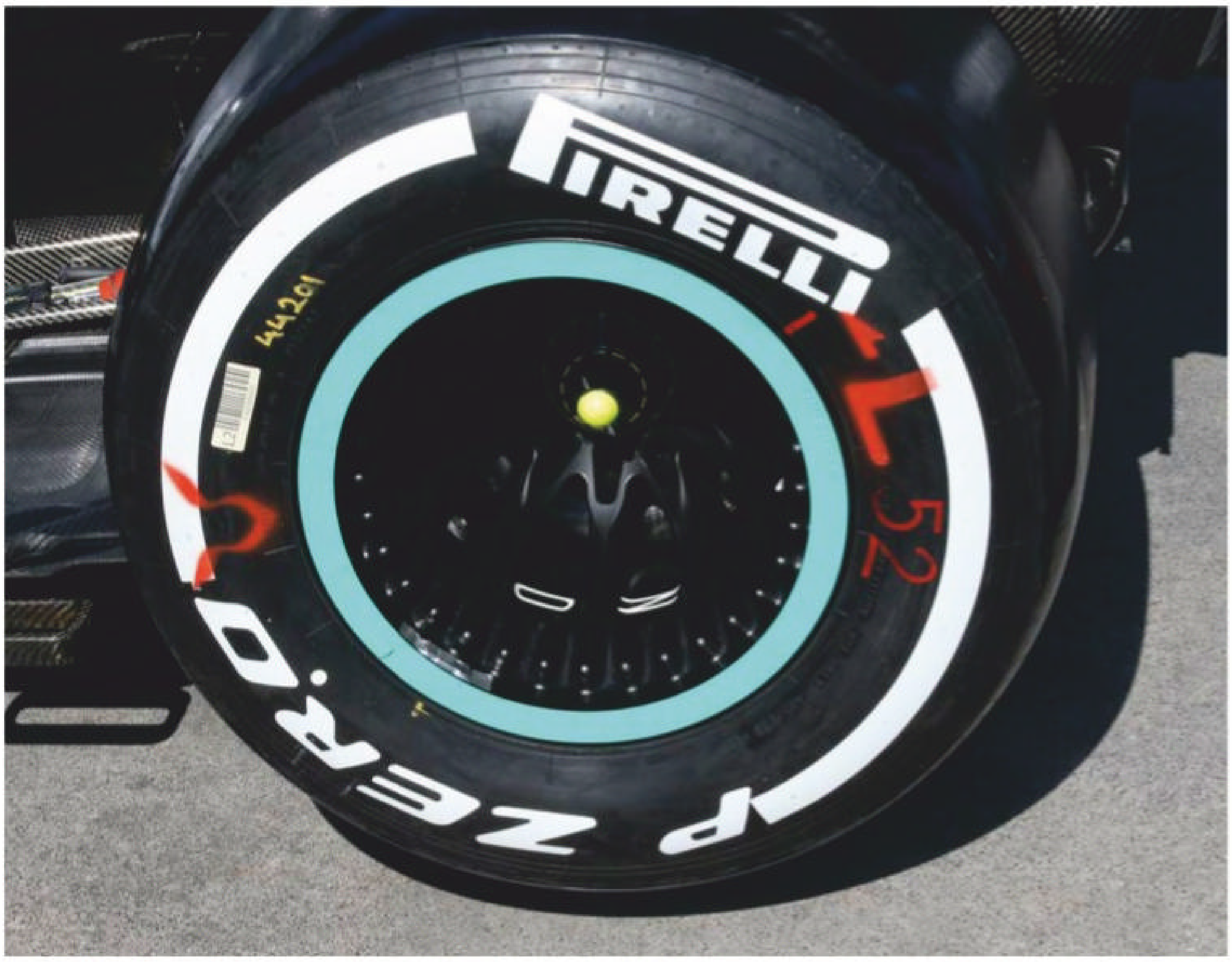
Board member

Moving downstream, the sidepod leading edge has moved rearwards by 50mm, while the bargeboards are now 100mm further forwards. Bargeboard height has been another major change, too, decreasing by 125mm from 475mm in 2018 to 350mm. Although the fundamental philosophy of the bargeboard area remains the same for all the teams, the specifics of the designs vary greatly to suit the individual concepts of each team’s racecar.

‘The main turning vane or bargeboard creates a very large side force, which is again



Teams have exploited a 5mm gap of freedom between the wheel rim and the duct. Mercedes uses two longitudinal openings



Rules restrict the amount of airflow through the wheel, but increasing the surface area of the rims helps to dissipate heat

‘Typically, everything is tyre driven but you wouldn’t take a huge risk on the brakes in order to try and achieve a tyre target’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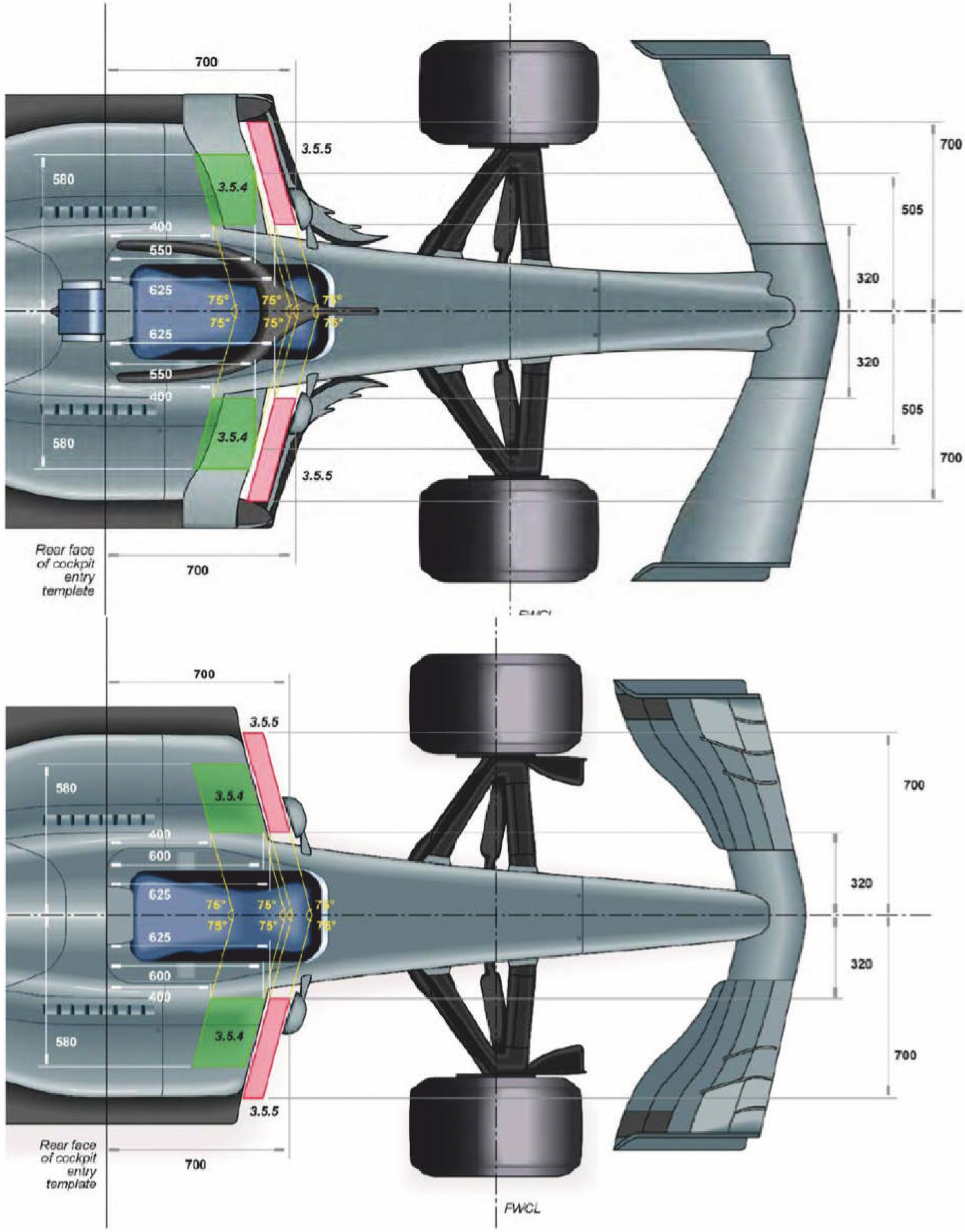


The bargeboard area is another key element in generating outwash. Bargeboard height has reduced by 125mm and they have moved forwards by 100mm for 2019 (top)

Although the fundamental philosophy of the bargeboard area remains the same for all the teams, the specifics of the designs vary greatly

another form of outwash as it pushes the wake from the front wing and the front tyre wide. It also helps to generate local downforce,' explains Melvin. 'In doing so, it has a similar effect to having a wing stood vertically and so there is a downwash to fill in the air behind the bargeboard. Therefore, at the font of the sidepod there is a very strong downward flow sucked under the floor and therefore the flow that comes into the sidepod inlet, especially as they are now very high, is clean. We certainly take care and attention in this area, but there aren't any specific parts within the bargeboards that guide air into the sidepod inlet.

'It is very important for us to have small radiators and small sidepods, so the challenge is to have a small inlet that takes clean flow and in a short distance diffuses that so that the radiator can work well,' Melvin adds. 'It's just an exercise in packaging so it's less about flow control upstream and more about

The rear wing end-plates have been simplified for 2019 with far fewer louvres now in evidence. Top is Toro Rosso (with 2019 on left) and bottom is Haas (again with 2019 on left)

‘By making the rear wing taller, wider and more powerful we actually throw the dirty air of the leading car up and over the trailing car’

packaging choices, how we put the expansion of the radiator duct and where we choose to place the radiator volume.’

Another way the 2019 Formula 1 regulations have been modified to move the wake higher and over the following racecar is through the use of a higher, wider and deeper rear wing, with a more powerful DRS. ‘The rear wing also creates a big wake of turbulent and dirty air behind it, but it also throws air upwards at an incredible rate,’ says Allison. ‘By making the rear wing taller, wider and more powerful we actually throw the dirty air of the leading car up and over the trailing car.’

The 2019 rear wings are now 100mm wider and 100mm deeper than last year, but most importantly are 50mm higher, as per the technical regulations. These dimension changes have also resulted in a more powerful DRS – up to 25 per cent compared to 2018 according to some estimates, due to the width of the opening increasing. ‘Generally, the wing loading has gone up and as a result there is a whole further loop of structural calculations and you need to make sure that your actuator is working,’ says Egginton. ‘Everything has got to be structurally a bit stronger to cope with these loads, and there are the pull down and pull back regulations that you still have to meet so it sort of defines itself. We did do a chunk of structural analysis simulation, as every team would have done, to make sure that we have not omitted anything, but so far it has not been a topic of much discussion.’

Another impact of the larger rear wing is the increased interaction with the rear brake ducts. ‘All the winglets that turn the flow upwards and create the upwash from the rear brake duct now have a rear wing sat above them,’ says Melvin. ‘So, it is an enhanced level of interaction of the upward flow [with the rear wing]. We designed them to work in sympathy and that’s really the rationale for the split designs.’

Fresh air

Whether these regulations will improve track action as promised, is a question yet to be resolved. But what they have already achieved is variety. Each team has interpreted the rules slightly differently and therefore each car has been designed with its individual concept. Although these rules might not be a revolution, they have already induced enough variability to spice up the 2019 season. The question is who has got it right and who has got it wrong? Only when all the F1 teams converge on the same solution will we know the answer.

Fade to grey

Why Pirelli's new colour coding system is merely the tip of a development iceberg

By GEMMA HATTON

Pirelli is using just three sidewall colours during the grand prix weekends this year. Grey is the hardest compound on offer while red is the softest and yellow falls between the two

Just in case the Formula 1 teams didn't have enough regulation changes to get their heads round for 2019, the tyres have completely changed this year too. Not only has Pirelli brought new compounds and new constructions for this season, but also a new naming convention – the latter providing some entertaining commentary as everyone continues to accidentally revert to last year's terminology.

Instead of the colourful rainbow of seven compounds from last year (Superhard – orange, Hard – blue, Medium – grey, Soft – yellow, Supersoft – red, Ultrasoft – purple, Hypersoft – pink), we now have only five slick compounds to contend with, but only three colours. Puzzled? In an attempt to simplify the confusing world of F1 tyres, Pirelli has decided to bring only three colours to each race: grey which will be the hardest compound of the three, red which will be the softest compound, and yellow which will be in between. Calling a yellow-walled tyre the 'medium' is going to take some getting used to.

Rainbow warriors

'You have fans that want to know everything about the technical details and they were happy with the rainbow with all the different colours of last year,' says Mario Isola, head of F1 and car racing at Pirelli. 'Then there are the fans that told us it is too complicated and they cannot remember seven colours. Now, for them and probably the majority of fans, it is a lot easier to understand, but we will continue to give information about the different compounds at each race because we cannot exclude the fans that are interested in the more technical aspects of the sport.'

Five compounds have been homologated for 2019 and Pirelli will nominate the three compounds most suited to each track's individual layout and severity. The compounds themselves are now no longer called, Hard, Medium or Soft, and are instead called Compound 1 (C1) and so on. C1 is the hardest, and each compound then decreases in stiffness until C5, which is the softest.

'Compared to last year, I can say that the C1 is similar to the hard compound, but is a bit softer, because the hard and medium from last year were not used a lot because the general comment was they were too hard,' Isola says. 'C2 is similar to last year's medium although slightly softer again. C3 is the soft from last year.

Blistering was a regular occurrence with last year's rubber and in an attempt to rectify this Pirelli has completely redeveloped its tyres

Pirelli prescribes minimum starting pressures which are usually much higher than what the teams want, so that the sidewall will remain stiff

C4 is the ultrasoft from last year and the C5 is now a new hypersoft that we have designed. It has the same level of performance, but it has better mechanical resistance.'

Blister storm

Blistering was a regular occurrence last year and to try and rectify this Pirelli has completely redeveloped its 2019 range of tyres. Blistering is where overheating of the rubber creates hotspots within the bulk of the tyre which essentially 'explode', blasting sections of rubber off the tyre, leaving the drivers with less rubber to generate grip. These hotspots usually occur in the centre of the tyre, where the tread is the thickest and also usually the hottest, creating a central band of effectively boiled tyre – which was seen at several races last year.

Although you might think that the softer compounds would suffer most from this phenomena, because they operate best at higher temperatures, the reality is in fact the opposite. Because the softer compounds wear more, their tread becomes thinner and therefore there is less rubber to generate the heat which can develop into those threatening hotspots. The harder compounds, on the other hand, experience less wear and therefore retain their tread thickness and consequent heat. To try and manage this overheating, the tyres need to be designed to not only resist this temperature in the first place, but also to distribute this heat, to avoid the formation of local hotspots.

To do this Pirelli has not only developed a new construction, but also incorporated new materials and a thinner tread into the 2019 spec tyres. 'We have a new construction and new materials that are able to manage the heat going into the tyre in a much more effective way,' says Isola. 'The new compounds are also designed to reduce blistering and we have reduced the tread thickness which we introduced last year at three races and it worked well. Also, the compounds have been designed with a slightly wider working range to cope with higher temperatures to again try and reduce overheating. And this was the main focus for this year.'

Blanket coverage

Another big change has been the tyre blanket temperatures. Although the maximum blanket temp for the fronts has remained at 100degC, as it was last year, Pirelli has dropped the maximum temperature of the rear tyre blankets by 20degC to 80degC. 'From talking to the teams, generally they were worried about possible warm up issues with the fronts last year, no one was worried about the rear tyres,' says Isola. 'Last year we saw quite often that the out-lap was very slow to try and keep the rear temps low, or teams were removing the blankets in advance to cool the tyres. So, we decided to reduce the rear blankets to 80degC, but maintain the fronts to 100degC, because sometimes it can be tricky to warm the fronts. This also means for the rears we had the opportunity to prescribe lower starting pressures [for testing], this was all done in an effort to reduce overheating.'

Pressure relief

Pressure is another often confusing facet of tyre engineering. If a tyre has a low running pressure then the downforce of the car can squish the rubber into the track more easily, resulting in a larger contact patch and consequently more grip. This is what the teams are always pushing to try to achieve. However, lower pressure tyres have a sidewall that is not as stiff, and is therefore less resistant to failure. This is why Pirelli prescribes minimum starting pressures which are usually much higher than what the teams want, so that the sidewall remains stiff to reduce the likelihood of failure. The teams and the tyre manufacturer are constantly battling over each increment of psi, as is the case in most other forms of motorsport.

This year, because the rear tyre blankets have dropped by 20degC, running pressures seem to have increased. This is because, as the laws of physics stipulate, when temperature increases, so does pressure. With the rear tyres starting 20degC cooler, it takes longer for them to get up to their optimum operating temperature and in that time the pressure has longer to build up. So could a 20degC drop in blanket temperatures actually equate to higher running pressures, despite starting a couple of psi lower? With reports from Melbourne highlighting that rear running pressures were 3psi higher compared to last year, the answer seems to be yes. Of course, this means a stiffer sidewall and an increased resistance to failure for Pirelli, but also a much smaller contact patch size for the teams to exploit.

The maximum temperatures of the tyre blankets at the rear of the car have now been dropped from 100degC to 80degC

RUTRONIK
TOMMY TULPE

The Force India name is absent from the F1 entry list for the first time since the start of the 2008 season, as a result of the team's financial collapse halfway through 2018. The team still exists, though, now under new ownership and bearing a new name, Racing Point. It's the same team that saw out last season using a Force India VJM11, and it is also a continuation of the team which started life in 1991 as Jordan.

Force India's financial failure came at a crucial time in the development of the team's 2019 design, then called the VJM12, and some very tough choices had already been made. 'The company was in dire straights, and had fallen into administration,' Racing Point technical director Andy Green says. 'We did not know what was going to happen and at that point we had to make some big decisions on what

'We are now able to put on track the car we want to put on track, and not just the car we can afford to put on track'

Proving a Point

After years of punching above its weight the organisation formerly known as Force India now has the funding to up its game big time. But can its 2019 F1 challenger, the Racing Point RP19, live up to the team's lofty ambitions?

By SAMUEL COLLINS

we were going to do with the car because there was a chance that we were not going to get a big cash injection but we were still going to have to get a car out for 2019.'

With the new aerodynamic regulations the sport's smallest team in terms of budget, and second smallest in terms of staff (Haas has fewer people), already faced a battle just to be ready for 2019, and with a bank balance in the red things were looking bleak. 'We had no money, no idea what was going to happen, and had to make some choices to keep us running,' Green says. 'That meant finding the most cost-effective way to keep developing the new car and we ultimately decided to use as much of the 2018 car as we possibly could. What we had to avoid was stopping development for two months while we waited to understand what the future held. If we had stopped it would have been a significant blow to our 2019 competitiveness. Looking back, we know it was a good call.

'The most important thing we realised was that with the rule changes development had to continue in the wind tunnel and in CFD,' Green adds. 'But we knew we could not afford to

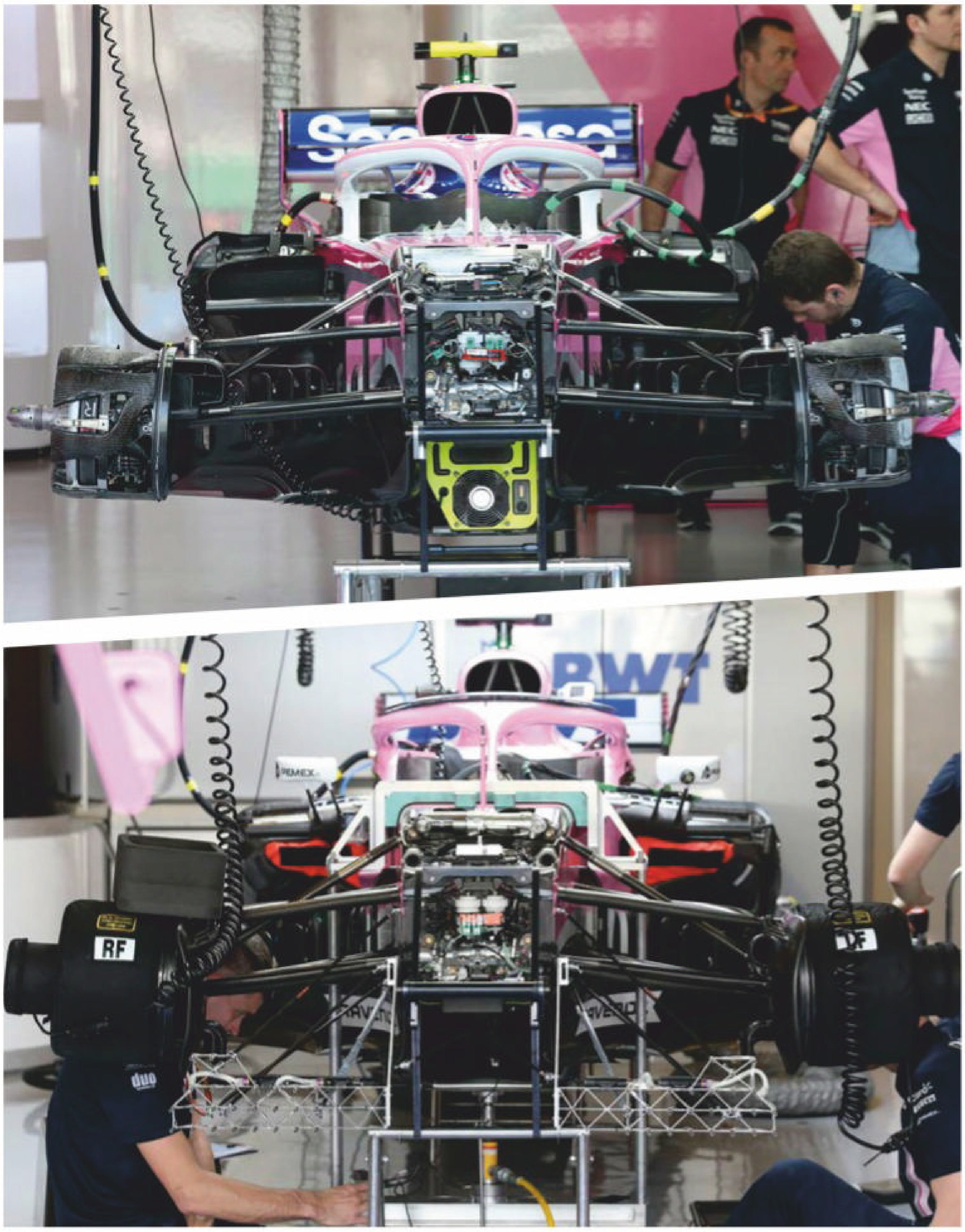
To say the Racing Point RP19 is merely a re-badged Force India VJM11 is simply not accurate

change the model architecture, so we decided to keep it all the same, then at least the guys in the wind tunnel can keep developing a 2019 car. With that in mind we chose to carry over the chassis, gearbox and suspension, which would mean that the aerodynamic guys could carry on working at very little cost.'

Making a Point

With the choice taken to retain the VJM11 monocoque for development, other design elements were then locked in. Mercedes had already agreed to supply its latest specification power unit, but the team opted to use the older Mercedes transmission it had fitted to the 2018 car. This limited it to using the same pullrod actuated fully hydraulic rear suspension used on the VJM11. Thus much of the rear end of the new car, given the type number RP19, was a straight carry over from the 2018 design.

But to say the RP19 is merely a re-badged Force India VJM11 is not accurate. The monocoques are brand new, not modified VJM11 tubs, and while they came out of the same moulds the 2019 chassis is significantly different in some areas. Most obviously the upper side impact structures have been relocated, moved lower to enable the team to



The Racing Point RP19 in the garage (top). It clearly retains many of the design features of the Force India VJM11 (bottom)

adopt the sidepod concept that was introduced by Ferrari in 2017 and is now used by all the F1 teams except for Mercedes. This is something which offers an aerodynamic benefit but structurally is quite difficult to do, especially if you are using a tub not designed for it.

'What we did do was make some modifications to the mould, things like side impact structures, it was quite a challenge,' Green says. 'We had to do a lot of FEA work on that, and design a big structure to sit behind it, it's a challenge taking it away from a structurally efficient place and putting it in the middle of a panel. Aerodynamically it is the right way to go, but it is heavy. We also made a few other changes such as the nose pins for the regulations, so we still had to make new chassis, re-homologate them, and do all the crash tests. There were some details we changed, but in design terms it is the same, essentially.'

When the team's new owners arrived during the summer of 2018 the investment came just

RP19 keeps the VJM11's distinctive hump where nose meets tub

in time to make another set of changes to the front end of the car. 'The change of ownership came a few months too late to affect the fundamental philosophy of the 2019 car, so we set out to work in the same way we had done before,' Green says. 'But one of the areas we did change was the front suspension. We were really obliged to do that due to the regulation

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changes to the front brake duct. It was not really possible to carry that over, so we decided to change it. We had the back up plan of modifying last year's, but it was not something we wanted to do. As it turned out the team was sold and there was an injection of cash which came in just enough time to design the new front suspension and get it on the car for testing. We will change it again in a few races time. The internals are similar but laid out differently.'

Talking Point

But utilising the VJM11 moulds has resulted in some areas of the RP19 chassis not being ideal for 2019. At the rear of the monocoque, for example, carrying over the chassis means that the Racing Point is fitted with the same fuel cell as the VJM11. This is a particular issue as for 2019 the maximum fuel permitted for a race distance has been increased by 5kg to 110kg, meaning that the RP19 has an undersized fuel tank, and the Mercedes power unit has been designed with that 110kg fuel allowance in mind.

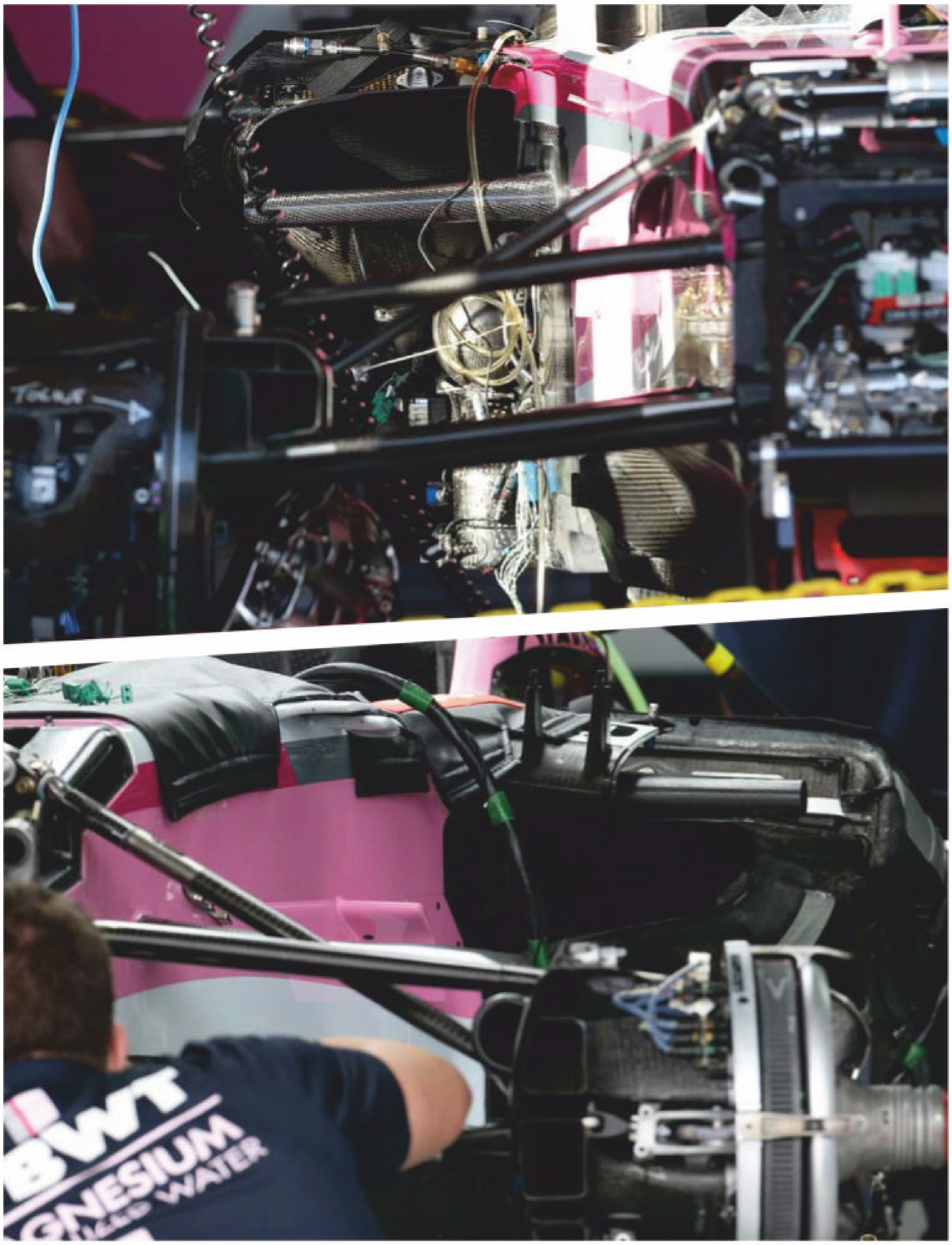
'We have kept the same fuel cell as 2018, but I do think we will be marginal in a couple of places,' Green says. 'The Mercedes is a very efficient engine, and just because the fuel allowance has gone up we won't use it all. We think we can just do it at almost every race; Singapore is the one which could have us over.'

This means that the engineers will have to pay a lot of attention to the specific gravity of the Petronas fuels that the car will run on, especially as this is a major area of in-season development. 'We have to be really aware of the fuel density predicted to be used in the season, it is not just the fuel we use now but it is the updates to the fuel and that can change the specific gravity,' Green says. 'You could go up or down 10 litres during the season. That is a substantial volume change, so we talk to the fuel suppliers, and we hope we have covered that.'

Because of the growing financial constraints it was under Force India had become the most financially efficient team in Formula 1, remaining extremely competitive while not spending very much money. Only Red Bull, Ferrari and Mercedes were ahead of them in 2016 and 2017, while the team would have come fifth in 2018 had it kept the same identity all year (Force India was disqualified from the constructors championship after the Hungarian Grand Prix and the new Racing Point team only scored points from Belgium onwards).

Cash Point

But with a big increase in budget the team can now start spending money in a way it never could before, something which could change the entire philosophy of how it operates. 'Last season we carried on adding some performance to the 2018 car by developing the parts we had, but often the upgrades never made it past the wind tunnel model, as we had no way to produce them,' Green says. 'We had to keep car development progressing at all times, otherwise we'd just fall further behind. It was the only way to work given the situation we were in. It's been a massive change, and one for the best, with a real change in development philosophy. This year, we will be bringing updates to the car as soon as they're ready. We won't be waiting to put together bigger packages, but will focus on making incremental gains at every race. The improved financial situation of the team helps this strategy a lot, but this situation owes a lot to the change in regulations as well. A new set of aero rules means the development slope has become steep again. The gains are not going to taper off into marginal increases this year, we are in a situation in which we find significant performance at regular intervals. The model is developing at such a fast pace we cannot afford not to bring parts to the car as soon as we can.'



One of the main differences is the side impact structure location; high on the VJM11 (bottom) and lower on the RP19 (top)

Point of no return

It is not only the car which will see a lot more development. The organisation's headquarters at Silverstone, is also set for some big upgrades, while the team is to be enlarged. 'There is a huge amount going on behind the scenes and I would say it has been the busiest winter I can

With a big increase in budget this once impoverished Formula 1 team can now start spending money in a way it never could before

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remember,' Otmar Szafnauer, team principal and CEO of Racing Point says. 'Not only are we delivering the new car, but we are also planning for the future and trying to improve our facilities and tools following years of underinvestment. We are expanding the current factory to accommodate a growing workforce and simultaneously planning the build of a new facility, which will also be located in Silverstone. These are not easy tasks and they require lots of energy and resources to deliver. The long term aim is to take this team to the very top of the sport. In the short and medium term we need to take the fight to the top three teams and establish our position as a podium contender. This won't happen overnight and the new owners are realistic about the amount of work needed to get us to that level. We are putting the building blocks in place to deliver on these ambitious targets and it's important that we take a good step forward in 2019.'

The 2018 spec Mercedes transmission and the rear suspension from the Force India VJM11 is used on this year's RP19

Power Point

While the wider plans are very much in progress the team is already seeing small changes in the factory as many issues left unresolved for financial reasons are being dealt with. 'New hardware is already arriving at the factory,' Green says. 'The first difference was being able to use PCs and laptops which were not eight years old, that even meant shifting to a new version of Windows all of a sudden. Paying bills on time means getting parts on demand and it is a different way of working, one which we are still getting used to, it's actually a bit of a shock at times but I think its called "normal". So we are close to being a normal team now. We are now able to put on track the car we want to put on track, and not just the car we can afford to put on track, that is something we have never been able to do before and that is exciting. It means we can develop in the way our competition do.'

However, Force India's financial shortfalls were the thing that made it so efficient in the first place, the engineers at Silverstone simply had no other option than to ensure that every development brought to the car would be effective, failure simply was not an option. 'Previously, when we brought developments to the car we had to be certain that they would work, so we didn't push everything to the optimum as it was too big a risk to do that,' Green says. 'Now we can, and we can afford to fail in a few areas in the quest for performance.'

With a larger budget it could be argued that there is a risk that this efficiency is at risk of

'In the short and medium term we need to take the fight to the top three teams and establish our position as a podium contender'

TECH SPEC: Racing Point RP19

Chassis
Carbon fibre composite monocoque with Zylon side anti-intrusion panels, based on Force India VJM11.

Power unit
Mercedes-AMG F1 M10 EQ Power+ 1.6-litre V6 turbocharged engine plus energy recovery system.

Transmission
Mercedes Formula 1 (2018 spec), composite casing with metallic cassette insert, semi-automatic with eight forward speeds and one reverse. AP Racing multi-plate clutch.

Suspension
Aluminium uprights with carbon fibre composite wishbones, track-rod and pushrod (front), pullrod (rear), inboard chassis mounted torsion springs, dampers and anti-roll bar assembly (front), full hydraulic package (rear).

Brakes
920E brake calipers and in-house design brake by wire system with carbon fibre discs and pads.

Electronics
FIA single ECU (by McLaren) with in-house electrical harness.

Dimensions
Width, 2000mm; Length, 5600mm.

Weight
Overall vehicle weight 743kg (including driver, excluding fuel) Weight distribution between 45.4 per cent and 46.4 per cent front.

Racing Point plans to introduce a completely new racecar concept for the 2020 season, one which will last for just a single year

being lost, though Green stresses that the team's philosophy in that respect will not change.

'We have cleared all the debts so from now it is about the future,' he says. 'It is taking time for the money to turn itself into infrastructure and then car performance. That takes time, but it is happening at the pace we want it to. We don't want to expand too fast too soon, and we will carry on in the same mindset we have had for the last few years. When we grow we will grow organically, and find new people who fit into the team. We are looking at it as a way of becoming even more financially efficient, we were not being as efficient as we could have been. We had to make decisions based on the money we had at the time, and that meant we spent it inefficiently. Now what we have to do is to take our way of working and grow, as we want to remain the most efficient team on the grid. It is actually crucial as we know there is a cost cap coming in, and that will bring it all to us.'

As the 2019 season continues Green and the Racing Point engineers will start to develop the RP19 in an attempt to keep it near the front of the pack, and he re-emphasises that it will now be the sort of continuous development that was not really an option in the Force India days. As ever in Formula 1, money talks.

But in one respect perhaps Racing Point was a little lucky. Force India had not wanted to build a new chassis for 2018, preferring to retain the VJM10, but a small rule change forced the team to create a new car, and that chassis has ended up forming the basis of the Racing Point RP19.

Points finish

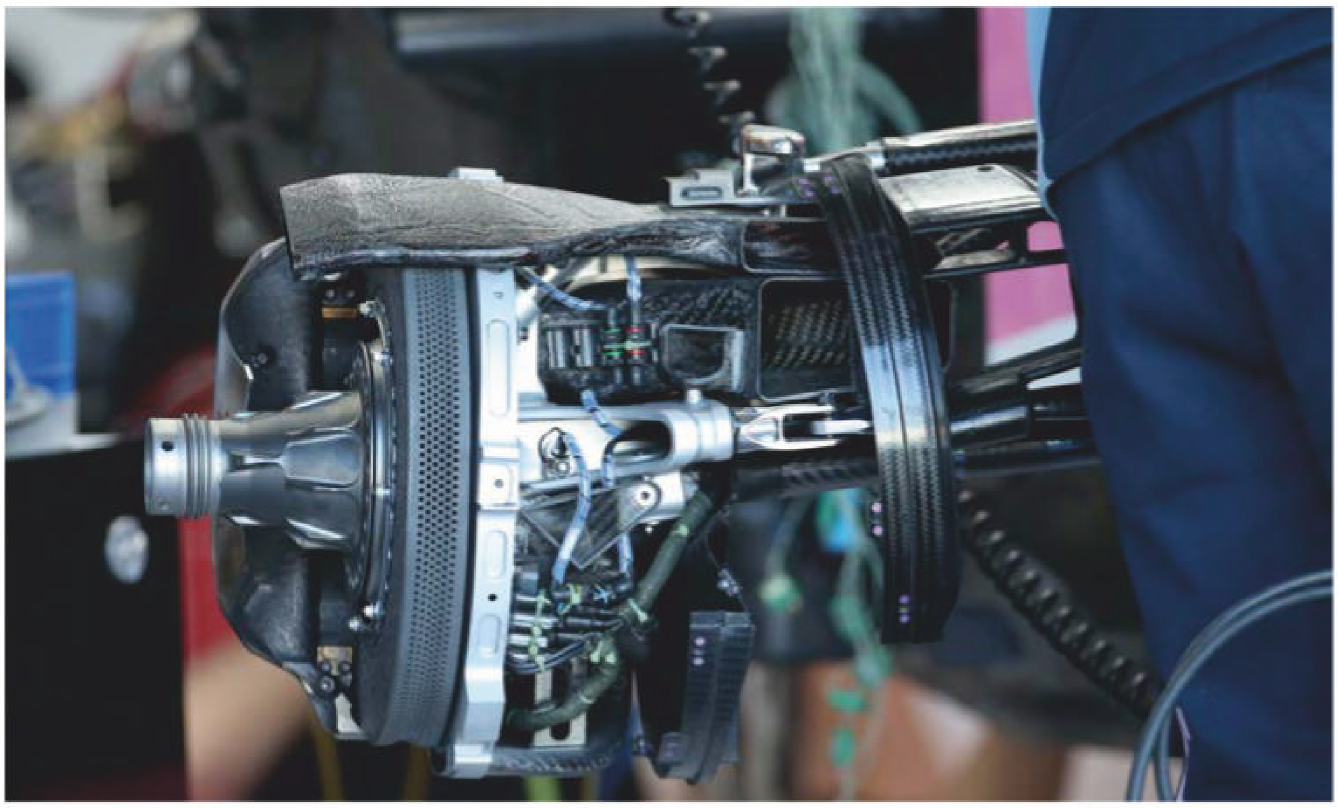
The first fruits of the new investment were not really clear at the Melbourne season-opener, but then the circuit is a notoriously difficult venue on which to gauge the worth of a Formula 1 car. That said, one of the cars did make the top 10 in both qualifying and the race.

Yet even with only the one race done at the time of writing attention has turned to the RP20. The 2021 regulations mean that every team will have to adopt a completely new car concept for that season, something which would normally encourage a team to continue to develop a concept through 2020, but Racing Point plans to introduce a new car concept *next* season, one which will last for just a single year.

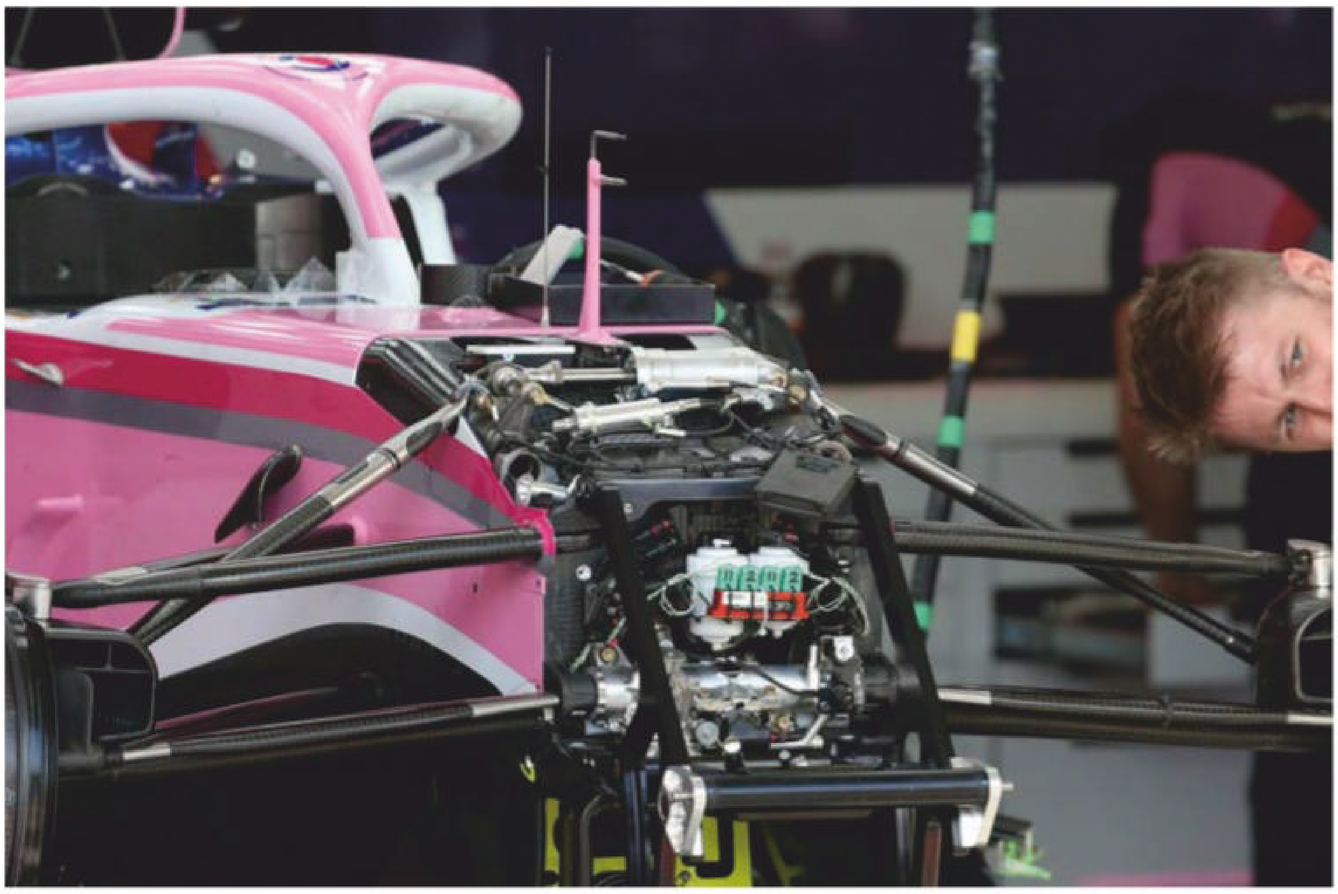
'We will do a new chassis for 2020 as we think there is performance to come from doing that,' Green says. 'We are not going to sacrifice that gain in performance because of new rules in 2021. One of the things we can do is to completely optimise the cooling system for the power unit. It will be a completely different philosophy to what we have now. The design is incredibly efficient in terms of aerodynamics but a little bit heavier than what we have, but I think that it will conceptually carry over for the next seven years. I don't see the power unit architecture or demand changing in that time. That change alone means a new chassis, but we think it is a worthwhile expenditure.'

Pointing ahead

The outlook for Racing Point is mainly one of optimism. While the team accepts that the RP19 is not perfect, it believes it can still be competitive. But the real focus is on the future. 'This is not even a new chapter, it's a new book,' Green says. 'It's the most exciting time for the team and the vision the shareholders have for the company is incredible. I can't wait.



Point brake. The front suspension needed to be redesigned because the brake duct regulations changed for this season

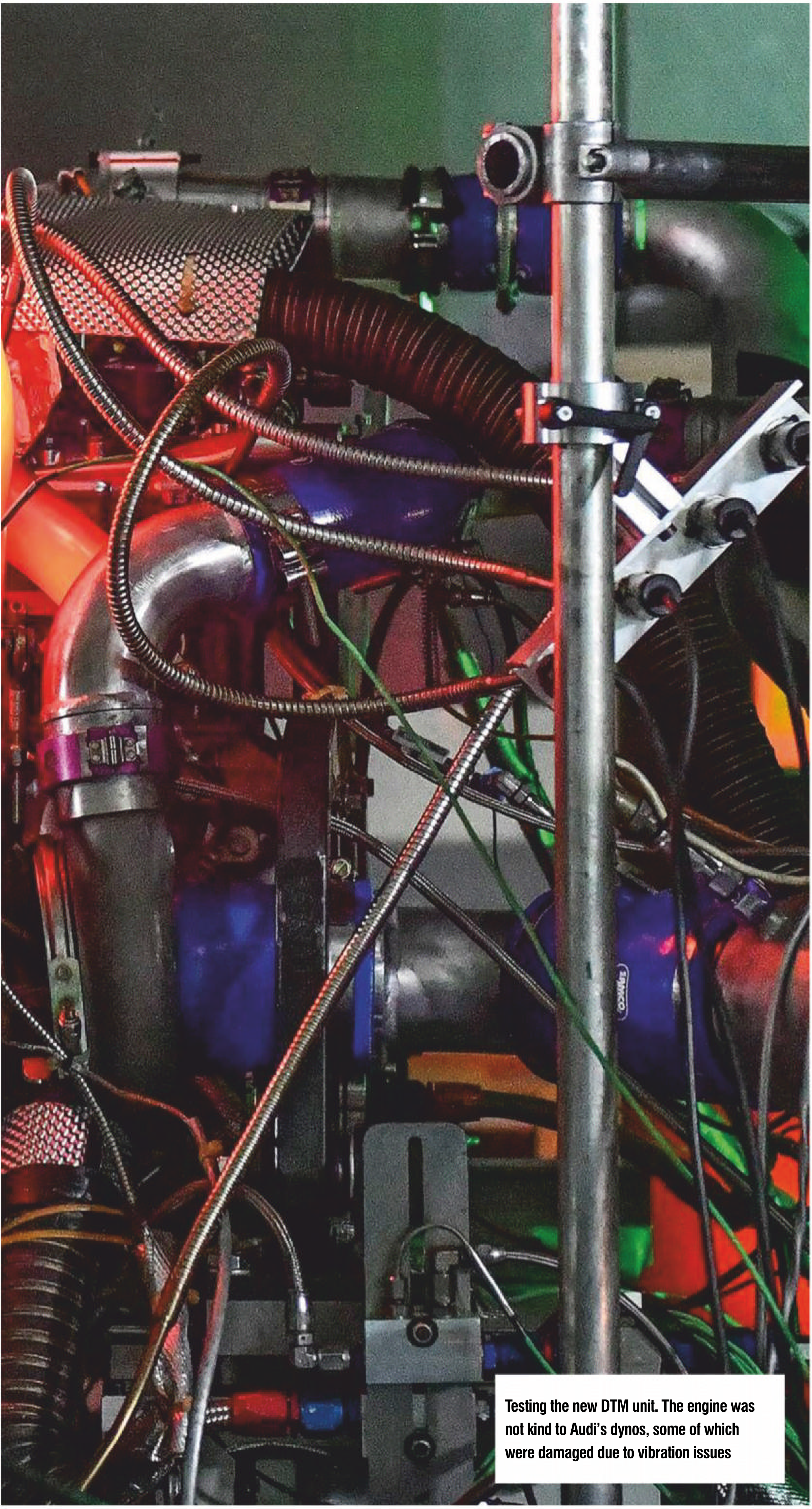


Suspension components and front bulkhead. The RP19 monocoques are brand new and not simply modified VJM11 tubs

The car sported new mirrors at Melbourne. A bigger budget means continual development is a welcome change for the team in 2019

Race in-line

The new DTM engine will produce around 100bhp more than the outgoing V8 and along with the weight reduction this means the cars should be significantly faster



Testing the new DTM unit. The engine was not kind to Audi's dynos, some of which were damaged due to vibration issues

The DTM has taken a massive step towards alignment with the Super GT series as it moves from V8s to four pots. But building an engine with more power per cylinder than F1 is quite a challenge, as *Racecar* discovered when we examined Audi's new unit

By RACECAR STAFF

It is a concept that was more than 10 years in the making, but this year Europe's highest form of touring car racing, the DTM, will switch to a 2-litre, 4-cylinder in-line turbo engine for the first time. With the Super GT series in Japan adopting a similar engine formula, the introduction was a critical step towards the global Class 1 regulations so craved by the German manufacturers in the DTM.

This move was required to bring the engines into some kind of line, ready for the proposed joint races in which the six manufacturers, three from Japan and three from Europe, will compete. The Super GT cars moved to a 4-cylinder turbocharged engine formula back in 2014, but it has taken the DTM a further five years to replace the normally aspirated 4-litre V8 powerplants that had been a feature of the series since the turn of the century.

Aerodynamically, the DTM cars switch to single element rear wings, compared to double element wings in 2018, while the minimum weight has been brought down below 1000kg for the first time, largely because of the weight reduction in the engine bay due to the new engines. With more power and less weight, cooling has become a top priority for the brakes and engines, leading to new front aero design.

Global reach

Back in 2008 a 4-cylinder turbo concept called the Global Race Engine (GRE) was designed to bring more manufacturers into top level racing, and this was covered by *Racecar Engineering* in 2009. But ultimately it did not deliver on its promise to provide powerplants for all forms of motorsport, from F1 through to F3 and rallying. The original idea was for 2-litre forms of the Global Race Engine to be run in the top classes and 1.6 in the feeder formulae, but once Formula 1 adopted the 1.6-litre V6 power unit, the concept withered on the vine.

However, when the DTM was looking for a new engine, the GRE idea was resurrected, and while this was vetoed by Mercedes, with it leaving the series at the end of 2018 BMW, Audi and new arrival Aston Martin were free to press ahead with the concept, while Audi was able to finish a build programme that it had been working on since late in 2014. It should be noted that these engines in their final specification bear little relation to the original GRE after several years of development, and rule changes.

The new units weigh 85kg, down from the 148kg of the outgoing V8, which will lead to a change in weight distribution for the new DTM racecars. They are also bespoke racing engines, designed to complete a full race season of 6000km between rebuilds in a bid to reduce the running costs off the teams.

Keep it lean

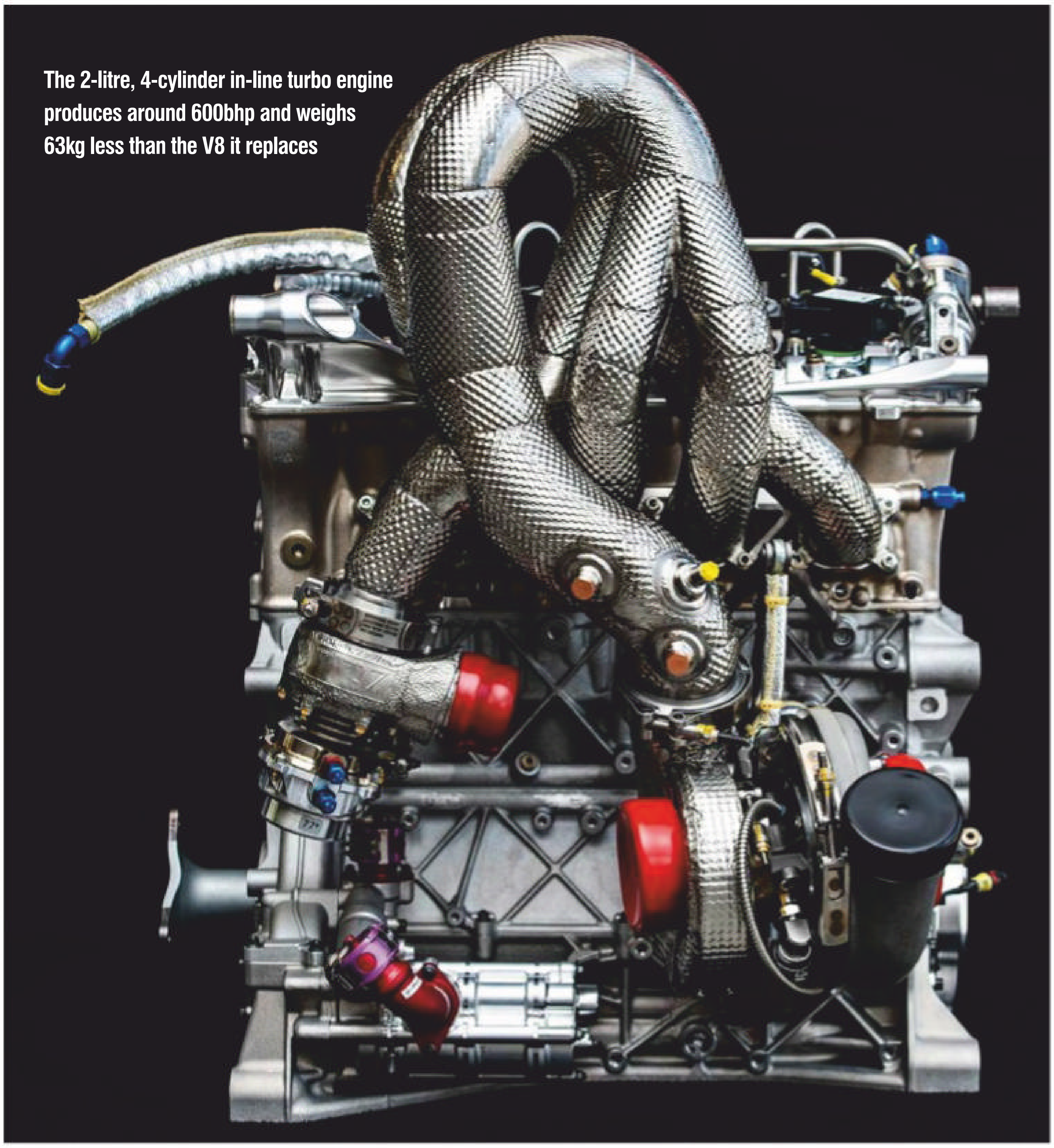
For the first time, the DTM engines are governed by a fuel flow restrictor rather than by air restrictors, leading to a new lean-burn philosophy. This is a major change in engine design, but the Japanese are also running a fuel flow restrictor in Super GT, and so everything possible was done to align the regulations to give rise to the global formula. That said, the DTM series will run on a single specification of fuel this year – pump spec petrol supplied by Aral – and it will still feature a single tyre supplier, so there are still issues to overcome to bring the cars fully into alignment.

Audi's engineers are clearly proud of their creation, and it's easy to see why. The brief was for a 4-cylinder engine with 600bhp, more power per cylinder than a Formula 1 car, which had to last an entire season – as is required by the DTM regulations. Such longevity was a challenge faced by the piston specialists who simulated the perfect spray pattern, material choice for the cylinder and piston, the compression ratio, and design to achieve this. Audi then applied cooling techniques learned from the Le Mans diesel programme which helped to accelerate the development cycle.

A normal build programme, such as the first of Audi's diesel Le Mans engines, was 30 months, but the DTM engine was nearly five years in the making. Part of that delay was to do with the regulations, with development banned for a year. But there was also problems with Audi's own dynos, which suffered with vibration issues, and an entire season of development was lost in 2015 as these were upgraded to cope with the new 4-cylinder powerplants.

'One of the biggest challenges is vibration because the 4-cylinder is a nasty kind of engine,' says Audi's head of powertrain Ulrich Baretzky. 'We really spent a long time to make the engine suited to the dyno, because it destroyed the shafts and everything. It was really mad.

'You have to find the right balance with the stiffness of the crankshaft, the weight, the friction and the torsional vibration area, and this is a real challenge,' Baretzky adds. 'It sounds silly, but this was really complex. The engine was shaking and moving, so everything that was not tight would fall off it, or where it is coming together with other vibrations it is getting into its own frequencies and destroying itself, and we had never seen this before.'


The 2-litre, 4-cylinder in-line turbo engine produces around 600bhp and weighs 63kg less than the V8 it replaces

The new DTM engines are designed to complete a full 6000km race season between rebuilds

Formula 1 loadings

Integrating the turbocharger was a relatively easy task when compared to upgrading the dynos, and piston design was also fairly straightforward, to Baretzky's surprise. 'We really expected it to be more difficult because of the load, 150bhp per piston is a lot, it is like F1 with 900bhp and six cylinders, so we are close to Formula 1 loadings,' he says.

A turbo anti lag system has also been introduced, which keeps the turbocharger spinning even when the driver is on the brakes, to maintain the charge pressure.


The turbo will be kept spinning thanks to a clever anti-lag system

Simulation techniques certainly helped save the dynos from further damage, with up to 85 per cent of the design work now taking place on computer, before the single-cylinder testing began. And this was a critical part of the design phase. 'If you have such a lean combustion process [you can have] abnormalities that can destroy the engine in seconds,' says Baretzky.

'The turbo is very sensitive, and it is like a nuclear powerplant, if the temperature is running [high] there is nothing you can do to stop it, or very little. This was more challenging than the diesel.'

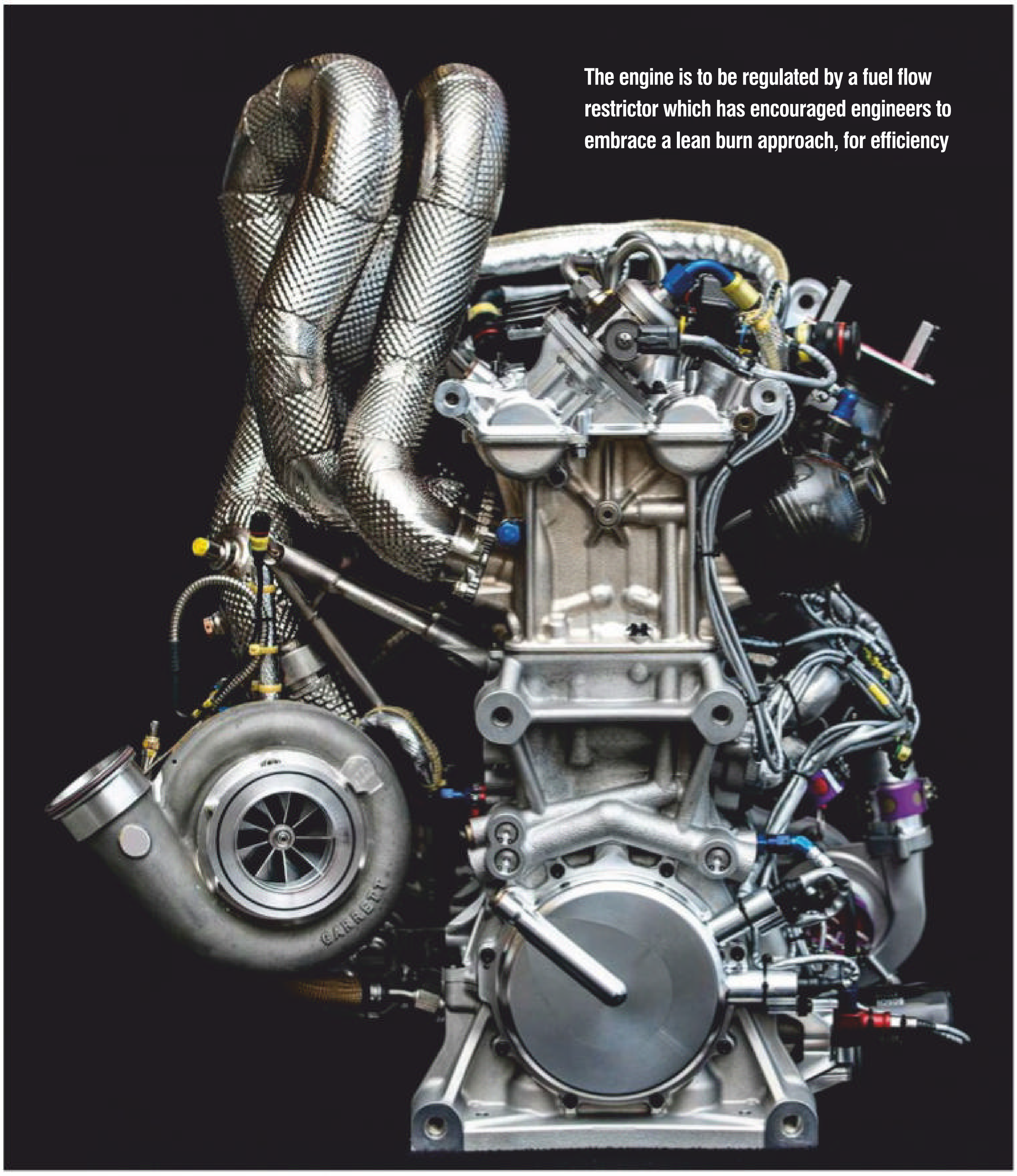
More power

The new engine will produce more than 100bhp more than the outgoing V8 and along with the weight reduction this means the cars should be significantly faster than the old cars too. An extra 30bhp is available to drivers via a push to pass system which, when coupled with DRS, should help to produce more overtaking.

The push to pass function, says Audi, increases the overall load even though it is only available in small bursts. 'Thirty horsepower doesn't sound like a lot but it posed a great technical challenge that we had to master,' says Stefan Dreyer, head of powertrain development at Audi Motorsport. 'It is clear that the engines have to last for the full season, in other words for 6000 kilometres. The question is, how closely would you dare to go to the limit right in the first race at Hockenheim? After all, you want to reach the finale without engine failure. That's a difficult choice for all manufacturers and in qualifying it may well make the difference between pole position and 10th on the grid.'

Go with the flow

The key difference with this engine, however, is that it is regulated by a fuel flow restrictor, similar to Formula 1 and the WEC, although not the same as a fuel flow meter. This means that the engine is restricted not by air, but by the amount of fuel going in to the engine, governed at 95kg/hour, with an extra 5kg/hour for the push to pass. This has encouraged engineers towards lean burn, allowing them to talk about high efficiency engines, but it will be interesting when the racing starts to see the different trends adopted by the three manufacturers as they head into their first season of competition with these units.



The engine is to be regulated by a fuel flow restrictor which has encouraged engineers to embrace a lean burn approach, for efficiency

The new engine will propel Audi's RS5. DTM cars are lighter this year and now use single-element rear wings

'When you see this 95kg limit you have two ways to manage the efficiency; you take away fuel, or you create more power,' says Baretzky. 'Maybe there will be two or three races before you see where people are. Everyone will be careful not to break an engine at the first race. It can even depend on the race track, whether one is better at one, or another.'

One other strategy decision is how to set the car up on the rear axle, with 100bhp more power to deliver. 'We will work on it hard, how consistent you make the use of the tyre, the performance; when it's dry is one story, and when it is wet it is another story altogether,' says Dreyer. 'It will be exciting for everyone.'

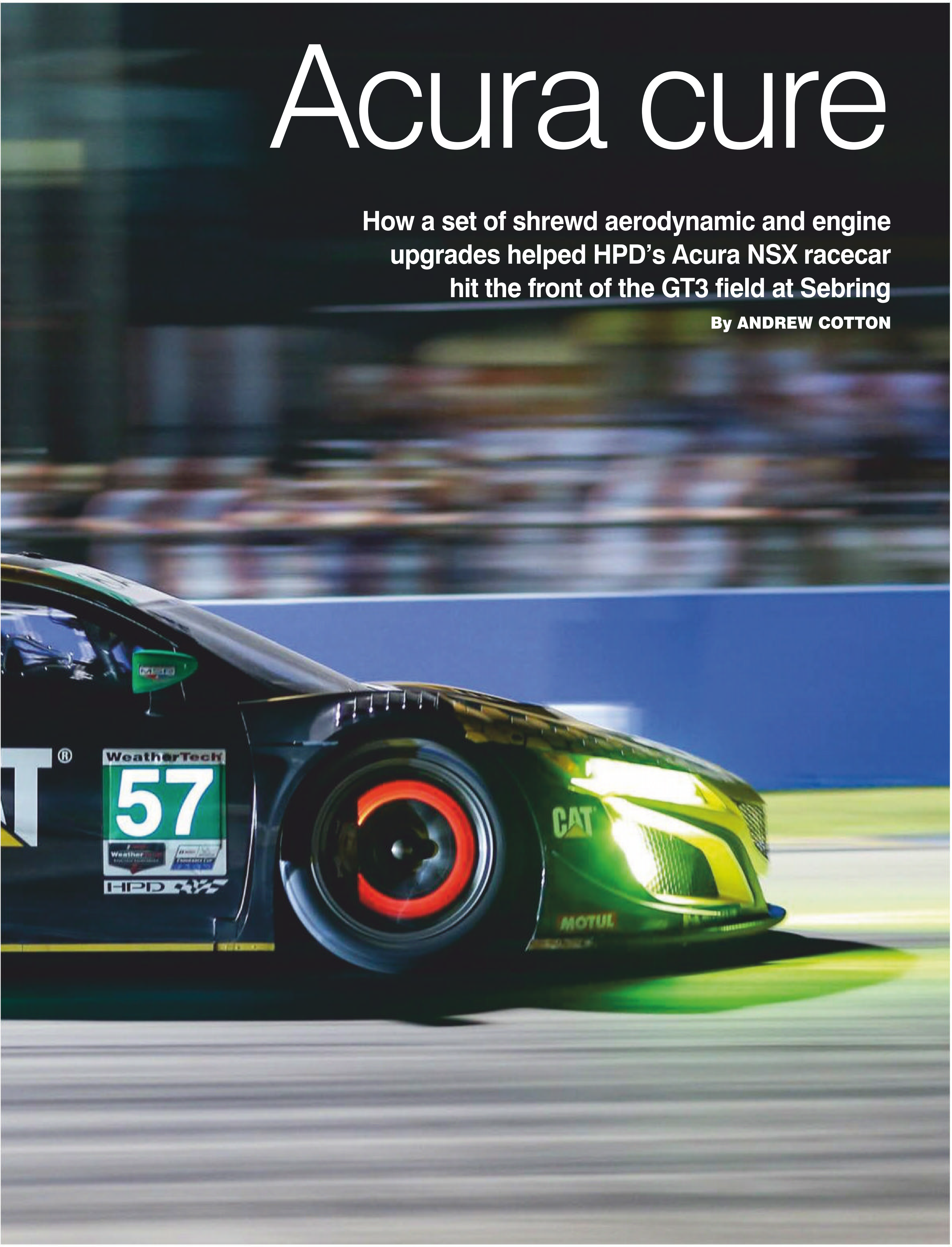
Audi applied cooling techniques learned from the Le Mans diesel programme, which helped to accelerate the development cycle

‘The big thing in our view is having a car that fits in the middle of the performance windows’

Acura cure

How a set of shrewd aerodynamic and engine upgrades helped HPD's Acura NSX racecar hit the front of the GT3 field at Sebring

By ANDREW COTTON



The Acura showed good pace at Sebring but much of the development has really been about making it a racecar that gentlemen drivers will feel comfortable in

This year Acura has hit the headlines with an increased racing programme with its NSX GT3 . The Honda brand will run in the Blancpain Endurance Series as Jenson Team Rocket RJN, confirming a partnership with former Formula 1 champion Jenson Button – whose father founded the Rocket Motorsport team in karting and won 11 British championships in junior categories – and Bob Neville's RJN team, which for years has been associated with Nissan.

The Rocket RJN team will contest the Silver Cup in the Series, but Honda has also announced the JAS team will compete as a factory entry in the Intercontinental GT Series. Other customer programmes in the US and Asia round off the campaign for the year and put the manufacturer firmly on the GT3 map.

Acura has long since hit its target of selling 20 cars in the first two years, and this year introduced its own evo kit, which can be retro-fitted to old cars as well as factory-built on new ones, to widen the operating window.

HPD's engineers concentrated on aero development, reducing drag while maintaining downforce, and having the engine running at a higher lambda in accordance with the rules. The car took part in the Balance of Performance testing at Paul Ricard early in March. Trend Hindman then put it on pole for the Sebring 12 hours before the end of the same week.

The car now runs at the regulated 0.88 lambda having competed at 0.85 since its introduction in 2017. 'When we did our original homologation they didn't have a rule in place as far as lambda, so we ran 0.85 lambda, and they made the rule after we made our homologation,' says Lee Niffenegger, the NSX GT3 programme manager. 'The FIA has plenty of unwritten rules, and they didn't tell us about it. We ran around 0.85 or 0.86, so for 2019 we have changed turbos, but just to the European spec NSX OE turbo. It is completely off the shelf, no modifications, it just has some different materials in it to achieve the higher exhaust gas temperatures, so we can run it leaner and hotter.'

The engine comes straight from the factory, with just a bit of external machining on the block due to the fact that the customer car is not a hybrid. It is then given to HPD, which fits the GT3 wiring harnesses and other components to prepare it for racing. In race trim the car produces around 10 per cent more power than the production car's ICE engine alone.

Aero development

But the really noticeable difference comes with the aero that has been developed to improve straightline speed and to open out the operating window of the car to improve performance in all conditions. The old car's operating window was just too narrow, meaning that it had circuits on which it would perform well, and others where it wouldn't.

'The aero development was around driveability for the gentlemen drivers,' says Niffenegger. 'Our first [version of the car] had some comments on the driveability concerns that the drivers had. The whole thing was to expand the tuning window to help them, so [we focussed on] drag reduction and driveability. The idea is that we wanted to build up the tuning of the car based on what we learned. The old one was a bit pointy on the front end, a little too much front grip.'

The team developed a new rear wing and adjusted the strakes in the rear diffuser, although it kept the same ceiling height. It changed the front splitter and added louvres

TECH SPEC: Acura NSX GT3

Chassis
Production multi-material, aluminium-intensive spaceframe, manufactured at the Performance Manufacturing Center in Ohio, alongside production Acura NSX vehicles.

Engine
Acura 3.5-litre, 75-degree, twin-turbocharged DOHC V6, using the same design specifications as the production NSX, including the cylinder block, heads, valve train, crankshaft, pistons and dry-sump lubrication system.

Transmission
Paddle-operated, 6-speed sequential gearbox; rear-wheel-drive.

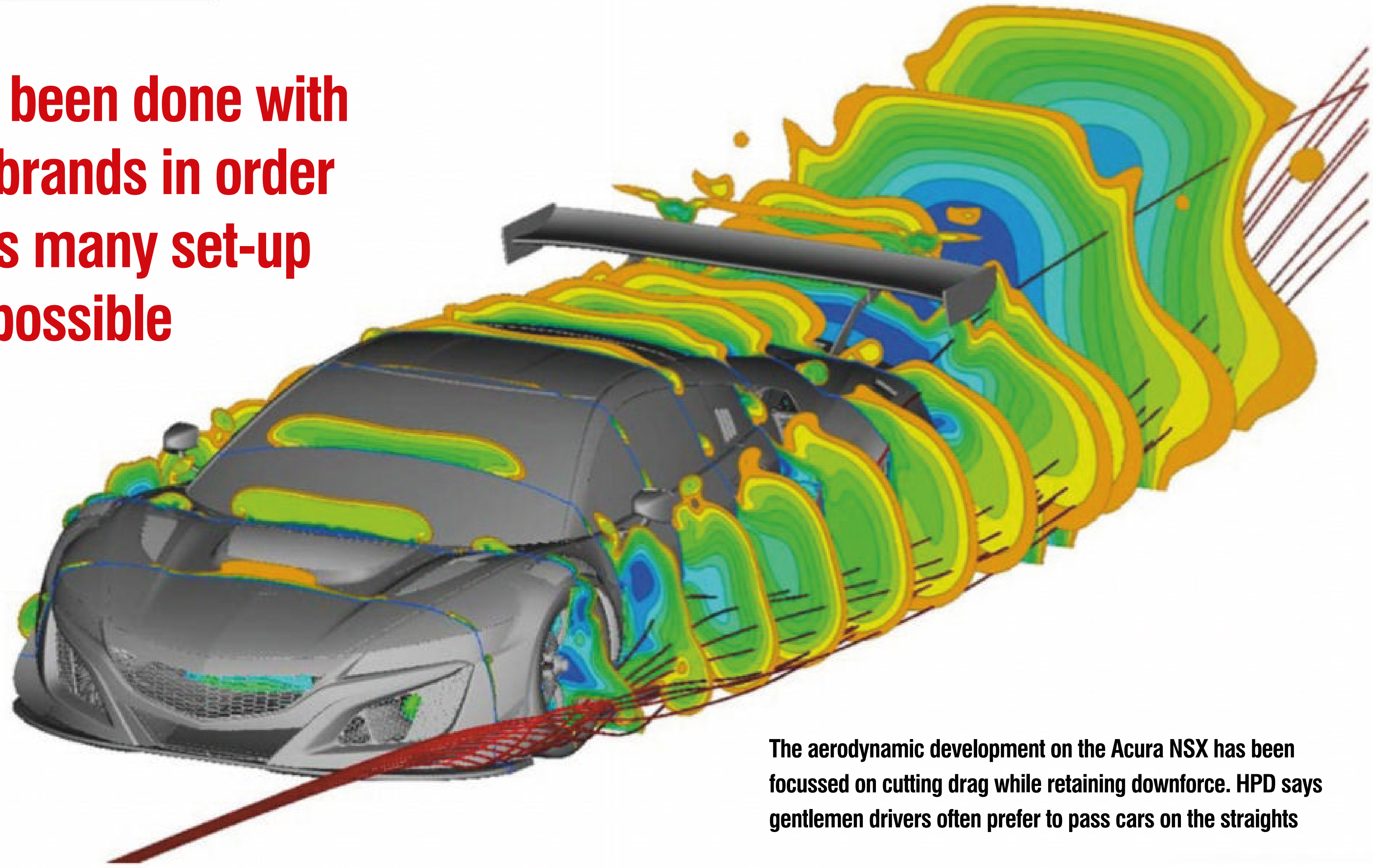
Safety equipment
Steel roll cage, carbon fibre driver's seat shell, 6-point safety harness, fresh air intake system, on-board fire suppression system.

Fuel capacity
25.888 US gallons (98 litres).

Dimensions
Length 4470mm; width 2210mm; height 1219mm (without rear wing).

In race trim the non-hybrid GT3 produces around 10 per cent more power than the production car's internal combustion engine

Testing has been done with lots of tyre brands in order to ensure as many set-up options as possible



The aerodynamic development on the Acura NSX has been focussed on cutting drag while retaining downforce. HPD says gentlemen drivers often prefer to pass cars on the straights

over the front wheel to help air to escape from that area. This change in particular was aimed at the VLN market, where rules are slightly different due to the fatal accident with Jan Mardenborough's Nissan GT3 car at the Nurburgring in 2017 – when the car cleared the catch fencing and killed a spectator.

'The ducts come out of the main radiator exhaust and pull some more air through there,' explains Niffenegger. 'The louvres are part of the front wheel arch. Part of that idea was based around the VLN rules, because of the car that took off a few years ago. They now mandate louvres. Ours didn't have them, and if you don't have them they have a specific requirement for them, but if you homologate them with the FIA they accept the homologation.'

Tread carefully

The car was not specifically developed with the new DHD2 tyre that was introduced to the Blancpain series in 2018, following some high-profile problems for the Audi and Lamborghini teams. In the US, Pirelli only used the DHC tyre before going to the latest European spec, missing out the troublesome DHD. However, the Acura design team is confident that it has nailed the position on the performance window, safe in the knowledge that this customer tyre is likely to last at least another two years.

Testing, however, has been done with many tyre brands in order to ensure there are as many set-up options as possible. That was one reason why the factory actively sought to have cars in the Pirelli World Challenge in the US as well as the IMSA series on Michelins. They have also conducted some testing on the Super GT tyre, too, which was 'a different planet', according to the design team.

Tyre wear is a key to endurance racing even with the single-stint characteristics, but Honda has worked hard to ensure that this race car will make the tyres go for a full stint whether it is 40degC in the Arabian desert, or closer to 0degC at night during the Spa 24 hours.

'The big thing in our view is having a car that fits in the middle of the performance windows,' confirms Niffenegger. 'While others have a very good car, the characteristics of their car and the BoP means that it can be very difficult to race. One of our goals is to make our car perform to do the ultimate lap time, but also [to be able] to do the BoP to make the car still raceable. Gentlemen drivers prefer to pass on the straight so if you have too much drag then you start to run into problems on the higher speed circuits.'

Feedback from both amateur and silver drivers has so far been good and the update kit is now fitted to all the GT3 cars that are racing around the world. On the performance seen at Sebring, it's working, and it should work beyond Sebring, too. 'I think we are going to see a little less [variation of circuit performance] with this wider tuning range, we expect a little more consistent performance,' says Niffenegger. 'We saw circuits last year where we were very good, and others where we struggled. We will now have more consistent performance.'

There are two additional cars racing in Japan this year, and another one or two will be competing in the Blancpain Series Asia, while two customer cars are entered into the Blancpain America series. HPD failed to find a team to run the Blancpain Sprint series, but it has not yet given up hope, aware that its car now has a long shelf life. 'As this year goes on, for those who are still looking about, we have three years in this configuration, so there are a few years yet to run it,' says Niffenegger.

Aero changes have included a new front splitter and rear wing, while the strakes in the rear diffuser have been adjusted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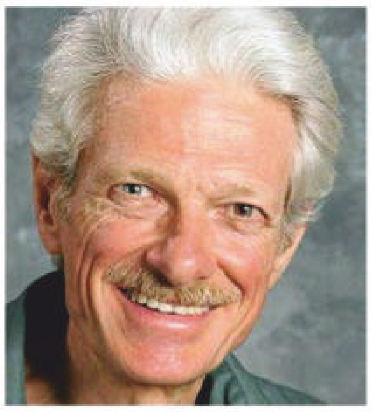

Decoupling roll and heave in a suspension system

The advantages of a set-up that separates the car's handling modes

Q I have been intrigued by the possibility of decoupling roll and heave in suspension systems. I understand that Porsche and Audi have been examining this concept in recent years. What do you know about this concept, and what potential do you think it has?

THE CONSULTANT

A In this context 'decoupling' roll and two-wheel heave (sometimes also called ride, to distinguish it from four-wheel heave) means using completely separate springing and damping for the two modes. There are various ways of doing this. Some predate the recent Porsche and Audi efforts. A monoshock front suspension with a slider and Belleville washers for roll springing would qualify. Some systems invented for Formula Vee rear suspension would also qualify.

Porsche has used a system like this for the front of the car. It applied for a German patent in 2011 and this is still pending as of February 2019 (the patent number is DE102009057194A). Achim Schulz is listed as the inventor. The patent description is in German and if you are searching in English you get the German, processed with Google Translate. The resulting language is almost completely unintelligible, but with my smattering of German and the illustrations, I can see how the system works.

Indeed, the language perhaps might cause a few giggles for English speakers. The system is described as a 'stroke wank' or 'hub wank' system. But just to get this straight from the very beginning 'hub' is German for heave and 'wank' is German for roll.

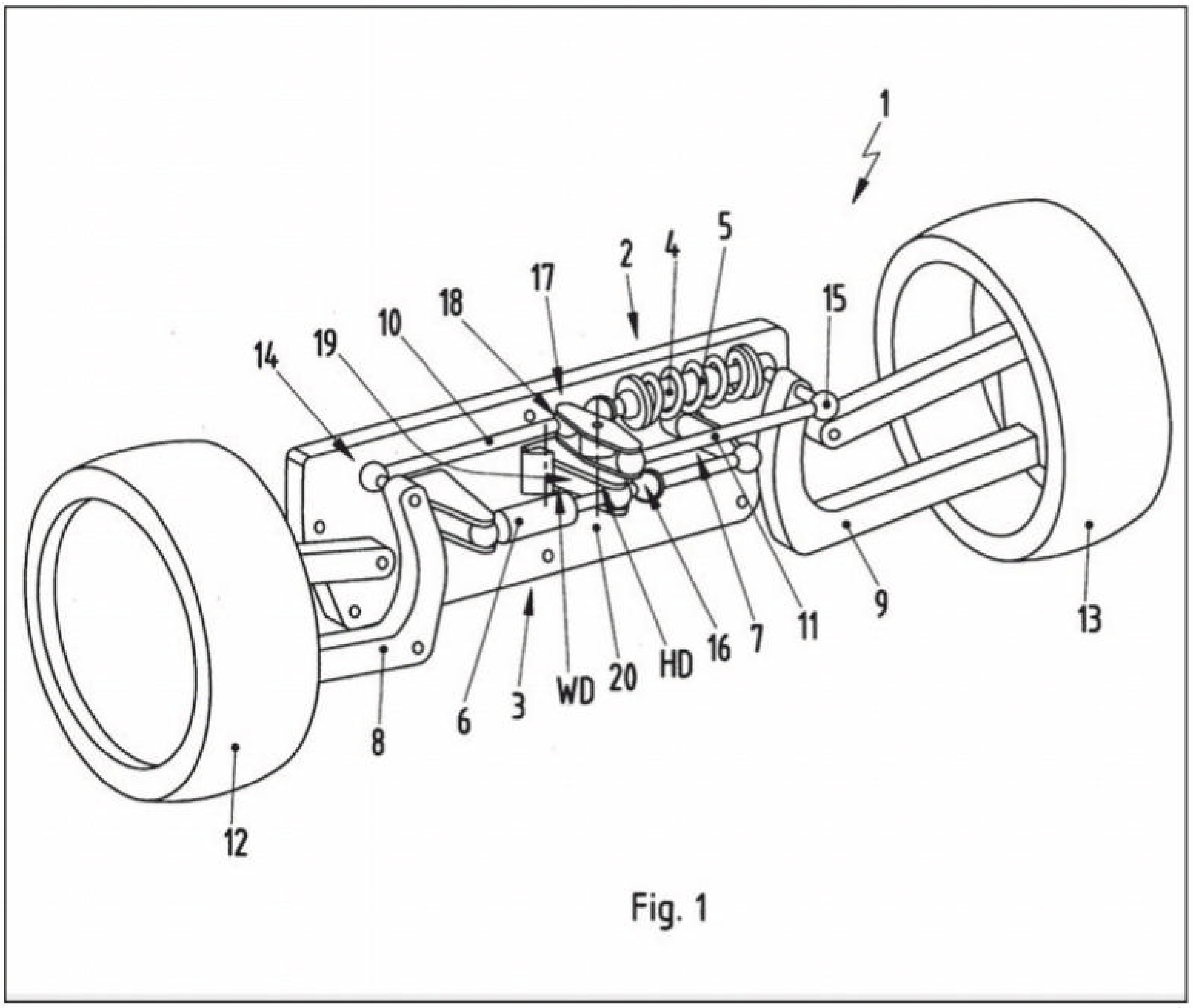

Figure 1: The decoupling system for a front suspension as shown in the patent (refer to text for key). ***With thanks to Porsche***

Figure 1 is an illustration from the patent description. In this image items 4 and 5 are the coilover that springs and dampens ride, or synchronous motion of the right and left suspensions. It attaches to rocker 17 and lower control arm 9, which would be the one for the left wheel assuming that the illustration shows the system from the front. It functions like the 'third' coilover used in more conventional layouts, or the single coilover in a monoshock system. This unit holds the car up. Item 6 is a damper for roll, or oppositional motion of the wheel pair. The spring for roll (anti-roll bar) is not shown but would probably be a torsion bar located behind the bulkhead, operated through a rotating blade adjuster (item 7).

There are two rockers in the system, items 17 and 19. The upper one, item 17, for ride, mounts to the lower, item 19, for roll. The pivot axis for the ride rocker is designated HD. The pivot axis for the roll rocker is designated WD.

Ride and roll

In pure ride, the upper rocker swivels and the lower one doesn't move. In pure roll, the rockers both swivel with respect to each other but the top one does not swivel with respect to the bulkhead; it just translates laterally, carried on the lower rocker. The motions in pure roll are such that the lateral distance between points 14 and 15 remains constant, and the length of the ride coilover does not change.

The operation of this system could be duplicated by starting with a more conventional pushrod and rocker suspension with a third coilover and a T-bar, removing the two main coilovers, and adding a pair of dampers connecting the rockers or the T-bar bar links to the middle of the cross of the T-bar.

Absent of any front to rear interconnection, the main advantage of a system with completely separate springing and damping for ride and roll is that it makes it easy to tailor rising/falling rate effects and damping properties for the two modes individually. This is appealing, but things get more interesting when we consider the possibilities of interconnecting the roll and ride springing or damping of the front and rear suspensions.

It gets interesting when we consider interconnecting the roll and ride springing, or the damping, of the front and rear suspensions

With lots of downforce, especially when this is dependent on ground effect aerodynamics, we may wish to have the racecar stiff in heave

To understand this, it is necessary to think in terms of the four modes of motion that are possible for a four-wheel suspension system:

- *Heave*: synchronous motion of all four individual wheel suspensions.
- *Roll*: oppositional motion of right and left wheels, in the same direction at the front and rear; synchronous motion of front and rear wheels, in opposite directions at the left and right; oppositional motion of diagonal wheel pairs, in opposite directions front/rear but same directions right/left.
- *Pitch*: synchronous motion of right and left wheels, in opposite directions at the front and rear; oppositional motion of front and rear wheels, in the same direction at the left and right; oppositional motion of diagonal wheel pairs, in the same direction front/rear but opposite directions left/right.
- *Warp*: oppositional motion of right and left wheels, in opposite directions at the front and rear; oppositional motion of front and rear wheels, in opposite directions at the left and right; synchronous motion of diagonal wheel pairs, in opposite directions.

Warp factor

Any possible displacement of the four-wheel system can be described in inches or millimetres of roll, pitch, heave and warp. Each wheel has elastic wheel rates (force change per unit of displacement) in each of the four modes. The four modes are shown in **Figure 2**. The roll, pitch, and heave modes correspond to movements of the sprung mass with respect to the road. Warp only occurs in response to road irregularities.

With independent suspension, we need to limit roll and pitch displacements to control wheel camber. If the car has little downforce, we may wish to leave heave relatively soft. With lots of downforce, especially when this is dependent on ground effects, we may wish to have the car stiff in heave to avoid large changes in ground clearance and undercar aerodynamics. But in all cases, we'd like the car soft in warp, to help the car ride bumps without compromising other considerations.

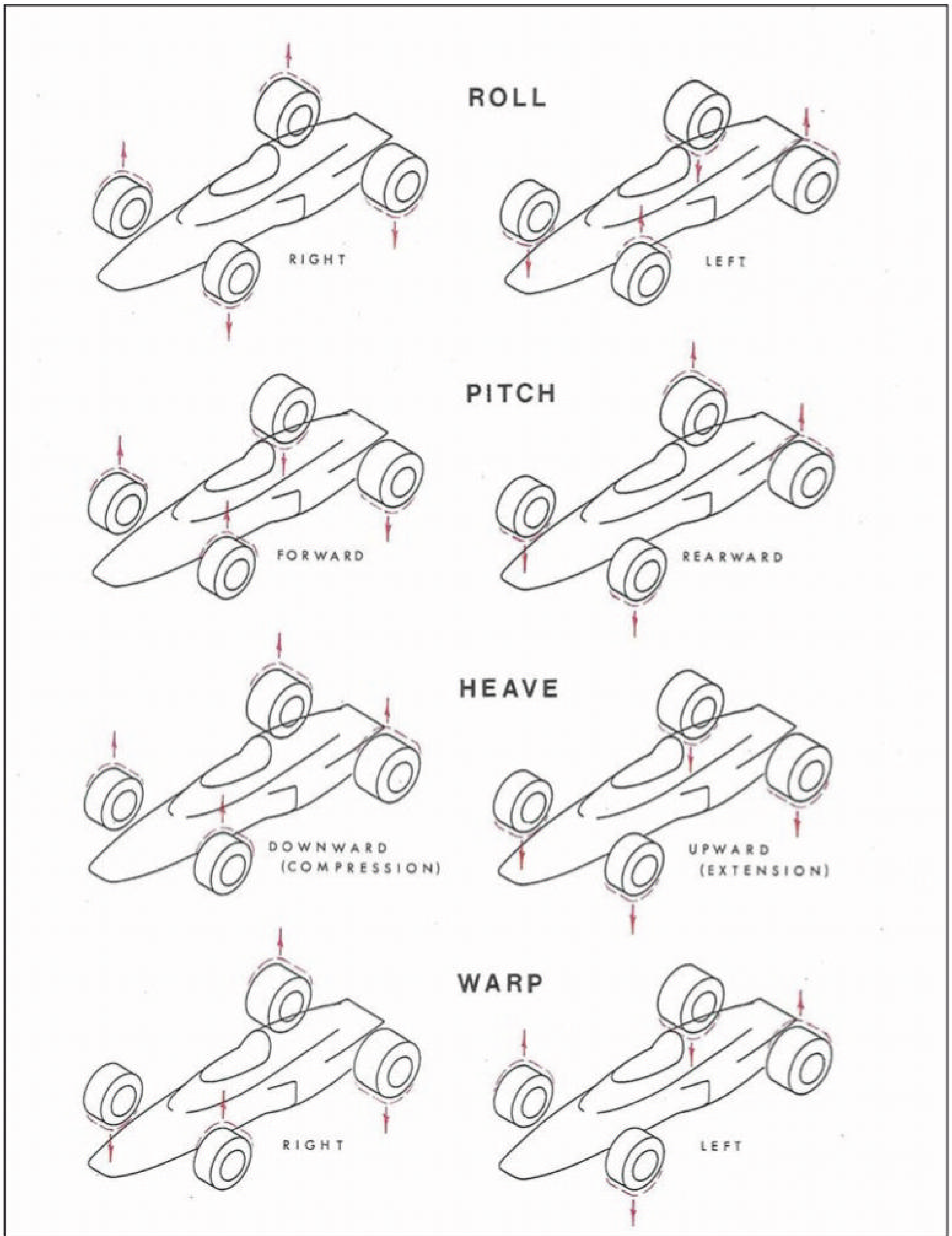

Figure 2: This neatly illustrates the four modes of motion that are possible with a four-wheel suspension system on a racecar

Interconnection

With independent suspension having no front/rear interconnection, each wheel's rates for roll and warp are the same, and each wheel's rates for pitch and heave are the same. With front/rear interconnection, we can get different rates for each mode at each wheel. This is the key to making the car soft in warp, or in warp and heave, without softening it in the other modes.

Elastic devices (that is springs of various kinds) that connect a pair of wheels, such as an anti-roll bar, always stiffen two of the modes and not the other two. To stiffen only one mode, we have to interconnect two interconnective devices.

That's what makes it really attractive to have discrete interconnective devices controlling ride and roll for the front and rear wheel pairs. We can then interconnect these, usually hydraulically. To do this successfully, we need discrete devices for roll and ride at both ends of the car. To get soft wheel rates in warp, we then establish an anti-synchronous relationship between the front and rear roll springing and damping devices – one that resists roll in the same direction at both ends (four-wheel roll), while more freely permitting roll in opposite directions at the front and rear of the car (four-wheel warp).

CONTACT

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The Buzz brings you bang up to date with the electronic systems currently in use in high-end motorsport through a series of exclusive insights from top engineers at industry-leader McLaren Applied Technologies

The electronic solution for racecars across the globe

How and why the Graphic Development Environment tool developed and supplied by McLaren Applied Technologies is being put to use in virtually all of the world's top racing categories

In F1 GDE is used to control a number of car and powertrain functions

XPB

While some things once thought central to motorsport have disappeared, on a fundamental level it remains an engineering exercise at heart. It's no surprise then that some tools and processes are still intrinsic to the very make-up of the sport. For example, many of the products provided by McLaren Applied Technologies (MAT) are universally applicable to motorsport, and Formula E, Formula 1, NASCAR and IndyCar all have this in common – specifically, the toolsets Graphical Development Environment (GDE), System Monitor, and ATLAS, which stands for Advanced Telemetry Linked Acquisition System.

Block buster

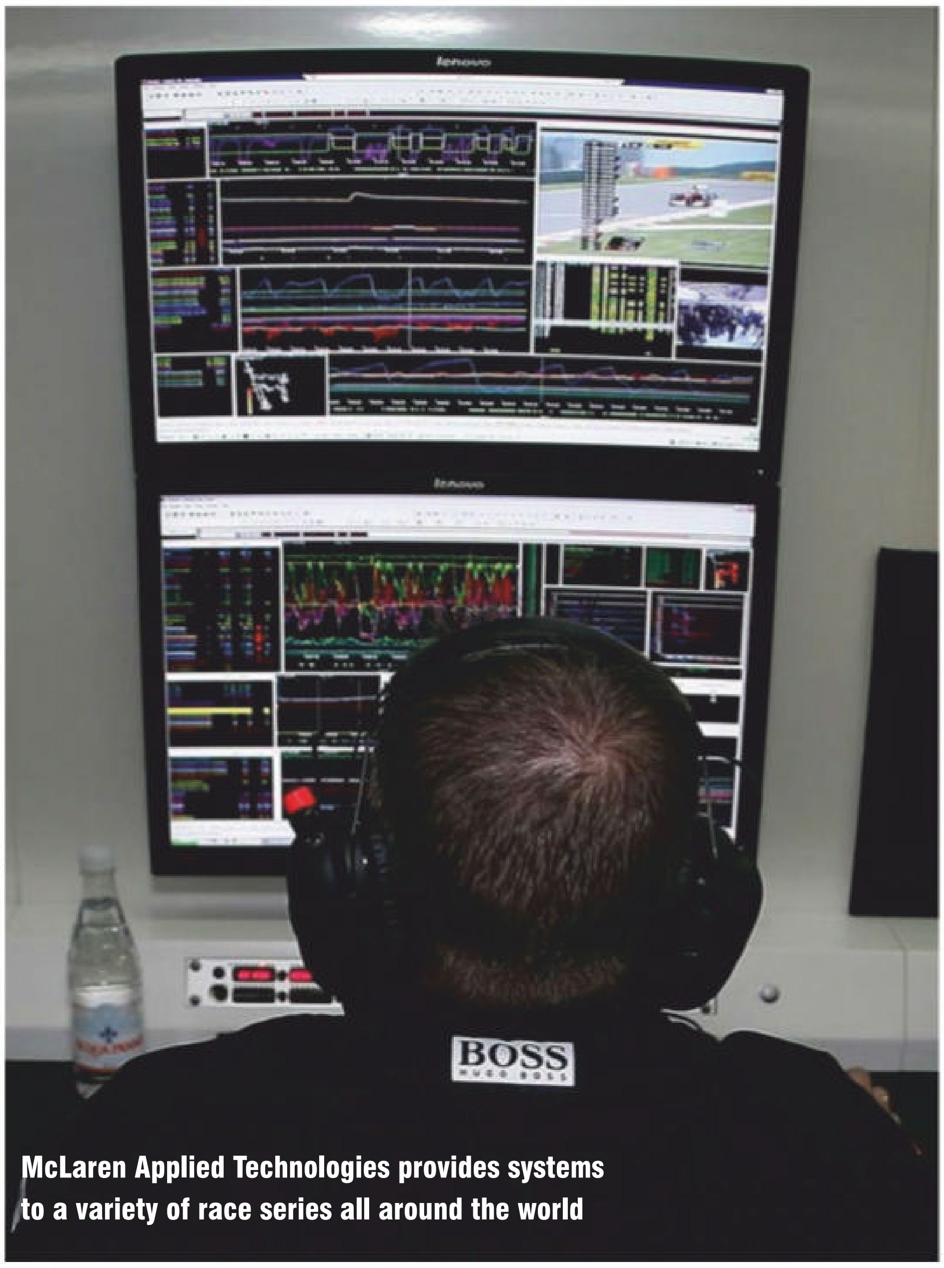
At the lowest level of commonality, GDE provides model-based development blocks that enable rapid development of custom low-level code that is auto-generated. In NASCAR, the blocks are used for traditional engine control, but also provide oversight for scrutineering, to ensure that teams are within the rules. Along with engine control and scrutineering functions, the models for IndyCar are used to ensure accurate turbo boost regulation.

In Formula 1, the aforementioned control strategies are used along with high-fidelity seamless shift gearbox and differential control. The F1 environment also combines the internal combustion engine (ICE) and the hybrid systems with control strategies that enable a complete powertrain control architecture. This complete architecture is also seen in FE, where the entire powertrain can be controlled from a single controller. Functions such as battery management, inverter control, brake-by-wire and re-gen are also efficiently developed with the MAT GDE tool.

Using GDE, models are built into embedded applications. Multiple applications per controller then combine to create a complete system within the controller.

Furthermore, multiple applications can co-exist on a single

In Formula E functions such as battery management, inverter control and re-gen are developed with the GDE tool



McLaren Applied Technologies provides systems to a variety of race series all around the world control unit or across an array of platforms both on and off the vehicle.

IndyCar uses GDE to facilitate manufacturer involvement in continued control system architecture development. Both the manufacturers taking part in IndyCar have experience of working with model-based embedded systems, and they are permitted to steer the development of the platform via code managed by McLaren Applied Technologies. This process includes the collaboration of all parties: IndyCar, MAT and the manufacturers, and is made possible thanks to a separate scrutineering application controlled by IndyCar.

This scrutineering application works in a similar manner for Formula 1. The Formula 1 control system includes nine applications and is the basis for the entire control of the 200mph-plus racing machines. The FIA's scrutineering application is used as a watchdog to monitor all inputs and outputs of other applications. This ensures that the teams and engine manufacturers are not carrying out tasks or tuning beyond the boundaries stipulated by the regulatory body.

The GDE automatically generates low-level code that is specific to McLaren Applied Technologies hardware, such as the TAG-400i that is used in IndyCar. GDE includes blocks for specific targeted hardware functions, such as reception and transmission of CAN data, or analogue inputs and outputs.

In Formula E the GDE tool is used to help control the complex brake-by-wire system on the Gen2 electric racecar

Brake-by-wire

Take the brake-by-wire control that is now used in Formula E as an example. It's a module that is enhanced by, and benefits from, GDE. Here a traditional front/rear brake bias adjustment is adapted to cope with the additional capability of braking energy re-generation from the electric powertrains used in Formula E.

For instance, if the brake bias is set at 55 per cent to the front and a braking event occurs, the following would take place. As the brakes are applied, pressure accumulates in the front hydraulic system. This is measured and fed back to the control system via a sensor. The model interprets this input and a sensor calibration is used to convert the raw output to an engineering unit.

Once this initial value is known, the driver brake bias input can be taken into consideration, and a calculation can be made to find the pressure required for the rear brakes.

However, the rear braking system is not a traditional system, but a combined drive-by-wire hydraulic and electric re-generative system. It must take into account the driver demand and the level of regenerative power the battery can accept in its current state of charge. The electric motor will also have a set maximum negative torque it can generate in its current state. The combination of front pressure demanded by the driver, desired brake bias, motor state, and battery state allow the output pressure of the rear brakes to be calculated with a tune-able pressure to torque conversion. This is then applied to the brake-by-wire and regenerative system, completing the driver demand brake request. All of these calculations occur in a single defined time slice and are continually calculated.

The systems sensor inputs can be modelled within the GDE for scaling, redundancy, optimisation and error levels. Event-based error conditions are generated for post-event analysis. Sensor models are applied to all inputs for this application ranging from brake pressure sensors, to battery current and temperature.

Interchangeable

The GDE's modular approach allows for separate sensor models and control system models to be interchanged and re-used. For example, the hydraulic pressure sensor input model can be used for both front and rear hydraulic pressures. In parallel to the input models, the brake-by-wire control system can be developed.

Because GDE is a model-based development tool, the control strategy can be developed and modelled as a standalone simulation and placed into the assembled model when appropriate for testing. This is achievable because hardware dependent interfaces will all live in the sensor models. The GDE development environment will pull the separate models together at build time to assemble a monolithic model that is then used to generate the eventual code that is to be run on the embedded system.

Tuning and calibrations are achieved with GDE blocks that tie into other McLaren Applied Technologies software systems: ATLAS and System Monitor. A new sensor may have a slightly different output curve due to small manufacturing variations. To achieve the required and consistent accuracy level, the updated sensor parameters are entered into System Monitor and saved as a data version. The data version is then loaded into the control system without the need to reassemble the GDE model. This interaction is vital in motorsport because small value changes need to be measured on track and later analysed. It allows for small incremental changes to be made without the need to make wholesale alterations to the application code.

The primary tool for tuning the MAT control system is System Monitor, a race-proven and developed software package. Analysis is carried out using MAT's advanced data-visualisation suite: ATLAS. This is one of several tools that we will be exploring in greater detail in future instalments of *The Buzz*.

The GDE's modular approach allows for separate sensor models and control system models to be interchanged and re-used

Driven does more, with less

Independent testing reveals Driven Racing Oils provides more horsepower with less wear

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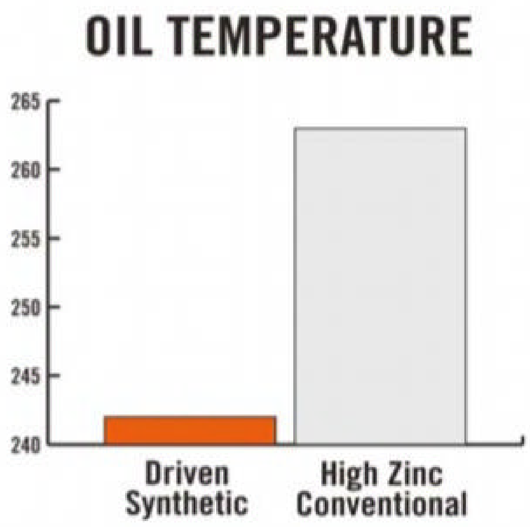

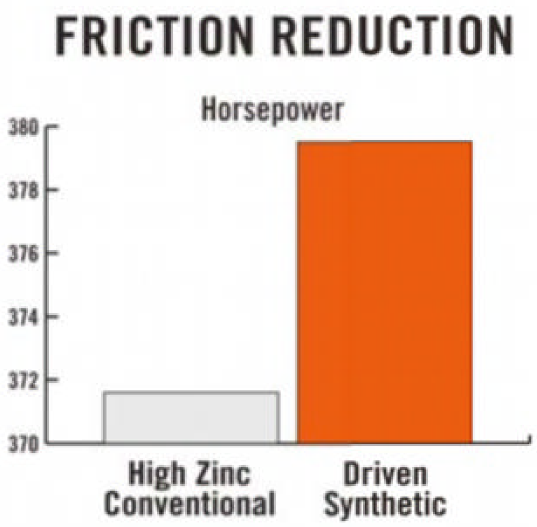

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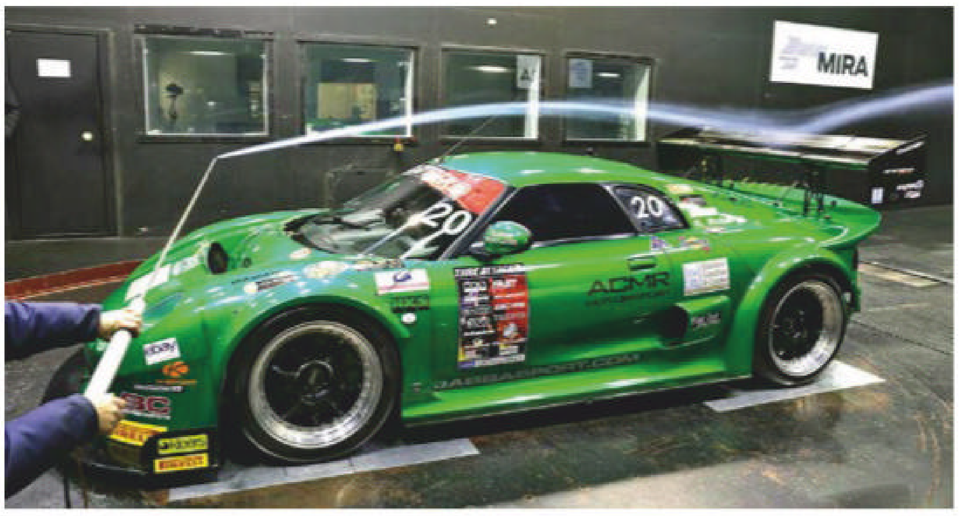
Does a Caterham really have the aerodynamics of a brick?

Our Time Attack aero study continues with some wing tweaks on the Caterham, while an old motorsport myth is examined

The Caterham R400 produced modest downforce while its aero balance needs sorting



The Noble's aero package has been heavily developed and it produced good downforce

The two racecars in our current wind tunnel project represent the smaller, lighter, nimbler approach to Time Attack, which, at the top level in the UK at least, still seems to be dominated by potent Mitsubishi Evos and Subaru Imprezas.

The Caterham R400 belongs to David Long, who won the 2018 Super Lap Scotland Pro class, while the Noble M12 RSR took Simon Roberts to victory in the 2017 UK Time Attack Club Pro class – he was the runner up in 2018.

While both cars represent the light and nimble approach, albeit one is smaller than the other, they are quite different in their aerodynamics. David Long only recently fitted wings to his Caterham, and the single element front wing was entirely new for our test session. As we saw in last month's project introduction the Caterham's aero package produces relatively modest downforce, and a satisfactory balance is an ongoing quest.

In contrast, Simon Roberts' Noble has been under aerodynamic development for a few years and we saw in our previous issue that it produces well-balanced, high downforce.

Table 1 shows the best in session aerodynamic coefficients for both cars (coefficients multiplied by frontal area, which are directly proportional to the forces, are given to enable direct comparison). The Caterham's total downforce represented 6.4 per cent of vehicle plus driver weight at 100mph, whereas the Noble's was 29.6 per cent at 100mph.

The R400 started the session with positive front lift

The Caterham's aerodynamic balance figure of 25.9%front was short of the target range, given that it had around 48 per cent of its static weight on the front axle. However, it actually started the session with positive front *lift*. We'll focus on the Caterham in this issue and examine how that front lift was turned into front downforce. We'll also look at a higher rear wing location, and examine whether the customary comparison with a brick is fair.

Wing sweeps

Front wing angle was increased in two steps from the initial installation angle and the data are shown in **Table 2**. The maximum angle tested was 10deg because it was known that this wing would peak at that angle at the installed height. The initial front lift was converted into downforce with the first adjustment and a further improvement was found at the maximum angle. Noteworthy was the small drag *decrease* with each front wing angle increase. The balance was well short of the desired 40-45%front and there was no alternative on the day but to reduce rear wing angle to improve this.

The rear wing started at 6.5deg measured over the top surface and was reduced in 2deg increments (**Table 3**). The responses were essentially linear (with some wobbles), and obviously decreasing rear wing angle saw decreased total downforce and –L/D values, but balance (%front) improved each time.

Front lift sources

Theoretically the rear wing angle could be reduced further; the wing would still make some downforce and balance would improve, but clearly the better approach would be to look for improved front downforce and

Table 1: Baseline numbers on the test cars

	CD.A	CL.A	CLfront.A	CLrear.A	%front	L/D
Caterham	0.866	-0.318	-0.083	-0.234	25.9%	-0.368
Noble	1.446	-2.571	-0.914	-1.657	35.6%	-1.779

Table 2: Front wing sweep on the Caterham

	CD	CL	CLfront	CLrear	%front	L/D
4deg	0.700	-0.271	+0.074	-0.345	-27.1%	-0.387
8deg	0.698	-0.338	-0.009	-0.329	2.7%	-0.484
10deg	0.693	-0.362	-0.039	-0.323	10.8%	-0.522

Table 3: Rear wing sweep on the Caterham

	CD	CL	CLfront	CLrear	%front	L/D
6.5deg	0.693	-0.362	-0.039	-0.323	10.8%	-0.522
4.5deg	0.679	-0.302	-0.052	-0.257	16.8%	-0.455
2.5deg	0.669	-0.278	-0.057	-0.221	20.5%	-0.416
0.5deg	0.661	-0.243	-0.063	-0.179	25.9%	-0.368

eradicating sources of front lift. We were constrained on the day to a visual search only, having maximised the front wing's downforce (other than by fitting a Gurney, which would have added another modest increment).

The upper surface of the front mudguards featured mini spoilers just behind the top to trigger flow separation, a proven method of reducing lift and drag. However, the use of smaller diameter wheels and tyres than standard meant there was a large gap between the front of the mudguard and the tyre, and the smoke plume clearly showed air entering this gap and then spilling out. Lift and drag would certainly be accruing here. And while we could do nothing on the day, some new mudguards that will mitigate this problem are now to be fitted to the Caterham.

There would also be some lift reductions possible from improved extraction on the downstream side of the front-mounted radiator, but sadly, once again, the time constraints prevented this being examined.

High rear wing

Clearly we were not seeking more rear downforce at this stage, and it will not have escaped the reader's notice that the rear wing was mounted behind the roll cage so far. An oft-asked question about this type of open car with exposed roll cage is: how much effect does the cage have on the rear wing? The wing was functioning more than adequately in this instance in a location below the top of the cage, but were more front downforce to be available the situation might be different. So we tried a higher location, nicely above the top of the cage, and the wing was at 0.5deg measured over the top surface; data shown in **Table 4**.

Unequivocally then, the wing was able to generate significantly more rear downforce in the higher location. In fact it generated the same rear downforce (-CLrear) at 0.5deg as it would have at 5.5deg in the lower position (see **Table 2**). Interestingly though, interpolating between the drag figures at 4.5deg and 6.5deg in **Table 2**, drag would be lower at 5.5deg rear wing angle in the low location than it was at 0.5deg in the high location, around CD = 0.685 compared to 0.701, or 2.3 per cent lower. Might the lower wing position have interacted beneficially with the inclined 'diffuser' (the fuel tank underside) to help achieve these numbers?

The smoke plume clearly showed the air spilling out of the front mudguard, a sure sign of lift and drag generation. The mini spoilers on the top of the mudguards can be seen here

Table 4: The effects of raising the rear wing height

	CD	CL	CLfront	CLrear	%front	L/D
Low wing	0.661	-0.243	-0.063	-0.179	25.9%	-0.368
High wing	0.701	-0.337	-0.046	-0.290	13.9%	-0.480

Table 5: The effects of removing the wings

	CD	CL	CLfront	CLrear	%front	L/D
Best run	0.661	-0.243	-0.063	-0.179	25.9%	-0.368
No wings	0.643	+0.214	+0.285	-0.071	132.8% (front lift)	+0.333

The brick

The CD of a cube is widely quoted at 1.05. The CD of a Caterham-sized brick in ANSYS CFD was eight per cent less than a cube. **Table 5** shows the numbers on our Caterham with wings removed. With or without wings, the Caterham is nothing like a brick!

Noteworthy in **Table 5** is the front lift with the wings removed. Clearly the front wing was doing a lot of work by eradicating the intrinsic lift, and collectively the wings converted 214 counts of lift into 243 counts of downforce, even at the lowest rear wing angle, for just 2.8 per cent extra drag.

Next month we'll focus on the Noble.

Racecar's *thanks go to David Long and Simon Roberts for providing the cars.*

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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The rear wing was able to generate more downforce in the higher location

Caterham without wings. Despite its reputation this car is not a 'brick' in terms of drag

The higher wing position, away from the influence of the roll cage, proved to be effective


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Lifting the skirts on ground effect

The Lotus 79 kick-started the ground effect revolution in Formula 1 following its dominant performance in 1978. It was also a very nice looking racecar

Modern Formula 1 aerodynamics are notoriously complicated but was it really far simpler 40 years ago? We take the CFD time machine back to the age of ground effects to find out

By SIMON MCBEATH

They say that all race fans have favourite periods of racecar design. This may have something to do with the cars one grew up watching. It may be down to aesthetics. Or it may be because of fascination with the engineering. But one thing is certain, racecars are a lot more complicated now than they once were.

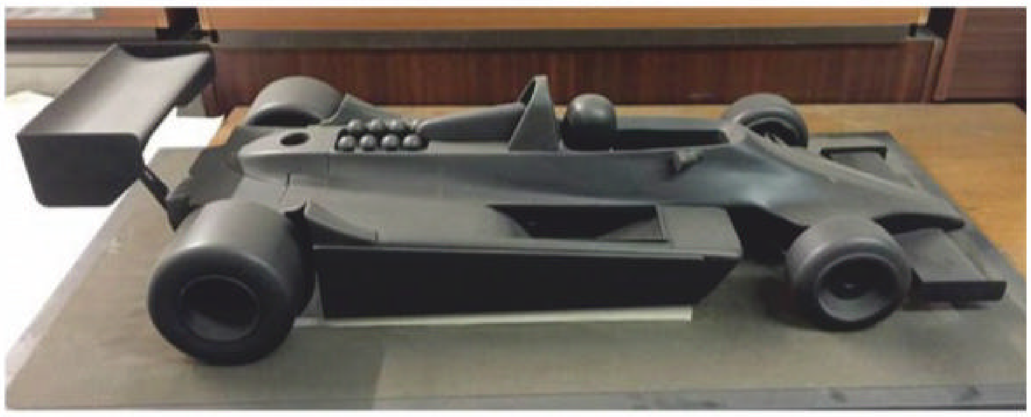
Pre-aerodynamic aids (effectively pre-1967 for single seaters) F1 cars were perhaps as simple as they could be – you might use the word *pure* instead of *simple*. However, once F1 engineers got a grip (no pun intended) on the benefits that aerodynamics and specifically downforce could bring there was no going back.

It might also be argued that the appearance of ground effect and its successful application to racecars in the late '70s and early '80s produced another pure concept. Thanks largely to the work of a small group working for Peter Wright, this magazine's technical consultant who was then in charge of the wind tunnel programme at Team Lotus, beautifully integrated aerodynamic packages that exploited a large proportion of the plan area of the cars with an elegantly simple yet highly potent principle became the norm for a few years. But the reader would be correct if they were sensing writer bias here, so to be totally upfront about this, was there ever a more beautiful Formula 1 car than the JPS-liveried Lotus 79, or one that had cleaner lines than the Williams FW07?

The chance, then, to do some CFD on a CAD model of a 1982 ground effect F1 car (which for now must remain anonymous in deference to the owner's wishes) was a great opportunity not only to examine how the aerodynamics on cars of that era functioned, but also to study what happened when things went wrong.

Sliding skirts along the outer, bottom edge of the sidepods (which had downforce-inducing profiled undersides) were originally the key to maximising the underbody's downforce contribution. The objective was obviously to keep the spring-loaded skirts in full contact

Above and right: Wind tunnel models of the Lotus 79 with the skirt visible at the lower edge of the sidepod



Sliding skirts along the outer, bottom edge of the sidepods were originally the key to maximising the underbody's downforce contribution

with the ground at all times, but as history relates they didn't always slide up and down as designed. Sometimes a jammed skirt would see a car leave the race track at a tangent to the intended curve, on occasion with disastrous results. The high loads generated also brought related engineering challenges, such as the need for improved brakes and beefed up chassis and suspension. So there were major issues surrounding these skirted cars.

However, when the skirts were in full and consistent ground contact the cornering and braking power of these Formula 1 cars was impressive, and the step forward in lap time performance was very significant.

The questions

So how did skirted ground effect work? What happened when the skirts jammed? And what happened (aerodynamically) when the regulators attempted to enforce a minimum skirt to ground gap in Formula1 in 1981?

First, let's take a look at the aerodynamic performance of ground effect F1 cars from that period (they were banned at the end of 1982 and flat bottoms between the axle lines on Formula 1 cars became the norm). Our model looks to be representative for this purpose thanks to some in-period supporting data.

Table 1 highlights the key parameters derived from our baseline CFD run as coefficients, with comparison with some figures from a 1983 technical paper by Peter Wright at the same ride height and with skirts also in full contact (the data has been adjusted to represent notionally similar frontal areas). As can be seen the coefficients agree quite well between those derived in CFD for this article and the typical data published by Wright, which was obtained in the 5ft x 4ft Donald Campbell tunnel at Imperial College, London, on 25 per cent scale models of unspecified Lotus cars between 1978 and 1982 (Types 78, 79 and 91 were mentioned). Such agreement between

Table 1: The coefficients on our ground effect F1 model compared to Team Lotus-based data

	CD	-CL	-L/D
1982 CFD model	1.197	3.821	3.192
Lotus F1 ¼ scale	1.111	3.710	3.340

the data from different cars using different simulation methods, both of which had or have their individual shortcomings, provides confidence that the qualitative effects we're going to focus on here have a sound basis.

CFD can do so much more than just enable the calculation of forces and trends though. Not only does it enable us to break down the total forces into the respective contributions of each major part of the car, it also allows us to visualise the pressures and flows around the model, and easily to examine a few 'what if' scenarios, such as 'what if the skirts jam?'

Once our model had achieved a satisfactory front to rear downforce balance, this then enabled the distribution of the forces to be calculated. The dual-element rear wing featured a fairly flat, modestly cambered main element and a medium-steep flap angle, while the front wing was run at a shallow angle. This was common practice in period if front wings were needed. Sometimes cars would be run with no front wing, although one suspects this would probably be in circumstances that required lower drag, hence lower rear wing angles, hence the front wing could be dispensed with to maintain the aerodynamic balance.

Then and now

Figure 1 shows the drag contributions of the major components of our model alongside similar data from our article in V26N12, which (along with V27N1) featured a model created to the 2017 F1 regulations by Miqdad Ali of Dynamic Flow Solutions, used here as indicative of the numbers on recent Formula 1 cars. The 1982 car's body created a much greater proportion of the drag than was the case with the 2017 model, and given that the body width behind the front wheels has remained constant at 1400mm since then, this in part shows significant progress on drag reduction of the main body (which includes the upper and lower surfaces in this context), although it must also be related to the lower proportion of total downforce generated by the body. The 1982 car's bigger wheels, unsurprisingly, were also bigger drag contributors, but its wings made smaller contributions, especially the front but even the rear wing made proportionately less drag than that of the 2017 car.

Figure 2 shows the downforce contributions of the same component groups, and the contrasts between the 1982 and 2017 models were even starker. The bigger wheels on the older car generated more lift, partly because of their greater width but also in the case of the rear wheels because the long sidepod and the presence of the side skirt forced more flow over the rear tyres. The wings generated less downforce on the older car, commensurate with the lower wing drag contributions highlighted above. But the biggest contrast was in the downforce contributions of the car body; when its skirts were in full contact over 95 per cent of the 1982 car's total downforce came from the body compared to around 47 per cent on the 2017 car. In passing it ought to be said that the 2017 model (with no skirts of course) achieved somewhat higher total downforce than our baseline 1982 model for a not dissimilar drag level, highlighting 37 years of steady evolution in racecar aerodynamics to where we are today, for better or worse.

In order to maintain our test subject's anonymity we are restricted to non-identifying views such as the underside, but no matter because this is where most of the interest occurred. **Figure 3** shows the pressure distribution on our 1982 model's lower

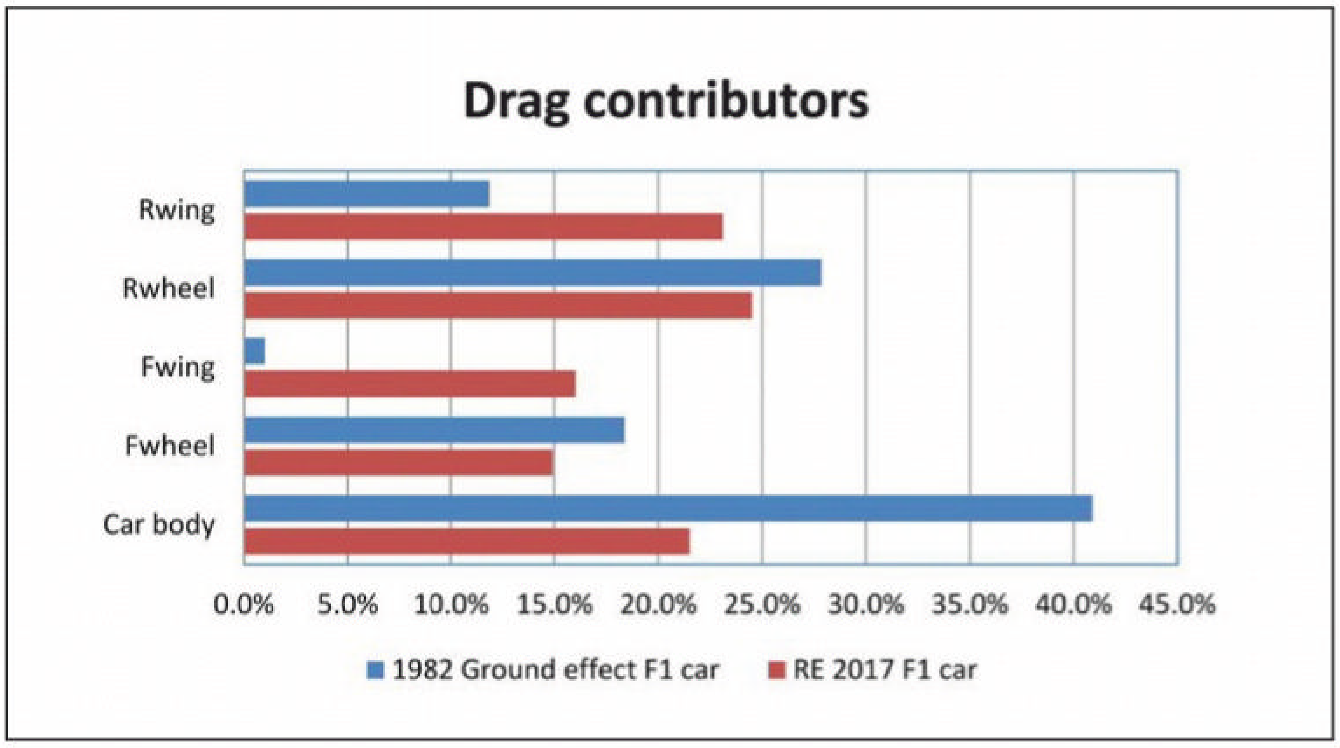


Figure 1: Drag contributions of the major components of our 1982 ground effect model compared to 2017 rules F1 model

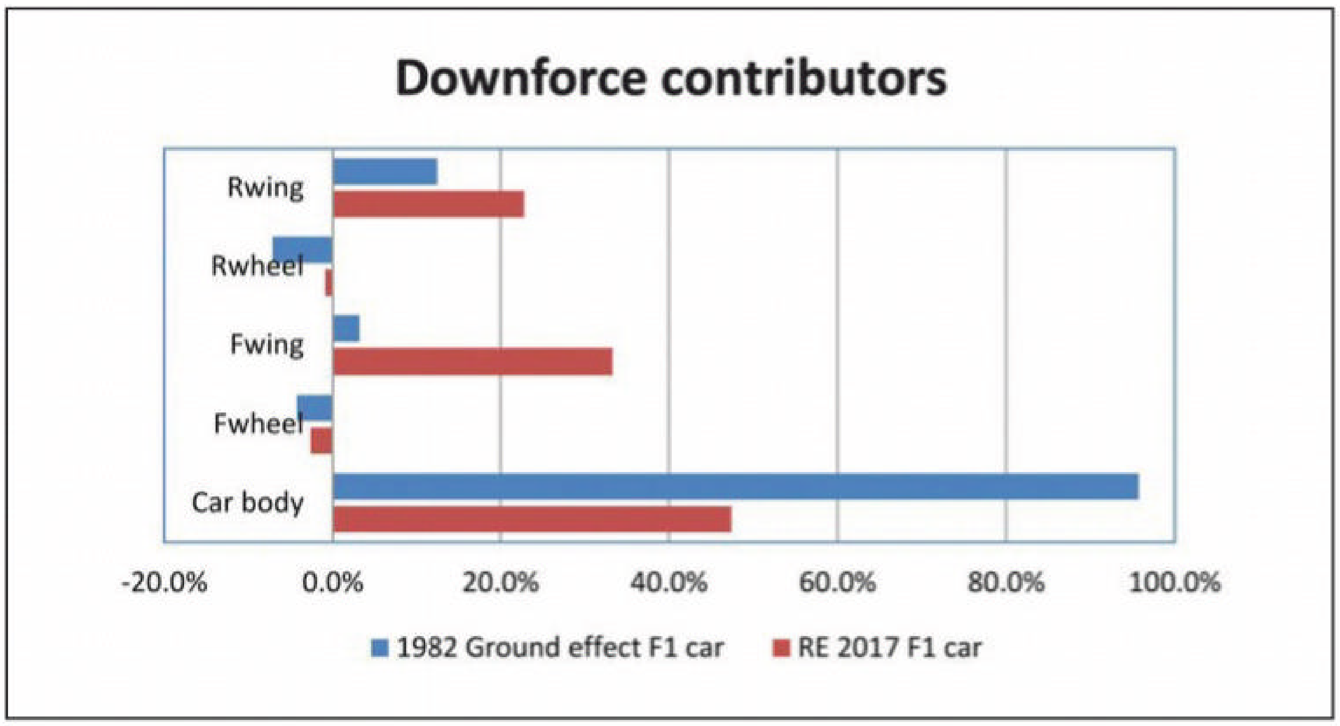


Figure 2: This shows the contributions to downforce and lift from all the major car components for our two F1 models

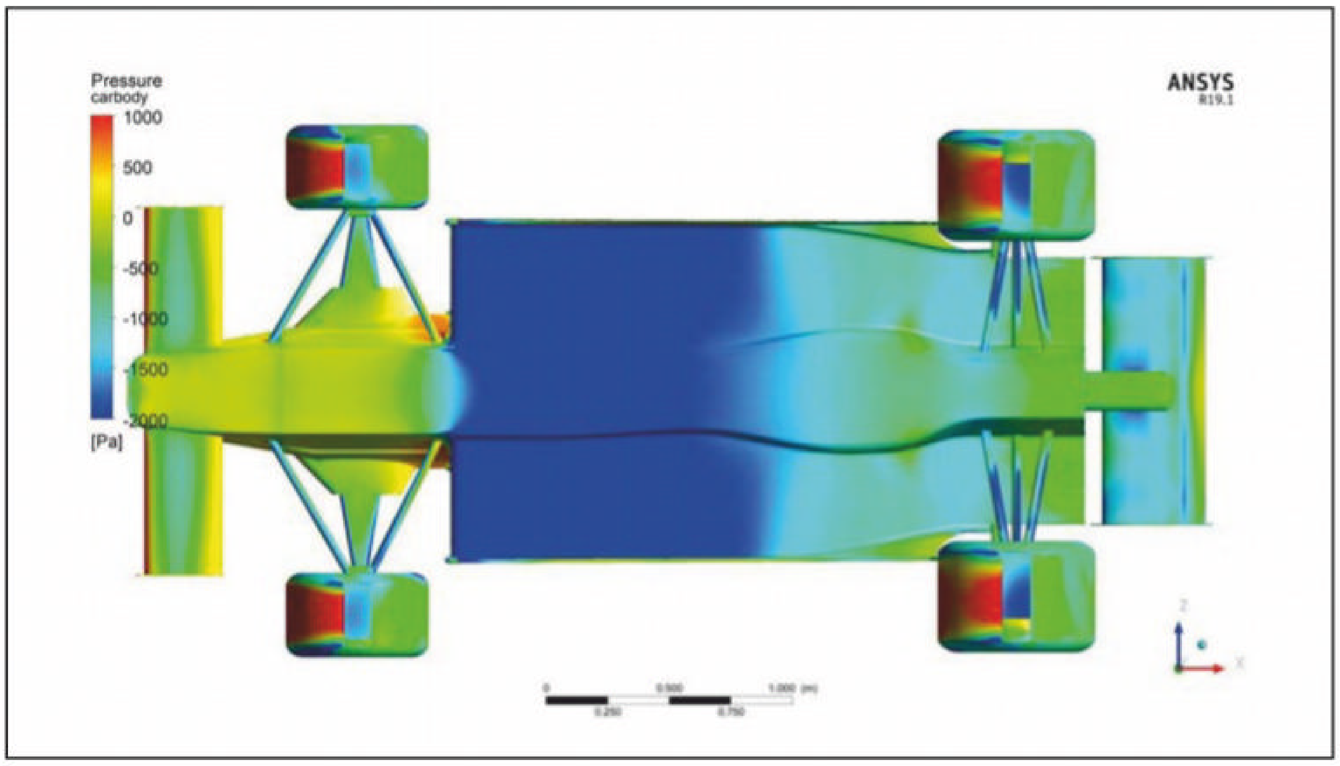


Figure 3: Pressure distribution on the underside shows where most of the downforce accrued on the 1982 skirted car

Illustrations (S. McBeath/ANSYS unless otherwise stated)

When the skirts were in full and consistent ground contact the cornering and braking power of these cars was very impressive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surfaces and it is immediately clear where the low pressure areas were generated. The front wing, which featured an end-plate reaching the ground to simulate a fixed skirt, exhibited relatively mild suction. The rear wing generated moderate suction, with variations across its span thanks to the wake of the driver, cockpit and roll hoop as well as those interesting flows coming up and over the rear tyres. But it's easy to see how the main underbody generated the vast majority of the car's downforce, since this is where the biggest pressure reduction was, and it was spread over a large plan area. The suction was concentrated in the forward underbody, hence only a small front wing (at most) was needed to balance the car. It's also interesting to note that although it was the tunnels either side of the chassis that did the work, the pressure reduction they induced extended right across the underside of the central chassis too.

In **Figure 4** streamlines have been initiated on a horizontal plane 50mm above ground level to show the flow velocities below the car. Note first that the 'low power' front wing created no apparent inwash or outwash component. The positioning of the tunnel entrances was such that only clean flow converged between the front wheels and entered the underbody while the dirty front wheel wake remained entirely outboard. The side skirts then ensured that no influx from the sides into the underbody was possible, and the accelerated flow in the forward underbody was virtually two-dimensional, remaining at high velocity (and therefore at low pressure) right along the flat throat region before then slowing down in the tunnel diffusers. Because of the side skirts, sideways influx only started at the rear of the sidepods, in line with the front of the rear tyres, and aft of this some of the rear wheel wake was drawn into the flow, issues which would have greater significance on subsequent skirt-less flat bottom Formula 1 layouts with aft-mounted diffusers, such as those we see today.

Skirting issues

Two different scenarios of skirt malfunction could be envisaged; firstly, the simple case of a horizontal gap beneath the skirt, as if it jammed up but remained parallel to the ground; and secondly, the case of the skirt being jammed at an angle, either front-up or rear-up. Taking the horizontal skirt gap first, **Figure 5** shows the reduction in downforce that Wright reported on the quarter-scale Lotus models in 1983. Our 1982 model also showed rapidly declining downforce in this same scenario, although drag altered very little with skirt gap, aspects verified in real-world straightline track testing.

Visualising how these big downforce losses occurred is very revealing. **Figure 6** shows the surface pressures on the CFD model's underside with no skirt at all in the lower half of image compared to the fully skirted case. Not only had the suction in the underbody throat been

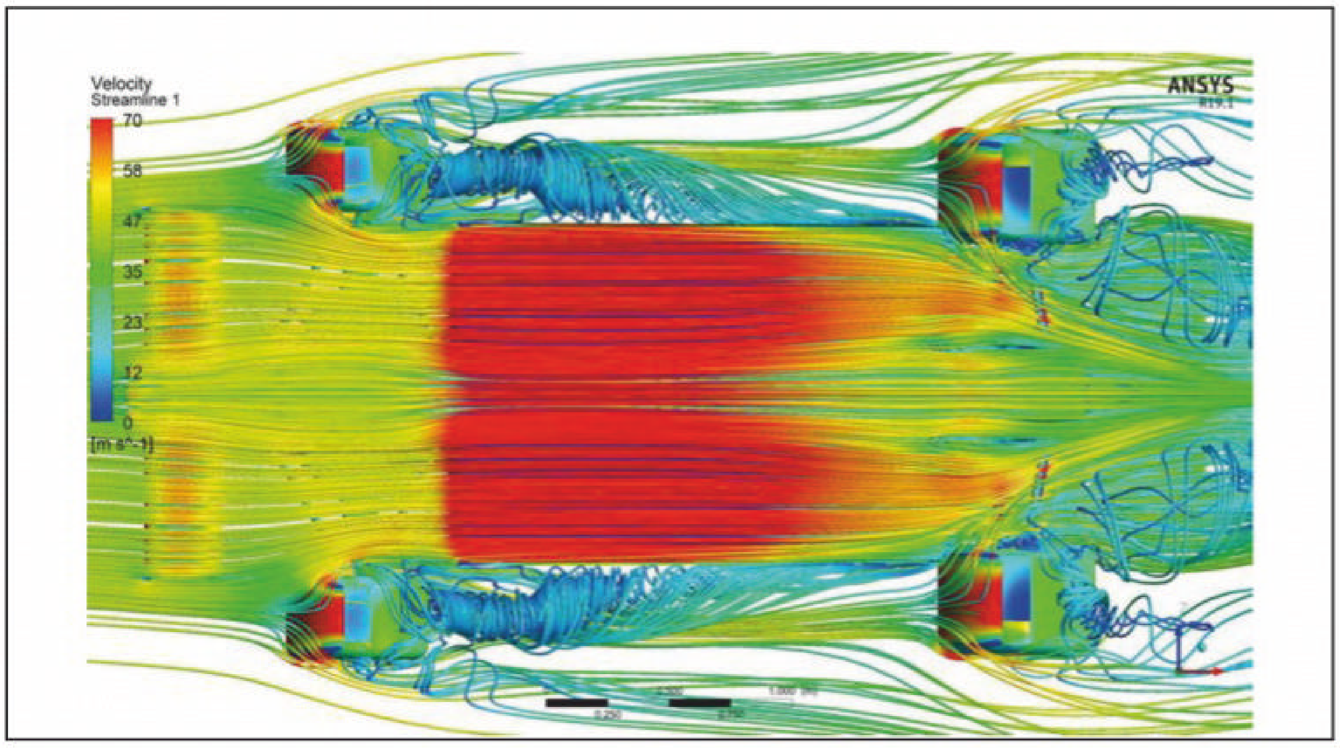

Figure 4: The streamlines show a fast, clean flow through the underbody, with the front wheel wakes entirely outboard

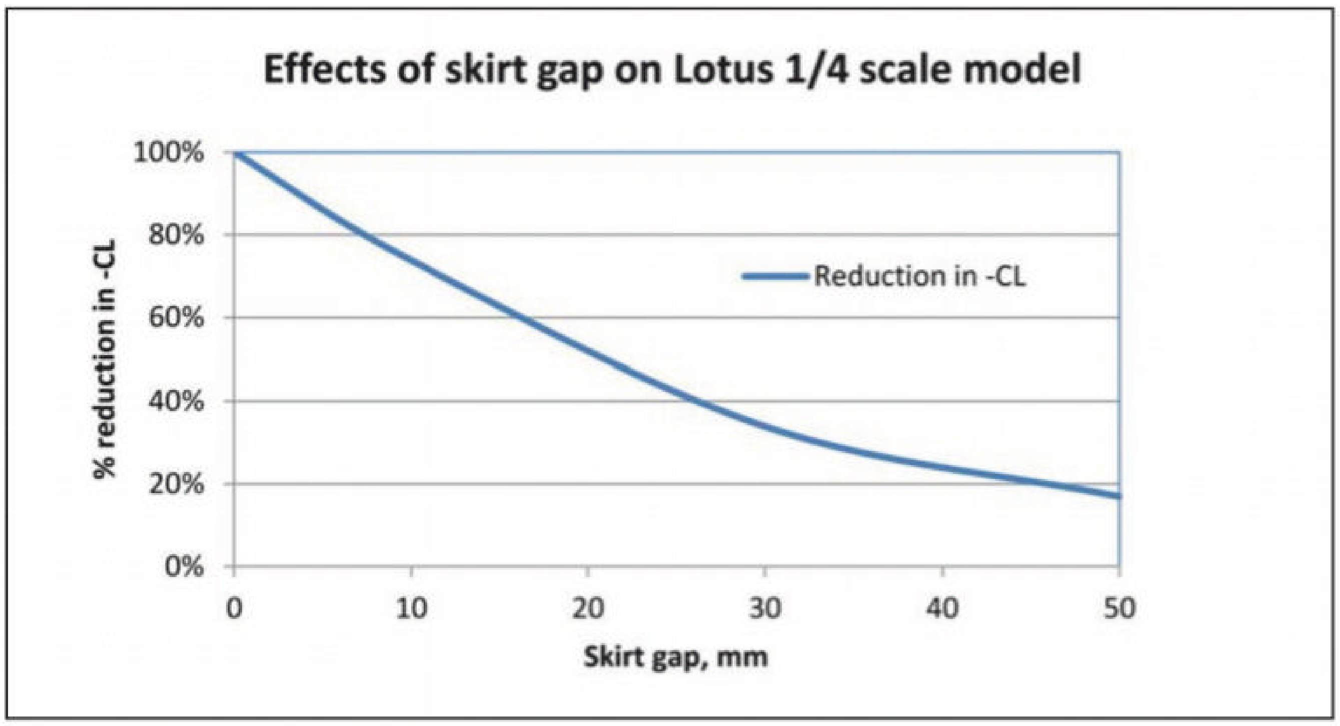

Figure 5: The effect of skirt gap on the downforce, as reported by Peter Wright on quarter-scale Lotus models in 1983

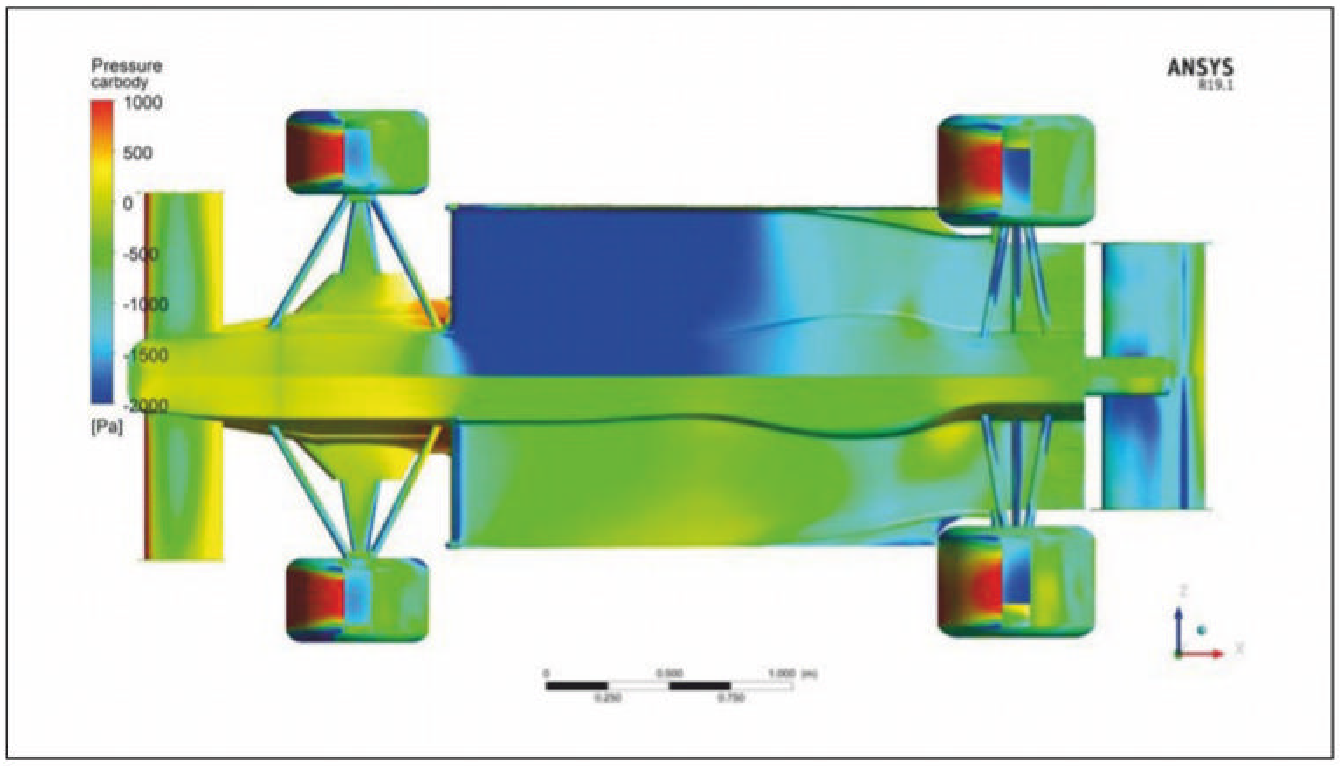

Figure 6: Having no skirt (lower half) drastically altered pressure distribution on the underside. Full skirt is upper half

Not only had the suction in the underbody throat been all but lost, but there was also slight positive pressure about halfway along the tunnels

all but lost, but there was also slight positive pressure about halfway along the tunnels. Over such a large plan area this increase in pressure represents a huge loss of downforce. Recall that in 1981 the FIA temporarily banned side skirts and mandated a 6cm minimum ground clearance; it is perhaps no wonder that the teams responded with some frankly ridiculous ways of lowering the cars after their static ride height checks in order to bridge the gap along the bottom outer edge of the sidepods.

Figure 7 shows the streamlines again projected on a horizontal plane level with the underside, and by comparing with **Figure 4** the very different flow regime is apparent. Not only did the removal of the skirt enable large scale inflow from the sides that now preferentially filled the tunnels, but it can also be seen that in the first third of the tunnel the streamlines actually flowed outboard of the edge of the sidepod. This was, no doubt, in response to the tunnels filling from the sides further downstream and to the obviously related slight positive pressure halfway along the tunnels mentioned above that all contributed to a much reduced mean velocity through the throat. The tunnels did still generate some downforce, at the inlet and also where the vortex that spun off the bottom edge of the sidepod created a drop in pressure in the diffuser.

Wing effects

The keen-eyed reader will have also noticed in **Figure 6** that the rear wing appeared to show increased suction on its underside in the model with no skirt compared to the fully skirted case. Indeed, there was a trend in the results that saw increasing rear wing downforce with increasing skirt gap, and the wing generated 35 per cent more downforce with no skirt than with the full skirt. What caused this effect? Contrast the predominant paths of the front wheel wake in **Figures 8** and **9**. In **Figure 8** it is clear that the full skirt prevented the front wheel wake from getting under the car, which in turn saw it turn upwards and over the rear upper edge of the sidepod ahead of the rear wheel. From here it entered and adversely affected the flow field of the rear wing, reducing the wing's downforce. In **Figure 9**, the absence of the skirt allowed most of the front wheel wake to pass into the underbody and much less (though still some) of it went upwards to affect the rear wing.

So increasing the skirt gap or removing the skirt entirely not only drastically reduced the forward-biased downforce of the underbody but it also increased the downforce of the rear wing. This contributed to further rearwards shifting of the overall centre of pressure that the massive loss of forward underbody downforce had already created. As a related side note, some of the cars around this time had a raised fence along the upper, rear edge of the sidepod and from what we have seen from this study this fence must have been to

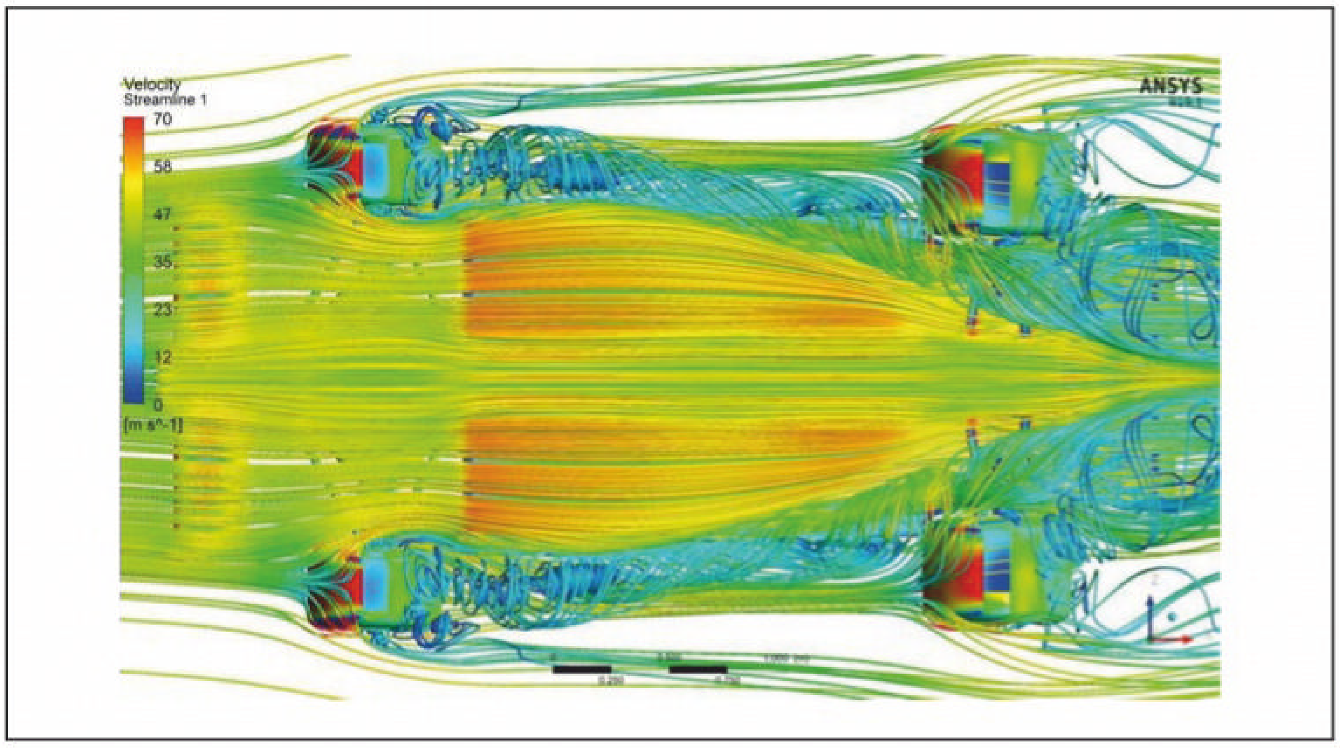

Figure 7: Removing the skirts significantly altered the flows under the racecar too. Compare this image with Figure 4

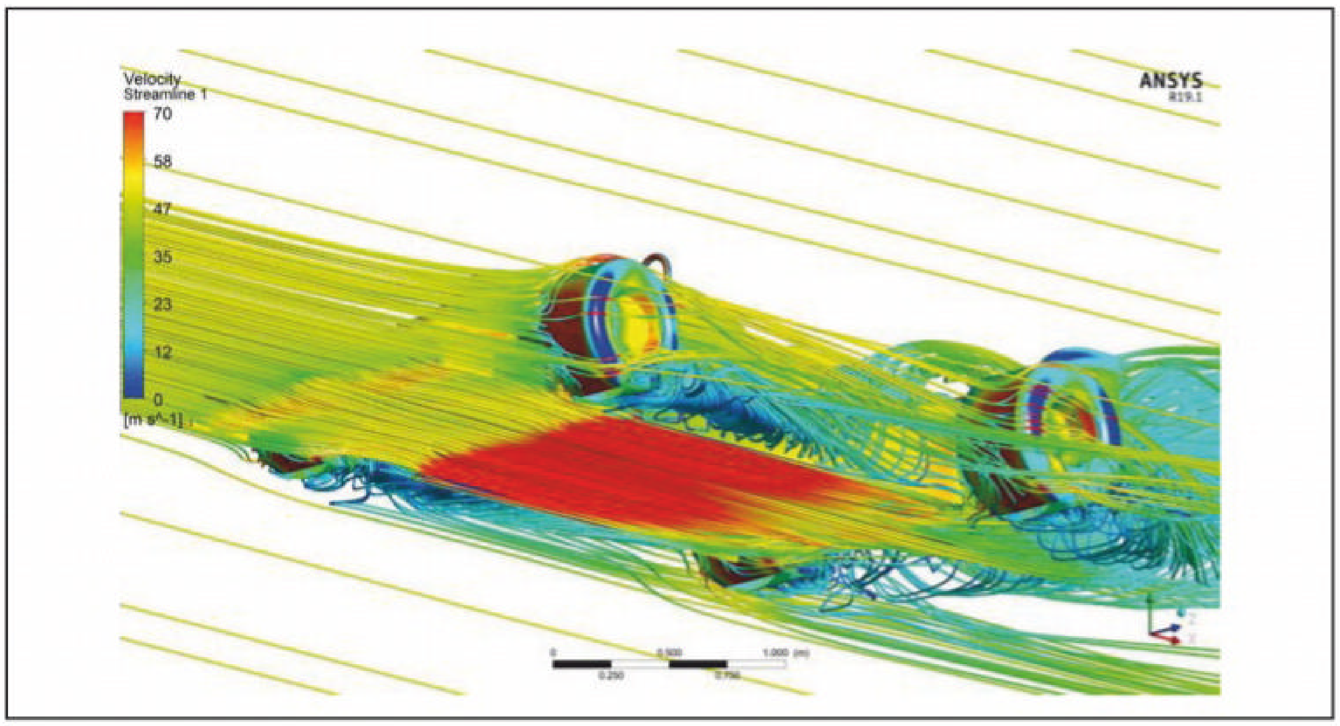

Figure 8: With full skirt the front wheel wake couldn't enter the underbody but it had a negative effect on the rear wing

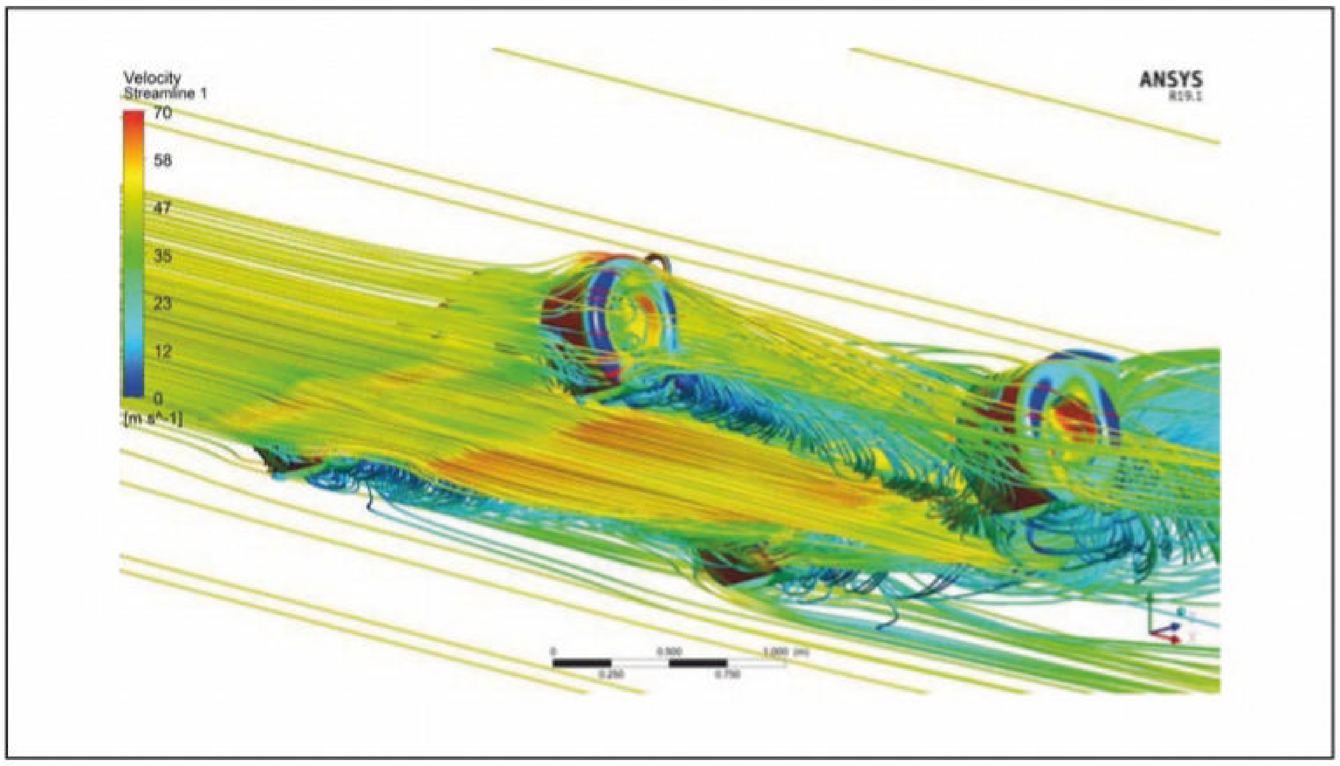

Figure 9: With the skirt removed the front wheel wake entered the underbody, not encountering the rear wing so much

It seems very clear then that any gap under the car's skirt was quite a bad thing because so much of the downforce was then lost

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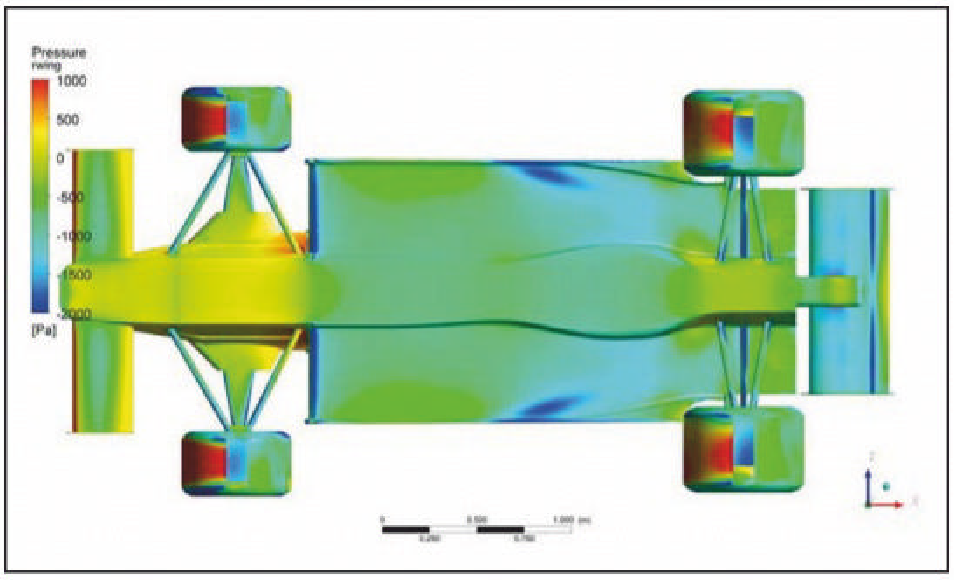


Figure 10: This is the underside pressure distribution resulting from a front-up skirt jam

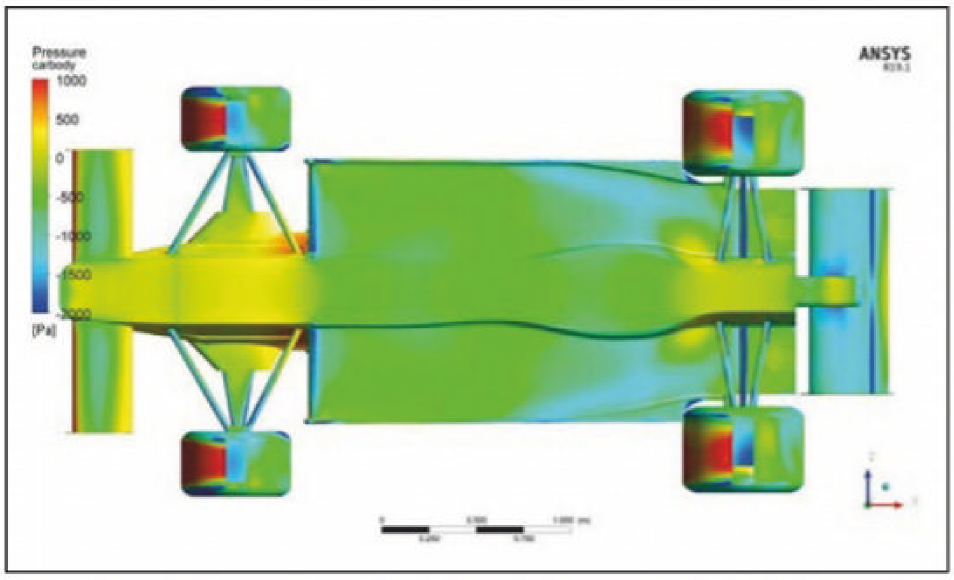


Figure 11: The underside pressure distribution that is the result of a rear-up skirt jam

Skirts had their issues, but whether they could have ever been made reliable became academic when flat undersides were mandated in 1983

steer the front wheel wake away from the rear wing when full skirts were deployed.

It seems very clear then that any gap under the skirt was a bad thing because so much downforce was lost. What then would have been the effect of a skirt jamming up at the front or the rear? Two cases were run, one with the gap ranging from 45mm at the front to 10mm at the rear, which we shall call a 'front-up jam', the other ranging from 10mm at the front to 45mm at the rear, a 'rear-up jam'. Again there was minimal effect on drag but the downforce losses were substantial in both cases. The more likely to occur front-up jam saw very slightly less overall downforce lost than the rear-up case, the latter showing losses not far short of the no skirt case.

The visualisation of the front-up jam in **Figure 10** shows that the surface pressures on the car's underbody were generally lower than in the no skirt case as shown in the lower half of **Figure 6**, with an intensification of the vortex-induced suction ahead of the narrowing skirt gap. Hence the downforce loss in this instance, while still drastic, was not as much as in the no skirt case. **Figure 11**, showing the underbody pressures in the rear-up jam case was more akin to the no skirt case, although the presence of the tilted skirt did cause some intensification of the vortex that added a little more suction to the forward diffuser region. In essence then these jammed skirt scenarios were really just variations of the no skirt case given the large downforce losses and balance shifts.

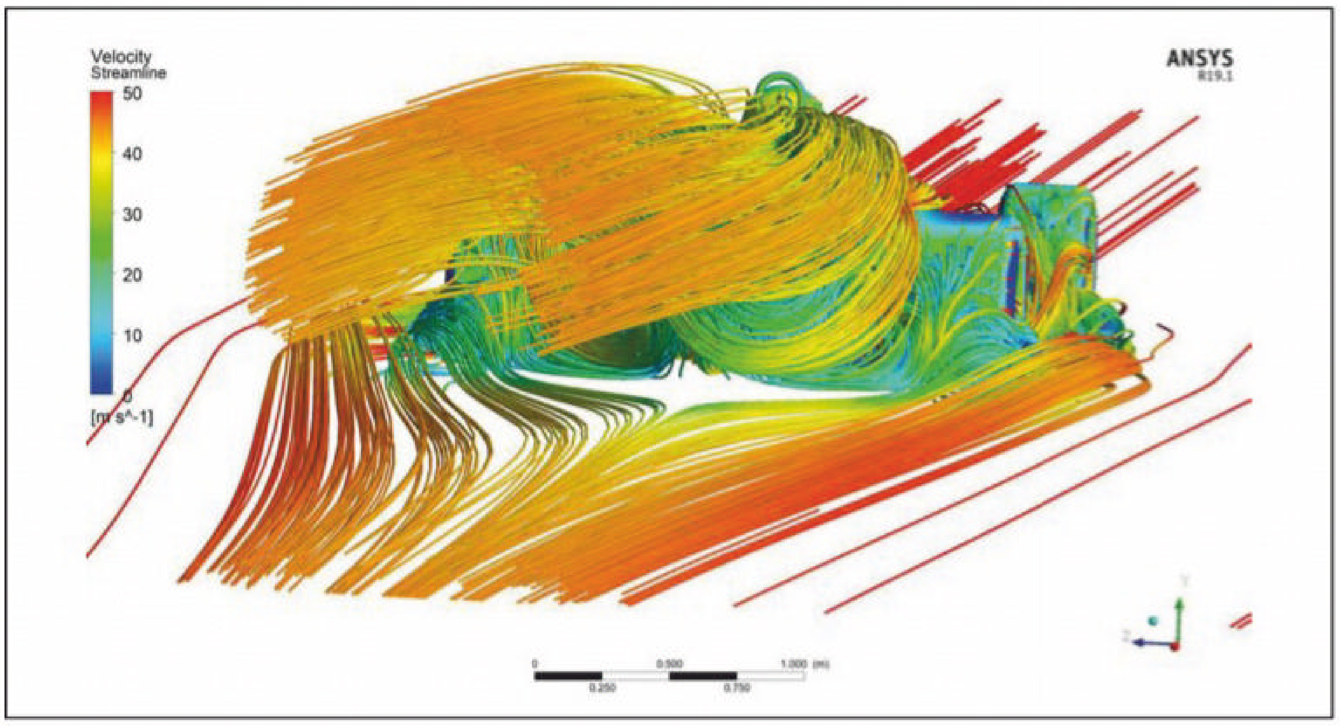


Figure 12: Streamlines show the wake of our 1982 skirted ground effect Formula 1 model; note inwash near ground level

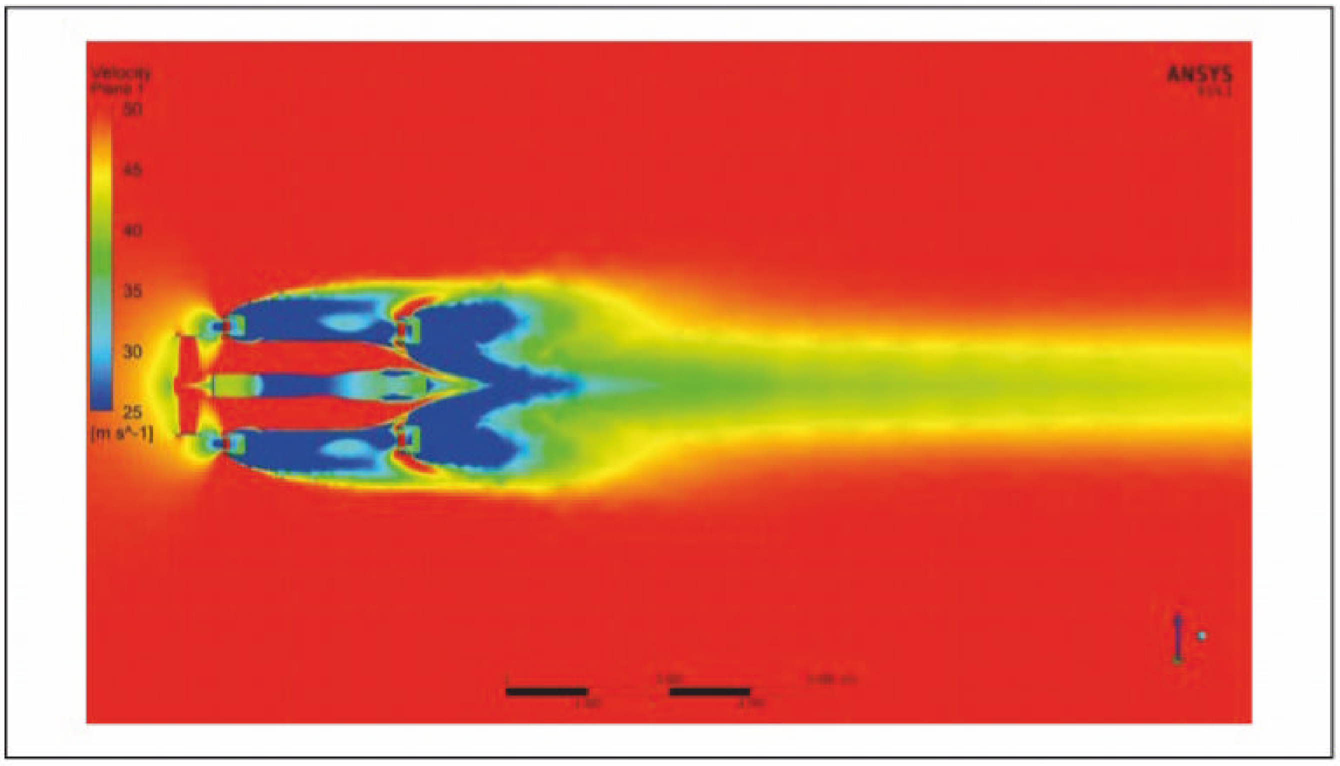


Figure 13: Wake on a plane 50mm above ground level narrowed significantly at just one or two car lengths behind model

Future ground effect

Skirts certainly had their issues then, but whether they could ever have been made reliable became academic when flat undersides were mandated in 1983, ultimately leading to the rules we have now in 2019.

It has been said that ground effect cars were able to run close enough to allow drivers to be able to race each other, and **Figures 12** and **13** show the wake in two different ways, revealing central upwash that seemed to entrain much of the rear wheel wake, and relatively clean inwash behind the car. **Figure 13** implies that at just one to two car lengths behind the car the wake at underbody level was not too badly disturbed, possibly explaining how the cars could run close. Maybe these, more than the 37-year-old qualities of ground effect cars, are among the current objectives of the FIA's research highlighted in the April issue of *Racecar*?

Skirts on a Group C sportscar

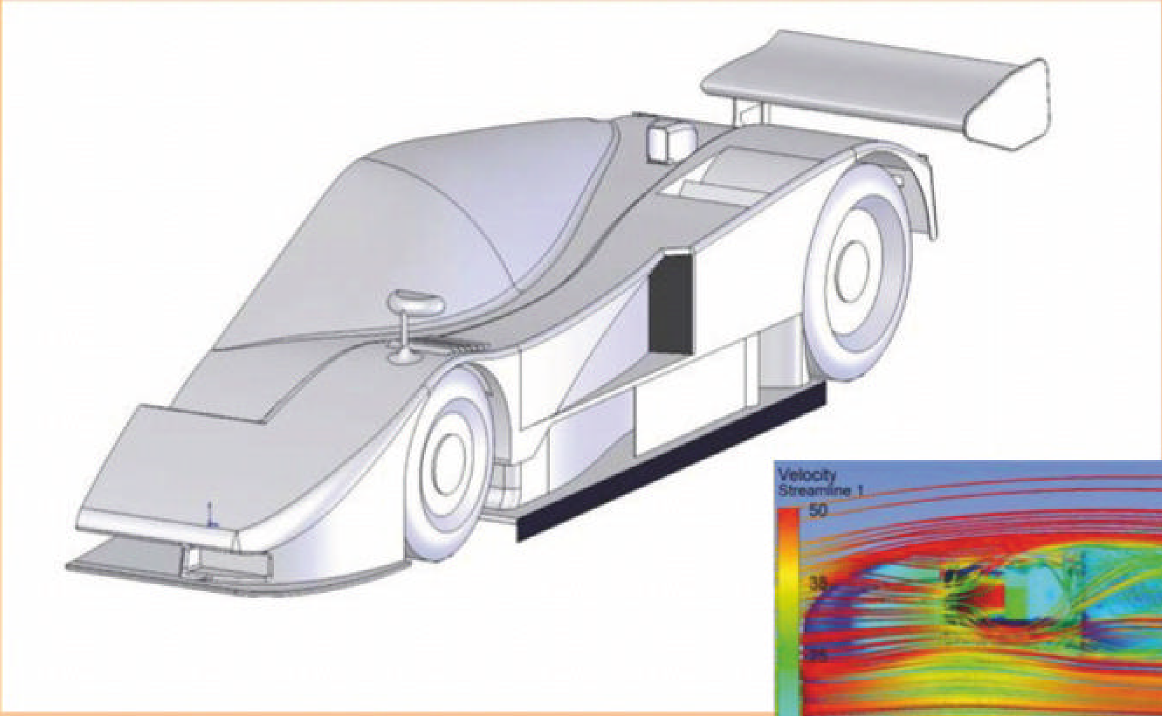


Figure 14: Mazda 787B Group C model with skirt fitted. The car, which famously won Le Mans in 1991, never raced with skirts in period as these had been banned

Table 2: The effects of fitting skirts on a Group C Mazda 787B model

	CD	-CL	-L/D
No skirt	0.426	1.909	4.478
Outer skirt	0.384	1.150	2.990
Inner skirt	0.368	0.995	2.704

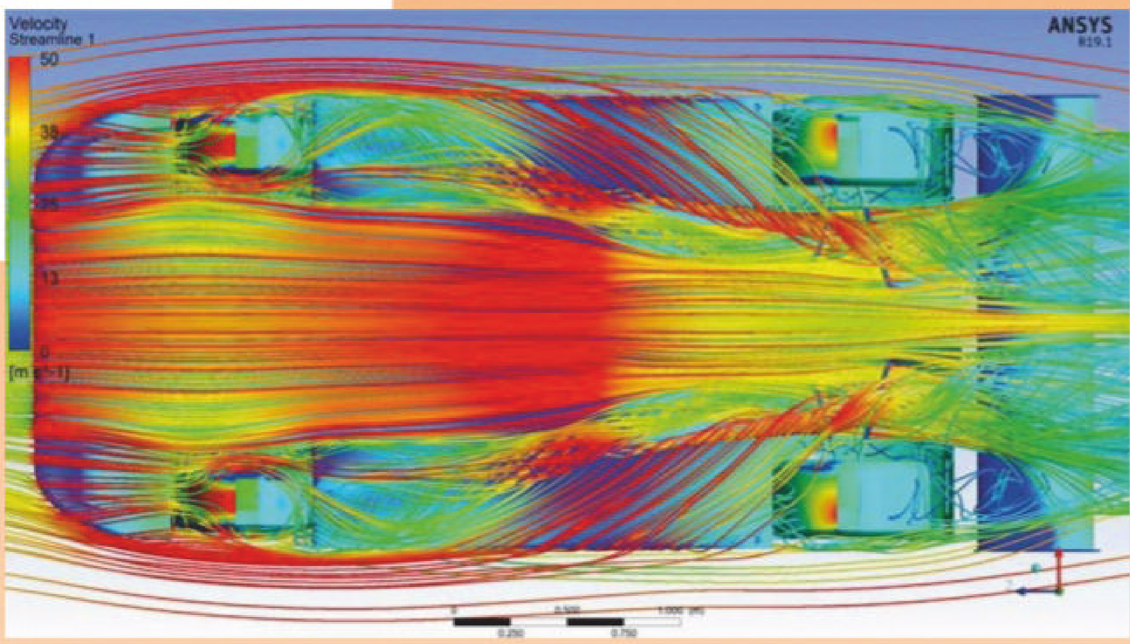


Figure 15: With no skirt the tunnels were partly filled by flow from sides, improving the underbody suction

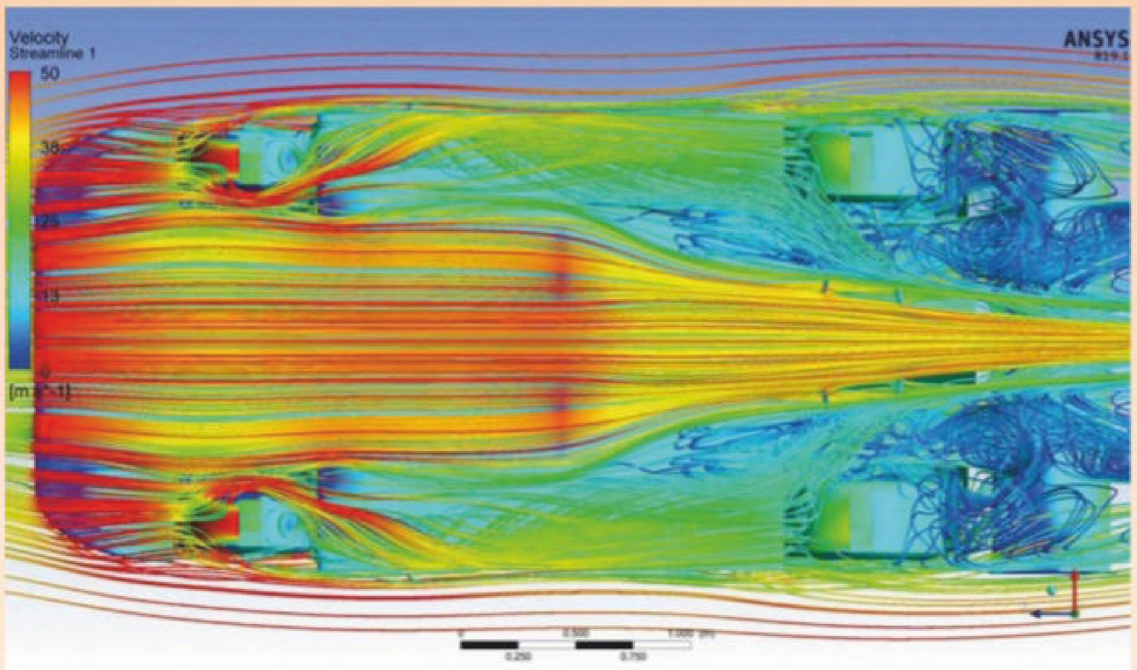


Figure 16: This shows how the outer skirt cut off all the lateral influx which meant the diffusers stalled

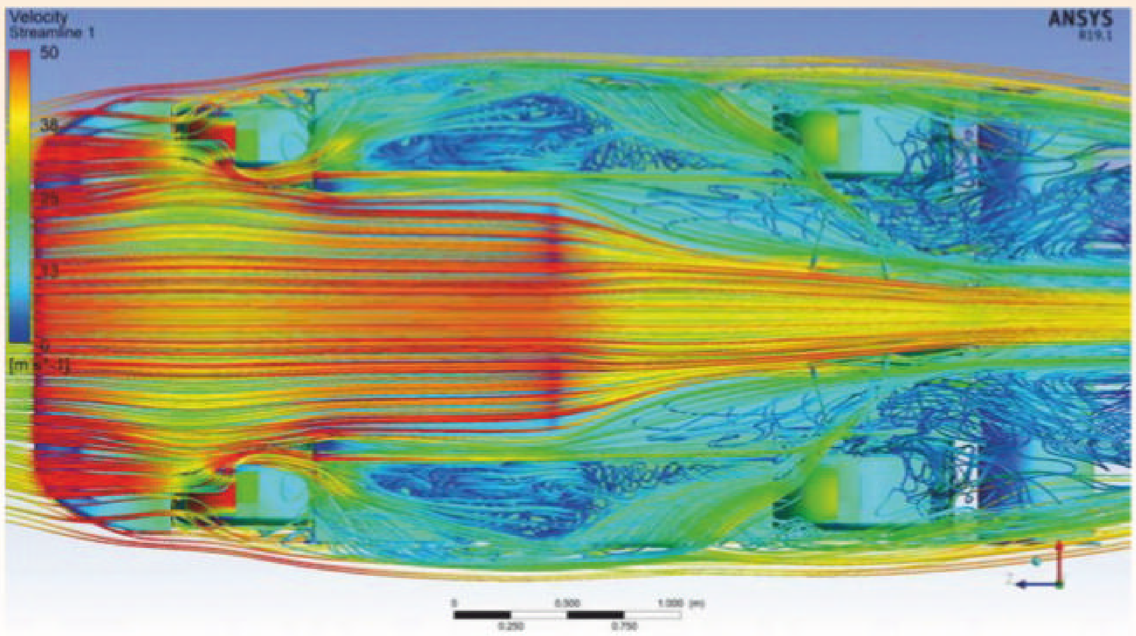


Figure 17: Inner skirt also cut off most of flow from sides, causing even greater downforce reduction

Skirts had long been banned when Group C produced probably the highest downforce levels seen on mainstream racecars. But would they have enabled Group C prototypes to have generated even more downforce? Readers may recall that in V28N10 (October 2018) we examined a model of a Mazda 787B replica in 1991 Le Mans-winning trim. By kind permission of project owner Mark Peters the model has been used again to examine the effects of skirts.

Skirts were first attached along the outer edges of the car's floor (**Figure 14**), then moved inboard by 350mm. The results are compared in **Table 2** to the best run from our previous article, which featured no skirt.

It is immediately apparent that this simplistic approach has caused very significant reductions in aerodynamic performance. Drag may have reduced (by 10 per cent and 14 per cent respectively) but downforce reduced by 40 per cent and 48 per cent compared to the skirt-less model. Why was this?

Figure 15 shows streamlines under the car in the no skirt case. The diffuser tunnels were being filled partly by flow from the front and partly by flow from the sides. The latter not only created suction under the outer flat underside, it was also being spun into large vortices in the tunnels helping to maintain attached flow, which in turn helped to pull high mass flow through the entire system, resulting in high underbody downforce. As soon as either skirt was attached the lateral influx was cut off and the diffusers stalled, leading to the reductions in downforce.

This is yet another example of how a device that works on one type of racecar does not necessarily work on another.

Motorsport Images

Karl Kempf secures the data-logging gear into the Tyrrell at Silverstone in 1977. This was when the world came to hear about the tech but it had already been around for a long time

Download history

Ironically there is a vast amount of data about everything in motorsport except data itself, but having contributed to the growth of telemetry during his long race engineering career our man is just the person to put that right

By RICARDO DIVILA

Data has been collected for thousands of years, as it's intrinsically important when making decisions about, well, everything. In racing, a subject dependent on machines and therefore based on engineering, it falls now into the 'must have' category and computerised on-board data collection is standard these days in everything from Formula 1 to some club racing. Of course, this hasn't always been the case.

The first tachometer we know about is considered to have been developed by Dietrich Uhlhorn in 1817. Uhlhorn needed a gauge to measure the speed of machines and his tachometer was first used to measure velocity on a vehicle (a locomotive) in 1840.

Samuel Smith Junior began selling clocks and watches in 1871. By 1900 Smith's was the premier clock and watch supplier in London and at the same time it was taking its first steps into the manufacture of automotive instruments, producing the first British odometer and speedometer.

But all the data measured back then and for years to come had to be memorised by the driver, to relate or mull over when trying to solve problems or go faster. Much as with today's data-loggers or telemetry, the driver was the black box, reporting the rpm through a corner and which gear they were in. See a higher rpm, it means the driver's going faster.

I still can remember the days when drivers could take you around the track map commenting on the info from memory. Today it seems a lost art, any questions to youngsters being answered: 'I don't know, look at the data.'

In computing, and engineering, the black box is a device that can be viewed in terms of its inputs and outputs, without any knowledge of its internal workings. The implementation is 'opaque'. Almost anything might be referred to as a black box: a transistor, an algorithm, or the human brain.

Mechanical data

The first recorded use of an on-board data-logging system was on the Auto Union Type D, designed by a team under the direction of Robert Eberan von Eberhorst, who took over when Ferdinand Porsche left Auto Union. Eberan-Eberhorst was heavily involved in the initial testing of each new racing car, and to help with this he developed an on-board instrument to record the data. It was a mechanical data-logging system recording on to a clockwork-driven paper roll such parameters as the throttle, steering and brake pedal inputs, fore-and-aft and lateral *g*-loadings, and suspension deflections. The system was unreliable, not surprising in the difficult environment of a hard-driven 500bhp grand prix car, but it did give data to be examined.

No slouch in technical matters, Eberan-Eberhorst was also involved in the development of side skirts and aerodynamic bodywork along the belly of the record breaking Auto Union streamliner car, additions that were some of the earliest experiments with ground effect downforce to have been applied to a car.

I was made aware of the work that was carried out by Eberan-Eberhorst after reading a copy of Earl C Cameron's *Investigation into the Development of German Grand Prix Cars between 1934 and 1939* back in the 1960s. Cameron had been sent to Germany after the Second World War by the British Intelligence Objectives Sub-Committee to study the development of 1930s grand prix racing cars, and he wrote a report about them, based on his interviews with designers at Mercedes-Benz and Auto Union in April and May 1947, and the blueprints he obtained. This aided British engine designers by presenting them with German design secrets.

Cameron was also technical consultant for the English Racing Automobiles (ERA) team, but sadly in June 1952 he rolled an ERA R14B while testing it. He died in hospital from a fractured skull. How a copy of his report ended up in the main library in Sao Paulo in Brazil escapes me, but it did give me ideas, so much so that when building my first F1 car I also became involved in building and developing a data-logger, working with EMBRAER (Brazil's main aircraft manufacturer, now part of Boeing), as it was not something that then seemed current in racing in Europe to my knowledge (see box out).

Aerospace connection

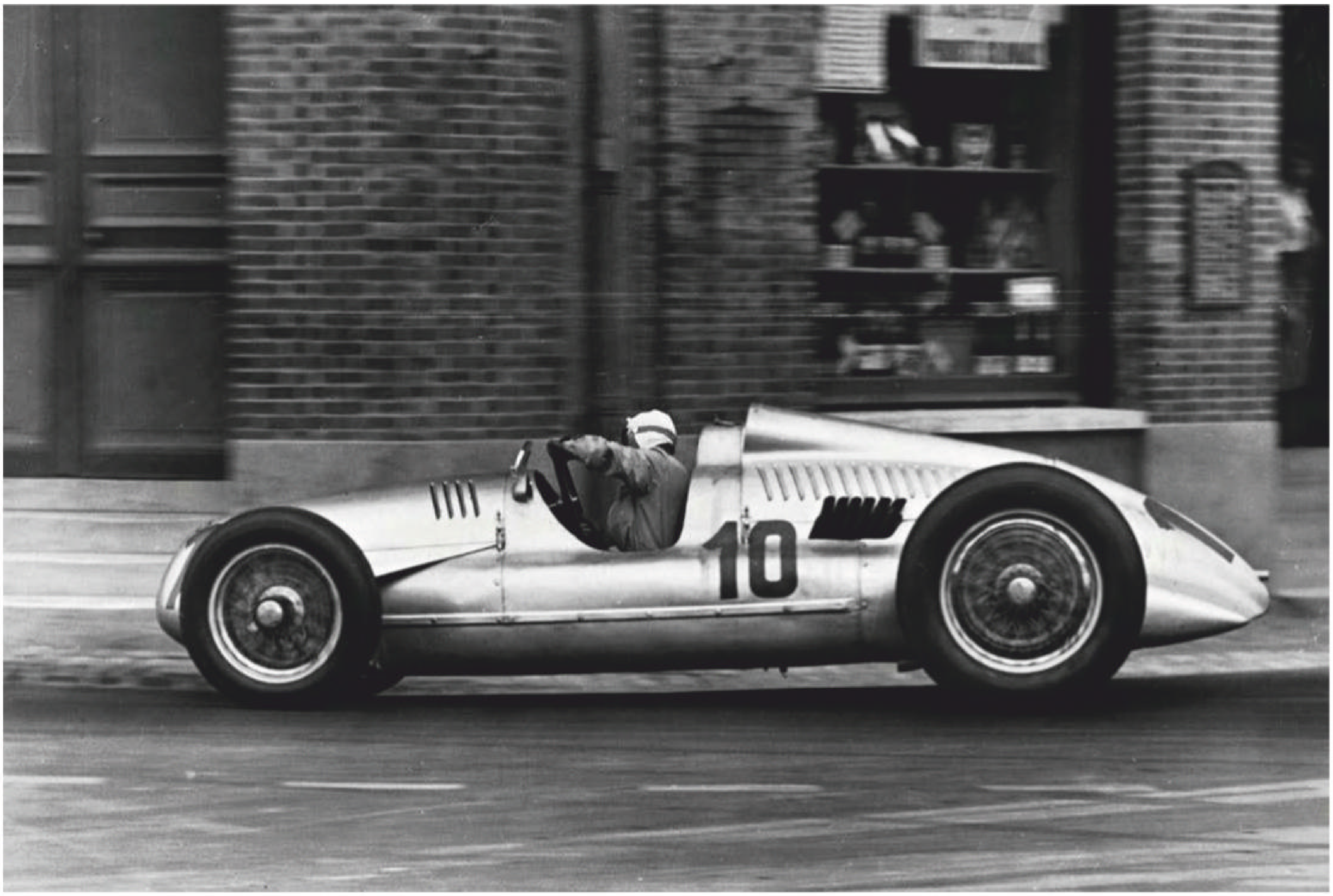
Racecar technical consultant Peter Wright has stated: 'Motorsport doesn't invent very much, what it is very good at is taking something from aerospace developed using government money and adapting it, if necessary, and implementing and exploiting it quickly as a key technology. You can't be as experimental in aerospace as you can in racing.'

The cancelling of several major aircraft projects such as the Blue Streak, TSR-2 and the supersonic Harrier and the consequent sagging state of British aerospace was one of the driving forces of the British teams' increasing technical sophistication, as it fed a lot of young engineers into motor racing, Lotus being one of the first teams to benefit from this.

De Havilland-trained racing enthusiasts such as aerodynamicist Frank Costin and his brother Mike and later designer Maurice Philippe brought aerospace technology to racing; in 1962 the first modern monocoque, and a fully integrated design by 1967, not to mention all the aero evolution that incremented Colin Chapman's reputation as an innovator. Data-logging was something used on aircraft for a very long time and thus transitioned into racing as all the aerospace bods were used to it.

The evolution of the modern black box as used in F1 is rather elusive, as understandably most teams did not publicise their use, trying to keep a perceived advantage to themselves. But one of the early ones was on a P261 BRM and was used while testing at Snetterton in 1965. It had taped-on accelerometers and transducers wired into a bulky recorder case in which all the

I can still remember the days when race drivers could talk you around the track map commenting on the info from memory



Audi

In the 1930s Robert Eberan von Eberhorst developed the Type D Auto Union GP car with the help of a mechanical data-logging system that included a clockwork-driven paper roll

recorded data was burned onto a light-sensitive paper roll for subsequent analysis.

Tony Rudd wrote about this in his biography, *It was Fun*. Graham Hill and his young team mate Jackie Stewart tried the system, and were advised of the results. 'I showed Graham that his technique of going deep into the corner, braking late; taking it fairly easy around the corner until he was clear, then giving it everything, was not the quickest way,' Rudd remembered. 'Jackie braked earlier, but not so hard, his car was stable in the apex and able to hold a higher speed. He then fed in a little throttle earlier, gradually increasing the amount, so that he was some 0.4s quicker. Jackie had been looking at the data and changed his methods and improved his time. Would Graham like to do the same? No, he would not.

'He also said he didn't give a stuff about that corner because it wasn't the critical one on the circuit, and in any case he was still quicker round a full lap than Jackie,' Rudd continued. 'The parting shot was "If your black box is so bloody clever, see how quick it can go without me."' As autonomous cars loom increasingly larger, we now have Roborace's Devbot ready to step right up and accept that challenge.

Rubber check

Other early users were the tyre manufacturers, in particular Firestone. Nigel Bennett, subsequently Lola's and Penske's ChampCar designer, was one of the tyre engineers at Firestone's European Racing Division, having come from Chelsea College of Auto and Aero Engineering in 1966. He worked closely with Ferrari's chief designer Mauro Forghieri, another whose first love was aircraft and was thus aware of the technology. Ferrari had started using telemetry at Fiorano and was working closely with the tyre supplier, on the basis that the more Firestone understood about the car, the better the tyre development would progress – tyres in those days being developed in parallel with the car, bespoke items, rather than today's supplier specifying tyres that the teams adapt to.

Bennett's Firestone colleague David Trevett had a Transit van full of acquisition and telemetry equipment, and he spent a lot of time at Ferrari in1969. The black box was 200mm x 100mm x 100mm, usually mounted on the gearbox and having its output on a paper tape, recording six channels: throttle position, steering angle and wheel displacement using transducers, plus longitudinal and lateral loads via accelerometers, and speed, by using a Barlow's wheel (actually invented in 1882). All the systems were analogue.

For start/finish localisation photo-electric cells would be used to generate pulse blips on the tape. They also had three infrared detectors aimed at one of the front wheels reading temperatures across the tyre. Given the limited amount of capacity of the electronics and the few channels, logging had to be allocated


Audi Sport

The amount of hardware required has diminished over the years. This is Audi Sport's first telemetry system back in 1989

sparingly, but it allowed for relevant channels to be recorded in turn. Though that used up some of the channels, you could still combine it with other parameters and, that way, you could work out how a car was handling. Lotus and Lola were interested in the Firestone system, too.

Lotus position

Returning to Lotus, Flight Systems and Measurement Laboratories (FSML) at Cranfield Institute of Technology was commissioned by the team to instrument an 'F1 Data Car' using an electronic measurement system in 1975. It was independent battery-powered, recording 24 channels on a cassette recorder at 10Hz logging rate. Recordings were recovered to a digital signal processing computer, also developed by FSML, using a software decoder, and then analysed on the same computer.

The company had made its own load sensors for the four corners, using LVDTs (linear variable differential transformer) for suspension movement, four wheel speeds with inductive measuring, driveshaft torque sensors, lateral and longitudinal *g* sensors, brake pressures, dynamic pressure sensor and steering rack position.

Aero measurements were used, playing their part in the development of ground effects, as they were able to estimate drag and lift from the data, even at that relatively low recording rate. The system continuously evolved from 1976 to 1983, finally being replaced by remote telemetry.

But this is not just about the UK. The spill-over from aerospace had been going on in America too, aerospace and defence being inextricably linked, and car culture benefiting from it. GM and Chaparral were early users, with a reel-to-reel tape from 1966.

Ford's efforts were spurred on by the development of the GT40, especially for sorting out aero instability past 180mph, and the flight test instrumentation department at Ford Aeronutronic, then the defence related division of Ford Aerospace, was called in to help.

Aeronutronic had a telemetry system used on the missile systems it developed, and volunteer engineers with special knowledge of aerodynamics, mechanics, radio telemetry systems, and instrumentation, working with Carroll Shelby's racing team in Los Angeles, installed the monitoring equipment on the car, and then took it to the Willow Springs track.

Apart from the telemetry on it, the car sported tufts on one side, and Phil Remington – a racing legend who was working at Shelby's – used his road-going Mustang with the boot lid off and with a photographer strapped in it to record the surface flow. After analysis, a couple of simple changes to the shape sorted all the problems. I heard this story when at AAR during the Nissan Deltawing build, when Remington, then 91, was still working on racing cars.

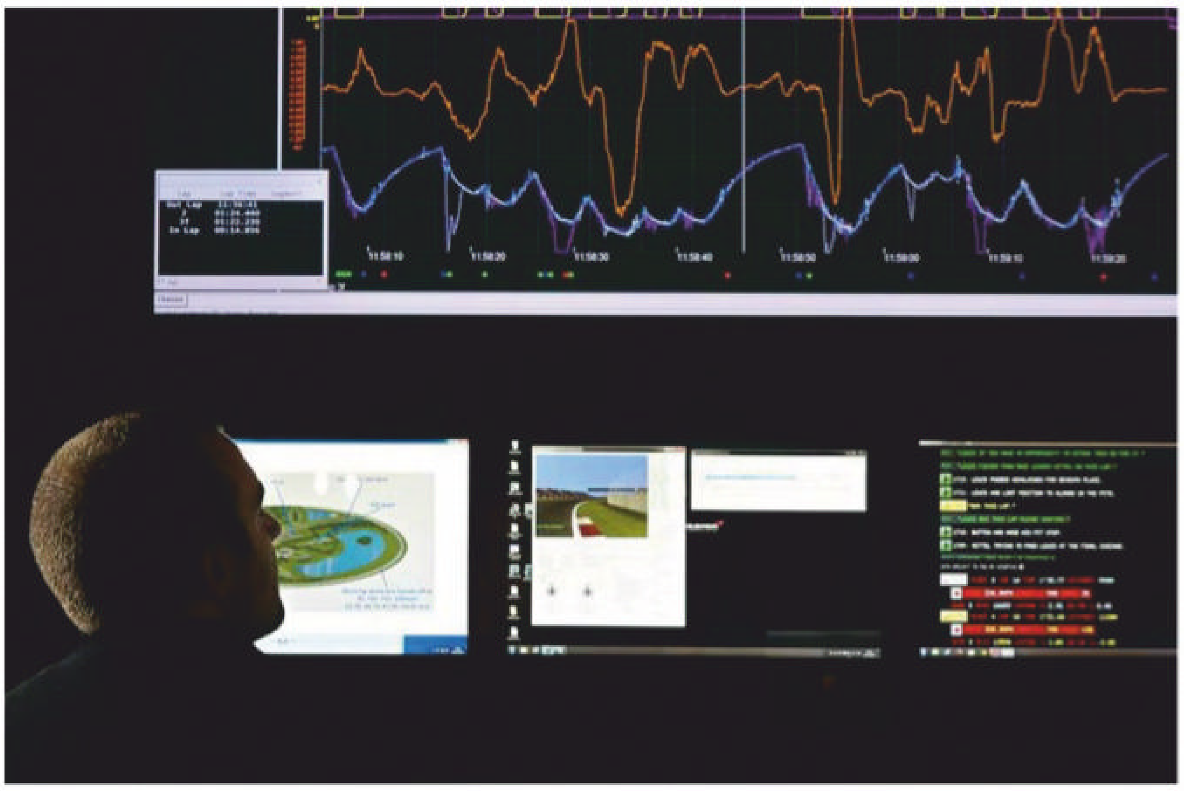
Into the limelight

Data acquisition broke out in the open when the Tyrrell team hired Firestone's Dr Karl Kempf and started to test openly in 1977 on the six-wheeler P34 designed by Derek Gardner. This is when the motoring press first came to know about

Graham Hill said 'if your black box is so bloody clever, see how quick it can go without me'

XPB

Ford's aerospace division was involved in the development of the GT40, helping to sort its aerodynamic stability beyond 180mph. It brought its own telemetry system to the project



McLaren Applied Technologies

The amount and variety of data that's available to modern race engineers is not far short of mind-boggling

With no electronics to analyse the data, rulers had to be used to measure the traces

data-logging and they made quite a lot of noise about it. I had the opportunity to swap many stories with Gardner about the perils and pitfalls of the early acquisition systems when he was a gearbox consultant at NME (Nissan Motorsports Europe). We seemed to have had pretty much the same problems with it.

But to return to the evolution of on-board data-logging development we also have to return to BRM. Because BRM was owned by the Rubery Owen engineering group, it had access to many varied engineering tools from the mother firm. One of these was a new-fangled unit called a computer, and Mike Pilbeam used this to produce suspension set-up tables.

By 1964, the team's R&D produced a little box logging up to 18 channels of data on paper tape. This system was very much ahead of its time, but it was also flawed, data being very laborious to retrieve from the black box, while with no electronics to analyse it rulers had to be used to measure the traces.

The Wright stuff

In 1967 Peter Wright, then a young aerodynamicist, joined BRM. By 1969 he was working at the Imperial College quarter-scale wind tunnel with a moving ground plane. The concept of wings on F1 had blossomed and grand prix racing had, for a little while, aerofoils up on stilts putting the load directly onto the uprights and not through the chassis, much like the Chaparral; but poor engineering had caused several wing-related accidents, and an imminent ban was in the offing.

Meanwhile, Wright's work at Imperial College with wing-shaped cars was showing useful amounts of downforce when coupled with side plates. This prompted Rudd to set up a 'Skunk Works' at a separate group to work in secret on the concept. 'One of our Formula 1 cars ran with stubby, aerofoil-section panniers at a Snetterton test and appeared to work compared with what we knew, but there was a lack of accurate measurement,' Wright has said of this project. 'We were all desperate for data to find out what was really going on.'

The project was eventually cancelled inside BRM, but after Chaparral came out with the sucker car, which was then banned, the concept of ground effects was there and couldn't be forgotten – of course, Wright eventually resuscitated it at Lotus and the rest is history. It is interesting to think about what would have happened if data acquisition were a bit better at the time when BRM was developing it.

BRM's system featured pen recorders, with the interference of vibration reducing its accuracy. Firestone's system was an adapted flight recorder, and was more robust and used an infrared pen on light-sensitive paper.

The digital age

Electronics were improving and the data systems were increasingly compact and reliable for automotive use, pushed forwards by the increasing use on engines of electronic equipment for ignition and injection systems.

By 1987 both F1 and ChampCar were running commercial systems for races

The first digital system in racing was probably BMW's, for its engine development for Brabham in Formula 1 in 1983. Using a Bosch computer-controlled injection system, it already had digitised engine signals such as rpm, temperatures, and pressures. With some extra electronics, BMW could temporarily store values in an on-board data buffer. It was a separate circuit board in the shielded ECM (Engine Control Module), a 16K capacity RAM storing 1000 data points from each of 16 channels, downloaded in the pits for analysis.

These days drivers seldom need to remember what happened in a turn as the data is invariably downloaded on to a laptop

XPB

Race tape

Around that time Honda was coming back to F1 with Williams, where Frank Dernie was already using a 4-channel tape recorder on his cars to gather data for computer analysis. The Williams-Honda alliance then made a deal to share computer technology with an American CART team headed by Ian Reed, an ex-March engineer with a computer background – in the applications for simulation and design. Reed brought in a hardware expert, Kurt Borman, who spent a couple of years developing a data-acquisition and analysis system. With four channels initially, recording data at half-second intervals, then using an Apple for analysis, it grew in capacity and accuracy; so when portables were coming on stream you could watch eight channels simultaneously.

This, of course, opened the floodgates for logging all sorts of data. By 1987 both F1 and ChampCar were running commercial systems for races, both having progressed from the big, heavy, limited capacity test systems to bespoke racing units. By the early 1990s, PI, which was also working in the data acquisition field, tried to patent the concept of dedicated data systems for motor racing, but it later abandoned the idea. It had started out in 1987, and its product was becoming widely used in racing – since then it has been bought out by Ford and is now associated with Cosworth, supplying analysis software and CLUs (central logging units).

The graphic interface and screen presentation was still being improved, of course, as DOS based computers were quite clunky, but CDS in the States did a lot to bring about a more user-friendly presentation from 1986 onwards.

Big data

PI's units were made specifically for racing, which was not the case with several other suppliers who adapted existing commercial loggers for motorsport use. Bill Mitchell, also known for his suspension geometry programs, did a lot of work with these, incorporating the racing teams' suggestions and demands, the resulting output being pretty close to what is accepted as industry standard nowadays. Incorporating track maps calculated from speed and lateral *g*, and several other graphic presentations, this made data analysis much easier than it had been in the early days.

Incidentally, the integration of electronics for engines has resulted in most ECU suppliers also producing logging units, these systems being very similar. Magnetti Marelli supplied its Wintax, Bosch the Darab, MoTec was an ECU and fuel injection company, Stack was a commercial data-logger company. And there are many others involved, including McLaren Techniques d'Avant Garde (TAG), which evolved into McLaren Applied Technologies, supplying a whole range of electronic management systems, loggers and analysis software.

The Copersucar data-logger

We brought in EMBRAER, the Brazilian aerospace company, in late 1974 to build the data-logger for the Fittipaldi F1 car, and we used it initially at Silverstone in early 1975. It was an offshoot of the loggers it had in aircraft development.

Reducing the size of the parts was a major challenge, available space being considerably bigger on an aircraft than an F1 car, and our final 9kg, 400mm x 200mm x 160mm recording box was quite an achievement.

The 1970s Copersucar/Fittipaldi F1 data-logger

Data from the four suspension LVDTs, lateral and longitudinal *g* sensors, steering angle, rpm and gear position came in and was converted to a 40Hz signal and recorded on a cassette tape recorder. That caused most of the problems, given its propensity to have the tape flutter over the recording head, giving signal drop-off due to the car's vibration and *g* forces. The logging unit and sensors weren't problematic; they were aeronautical off-the-shelf components, it was just the recording of data on tape – no flash memories or USBs then. Eventually the best solution was actually strapping the recorder to the driver and using him to insulate it from the vibration.

The data was downloaded directly into a six-channel polygraph, printing into a six-metre long graduated paper strip per lap, on which we had to measure with a ruler the movements or forces. Overlays were done by simply using lighter grade paper and holding different lap recordings superimposed against the light. Sticking them to a window and using sunlight was actually very informative, if also very time-consuming.

Slippery customer

Four-seater GT3 cars like the Nissan GTR (left of picture) are difficult to balance against more conventional GT cars such as the Ferrari 488 (far right) and Lamborghini Huracan

GT3 could be facing significant change this year, instigated by the FIA and from within, but what might it all mean for the popular customer sport category's future? *Racecar* assesses the situation

By ANDREW COTTON

There are some significant changes coming to the world of GT3 racing, with the SRO bringing in new staff to help with the Balance of Performance (BoP) on which the category depends, the FIA looking to introduce a new BoP platform altogether, while both have to deal with either new cars or evolutions of existing cars this year.

GT3 racing is prolific, and global, and has perfectly struck a balance between the needs of a customer racing programme and factory involvement. Manufacturers such as McLaren and Porsche have brought new racecars out this year, while Audi and Lamborghini have upgraded their existing cars, and have a global marketplace in which to sell them. The category is designed to take a car that a manufacturer wants to sell and balance its performance against the other cars, but the sheer size of some of the GT3 racecars has been identified as a potential problem by the FIA.

With the likes of Bentley's Continental GT, BMW's M6 and Nissan's GTR, each four-seater cars, compared to the two-seater Lamborghini Huracan, Audi R8 and Ferrari 488, the differences between the GT3 cars is now getting to be big, and in December the FIA made a proposal to separate out the larger cars and give them their own balance of performance.

Bigger Bimmer

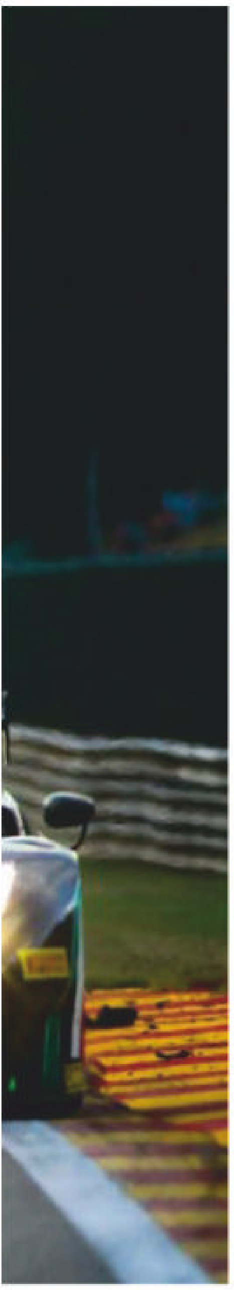
It was believed that the driving force behind all this was BMW, which had requested that it be allowed to use a bigger platform – one which is used for both a two-door and four-door M4 road car. The FIA has declined its request, but the reasoning behind the governing body's proposal is not actually that clear.

It's a move that has been rejected by the manufacturers anyway, though, who consider that the cars are already balanced and see no need for a different system, and by promoter Stephane Ratel, who had the initial vision to introduce GT3. Manufacturers held a meeting at Sebring, Florida in March to formulate their response to the FIA's proposal, while Ratel's view is that it is not broken, the paddock is harmonious, so there is no point in fixing it.

'I think GT3 racing continues to be tremendously successful,' said Ratel. 'We have record entries across most of our championships, we see not only success in our championships but others including GT Open and ADAC, they are not doing badly. And the real customer racing programmes with manufacturers that do the job, do it well – the new generation Porsche GT3, new generation Aston – I don't think [the manufacturers] are complaining about the sales, and that is just the latest cars that were presented.

'We have just started in America [with the Pirelli World Challenge] where I believe we have the largest potential for GT3, so we are far from being at the end of the GT3 development. We are in a situation where everything is going well, so why do something that doesn't need to be fixed, it is not necessary. If [the FIA] want to have an internal conversation, then why not look at it, but if it is in the public already, it creates

The FIA wants to separate out the big cars and give them their own BoP



unnecessary instability. We have just come out of the convergence process which has been going on for a number of years, and I don't see why with that behind us we have to go into another period of destabilisation.'

Convergence was a plan that would have seen common parts used in GT3 and GTE racing, including the chassis and engines. For GT3 manufacturers it was an inexpensive way to get to Le Mans, but for the GTE manufacturers there was no rulebook for GT3, and they did not consider it suitable for manufacturer motorsport. The idea was quashed by Ratel anyway, but now this new problem has arisen and few understand how or why.

One possible reason is that with Ford's GTE programme officially finishing this year, BMW yet to commit to a second season in the WEC, Ferrari running its GTE programme as others run their GT3 projects – with engineering and driver support but individually funded – and McLaren and Lamborghini cancelling their GTE plans, GTE is perhaps not looking so healthy. So could this move by the FIA be a way to get its hands on a GT rule set for the future GTE category?

'We have nothing to do with GTE and I do not see GTE going bad, it has a lot of manufacturers and it seems to be doing fine,' says Ratel. 'You don't fix one category by creating trouble for the others. It is two different concepts, and they have been working well together, next to each other. I don't see the point of disturbing one to solve the other.

'The decision [of Lamborghini and McLaren] is nothing to do with technical reasons, it is to do with the costs,' Ratel adds. 'It is a question of who pays. GT3 is customer racing. If you go to GTE it needs to be factory racing with factory paying. McLaren did not have the budget to do a GTE programme at Le Mans and WEC.'

In the balance

The issue of who will do the balancing of performance has been a hot topic recently, too, with rumours circulating that Claude Surmont, the Belgian who was brought in to develop and run the GT3 balancing system, was being sidelined. Ratel says that this is not true, and points to the fact that he has expanded from looking at the performance of cars in three championships four years ago, to 14 this year.

The SRO has signed a deal with Scott Raymond and his ORCA company, that is responsible for the performance balancing for the ADAC Nordrhein for the SP-9 class. However, Ratel is adamant that nothing will change for the SRO, or his Blancpain Series, and that Raymond's appointment is complementary to Surmont's work.

'The thing with Claude is very simple,' says Ratel. 'We have 14 championships at the moment. That includes TCA, TC, TCR even, but it is a bit different because we have an agreement. But still, we need to look at the relative performance of the car; GT4, GT2 and GT3. Six categories over 14 different championships and series cannot be the work of a single man. This was not possible. We reinforced the team by adding Scott Raymond and his company ORCA, this is correct, and Jacques Berger, who is more co-ordination and communication.'

The drive to improve communication was brought about following the decision to exclude the Black Falcon Mercedes team from the results of the final round of the Blancpain Endurance Series in Barcelona after tape was found on feeder pipes to the airbox. That decision was overturned, despite Audi being penalised for the same infringement after qualifying for the Spa 24 hours in July, and Ratel accepts that some of the responsibility rests with the SRO.

'We should have made a technical note to all the teams to say that you cannot have any tape,' says Ratel. 'Our technical direction is very much a one-man show; we did not have the resources for communication … The company is growing, the number of categories is growing, the number of championships are growing, and therefore we need some more people.

'The second issue is that, at the moment, the fact that Claude is totally handling BoP, is the most clearly identified point of failure in our company. If anything should happen to Claude, God forbid, we need someone to cover. His workload is phenomenal. We need to have a parallel system that understands BoP, and the idea is to create two different BoP systems, collect all the data, and let the two systems collaborate. There is no tension next year regarding Claude. We have a long-term understanding that we work together, and

This new problem has arisen in GT3 and few understand how or why

BMW wanted to race a new and bigger platform that is used in both two- and four-door form on the road but the FIA rejected its bid. Its M6 is already on the large side for a GT car

nothing has changed for him, and he is still in charge as technical director of the company, and the final decision is his decision.'

This year the need for information will be greater than ever, with new cars or evolution kits from almost all the manufacturers. Each has designed in more downforce, and with the BoP test taking place in March, the manufacturers were all looking for more engine power to bring the cars up to the target lap times.

However, Surmont has identified the Mercedes and Ferrari as the reference cars, and will pull the new cars back to that level during the test. 'If you analyse the three races where we had the new cars, so Abu Dhabi, Dubai and Daytona, you see that what they are trying to do BoP wise was not entirely correct,' says Surmont, who had to base the BoP for the Australian GT series at the beginning of March on those races as he had not yet done his BoP test.

'Abu Dhabi was the most correct of the three, because there you have a track that has long straights, so the car needs more power, but in Dubai the performance level of the Audi was too high,' Surmont adds. 'At Daytona, the performance level of several cars such as the Lamborghini and the Honda was too high compared to the Audi. The manufacturers are so afraid that we will underestimate the loss of v-max with the drag. Before it was easier, because with the drag level that they have on at Spa or Silverstone, if we miss and are wrong in the power, it might give 1s to 1.5s delta between the models. I think they have gone too far with aero and drag. They should have left the cars the way that they were. I don't see much that is positive for the gentlemen drivers or for customers in general.'

Aero escalation

The performance of the new cars is a particular worry for Ratel, as there are hundreds of GT3 cars racing around the world, and there is a need to consider grandfathering the old cars to protect the investment of many of the teams.

'The escalation needs to stop,' says the Frenchman ahead of the start of the Blancpain season in Monza in April. 'Each evolution is not engine evolution, it is aero evolution and they say that they want to make the car more driveable for amateurs but that is not true. They want more downforce to be more efficient. As Claude says, they add aero and then want more power, because that's the concept of BoP, it is a lap time average, so if you have more aero you need more power, so there needs to be from now on no more evolution, or a small reduction of aero, but you cannot go in big steps.'

While Ratel and Surmont want to pull back the new cars for business purposes, on other tracks such as the Nordschleife, Raymond's primary responsibility, the need to not have faster cars, is more pressing due to the homologation of the circuit. For Surmont, however, there are other measures that should be employed to slow the GT3 cars competing in the fastest VLN class; namely tyres and suspension development on GT3 cars.

'I don't know what they are going to do because they have already done a lot of stuff, and the cars are going faster and faster,' says Surmont, who says that he cannot take into account the German series when doing his GT3 balancing. 'I think they have more of a tyre problem than a car performance problem. With the freedom on the suspension that they have, it is difficult to take that into consideration for the normal GT3 cars and the tracks that we go on. The research into that is massive, so to lower the performance, they should limit the confidential tyres and the development of the suspension. That will get the lap times that they want to have on that track.'

The only issue still outstanding is that of the FIA and its involvement in GT3 racing. But Ratel believes that the market will sort itself out and there is no need for him to panic just yet. 'I think the market directs itself and the manufacturers know what they want,' he says. He also believes that this latest suggestion from the FIA will go the same way as convergence, and will die before it is born.

'I think the market directs itself and the manufacturers know what they want'

The FIA's proposal to separate out the larger cars such as the Nissan and the Bentley was not well received and GT3 founder Stephane Ratel believes the idea will sink without trace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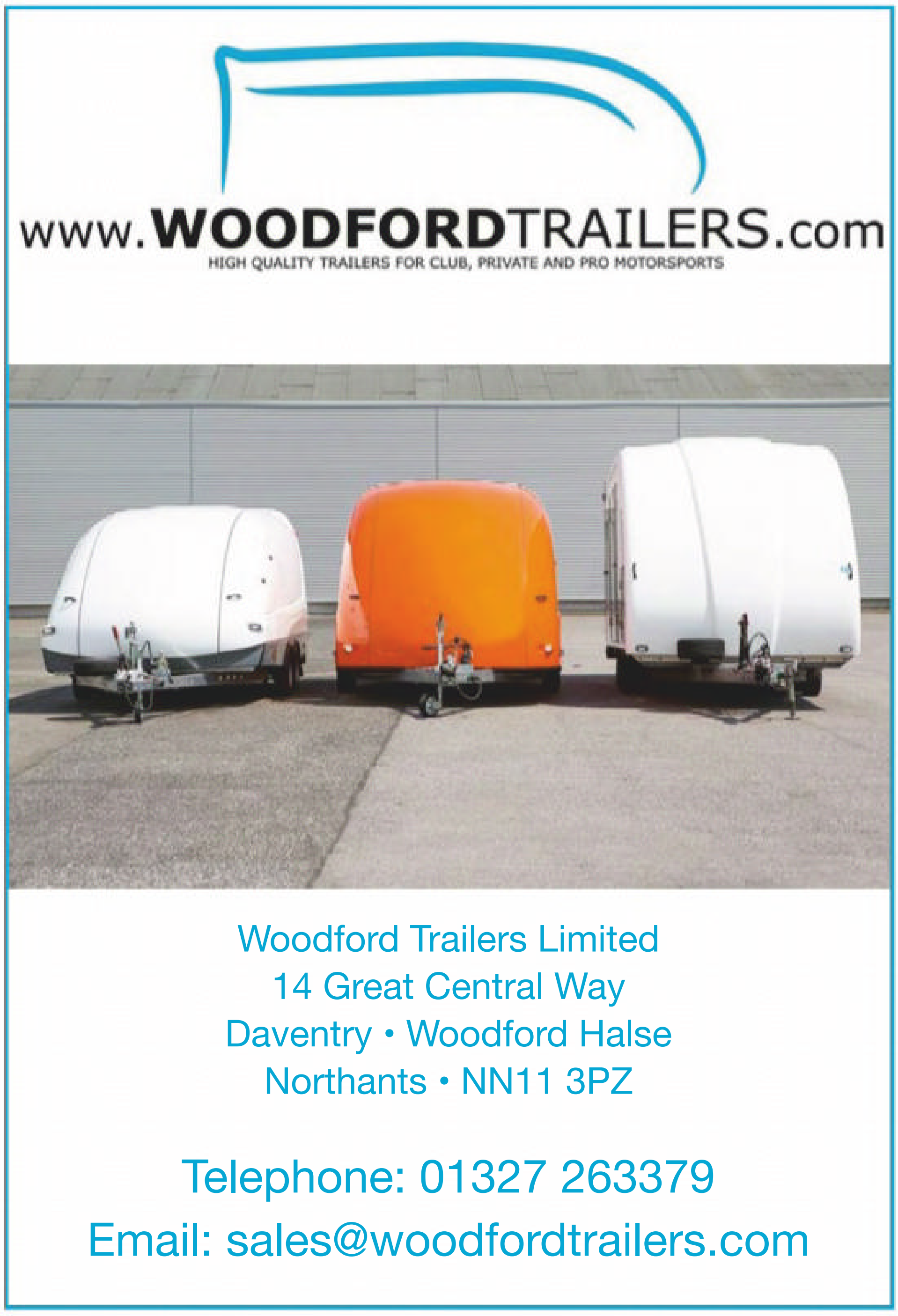
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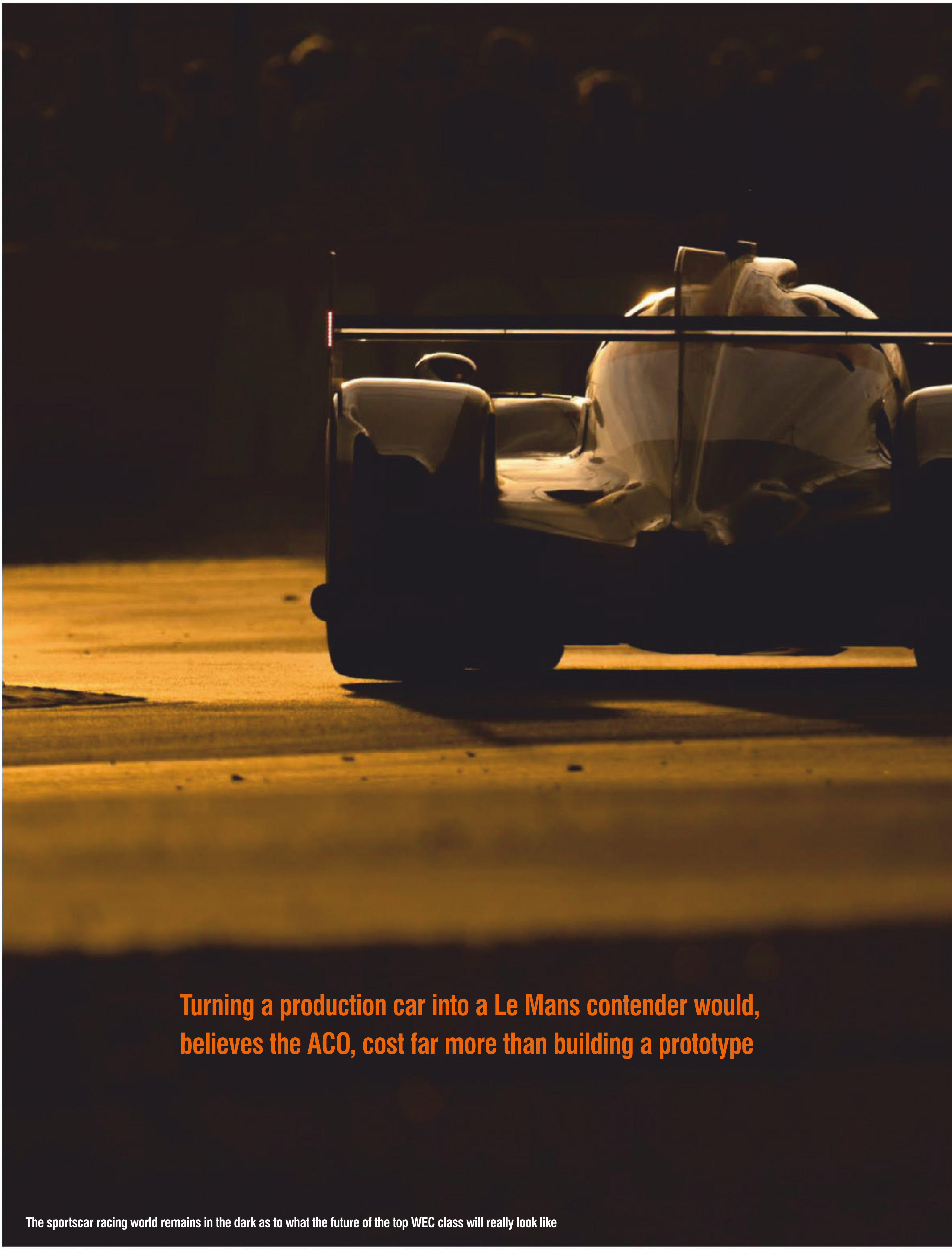


Turning a production car into a Le Mans contender would, believes the ACO, cost far more than building a prototype

The sportscar racing world remains in the dark as to what the future of the top WEC class will really look like

Hyper tension

The deadline is looming for the FIA's proposed hypercar regulations to receive manufacturer support, and yet at Sebring there was talk of a plan B for the first time. So are we any nearer to knowing the future of the top sportscar class?

By ANDREW COTTON

The FIA and ACO have unofficially given themselves until the Spa 6 hours in May before they consider alternatives to their hypercar plan, which will replace today's breed of LMP1 cars in 2020, under the current timetable.

The plan is ever-evolving, with the FIA World Council approving a set of technical regulations for hybrid prototypes in December, and announcing early in March that non-hybrid road cars would also be allowed to race. However, at Sebring the ACO said it was 'too early' to explain how the performance balancing between the two radically different concepts might work.

Non-hybrid road cars was a surprise addition to the rulebook, and many saw it as a last roll of the dice by the two organisations in a bid to lure a top manufacturer. It is believed that Red Bull Advanced Technologies is interested in joining under these circumstances, lining up alongside Toyota, Koenigsegg and ByKolles, but the French are really targeting Aston Martin, Ferrari and McLaren. Yet none of these have shown any sign of extending involvement beyond their attendance at the steering meetings.

The proposal for road cars was actually considered in November, but rejected on the basis of cost, and the ACO admitted surprise that the concept was now back on the table. Turning a production car into a Le Mans contender would, thinks the ACO, cost far more than building a prototype. Not only is there the performance element, but there is also the safety aspect too; fitting a roll cage into an Aston Martin Valkyrie would not be easy.

'We are investigating the possibility of introducing the road cars, but there is no point in sacrificing the best practices of safety and driver protection, says the FIA sport co-ordinator Marek Nawarecki. 'Of course, the standards and architectures [of the cars] are different but the FIA and the ACO has experience in both, and also in cars like GTE. Of course, nothing is decided yet.'

Anything goes

With no official explanation of what a hypercar actually is, the two French bodies have been able to open the rulebook to a point that pretty much everything is on the table, from a hybridised DTM shell to a GTE Plus concept or a current LMP1. The sole priority is cost, but few believe that can be kept under control given the wide scope that has been provided by the proposed regulations, which were released early in December. 'We have them, and they are approved, but it is a question of how we can implement them,' says Nawarecki.

The target lap time for the top class cars has been set at 3m30s with the minimum weight of the car at 1040kg, but that will lead to the next problem; what to do with the LMP2 category. The P2 cars qualified at Le Mans in 3m24.8s in 2018, and the fastest race lap was a 3m27.2. However, the power delivery from the Gibson engine is focused around the top end of the rev

The FIA and ACO had hoped to entice the likes of Aston Martin, Ferrari and McLaren (the latter's Senna pictured) into its hypercar based top class but have had little success so far

Toyota is ploughing a lone furrow in hybrid P1 at present and it is signed up to do at least one more season (2019-20), but after that its future depends on others joining the series

Whatever the new regulations will be the LMP2 cars will have to lose around 10 seconds per lap at Le Mans to reward the top class

range, and so smaller air restrictors would be catastrophic for their performance. More weight on a homologated car would only solve part of the problem and may create others. Whatever the LMP1 rule will be, the P2s will have to lose around 10s per lap to reward the top class.

The issue now is one of time. By opening up the class to production cars, the FIA and ACO believe that the likes of McLaren and Aston Martin can get board approval within two months, as they have already approached their money masters once with an outline plan, but achieving a result in such a short time-scale still seems unlikely.

One concession is a proposal to push the introduction of the regulations to 2021, to allow time for the manufacturers to build their cars, but that would mean a further two Le Mans 24 hours with the current cars, and there is no guarantee that Toyota would stay for that. The Japanese manufacturer will do at least one more year, 2019-20, but after that its future depends on support from other manufacturers to the concept. Such a move would mean that, by the time the new cars arrive, it will have been a three-year transition period. In the meantime Toyota has actually moved its 'red lines', and has now accepted that in order to drive the regulations over the line, balance of performance must be allowed.

What about plan B?

Should the idea fail to achieve the required support before Spa, the question then becomes one of a plan B, and while the FIA and ACO admitted that they would have to think of one, none were willing to discuss what it might be. 'The regulations are published now and if we open for the new technical solutions as requested now, we need to make the process as efficient and as quick as possible,' says Nawarecki. 'First, we need to investigate the current plan and get to the end of this process as soon as possible to be sure that it will be successful. We are in the process now, and we need to achieve as soon as possible and finalise as soon as possible, but we need to finalise the process and do all the other adaptations that we decided to do with the other manufacturers, and we will see. From my perspective, we are committed to the plan we have announced. This is the most important.'

In English, this means that the FIA is clear that time is pressing, but is unwilling to put an end date on the current plan, or a start date on a new one, which means that its options are now limited. Either it takes an existing set of regulations and adapts them to its needs, or it starts again. This is where the DTM and GTE solutions come in, proposed by BMW, but roundly rejected by organising bodies.

However, it is not only the car companies that are pressing for a decision. Tyre supplier Michelin has said that in order to have tyres ready for Le Mans 2020 it needs to be track testing rubber shortly after Le Mans 2019, and it has not yet been provided with the tyre spec for the new formula, nor the final weight of the car.

'We have the big lines [spec] but based on these we have also the first simulation of some of our partners, and we saw that it was a bit different in terms of tyres, it is not a copy and paste of the tyre we have right now,' says Jerome Mondain, Michelin's endurance racing programme manager. 'We need clarification and

Michelin 2019/20

Michelin ramped up its development programme for the next WEC season with a winter test of the LMP1 tyres at Sebring, to help provide an indication of the requirements for next year. 'The test here was a good opportunity to test in the hotter conditions the range for next year, because we are going back to Bahrain which is very high abrasion, and also thinking about Sao Paulo where we will go in summer,' says Jerome Mondain. 'We have to rearrange to develop our future range taking into account the much higher temperature than we expected this year, where we didn't go to Bahrain or any really warm places.'

One of the key developments for the new year will be the front tyre for the non-hybrid LMP1 cars. 'When we developed last year, it was a short period, with brand new cars, and not all of them,' says Mondain. 'That was a first shot. We are where we are. And also, because of the regulations, then the car evolved quite a lot in terms of knowledge and usage, but we worked to improve as well the spec for the whole championship. We are [using] the same tyre as in March last year. We will do the standard development as we do in all classes. We can do a standard development process on this car too.'

One change coming for next year is the plan to return to separate tyre and refuelling processes in a pit stop as the move this year to allow both simultaneously to 'improve the show' was a spectacular failure. 'We are happy to come back to that because it will basically [mean we are] able to show the value of the tyre over multiple stints, so that is good for us,' says Mondain. 'We don't expect a huge impact for WEC races except that this mix up with one tyre will be a bit more simple to watch for people or easier to understand, but keeping the tyre if it is stable will give you something which you cannot do with the current regulation.

'For us, this [current] regulation led us to using more tyres in Le Mans,' Mondain adds. 'On average we used two more sets per car than the previous year with the same number of tyres available, so it was not a solution. It did not bring more fun. We are happy to come back, and we expect next year that the tyre consumption will go down again to something similar to 2017, which is why we are in endurance.'

One of the issues associated with a road-based hypercar formula is ensuring the LMP2 cars are slower than the top class

Could IMSAs DPi, which is well liked by the manufacturers while also being relatively cheap, provide a workable alternative?

In order to prepare the field for the start of the 2020/21 season long lead-time parts must now be finalised

we need the technical regulation to know where we go, or propose something in terms of size.

'If we are to be ready for Le Mans 2020 we need to start soon after Le Mans and put tyres on the ground,' Mondain adds. 'We can start working on simulation but at some point we need validation on the track and the manufacturers need to give us the car, and we can put the tyre on the car. We have the weight, and so far from what we saw that is not the same thing. It has a huge impact on the tyre. We need to know a bit more, first to know if we can keep the same family of tyre, and even according to the size, but if we have to discuss the size of the tyre, it means a change in the draft technical regulation. We are waiting on the pure technical regulation. It must come soon, because we have to work. After Le Mans we have to have the project for the year after.'

In order to prepare the playing field for the start of the 2020/21 season, long lead-time parts must now be finalised, and the cooling requirements for the engine is a calculation that should have been already made to determine the overall requirements of the racecar. Without a final set of technical regulations even this has become something of a challenge, hence the doubt that the hypercar regulations can actually be achieved.

Another way

Waiting in the wings are the DPi regulations from IMSA. The American organisation has a basis for its chassis in LMP2, an ACO/FIA regulation, and has provided manufacturers with a way of racing for very little money. Team Penske, which runs the Acura, is believed to be doing so on around $6m a car, well short of the proposed €15m/car that the FIA WEC is targeting. The Americans could follow the lead of TCR founder Marcello Lotti and lease their DPi 2.0 regulations to the ACO for Le Mans, and then allow their manufacturers the option to race in one of the great endurance races.

It remains to be seen what the end result is, but the likelihood is that a plan B will be required, and must therefore be already written to allow teams time to produce cars for 2020. IMSA's new regulations are not due to be implemented until January 2022 at the Daytona 24 hours, but the Americans could accelerate its process and have this set of regulations ready to help out their European colleagues. Updates on progress will come before Le Mans.

Compare and contrast with maths

Racecar's simulation wizard shows how you can use three simple, yet hugely effective, groups of graphs to compare the set-ups of a number of cars

By DANNY NOWLAN

Recently I was given an assignment where I had to analyse a lot of data. I had to use this data to see how different the set-ups of the racecars in question were. When you are presented with a job like this the biggest trap you can fall into is that you start overlaying data, and then approximately one week later you have gone nowhere. But there is actually a very simple way through this mess, and I will highlight the areas you should really focus on here.

There are three different graphics you can review that will show very quickly how different set-ups are car-to-car. These are the damper histogram; the g-g diagram; and plotting front and rear roll as a function of lateral *g* and front and rear pitch as a function of longitudinal *g*.

The great thing about all these three graphs is that they give you a concise but very thorough snapshot of what the chassis is doing.

Let's review the damper histogram first. An example of this, which is a ChassisSim simulation of a V8 Supercar at Queensland Raceway (Willowbank), is shown in **Figure 1**.

The damper histogram is a statistical analysis tool that shows you where the damper velocities are spread. The horizontal axis is damper velocity in mm/s. The vertical velocity is the percentage distribution a damper velocity is spent in. For example, in **Figure 1** the peak low speed reading is 17.5 per cent in bump for the front left damper. That is, in the low speed section, say between 0 to 25mm/s, this is where 17.5 per cent of the damper velocity time is spent. What the damper histogram and its shape shows is a very quick first pass to see what the damper behaviour is. For example, if you have low speed components, say of 10 per cent, that is an immediate indicator that either the low speed damping of the damper is not working or the damper is being dominated by the high speed behaviour.

The second figure to consider in this analysis is the g-g diagram, which is the car's performance envelope; this was first coined in *Racecar Vehicle Dynamics* by Bill and Doug Milliken, and the results of the V8 Supercar simulation are shown in **Figure 2**.

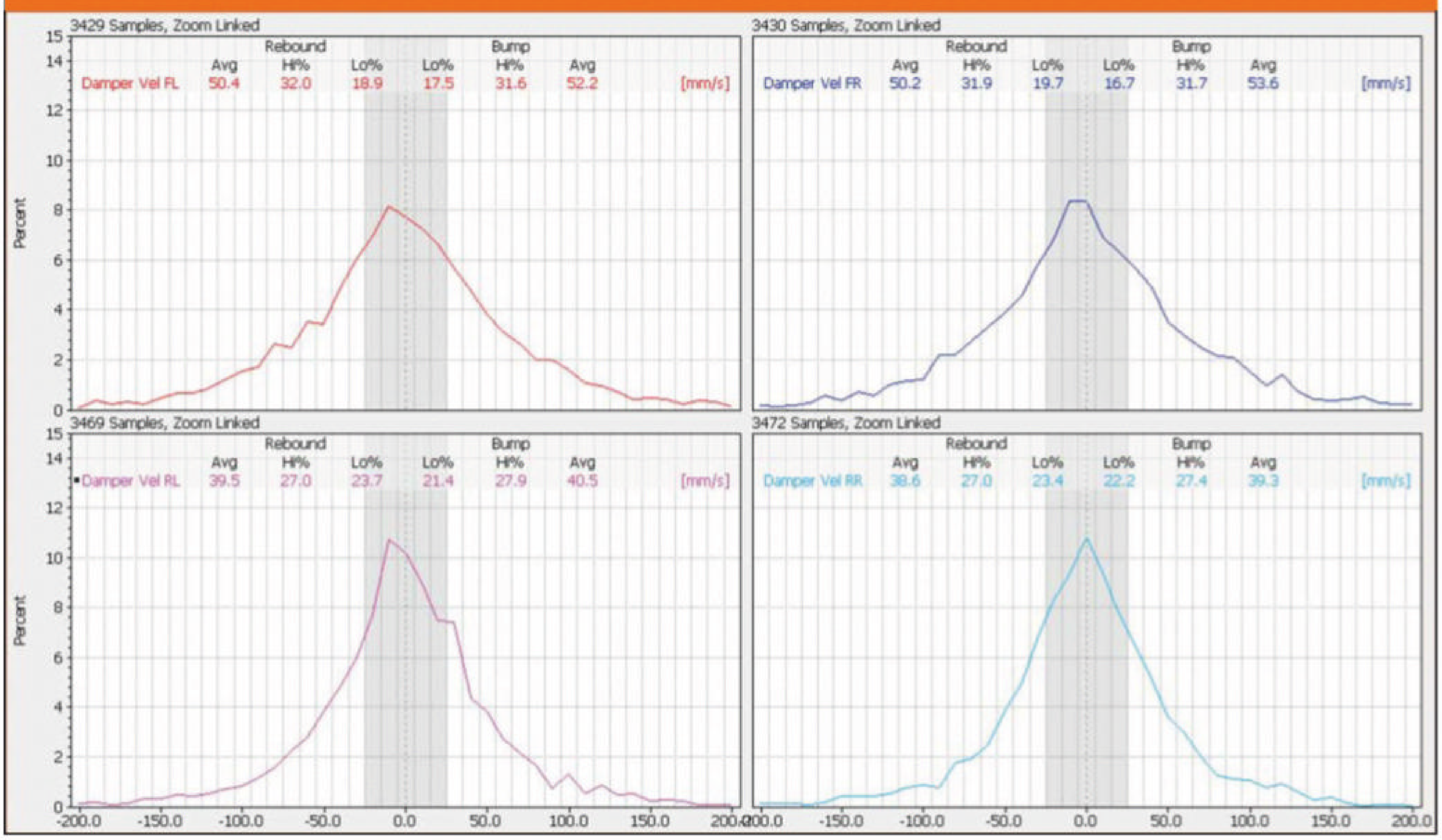
What the g-g diagram measures is the combined lateral and longitudinal acceleration of the car. One thing you can put in the bank is the faster the car can corner and the faster it can accelerate the bigger the g-g diagram will be. Also, a note here on why this diagram looks a bit flat; it is because this is a simulated lap and it is driving within the car's constraints. An actual lap will have a g-g diagram that is smaller in overall magnitudes but rounder in shape.

The plot thickens

The final graphic is the plot of front and rear roll *vs* lateral *g* and front and rear pitch *vs* longitudinal *g*. This plot for our simulated V8 Supercar is shown in **Figure 3**. And just to clarify what we have plotted see **Equations 1** to **4**.

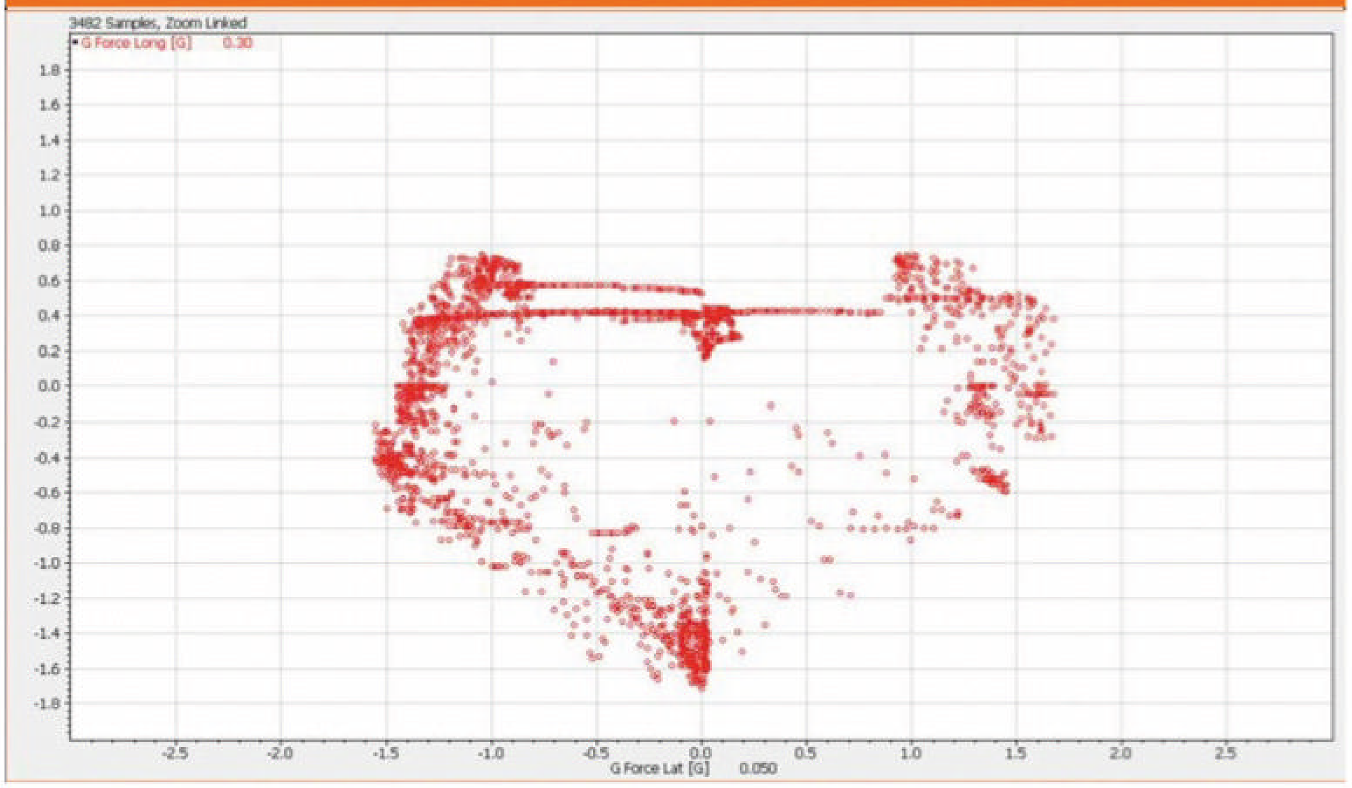
A couple of observations here. Firstly, since we are plotting body movement *vs g* the lower

Figure 1: Damper histogram of the V8 Supercar at Willowbank



The quicker the racecar is able to corner and the faster it is able to accelerate then the bigger the g-g diagram will be

Figure 2: The g-g diagram of the V8 Supercar at Willowbank



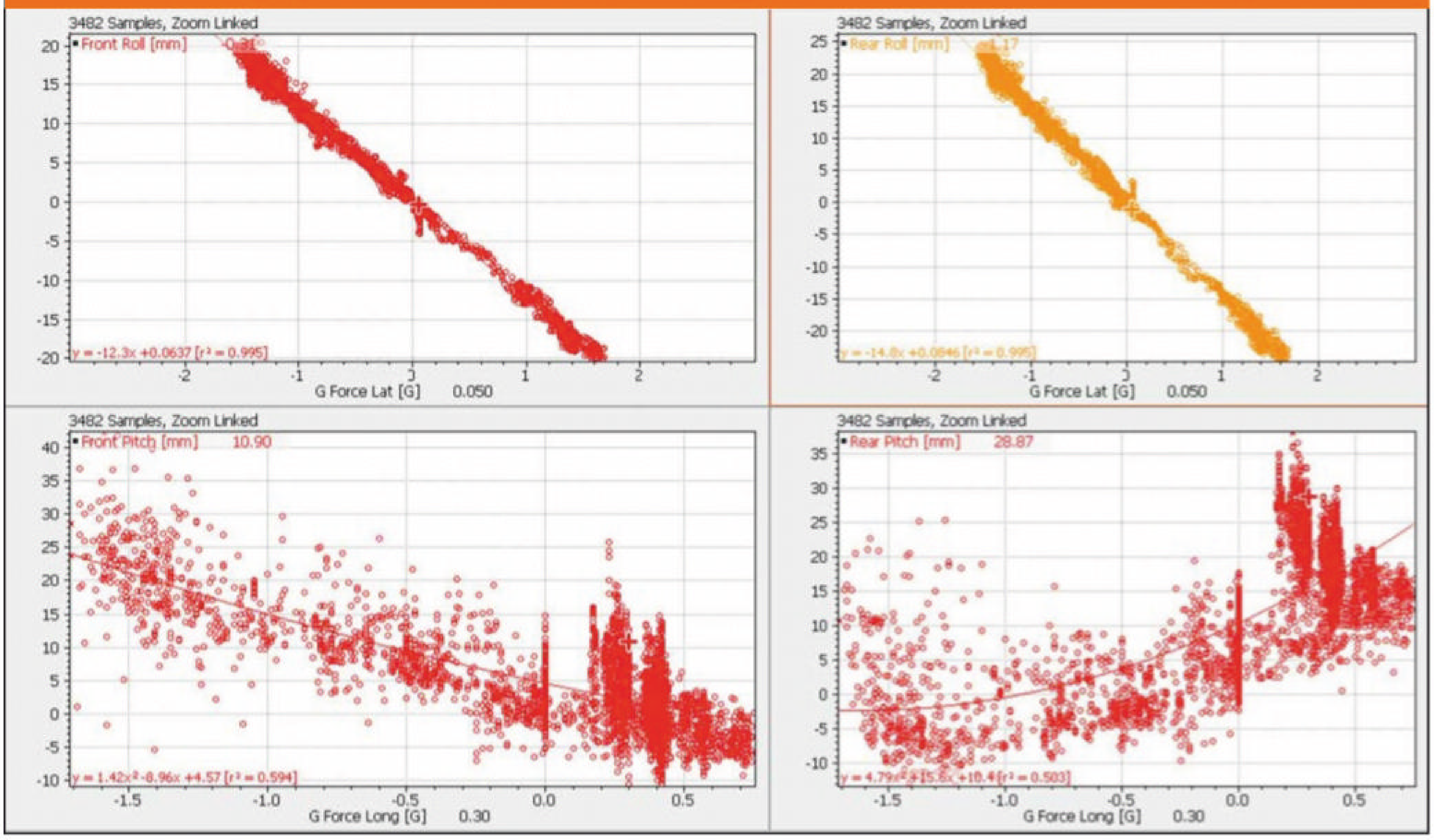
The lower the gradient of the slope on the graph then the stiffer the racecar's set-up is

the gradient of the slope the stiffer the set-up is. This can be a real trap for the inexperienced engineer, because sometimes we subconsciously associate stiffer with a larger gradient. There is nothing stopping you from showing it the other way around, but the gradients can look a little weird, which can make explanations to non-technical personal challenging.

The other thing to note is the spread in the pitch *vs* longitudinal *g* diagrams is primarily due to bumps. For a softly set up racecar like a V8 Supercar the rolls are typically double the pitches, which is why you get that spread in the pitch diagrams. However, the key thing that **Figure 3** will show, and very quickly, is whether the set-up is different; because if the combination of springs and geometries is different it will be reflected in the slopes.

One thing to note, though, is that the roll/pitch *vs g* approach will break down when the motion ratios from car to car are different. Consequently, if you are analysing different makes of car you have to resolve the roll and pitch movements at the wheel. This can catch people out if they are not aware of it.

Figure 3: Roll and pitch slope diagrams for the V8 Supercar



EQUATIONS

EQUATIONS 1 to 4

$$FrontRoll = 0.5 \cdot (Damper_{FL} - Damper_{FR}) \quad (1)$$

$$RearRoll = 0.5 \cdot (Damper_{RL} - Damper_{RR}) \quad (2)$$

$$FrontPitch = 0.5 \cdot (Damper_{FL} + Damper_{FR}) \quad (3)$$

$$RearPitch = 0.5 \cdot (Damper_{RL} + Damper_{RR}) \quad (4)$$

Where:

$FrontRoll$ = average differential movement of the front dampers
$RearRoll$ = average differential movement of the rear dampers
$FrontPitch$ = average combined movement of the front dampers
$RearPitch$ = average combined movement of the rear dampers
$Damper_{FL}$ = logged damper movement of the front left
$Damper_{FR}$ = logged damper movement of the front right
$Damper_{RL}$ = logged damper movement of the rear left
$Damper_{RR}$ = logged damper movement of the rear right

Each of these examples by themselves will tell you quite a bit, but all three together will act as an alarm and point to where you need to investigate further. The g-g diagram shows you the end result. However, when you combine this with both the damper histogram and the roll and pitch slope diagram you now have the tools to assist you in clarifying what is driving that g-g diagram, and in identifying the difference in the set-ups and quantifying which is the appropriate direction to head in. It will also show you what clearly counts in the set-up.

Virtual tuning

So let's consider a quick example of this. Taking our V8 Supercar at Willowbank we are going to make a number of changes so you can see the net results. To put all this in some sort of perspective the changes we will be making are summarised in **Table 1**. Let's now go through each of these modifications and see what they did. Also, for clarity, the base set-up will be coloured and set-up 2 will be black.

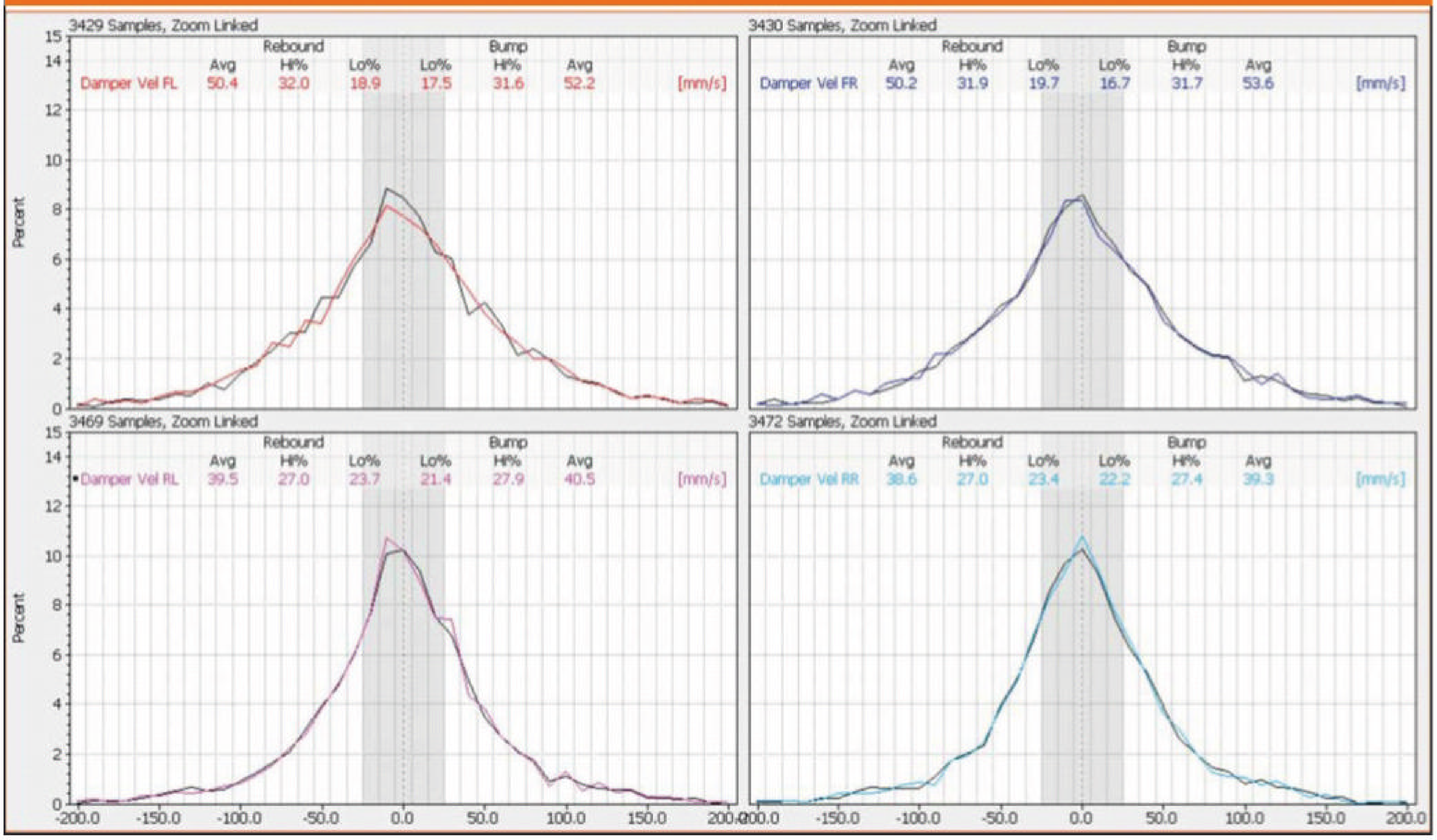
The first interesting point of comparison is the damper histogram. This is illustrated in **Figure 4**. Reviewing this, for the left front damper histogram the low speed peak is one per cent higher for set-up 2 as opposed to the baseline. For the rear histograms the low speed section of the damping curve is one per cent lower for both left and right. One thing to note is the similarity for the right front histogram. Also, Willowbank is dominated by right hand turns. Consequently, the right front will not be the dominant term since at mid-corner condition it is the most lightly loaded. So, all in all, this change would have the effect that we would expect.

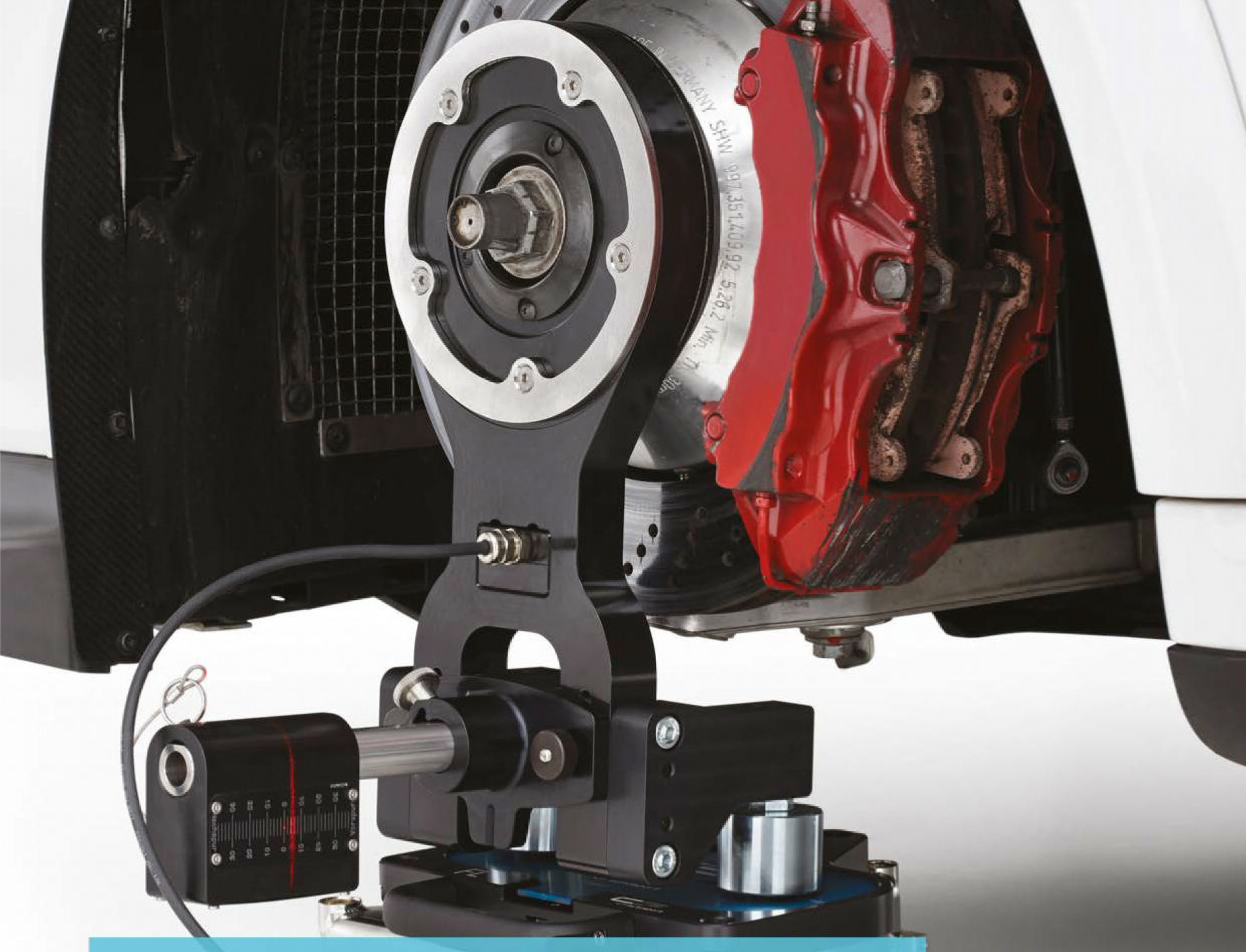
An old spec V8 Supercar in action at Willowbank. A racecar like this, on this circuit, was used as the base model for our study. Note how the right front wheel is unloaded; a feature of this track is that it is mostly made up of right-hand corners

For a softly set up car like a V8 Supercar the rolls are typically double the pitches

Table 1: Changes to the V8 Supercar set-up at Willowbank		
Set-up Item	**Baseline**	**Set-up 2**
Engine power	450kw	470kw
Front damper	Standard	+ 10 % front bump and rebound
Front and rear roll bars	Standard	+10% rates front and rear
Rear anti squat/anti dive	33%	43%
Lap time	69.5s	69.22s

Figure 4: Damper histogram of the comparison between the V8 Supercar set-ups





The next thing to consider is the g-g diagram, which is illustrated in **Figure 5**. What is abundantly clear from this graph is that the primary change is the effect of the engine. If we look at the acceleration component of the g-g diagram this has increased by an average of 0.05g. However, under braking and turning the g-g diagram is virtually identical. This tells us that the chassis changes have not had a big impact on the racecar's performance.

Fever pitch

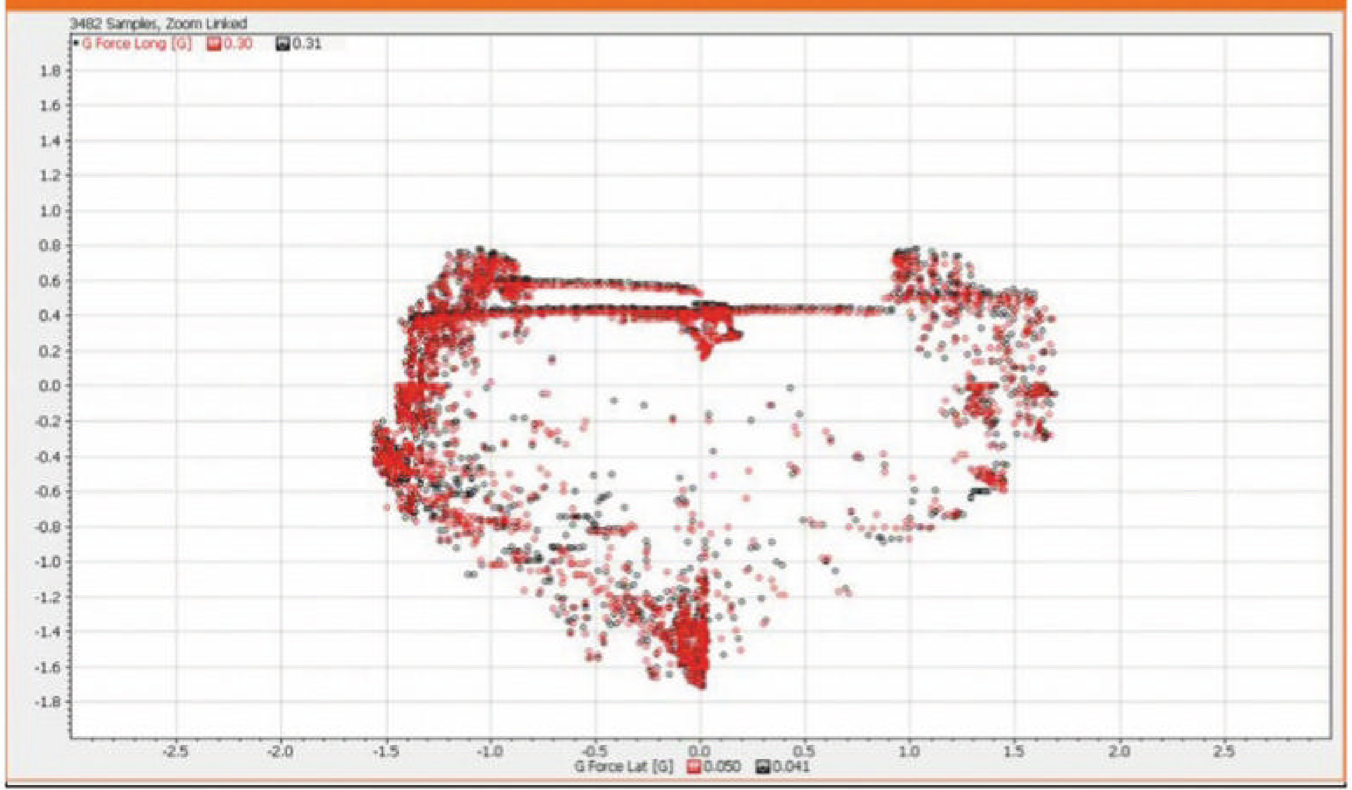
Lastly, a review of the pitch and roll slopes is very instructive. This is illustrated in **Figure 6**. As can be seen, the comparisons are quite subtle which you would expect given the small changes. However, the results do speak for themselves. For example, the roll gradients for the set-up changes do reflect the set-up changes given for set-up 2, because both the roll slopes front and rear for set-up 2 are lower then the baseline.

Also, the rear pitch *vs* longitudinal *g* slope reflects the increased anti-dive for set-up 2. This is seen with the lower rear quarter being slightly more populated, as we can see from the black data points in this sector of the graph.

A couple of things to note with the changes that we have tried here. In this particular set-up the roll bars were more like trim tabs, so they were never going to have a massive impact. What did make its presence felt, though, was the engine change, which we would expect.

That said, all the changes showed up in the way that you would expect them to. Consequently, we now have a good tool to review different set-ups, even though the changes we presented here were quite subtle.

Figure 5: The g-g diagram of the comparison between the V8 Supercar set-ups

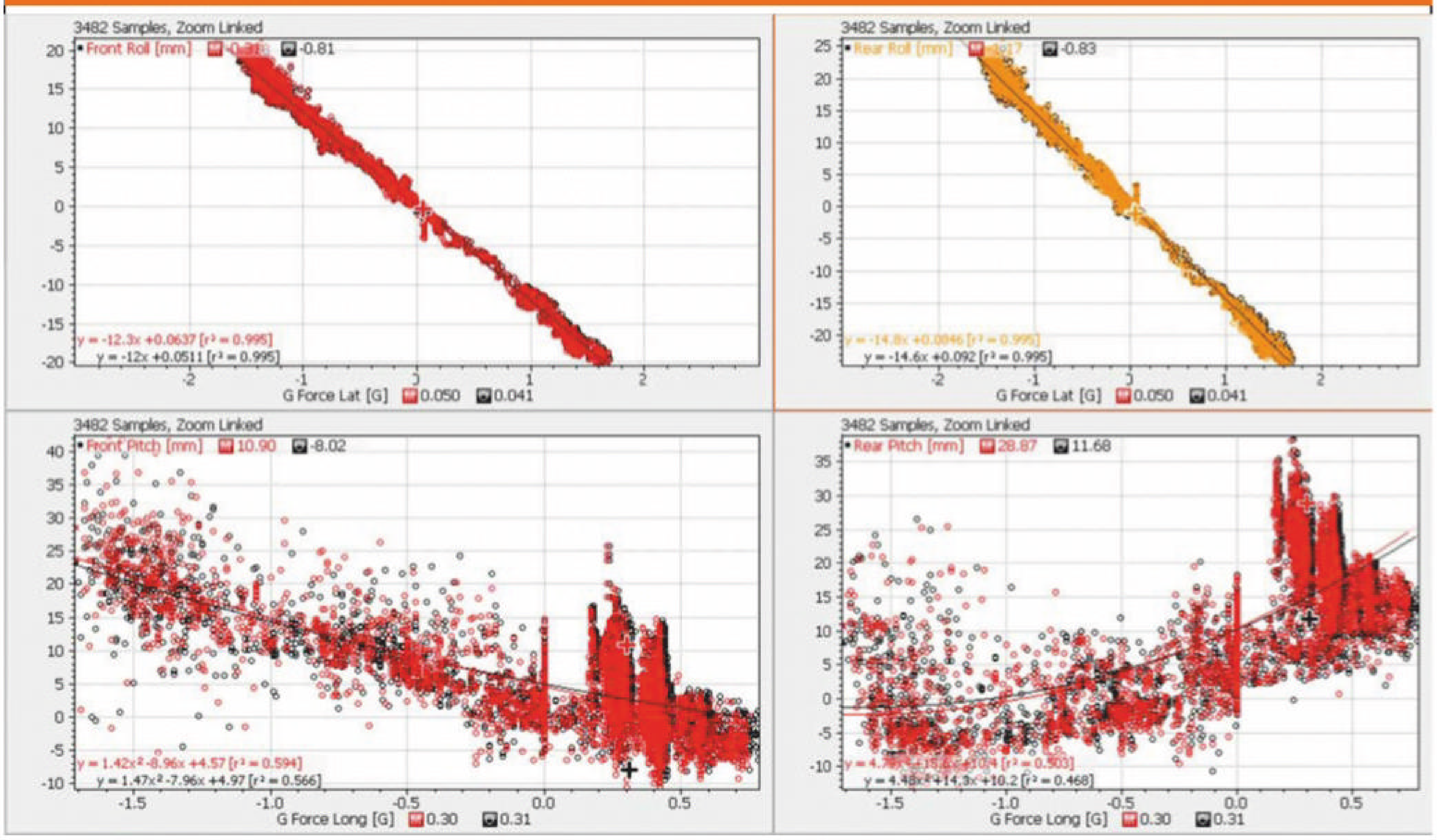


The other thing to note here is that we are looking at simulated data. For reasons we have discussed previously simulated data is much more consistent then actual data. This boils down to the fact that if you make a change that affects the car stability the driver will react much more than the simulated data, because a driver doesn't know the amount of grip that is available while they are also acutely aware of their own mortality. Consequently, when you make changes you will see bigger impacts in the g-g diagram, so be mindful of this.

Yet while what we have presented here is a great tool it doesn't replace having a more in-depth look at the data, though it certainly casts a light on where to look and helps with your analysis. And if you have to go through a lot of data the tools outlined here are a very good first port of call, so that you can identify what you need to look at. It is also all covered in most data channels you will have access to.

In closing, we have presented a series of tools to help classify the effect of different set-ups. As we saw from our basic example the changes went the way we would expect. The g-g diagram tells you the effect of a change. The roll and pitch slope diagrams combined with the damper histogram tell you where to look and how to classify what did what. Once you know this you are well on your way.

Figure 6: Pitch and roll slopes for the comparison between the V8 Supercar set-ups



Interview – Jay Frye

Fast and loud

The recently appointed IndyCar president reveals the simple secret behind the ongoing success of the premier US single seater series

By MIKE BRESLIN

'You have got to take care of your partners, you have got to remain relevant, but you also have got to give your fans what they are looking for'

Outside of philosophy seminars there are few activities that dwell quite so obsessively on what they actually *are* as much as motorsport. Witness the never-ending debate in Formula 1 about whether it's a sport or a business, entertainment or high speed development lab. IndyCar, on the other hand, seems to know exactly what it is, and this can be encapsulated, according to its president Jay Frye, in two words: 'fast and loud'.

The US series is going through a bit of a purple patch at the moment, with ever growing TV numbers and race day attendances, and more teams competing. Which is, says Frye – who led the competitions and marketing department before his elevation to president in January – all part of the plan. 'I think part of it [the reason for the success] is we came up with a paddock-wide initiative which was this five-year plan; where are we going in the future, what are we doing, how's this going to look. The first thing we had to do was get our identity back; and I think the new aero kit did that [the UAK18, introduced last year].' And what is that identity? 'We are an open wheel series that has a historical feel.'

One of the key aims of the five year plan was trying to recruit new team owners, Frye says. 'The goal was to get a couple, and now we're up to six or seven new teams coming into the sport. So it appears to be working, in terms of the car count going in the direction it is, and again this was a phenomenal effort by everybody in the paddock … from team manager to driver to owner, we include everybody.'

But if there is one missing ingredient in IndyCar's resurgence it's that there are still just the two manufacturers involved, Honda and Chevrolet. 'We are working hard to get a third [OEM] and there seems to be a lot of interest,' Frye says. 'A lot of them are very aware of what we're doing, they're curious, they're enthusiastic. When we talk to them we show them what we understand the development costs will be, this is how it will work, here's how the teams are integrated. And they say they have never seen anything like that, where we've put numbers to it. Obviously, it's not inexpensive, but it is much more economical than they thought it would be.'

Keeping it real

Interestingly, Frye says OEMs are not put off by IndyCar's non-hybrid/electric approach. 'One of the things we have talked to them a lot about, is about being authentic, and being who we are and doing what we do,' he says. 'This series historically is fast and loud, and that's our direction … Honda and Chevrolet are our [current] engine manufacturer partners, and they are phenomenal. We collectively came up with the rules for the 2.4-litre [engine formula for 2021 to 2026]. That was them, IndyCar didn't mandate it, we worked with them to come up with what's next, and they suggested these regulations, so it's relevant to them, it's relevant to where they are going.' And the same goes for other OEMs, Frye says. 'It's what they are doing in the market place, most of them.'

But no manufacturer will be attracted if the fans aren't, which is why IndyCar has worked unstintingly on improving the quality of the show, the 2018 body kit being the most obvious manifestation of this. However, last year's Indianapolis 500 was not a thriller, and IndyCar has needed to look at its high-speed oval aero performance (see last month's issue, V29N4). That said, Frye believes the negatives have been overstated.

'If you go back to the 500 last year, I think part of it was that it was the hottest day that we had had in years. I think the car did a phenomenal job. I think there were some really great moments. But having said that we always want it to be better. So we have come up with some tools that allow the teams to adjust the car based on their wants and their drivers' wants … I think [this year's race] will be an exciting 500 for sure.'

While nothing can touch an IndyCar at Indianapolis in terms of speed around a circuit – the cars can exceed 230mph – at the time of writing the series was about to visit COTA, which also hosts the F1 US GP. Predictions were that the US cars would lap some 12 seconds off F1, but Frye believes they will not suffer in comparison. 'It's not an apples to apples comparison,' he says. 'What Formula 1 does is great. But we've gone in a different direction, with our cars we're peeling more downforce off them, where the F1 cars have massive amounts of downforce.'

COTA is a new addition to the schedule this year, along with the much-anticipated return to Laguna Seca, while long term there's talk of taking it outside of North America again, with a return to Surfers Paradise in Australia often mentioned and a race in Argentina a real possibility. 'We talk to people all the

IndyCar started its season at St Petersburg, Florida, in March. It is currently trying to entice a third OEM to join Honda and Chevy time, globally,' Frye says. 'It's just the timing, how it fits, it's what they have got going on, it's what we have got going on. My history is on the team side, and I always thought, "how hard is it to make a schedule?". It's very hard. You've got competing series, you've got broadcast partners, if it's street racing they have got to build the course, and then there's the weather, it is a very difficult process to go through.'

Cockpit protection

Another difficult process is sorting out the cockpit protection. IndyCar has opted to use the Advanced Frontal Protection (AFP) device, a relatively unobtrusive titanium piece that sits in front of the cockpit along the centreline of the chassis, as an interim solution this season, before it introduces its screen. 'We were working on [the screen] project for a couple of years,' Frye says. 'But actually the AFP piece started around 2012; in a different configuration, it had been on a car, they tested it. So we got into last fall, where we had, not setbacks, but to put something like this [the screen] on a car it has to be right, a hundred per cent right, so we have a little more work to do on the screen. So we resurrected this project that was started in 2012, because it is something that's easy to do, it's economical, it can be done quickly. Dallara, our partner, have some new technology that made this possible, I guess in 2012 it would have been more complicated. So we thought, yes, let's go forward with this. But we are still full speed ahead on the other project.'

The screen, and the AFP, is undoubtedly a more aesthetically pleasing solution than F1's Halo, but Frye says IndyCar also looked at this before deciding it didn't quite work so well for the different demands of the series. But then that's the point, IndyCar is different. And it knows it. 'At the end of the day, different groups have different niches, like Formula 1 has the way they do things and operate, Formula E has the way they do things and operate, as does NASCAR,' Frye says. 'So we have our thing; people want to be entertained, and fast and loud is entertaining. I think at the end of the day, your fans, what do they want? You have got to take care of your partners, you have got to remain relevant, but you also have got to give your fans what they are looking for, because we're here because of them.'

RACE MOVES

XPB

Masashi Yamamoto is now F1 managing director for Honda, a newly-created role which will see him concentrate on its efforts in Formula 1 rather than overseeing all of its motorsport campaigns. **Hiroshi Shimizu** has replaced Yamamoto as general manager of motorsport. Yamamoto's new position reflects the fact that Honda is supplying two teams this year, Red Bull and Toro Rosso, the first time it has done so since returning to Formula 1 in 2015.

Michael Masi, one of the FIA's two deputy race directors in Formula 1, stepped in to fill the three mandatory senior officiating posts at the Australian Grand Prix in the wake of **Charlie Whiting's** sudden death (see obituary page 96). Masi was race director, starter, and the FIA safety delegate at the event.

Andrew Roberts has joined motorsport, automotive and technology PR firm Influence Associates as its chief operating officer. Roberts comes to Influence from Bentley, where he had been director of global communications since 2014. He has also worked in senior PR roles at Mercedes-Benz UK and Land Rover.

Martin Young has been appointed team manager at F3 Asian Championship outfit Absolute Racing. Young comes to the team from Fortec Motorsport, where he had held the position of team manager since 2012 – helping the outfit to achieve multiple wins in the Formula Renault Eurocup and the Northern European Cup. Young's duties will include running the day-to-day operations at Absolute's Shanghai base.

It's been reported in Denmark that **Martin Reiss**, who is a respected deal maker in the Formula 1 paddock, is now **Kevin Magnussen's** manager. Reiss is also the manager of Magnussen's team mate at the Haas Formula 1 operation, **Romain Grosjean**.

Former Ferrari boss **Sergio Marchionne**, who passed away in the summer of 2018, was posthumously declared the winner of the prestigious World Car Person of the Year award presented at the Geneva Motor Show in March. More than 80 World Car Awards (WCA) jurors from 24 countries collectively decided on Marchionne by secret ballot.

NASCAR will hold its end of season awards banquet at Nashville at the end of the year, moving the high-profile event from Las Vegas where it has been held for the past decade. 'This year, we set a course to look at everything we do through a different lens, including how we celebrate the champions of our sport,' said NASCAR president **Steve Phelps**. 'Nashville's energy, vibrant entertainment scene, and deep-rooted lineage in motorsports informed our decision and we believe our fans and industry will embrace the move to the Music City.'

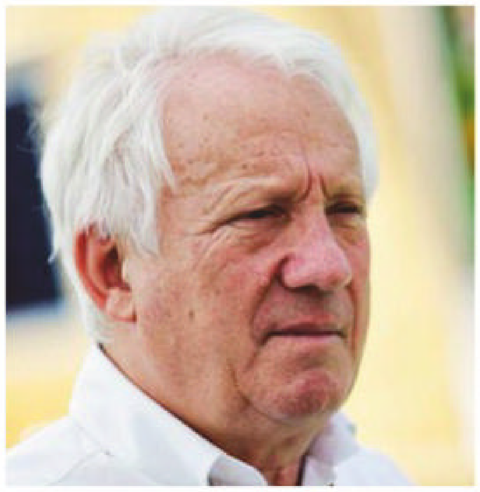
Veteran US single seater team bosses **Neil Enerson** and **Jay Green** have joined forces to form Team E-Jay Racing, an outfit that will run **Nate Aranda** in the USF2000 Championship this season. Green, a former driver turned car owner, previously ran Jay Motorsports for many years in SCCA spec categories, while Enerson's Team E Racing competed in Indy Lights and also in USF2000.

Anthony Pasut, the fueller on the JTG Daugherty Racing No.37 Chevrolet in the NASCAR Cup, suffered multiple leg injuries in a pit-road accident at the Atlanta Motor Speedway round of the series in February. Pasut, a Hendrick Motorsports employee assigned to the JTG Daugherty team, was left with a broken fibula, a torn anterior cruciate ligament and other injuries to his right leg after the incident.

Eric Boullier, formerly the racing director at the McLaren Formula 1 team, is now part of the organisation behind the French Grand Prix. Boullier, who stepped down from his post at McLaren last summer, is now a strategic advisor (sport and operational) as well as a global ambassador for the Paul Ricard event.

NASCAR Xfinity crew chiefs **Taylor Moyer** (No.8 JR Motorsports car) and **Timothy Goulet** (No.74 Mike Harmon Racing entry) were each fined $5000 for lug nut infractions at the Phoenix round of the second-tier NASCAR series.

OBITUARY – Charlie Whiting



XPB

The Formula 1 paddock was rocked by the news that Charlie Whiting, for so long a key player in almost every facet of the running of F1, had died suddenly of a pulmonary embolism at the age of 66, just a couple of days before he was due to unleash the field for the season-opening Australian Grand Prix in his role as official starter.

Race starter was just one of Whiting's jobs in F1, and he was also responsible for writing both the technical and sporting regulations, and for policing them, as well as being in charge of each grand prix in his capacity as race director, and also assessing circuit safety and the suitability of future grand prix venues.

All this was a far cry from his start as a racing mechanic on the UK national scene and then his elevation to F1 via a stint at Hesketh before a fateful move to Brabham in the late '70s, while it was owned and run by Bernie Ecclestone. By 1981 he was chief mechanic, overseeing Nelson Piquet's world championship triumph that year and again in 1983.

When the Ecclestone era at Brabham ended in 1988 Whiting, who was by now the team's chief engineer, moved to the FIA, on Bernie's prompting, becoming the technical delegate in 1990. His responsibilities gradually expanded from there, and in 1996 he became race starter, and this was quickly followed by promotion to race director and safety delegate, as well as him taking on responsibility for the tracks.

Red Bull boss Christian Horner spoke for many when he said: 'He was a racer. That was his background. When you spoke to him about his days at Brabham, working for Bernie, there was always a smile on his face. He knew all the tricks in the book and that made him the ideal guy to become poacher turned gamekeeper when he took on the role with the FIA … I think there is a huge debt of gratitude owed to Charlie for what Formula 1 is today, the safety, the lives that his actions actually saved.'

Charlie Whiting 1952-2019

Paddy Lowe takes 'leave of absence' from Williams

Williams chief technical officer Paddy Lowe has left the post in the wake of the team's disastrous start to the season.

Lowe's tenure at Williams began at the start of the 2017 season, when he replaced Pat Symonds as the team's tech boss and also became a shareholder in the organisation. He joined from Mercedes, where he had helped it to three championship victories in a row.

Lowe had been under pressure after Williams was forced to miss two days of pre-season testing following car build delays. This was compounded when it was discovered the car was running with some illegal parts, including a seventh member in the front suspension when only six are permitted, and mirrors which fell outside of the regulations. On top of this it has proved to be slow, both the Williams FW42s propping up the grid at the Melbourne season-opener.

XPB

Lowe is no longer leading the Williams technical team

This all follows a poor 2018, when the first of the car's Lowe was responsible for had fundamental aerodynamic issues and the once-great team came last in the constructors' championship.

Although Lowe denied his position at Williams was under threat during the Barcelona tests it's been reported that a team spokesman has said that Lowe 'is taking a leave of absence from the business for personal reasons'.

Lowe was originally at Williams between 1987 and 1993, before moving to McLaren, and then on to Mercedes in 2013.

RACE MOVES – continued

Jody Egginton has been promoted to the technical director role at the Toro Rosso F1 team, following the departure of **James Key**, who at the time of publication will be taking up the same position at McLaren. Egginton, who was previously deputy technical director at Faenza, came to Toro Rosso in 2014 from Caterham, and before that he had worked at Force India.

Three members of the McLaren F1 team had to undergo medical treatment after being involved in a fire in the team garage at the Barcelona circuit following a private filming day with the new car, the MCL34, in late February. McLaren said: 'Three team members were taken to the medical centre for treatment and were released shortly after.'

Brian Till is now the steward of the meet for the Formula 4 US Championship and F3 Americas Championship. Till won the 1990 Formula Atlantic Championship in the US and made more than 20 starts in a four-year CART career.

XPB

Riccardo Musconi is now race engineer for **Valtteri Bottas** at the Mercedes Formula 1 team. Musconi, who previously worked as performance engineer for **Lewis Hamilton**, takes over the position left vacant with the departure of **Tony Ross**, who has left the F1 operation to take up a position with the Mercedes Formula E project.

NASCAR artist **Sam Bass**, who was well-known for the distinctive car liveries he created – including the iconic 'Rainbow Warrior' scheme on **Jeff Gordon's** Chevrolet – and also for paintings and the artwork on many race programme covers, has died at the age of 57. Bass, who was NASCAR's first officially licensed artist, had been battling kidney failure for some time.

David Richards, the founder and boss of Prodrive and the chairman of Motorsport UK, raced a Frazer Nash in the VSCC's (Vintage and Sports Car Club) Pomeroy Trophy in February. The 1981 World Rally Championship winning co-driver took the car to second in class at the Silverstone-based event.

Former F1 racer and current Toyota LMP1 driver **Fernando Alonso** has launched a new esports team. The squad has been formed as a partner venture to his FA Racing operation, which competes in real-life categories such as the Formula Renault Eurocup, and the Veloce Esports team. Until last summer Alonso was also involved in the G2 esports team, but he split with the Spanish organisation after less than a year.

NASCAR Cup crew chief **Adam Stevens** was fined $10,000 after the No.18 Joe Gibbs Racing Toyota he tends was found to be running with improperly installed lug nuts at post-race inspection following the Phoenix round of the series. The Kyle Busch-driven No.18 was also the winner of the race.

The popular Pirtek Pit Stop Challenge, which sees crews in Australia's Supercars series battling for the quickest stops throughout the season, will have an extra qualifying round this year, bringing the total to eight. The top four crews at the end of the season go into a shoot-out at the Bathurst 1000, with a A$20,000 ($14,000) prize up for grabs.

◆ 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**

Change is in the air

The MIA's CEO explains why the industry has much to gain in the coming years

We are certainly in a period of exceptional change. And there's no doubt in my mind whatsoever that the most fun in business occurs during a period of change or business growth. Beyond that, it's also an important time for businesses to take stock and wisely choose their direction of travel for the next few years.

As I write, neither Europe nor the UK have a clear view as to what our future trade relationships will be, except that they will change. In addition to this, our relationships with our politicians in the UK are going to be substantially affected for years to come, creating a different climate in government with regard to its relationship with businesses.

The damage done by the past two years of debate, consultation, argument – and stupidity by some – has not impressed the wider business community on the whole. Social media means that immediate comment and information is shared faster than ever. It is not always based on well-considered facts but, nevertheless, it powerfully drives change.

The motorsport sector also faces substantial internal change, in the way important race series are organised, funded, promoted and directed as regards to their technical regulations.

Over the next two years, most of the influential series will see substantial change on the technical regulations side of things – Formula 1, NASCAR, WEC, WRC, BTCC – the list goes on. These changes are to reduce costs for competitors or teams, increase the viewing audience or to satisfy the demands of major automotive brands – there are many people to please!

Chaos theory

Sitting at the centre of the Motorsport Industry Association (MIA) I have the benefit of enjoying discussions with small and large businesses which are planning to grow during this, apparently, chaotic time. This privileged viewpoint allows me to collect ideas from those most likely to succeed, and those who are already taking steps to succeed.

Hidden within apparently negative news there are a few rays of sunshine and it would pay to focus on these. For example, OEMs are reducing their engineering staff by thousands, which means highly-qualified engineers will be available to motorsport businesses. Also, the slow, but inextricable, rise of electric power across motorsport – from karting to motorcycle racing and through hybrids – will open up a range of technology-based opportunities for fast-moving, innovative companies.

Return of the ICE age

The internal combustion engine will require good engineers for many years ahead to consistently improve efficiency and utilise new fuel sources – a journey that's likely to be influenced by the speed with which hybrids are embraced in motorsport. There are so many variants of hybrids, from low tech to hi-tech, and their development again offers opportunities for those willing to embrace change.

Hybrids of some kind could be in the WRC by 2021, offering ever more lucrative opportunities to those motorsport firms which are not afraid to embrace change

In 2021 we will see hybrids in most touring car series and rallying, but at what level of technology will these be, from the relatively simple to the ultra-sophisticated? Cost control will probably demand the former initially over the first few years.

The current level of change across the automotive sector is quite exceptional. OEMs must urgently develop their next generation of vehicles by reducing weight and adapting to new technologies and techniques. There has never been a period where so many different applications require consideration, innovation and solution. This is a perfect time for the high-performance engineering community in motorsport to focus on delivering solutions in short runs, rapid time and at best value.

So make certain that you don't get left behind. You should now, with your colleagues, develop a three-year business strategy which identifies changes in your markets, your customers, technologies and even governments. This will indicate a direction for you to follow and to succeed, and will help identify that all the people in your business are going to have to adapt to change.

You need to link closely with your respective business community and the leading facilitator of that community, such as the MIA in motorsport. Many have spotted the value of such organisations and we are welcoming new members every week.

The reason is simple; the best way for you to stay on top of changes and gather relevant market knowledge is by meeting companies in the same sector. Make your business community association work hard for you, be sure to get best value from them. Attend meetings to talk with, listen to and hear from similar businesses about opportunities arising and of collaborations to be developed.

You're going to find your customers are changing too, so stay close to them, check you're fully aware of their direction of travel and that you can cater to them. The world around you is changing whether through governments, markets or technology. Stay well-informed on the changes you need to consider in your strategy. Spot those technology changes to which you can react quickly and profitably. Accept that life is going to change for you, your business and your employees, and be sure you take them with you on your journey.

Changing up

So many positive benefits will be enjoyed by those in motorsport who are fleet of foot and well organised, being ready to rise to these challenges at this exciting time over the next three years. I'm excited by the role that the MIA will play in this for our hundreds of members, whether delivering useful conferences, valuable network meetings, or influencing government on behalf of the industry.

The profit from this confusion will accrue to those who make themselves ready to embrace it. So good luck in creating your three-year business strategy to secure your success.

You should now develop a three-year business strategy which identifies changes in your markets, customers and even governments

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Far from the madding crowd

Having specialised in endurance racing for most of my career, I have become used to attending races with empty grandstands. The easy entry to the track on race morning may be a Holy Grail for those involved in more popular aspects of the sport, but when you realise the consequence of no spectators, the reality is different. No team or driver can bring sponsors to the track or they may see through the stories you have told to secure their money, and as a writer you realise that you cannot justify to your family why you missed another wedding, or funeral.

That is not to say that the show was poor; looking at the FIA GT Championship in the early 2000s, the cars were fantastic, the racing was wonderful and the stories that can be told reminded me of why I fell in love with racing in the first place. Jamie Campbell-Walter leading the race at Magny Cours when his throttle cable broke led to him pitting. The team owner decided to jam the throttle open, the rev limiter and kill switch could take care of the cornering. Jamie therefore had 600bhp from the Jaguar V12, or nothing. Small wonder that Vincent Vosse, when he passed in the Viper, wondered why the Lister was so quiet when he was alongside.

Then there was the story of the Russians celebrating the VE day anniversary in a Sicilian car park, and many more besides. But there was always that nagging doubt that any money was being made; and the majority of people were spending others' like water. Actually, in the days of the GT1 World Championship, they spent their own, too. The trip to Argentina to race around a volcanic lake was epic, a wonderful race, but expensive. One team owner said that he had never had the balls to open his books that year to examine the costs. I felt the same with my wedding.

It was not only the lack of spectators; it was also the knowledge that there was this fantastic, wonderful event and no one was watching. Today, race series are pitching for a digital or televisual audience, completely missing the point that you need crowds in the grandstands to share your appreciation of the race. Formula E cannot do the same as the racing is not thrilling. Close-up camera angles from cameras hidden in the crash barriers make the cars look quick on television, but in real life they are not. Formula 1 has gone the other way totally, with wide angle lenses from a crane that may as well be on the moon and make the cars looks slow. From the Australian GP someone posted a clip of the cars taken from a wall-mounted camera just on corner entry. The speed was awe-inspiring, as it should be.

At Sebring, for the WEC and IMSA joint event, there were apparently record crowds. No one really knows if that is true as figures are never released, but I'm pretty sure that the heavy rain on Saturday morning that left me with wet feet for the next 17 hours kept figures in check. I apologise to the IMSA technical team who kindly invited me to watch the grand prix with them for the smell emanating from my trainers. Pre-event sales were up, but there was space. As an event, however, it worked. The fans crowded around the cars in the paddock, whether they were dressed as Vikings and carrying a toy monkey or wearing monks' habits. The party atmosphere at Sebring is always a particular draw to the race, and the FIA was lucky this year to be a part of it.

Chasing crowd figures is apparently not in vogue, and the digital audience is considered more important, with more opportunities to sell other products, including the main event. Millions of eyeballs watching on television, or more likely computer, is more attractive to an organisation than a bum on a seat. I disagree, and Sebring was a perfect case. FIA WEC promoter Gerard Neveu admitted that the Friday night eight-hour race schedule was not ideal for the television audience, but to be part of such a weekend justified the decision.

For children and young adults to get close to the cars will encourage them to fall in love with them, and from there inspire them to get out and find a way of spending more time with them, either driving, or engineering. Having them watch racing on the television should be a way of keeping them informed before the main event arrives on their shores and they can see it for themselves. No one will fall in love with racing on a television or computer screen as they cannot appreciate the speed, or violence of a racing car until they see the BR1 going through Turn 1 at Sebring.

> **Getting children close to the cars will encourage them to fall in love with them**

For the fans to appreciate racing, however, the circuits must do more. Sebring provided wifi access throughout the site to allow people to follow the live timing, and keep up with the action, while the commentary on track and radio was critical to them figuring it all out. An eight-hour race requires more interaction to help fans keep up, although it was less critical at Sebring as the majority are there to party through the weekend. The Florida race is still one of my favourites. There will be plenty more events this year where the crowd in the paddock out-number those in the stands. There will still be time to laugh, but the echo that follows is always a shame.

ANDREW COTTON Editor

BREDA RACING
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