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COVER STORY

- 8 Porsche**
Developing the 2015 specification Porsche 919 Hybrid

COLUMNS

- 5 Ricardo Divila**
F1 falls foul of itself
- 7 Mike Blanchet**
On stupidity in motorsport

FEATURES

- 16 ORECA 05**
The new customer car from the French giant
- 22 LMP2**
A controversy is brewing over the junior prototype class
- 24 Formula 2**
Stefano Domenicali discusses the new FIA open wheel series
- 26 Driverless electric racing cars**
Peter Wright hypothesises on Apple and motor racing
- 30 World Rally Cross**
The MINI Countryman RX Supercar
- 38 A Race to the Sky**
Tony Quinn's wild hillclimb special
- 47 BTCC Honda**
Team Dynamics and the new Civic Type-R

TECHNICAL

- 51 Consultant**
Do cars really need suspension?
- 55 Databytes**
Different ways to limit pit lane speed
- 59 Aerobytes**
Optimising the Vuhl
- 63 Rigged!**
MIRA's new K&C rig
- 69 Metrology**
Part 1; Laser Trackers at Red Bull
Part 2; Scanning an open wheeler
- 75 Set up sensitivity**
Quantifying and optimising sensitivity
- 80 Tech update**
Drilling holes in NASCAR tyres
- 82 Tech Update**
The 2014 F1 developments that never were

BUSINESS NEWS & PEOPLE

- 84 Industry News**
F1 teams oppose wind tunnel ban
- 90 Racecar People**
The reinvention of Peugeot Sport
- 97 Products**
Quick action refuelling kits and other items
- 98 Bump Stop**

The future of LMP2 is under discussion ahead of competition debut in 2017



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Clear crystal balls

Black swans, grey cignets and a hissing goose - Formula 1 in the spotlight

Donald Rumsfeld once remarked that 'stuff happens'. Sometimes stuff does not happen. And non-events can be significant, such as the fact that the hound in "*The Hound of the Baskervilles*" did not bark.

In the same Rumsfeldian style, knowing things that will not take place is as useful as knowing what will. Although some non-events will remain unknown, others are known, and the following decades will have loads of them – not having a German GP is one of them.

The Roman poet Juvenal (Decimus Junius Juvenalis) lived in the late first and early second centuries AD. Like his friend Martial, Juvenal wrote satire, a particularly Roman genre of poetry that used sarcasm and irony to express moral outrage. Juvenal's Satires, a collection of 16 poems written in dactylic hexameter – the traditional meter of epic poetry used by Homer, Virgil and Ovid – are regarded as among the best examples of the form from antiquity. One could not, even in the wildest flights of fancy, envisage reaching those heights, but that should not stop one from at least trying.

In a like vein there has been a big kerfuffle about F1 grids and the quality of the spectacle. Remember folks, it's sold as show business so, in other words, it is "much ado about something", horribly misquoting the great Bard.

The curious decline of F1

Napoleon wanted his marshals to be lucky above all else, and there can hardly be a luckier man than Bernard Charles Ecclestone, who had the timing and the vision to see that TV revenues and the welding of disparate racing teams into a sales package could turn into a money making machine. And his vision resulted in the first alliance of mass-sports and TV. Arbitrage has always been more profitable than production, especially when you turn it into a trade-marked monopoly and fiercely defend your fief, but things don't seem to be running well lately. In fact, the clouds with the silver linings seem to be shaping up to create the perfect storm and there are questions in the paddock about the helmsman's ability to surmount the white-capped shoals ahead on present form.

How did we get here?

Perfect storms are supposed to be Black Swans – the disproportionate role of high-profile, hard-to-predict, and rare events that are beyond the realm of normal expectations in history, science, finance, and technology. At the most we can call this a Grey Signet. It's all fairly predictable, especially when the ingredients in the mix have an expensive commodity (racing cars and teams),

competition driven people for whom the ends justifies the means, the perfume of celebrity in a celebrity-driven world, egos that need 18-wheeler transportation, a financial economic crisis arriving on a predictable cycle (a penny farthing?) and card carrying financial predators, who make Stalin's scorched earth policy look bland. Scorched earth is a military strategy where every asset that is used or can be used by the enemy are targeted, and in racing this means other formulae. And, merchant banks are renowned for their benevolence (note the irony knob is turned to 11 here). Circumstance makes strange bedfellows, but cosying up to capital

The clouds with the silver linings seem to be shaping up to create the perfect storm



Predicting the future is not as hard as it seems, although black swans are hard to judge

investors requires one to heed the old advice that "when supping with the devil you need to bring a long spoon".

The erstwhile de-facto owners of F1 have made a solid return on their investment, but their subtlety did not reach the sophistication expressed by Jean-Baptiste Colbert, Minister of Finances of France from 1665 to 1683 under the rule of King Louis XIV. He always declared that "the art of taxation consisted in so plucking the goose as to obtain the largest amount of feathers with the least possible amount of hissing". There is a lot of hissing going on and the F1 goose is well and truly plucked.

Like philosophers, who say "we know it's possible in practice, we just don't know if possible in principle", one would acquiesce, noting that

in this case one speaks of 'principle' as the noun denoting either a rule or standard, especially of good behaviour, or the collectivity of moral or ethical standards or judgments. Steady on now you say. Such vitriolic contempt goes way beyond the call. An expression of wry surprise might have been more dignified, maybe even justified.

Such behaviour will be rather thin on the ground these days given the plundering and scalping of customers who have other choices for their couch spectating, and we will not even speak of the skinning that follows getting three-day tickets for a GP. The getting lost in the wilderness without a coherent perception of reality. One does not know the answer, but the crowd seems to be giving its verdict on the actual state of affairs

What happens next?

Ever since an excitable man named John blasted his acolytes with some of the most stunning apocalyptic revelations committed to text, predicting the future has remained a lively and popular human pastime. Thankfully, those who followed this jumpy prophet were careful to temper their words. "Prediction is very difficult, especially if it's about the future", quoth Niels Bohr, while H.G. Wells prefaced his influential 'Anticipations' as "imperfect and very hypothetical".

One will do the same, but at least in terms of the warrant for a priori dismissal, it is a null set.


As revenues diminish and the decimation of teams continues, investors will move over to easier pickings, obeying the dictum "In a breakfast the chicken (investors) is involved, the pig (teams) is committed." Sorry, pigs, the bacon was delicious.

Quoth W. B. Yeats=

*Things fall apart; the centre cannot hold;
Mere anarchy is loosed upon the world,
The blood-dimmed tide is loosed, and everywhere
The ceremony of innocence is drowned.
The best lack all conviction, while the worst
Are full of passionate intensity.*

The ceremony of innocence died in the mid-1980s and we are now in hard pragmatic times, but having a sport run for profit demeans the nature of it. Whiter the direction and form?

"And what rough beast, its hour come round at last, / Slouches towards Bethlehem to be born?"

And when the golden hissing goose finally dies all and sundry will indulge in seeing how things went wrong, which bad turns were taken, whose character defects came into play and who was, ultimately, to blame for the failure. 

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The big picture

Looking beyond one's own nose, or wallet, is key to survival in motor racing

The schedule for Silverstone's (excellent) WEC race stated that nobody under 16 years old was permitted on the grid walkabout. Given that there are 15-year-olds driving in F4, and F1 newcomer Max Verstappen would not have met this requirement only a couple of years ago, the world is a puzzling place sometimes.

But then 'stupid' seems to be a popular word recently. Torro Rosso's Franz Tost used this term to describe anyone querying Verstappen becoming a F1 driver at just 17. Cyril Abiteboul of Renault F1 explained early power unit failures as being due to a 'stupid part'. Stupid decisions sometimes get made in regulation-making. The attitude of some team owners in many formulae can be stupid; so can that of certain drivers.

Acting stupidly – and let's be a bit kinder and include 'without good judgement' – is something of which we are all guilty and is often the result of not looking at the big picture. Being one of the stupid people referred to by Tost – but comforted by the fact that others in this category include Adrian Newey, a man not noted for his lack of brain power – it seems obvious to me that this remark was made with typical motorsport blinkers on. The issue is not about the capability to drive the car. It is about responsibility and the increasing trend to develop what are worryingly close to child freaks, whose so-far short lives have been entirely dedicated to being a racing driver to the exclusion of almost everything else. After all, what's the rush? We are all supposed to live and work longer, so why the need to start a career – if it actually becomes one – earlier?

Working together

The big picture was obviously not on Renault's agenda when Abiteboul made his remark about a certain broken engine component. How can any part of a racing engine or power unit be stupid? All parts are included for a purpose and failure of any one of them, no matter how minor, will almost certainly lead to a compromised result or even a DNF. Therefore all items, no matter how small, require the same scrutiny and attention. Perhaps the desperation to increase performance led to such an attitude, which is very surprising considering the level at which Renault has operated in the past.

However, the big picture is alive and well in endurance racing. Although I personally (therefore you may well say "so what?") do not agree with some aspects of the ACO/FIA technical regulations, the WEC and its headline automotive manufacturer entrants appear to be well aware of the need to look beyond their immediate and individual racing objectives and consider what it is they are trying to achieve. Fundamentally, it is to sell more of their products at a higher profit and in new markets by demonstrating their technology and engineering excellence, and by introducing excitement into their image. Success in high-exposure competition also increases awareness of their brand and therefore its value. According to Interbrand, one of the world's leading consultancies in this field, the value of the Honda brand name increased by 17 per cent – to US\$21.673 billion dollars – following

is proved, and there is the risk of the championship collapsing, as has happened so often in the past. It can also be a big negative in a marque's popularity if it keeps winning easily. Thus, the WEC is run to a cleverly-conceived set of rules that delivers great, competitive racing incorporating interesting and varied technical approaches. Importantly they also have relevance to production car development and environmental issues. This has tempted in, and retained, no less now than four car manufacturers, all of whom can have a realistic chance of on-track success including the massively-prestigious Le Mans 24 hour race.

Time for a fresh start

Why endurance racing is succeeding where F1 is failing is perhaps due to these large corporations being run by professional management. They

possess less of a cavalier approach to business matters and prefer patient negotiations behind closed doors than the egoistic public utterings by those in F1 who should know better. The fact that they do not have to be in motor racing for their survival must also be a factor. So also may be the fact that the WEC is run by an organisation not entirely dedicated to making money.

GT racing promoter Stephane Ratel saw the big picture and the need for bringing in a much wider range of manufacturers and affiliated teams, hence the concept of GT3 was born.

Balance of Performance, brought in to deal with the Maserati MC12, is not popular with everyone, admittedly, but almost

overnight exotic production cars that would not have been competitive in GT racing – too heavy, lacking good aero – were able to participate and win. Subsequently the GT3 concept has been enormously successful worldwide, and the BoP idea has been adopted for other categories. In touring car racing, the organisers have grasped that giving it greater exposure and credibility, including the need to attract more manufacturers, means the need for events at circuits well-known to the public. Thus the championship now includes the Nürburgring.

Only big picture thinking will allow motor racing to continue healthily, but the problem is that some of the main players in the sport unfortunately have yet to understand this.



Big picture thinking is required to maintain interest from the fans, and from participants too

The WEC is run by an organisation not entirely dedicated to making money

their announcement of re-entering F1, although it's fair to speculate that it may have dropped a bit since. Such matters are important to shareholders, investors and the directors of these companies.

There are other benefits of course; genuine advances in innovation, attracting quality employees, in-company training and motivation and so on. Taken together, this understanding that there is more to gain than just the next race win has led them to positively work together with the championship promoters in a sensible and mature dialogue. Even if one manufacturer wanted to dominate by outspending its rivals the realisation is that this would defeat the reason for its involvement. Without strong competition little

Porsche's giant step

Lighter, faster, stronger and stiffer, the new 919 is a class apart from its predecessor

By ANDREW COTTON

On paper, out of the three manufacturers contesting the FIA World Endurance Championship, Porsche had the most to gain as it developed an almost entirely new second-generation 919 hybrid. The first year of the programme, a testing year, saw problems with the engine, and these problems carried over into the 2014 season, the first of racing. The two-piece bonded chassis was carried over from 2013, the engine problems that dominated the test programme meant a delay in introducing a new turbo, and the car raced throughout the season 30kg overweight. This year's car has addressed all of those problems as the company seeks a 17th Le Mans victory. Almost every component of the new car has been improved and the team's aggressive strategy means that it is the first to jump into the eight mega joule category and reap the performance rewards. The new 919 hybrid is a huge step forward compared to the predecessor.

Chassis

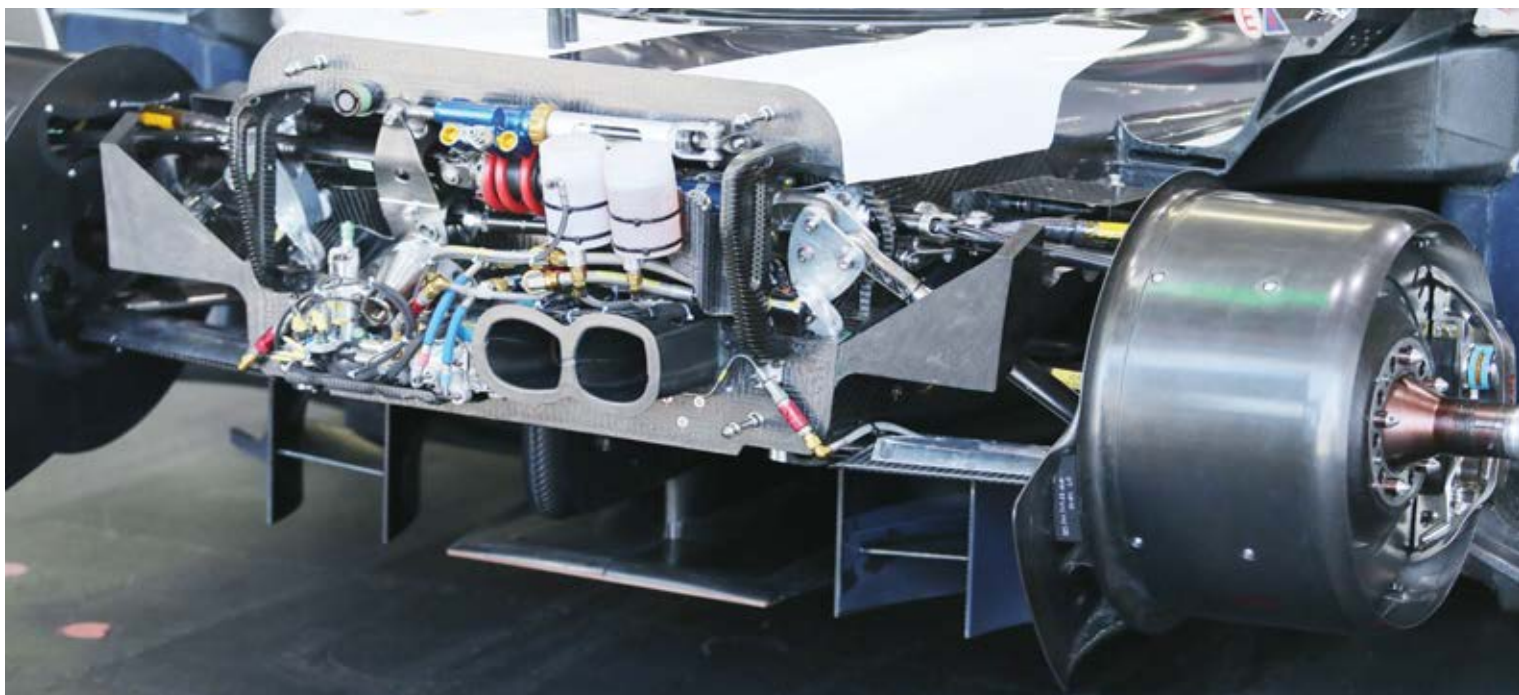
No manufacturer wants to build a new chassis every year due to the complexities of the process, the lead-time and the cost involved. Porsche carried over the 2013 two-piece bonded chassis into 2014. For 2015, however, it has switched to a one-piece monocoque that has meant not only a reduction in weight, but also the team at specialists Capricorn has been able to use different materials and processes that has increased stiffness.

'Let's say that [losing] the join already gives you a weight reduction, but using different fibres gives a further weight reduction,' says Porsche's technical director Alex Hitzinger. 'Then we could use different concepts due to structure, so we could increase stiffness where we wanted it. We could have done this from the beginning, but we didn't want to take huge risks so we said OK, the timing for 2013 was tight so let's go for the safe solution; a two-piece, and make the step for 2015. It dominated our development for this season because it affects the front suspension. The suspension layout and monocoque go hand in hand and you don't want to do that every year.'



The new 919 hybrid is a huge step forward compared to its predecessor





The 919 hybrid features a brand new one-piece monocoque and development has led to an entirely new front suspension layout

Porsche's whole suspension system has been the topic of discussion among rival engineers. While Audi has gone for a front-rear interconnected solution, Porsche has decided not to yet, although there is a FRIC system in development. For now, though, it has chosen to stick with its own philosophy, despite an aggressive approach with every other part of the car. Porsche is still coy about exactly how the system works, but at least Hitzinger was willing to divulge some information on what it was.

'We don't have front to rear interconnected,' he confirms. 'It is something that I have been looking at for quite a long time. It is definitely something that could be interesting if you do it in the right way, but if you do it wrong it could be a big mess. Last year we were not 100 per cent happy with our system. In terms of installation stiffness and so on it was not ideal and this is where we made a big step. Suspension is always a big compromise between aero, weight and stiffness, and you can make it very simple or very complex. There are trade-offs between how much complexity you want to put in weighed against performance so it is quite tricky. And some people say that you can never win a race with the suspension – if it works it is not a huge performance factor.'

'We made a big step on the battery – we redesigned it so that it is smaller and lighter, but we also increased the power'



Porsche has tidied up the bodywork at the rear of the car. The underfloor features interesting aerodynamic devices that have helped to improve the airflow and make the car less peaky and easier to drive

That still doesn't explain how it works. 'In very simple terms, you have the two principal motions, you have heave and roll,' continues Hitzinger. 'With a conventional suspension, your suspension in two corners always sees both roll and heave. In our car this is not the case. For us, the motion is completely separate. You have an element that sees only heave and an element that sees only roll. There are some tricky kinematics behind it but it means that you can, if you want, specifically change its behaviour in heave or in roll, you don't have the combination of the two. It is a purely mechanical system. It relies on springs and hydraulic dampers and so on. The front is left to right linked with anti-rollbars, but there is no link between the front and the rear. The team also worked to improve the rear of the car, improving the gearbox carrier so that the rear is stiffer and lighter, and the load path from the chassis over the engine to the gearbox has also been enhanced.'

Engine

The team continues with the two-litre, V4 engine, but the 2015 version is a vastly improved component compared to its predecessor. The team dealt with the vibration issue suffered by the first iteration of the engine that ran in 2013 in testing by introducing a new firing order, and the crank has been further refined for 2015. 'We changed a lot,' confirms Hitzinger. 'We changed the whole crankdrive, crankshaft, conrods, pistons, we changed the crank case in order to increase instillation stiffness, we changed the cylinder heads, exhaust and turbo.' Was the development of the crank a further refinement of the vibration issue? 'That was a firing order change, so that was a fundamental change, but now we have tweaked it to reduce weight, and increase stroke a little bit, so they are much smaller changes. We improved efficiency by raising cylinder pressure,



Development work on the second generation three-part powertrain has allowed Porsche to enter the highest energy recovery 8MJ class – no other racecar in the category turns over so much energy

so therefore need to increase the strength of the load capacity of piston and conrods...There is a big knock-on effect.'

The engine development over the winter of 2013/14 meant that other development parts were held back in order to just get the car to race. Already the team had a plan to develop the turbo, but delayed its introduction until the start of the 2015 season and features a new technology that is finding its way into production cars. 'On a turbocharged engine you want to reduce turbo lag,' explains Hitzinger. 'You want to develop a new turbocharger that has a better response time, so we have a new turbine technology and compressor technology. It is something that is not widely used yet, but it is already used in some areas in road cars and it is a new trend that is emerging. We use a VTG on the exhaust energy recovery system, but this is fixed geometry because you don't need two VTGs in the system. Basically, it is a different

turbine geometry and different compressor geometry where you reduce the inertia of the rotating parts so you can accelerate them quicker. We were looking at introducing it last year, but I didn't want to, to avoid the risk because it was tight in terms of timing and so we introduced it this year instead.'

The exhaust layout is carried over from 2014 but is never the less interesting. One exhaust pipe comes from each bank of cylinders and each rotate through 180 degrees to combine in a single pipe. The layout then splits again, rotating again, to the right of the car through the turbo and to the left through the VTG MGU-H. 'The twin pipe exhaust helps aero efficiency, so it has an influence on the flow over the engine cover, and at the same time it reduces exhaust back pressure so improves engine performance,' says Hitzinger.

Of the separation of the MGU-H and the standard turbo, 'either you separate the standard

Twin exhaust layout has an aerodynamic gain and reduces back pressure on the engine, further improving performance

turbo and the exhaust energy recovery, or you combine it, like in F1,' says Hitzinger. 'We looked at both options and chose that one. If our exhaust energy recovery stops working we can continue to run. We still have a wastegate, so the combustion engine can operate normally, and you can optimise both individually. It is a bit heavier than if you combine the two, so there are pros and cons but we decided that this was the right way for us.'

Why, wondered our technical consultant Peter Wright, is the MGU-H using variable geometry? 'You need to control the operating conditions so you need to control the boost pressure and exhaust back-pressure, so you need some form of variable geometry,' says Hitzinger. 'We don't want to use the wastegate, because that would waste exhaust energy, so you have to have a controlling device and if the geometry on the standard turbo is fixed, use the VTG on the exhaust energy recovery system.'

Hybrid

One of the big talking points of the new Porsche is the hybrid system, which has been developed over a season of racing and is now capable of storing the maximum allowed 8MJ around the Le Mans circuit (the amount of stored energy is reduced on the shorter circuits by a set factor by regulation). One of the key problems with the 8MJ category is not being able to generate the energy to fully charge the battery over the course of a single lap. Significant development needed to take place. After Le Mans in 2014 the team accelerated development of the 2016 battery and introduce it in 2015. With their partners A123, which developed the cells, and with the team within Porsche that builds the battery, a smaller, lighter and more powerful





TECH SPEC

Porsche 919 Hybrid (2015)
Le Mans prototype LMP1 class

Monocoque: Composite material structure consisting of carbon fibres with an aluminium honeycomb core. The monocoque was developed on the basis of the 2015 LMP regulations and was tested in accordance with the 2015 FIA crash and safety standards. The cockpit is closed.

Combustion engine: V4 engine (90 degree cylinder bank angle), turbocharged, 4 valves per cylinder, DOHC, 1 Garrett turbocharger, direct petrol injection, fully load-bearing aluminium cylinder crankcase, dry sump lubrication

Max. engine speed: 9000/min

Engine management: Bosch MS5

Displacement: 2000 cm³ (V4 engine)

Output: Combustion engine: > 500bhp, rear axle

MGU: > 400bhp, front axle

Hybrid system: KERS with a motor generator unit (MGU) mounted on the front axle; ERS for recuperation of energy from exhaust gases.

Energy storage in a liquid-cooled lithium-ion battery (with cells from A123 Systems)

Drive system: Rear-wheel-drive, traction control (ASR), temporary all-wheel-drive at the front axle via the electric motor when boosted, hydraulically operated sequential 7-speed racing gearbox

Chassis: Independent front and rear wheel suspension, push-rod system with adjustable dampers

Specifications:

Porsche 919 Hybrid 12

Brake system: Hydraulic dual-circuit brake system, monoblock light alloy brake calipers, ventilated carbon fibre brake discs (front and rear), infinitely variable control of braking force distribution by driver

Wheels and tyres: Forged magnesium wheel rims from BBS; **Michelin Radial tyres, front and rear:** 310/710-18

Dimensions/weights:

Minimum weight: 870kg

Length: 4650mm

Width: 1900mm

Height: 1050mm

Fuel tank capacity: 68.5litres



The two-litre V4 engine powers the rear axle with over 500bhp. When the driver recalls the stored energy from the battery, an extra 400bhp drives the front axle

‘Hypothetically, if you can do just about 8MJ at Le Mans, there is a good chance that you cannot do the maximum allowed on the other tracks’

unit was built. However, due to the uncertainty of its performance, the space in the monocoque was still left large enough that the 2014 battery could be accommodated if necessary.

‘The battery is the biggest weight contributor,’ says Hitzinger. ‘We made a big step – we redesigned it again so that it is smaller and lighter, but at the same time we increased the power. This was by far the biggest step in terms of power density increase on the battery side.

‘We had changes to the MGU-H and MGU-K and to the power electronics as well. The whole system has to deliver more energy so it needs to be more powerful. When I saw for sure where we were weight-wise and energy-wise at Le Mans, I said OK, we can’t wait for the new battery in 2016, we do it for 2015. We did in six months what we originally planned to do in a year. We made a new cell, and a completely new battery. Cooling is where we are really good. We have a clever cooling concept that allows us to stress the battery heavily without over-stressing it.’

There were no figures available for the efficiency or power density of the new hybrid system, but it is clear that this is a huge step not only in technology, but also in performance. Over one lap at the Paul Ricard circuit, the Porsche was able to lap almost as fast as the old Peugeot 908 HDI FAPs in all of their V12 glory. Many are expecting that the reduced weight, coupled with the higher MJ category will see the Porsche excel in qualifying, although race pace is still a concern.

‘It is always a trade-off, because you get less fuel amount,’ says Hitzinger of the leap to 8MJ. ‘If you are comfortable in the class in terms of how much you can recuperate, it is always a gain. Then you have to look at 8MJ at Le Mans, it does not mean you can gain that in other tracks because of the braking zones, yes, and more because of the factor 1.55. Pro-rata you can do a lot more. Hypothetically, if you can do just about 8MJ at Le Mans, there is a good chance that you cannot do the maximum allowed on the other tracks. It may still make sense if you can do 7.5MJ. If you can do 7MJ, that is the break-even point. Then it is worse at the other tracks, and it doesn’t make sense anymore.’

Stint time

One of the key areas for development for Porsche was improving the stint time for the cars. In 2014 rival teams quickly noticed that the Porsche was not able to compete as well in the races as in qualifying.

The team has worked on the suspension kinematics to improve the tyre performance over a longer distance, and the team has undoubtedly learnt more about which of the Michelin tyres to use, and when. However, there are other factors in using the tyres efficiently, including the downforce levels that are run, and how the energy is recuperated and distributed. While Toyota uses both the front and the rear axles, Porsche generates only to the front axle



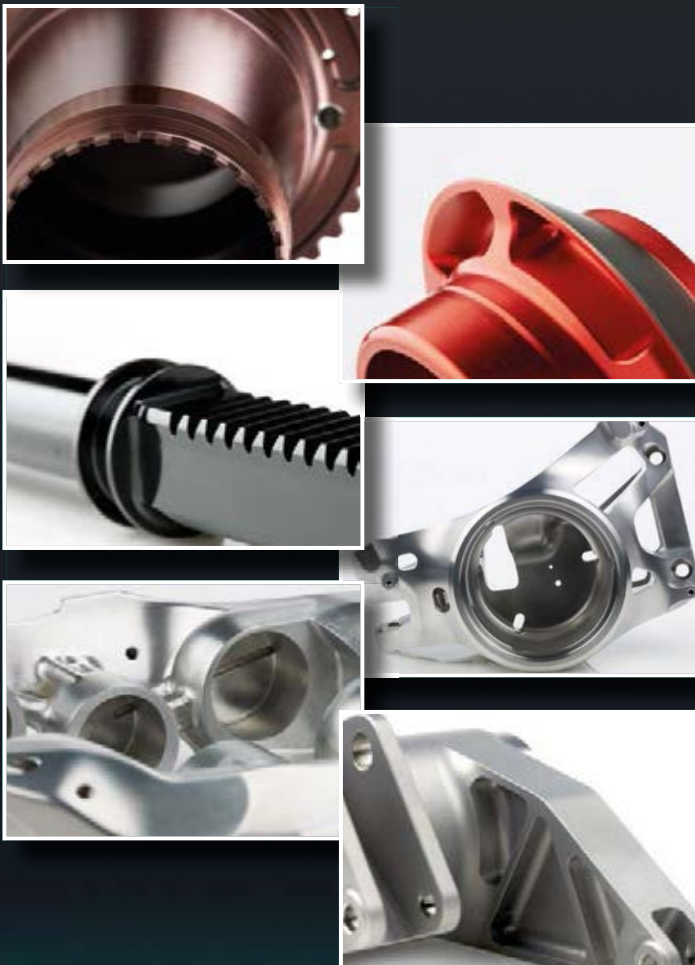
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and that loads up the front tyres that already have braking and steering inputs to deal with. Tyre usage between the two manufacturers is very different, and Porsche's approach is more in line with Audi's.

'I think there are two main points for the development,' said Porsche's team director Andreas Seidl. 'One was the weight, which was a lap time benefit, and the second target was the stint performance. One-lap performance was always there. Stint performance means everything – how you use the tyres, which is kinematics, aero, how you apply the power train. With the over weight that we had last year we had to touch everything.'

One of the key areas of development, alongside losing weight and increasing stiffness, was to improve the aero sensitivity of the 919 hybrid. 'There is no point in having very peaky aero which on certain corners is very good and on others very bad,' says Hitzinger. 'Last year we kind of had that, with downforce changes through the corner, and for the driver it is about

predictability. The driver needs to know what to expect, otherwise he is slow.' After Toyota won its argument regarding the braking system in the TS040, Porsche also developed a brake by wire system with an external partner and has been able to improve the brake pedal feel for the drivers. Last year's car featured an hydraulic system while the 2015 evolution has an entirely electronic brake system. 'Last year we had a brake pressure reduction system in order to basically compensate for the hybrid braking torque, but this was a different system,' says Hitzinger. 'It was purely focussed on being able to compensate that influence, but it still had a feedback to the hydraulic system in a way that the driver could feel. The driver knew what the system was doing and it influenced his braking. We changed the concept and now it is completely invisible to the driver, and he doesn't know whether the system is on or off in the braking areas. We worked with a partner who had a lot of experience and so for us it worked well from the beginning.'

EoT

Post Le Mans, the now famous Appendix B will be revised. The figures across the board were slightly manipulated to give a greater incentive for a manufacturer to reach the 8MJ category with a minimum weight of 870kg. Now that Porsche has achieved this target, the expectation is that the figures in each of the MJ categories will be revised downwards. 'In the regulation there is the ERS incentive, which depends on whether there is an 8MJ car or not,' says Hitzinger.

'It is about what is achievable. Last year, with the current minimum weight, it was not achievable to get into an 8MJ class. This has changed now because we have made this step. The ERS incentive is applied to all classes, but that will affect everyone. It is not specific to 8MJ, it will change all of the Appendix B. The ERS incentive changes across the board for Appendix B because there is an 8MJ car.'

The new 919 did what was expected of it in the first race of the WEC at Silverstone. Such was its advantage in the new qualifying system that Audi and Toyota chose to concentrate on race performance. During the race, one of the Porsches had a problem with a gearbox bearing, the other finished on the podium. One thing was clear from the test at Ricard and the opening round - Porsche has made an enormous gain in lap time with the new car. The question is; will it be enough to extend its winning record at Le Mans? R

Hatz off for a good decision

When Matthias Muller took over as President and CEO of Porsche, his first act was to announce that he would initiate a return to top level motorsport, either Formula 1 or endurance racing. Ultimately, it was endurance racing that won and Porsche returned to what customers and media considered to be its natural home. Porsche AG's

board member for research and development, Wolfgang Hatz, reckons that the decision not to enter the new hybrid Formula 1 era was correct. 'A lot of people thought that we would do Formula 1, but I believe our decision was absolutely right,' says Hatz. 'As a company it was the right decision to go back to endurance and do this programme.'

Is the technology return higher for manufacturers in sports car racing and does it justify the reduced spending return of sports car racing?

'Absolutely. Yes. The regulations are much more free than in F1. Here, you get the energy amount per lap, and then you decide what you want to do. That is your decision; you can use a diesel, a V8, a two cylinder if you like.'

At the beginning of the year there were rumours of Audi going to Formula 1, based on the fact that two VW manufacturers were competing in sports car racing with such a limited financial return for huge expense. How sustainable is this situation?

'I cannot talk for Audi but I can talk for Porsche and I can tell you that our budget is much smaller than our competitors' budget, but we have a good budget that allows us to make a competitive car. Money is important but it is not everything. More money is not necessarily a better solution. As we do everything internally we have the cost under control and the

technology under control and I know that our budget is much smaller than competitors' budgets!'

At the head of the company, the VW Group has a talented engineer in Ferdinand Piëch. What happens when he goes? Will that change how the VW Group approaches its racing activities?

'What we have achieved as Porsche at least is that we are quite independent in our decisions as long as our company is one of the diamonds of the group and we bring quite a bit of return. That gives us also the opportunity to take our decisions ourselves. Porsche always has a special treatment in the VW Group. The majority of the owners are also on our supervisory board, and they have a good look at our company but we have shown in the past that we keep our brand high with the products and, as long as the results are good, they are quite happy with what we are doing, so that gives us more freedom. If we had financial trouble, that would obviously change things!'



Porsche's Wolfgang Hatz says that WEC racing better suits the company's engineering philosophy – in comparison, F1's strict regulations were less appealing



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Subtle evolution

We talk to ORECA to see whether or not the new 05 has what it takes to challenge LMP2's old guard

By SAM COLLINS



ORECA's LMP2 car bears a striking resemblance to its LMP1 sibling, but beneath the skin it's essentially an all-new car

When ORECA's new LMP2 car first appeared, running on its home track at Le Castellet, many people claimed that it was simply a baby version of the LMP1-L Rebellion R1. This was understandable as the two cars come from the same design office, the same production facility and look uncannily similar, but the reality is that the two cars are quite different when you take a closer look. Of the 5000 parts used on the ORECA 05 bill of materials, only 1000 of them are the same as that of the Rebellion, the other 4000 are all new.

Work on the new car officially started last summer but thoughts about its general layout began much earlier according to Christophe Guibbal, director of the ORECA Design Bureau.

'We started with the Rebellion R1 chassis as a basis as it was already homologated in LMP1. When we designed and built that, we crash tested it to both LMP1 and LMP2 weights as even back then we thought that in future it could be the good basis of a P2 car,' he admits.

The rules of the LMP2 class feature a cost cap and that drove a number of elements of the design of the 05, not least the selection of the existing Rebellion chassis. 'In the development of the car we used a lot of parts we already had on the shelf, things we had already designed in the past. In fact the rear end concept of the ORECA 03 is similar to the Rebellion, but on the Rebellion things are a higher standard. If we used the parts from the Rebellion on the new car we would not be able to meet the cost cap.

We have carried over the entire front suspension concept, but we have reduced the cost of the parts. On the R1 we used a lot of titanium parts, but on the LMP2 there are no titanium parts, simply for cost reasons,' Guibbal explains.

The suspension layout at the front of the car was largely defined by the layout of the tub, so the LMP2, like the R1, features double wishbones with pushrod actuated torsion bars and dampers from ORECA's near neighbours PKM. 'The front suspension is quite different between LMP1 and LMP2, even though it looks similar,' Guibbal explains. 'On the LMP2 car we use the same machined upright as we used on the ORECA 03 with the same bearings, but all the kinematics are quite different between all three cars as the pickup points are very

‘In the development of the car we used a lot of parts we already had on the shelf, things we had already designed in the past’



different. We use a completely new aluminium rocker on the LMP2 while on the LMP1 that rocker is titanium. Both LMP1 and LMP2 use PKM dampers, but not the same specification or concept. Of course we work closely with them as they are just 200 metres from our office.'

Electric avenue

Mounted to the front bulkhead of the car is a new steering system which Guibbal hopes will improve one of the weaker points of the ORECA 03 which this new design directly replaces. 'On the 03 the steering was not the best element of the car, and we had already reached the limits of what we could do with the concept on it, so it was clear we needed to do something different on the new car. So we went with a

Kayeba electric power steering system, which is a really nice solution for customers as it allows you to have different setups for different drivers. What a pro driver wants is something different to what the gentleman driver needs. When the drivers switch over during a race they can change a setting on the dashboard to give them the steering map they prefer. That is something that is not possible with a hydraulic solution.'

At the rear the suspension again appears to be similar as does the overall layout, where in the Rebellion a Toyota RV8K was found in 2014 and an AER P60 twin turbo V6 is located for 2015, the LMP2 car houses an ORECA-tuned Nissan VK45DE V8. It can also accommodate other units such as the less popular Judd and HPD offerings. All of those engines, either in the

LMP1 or LMP2 versions, drive the rear wheels through a transverse Xtrac P1159 gearbox.

It is a transmission that can trace its roots right back to the units that won Le Mans in 1999 and 2003 in the BMW and Bentley prototypes respectively. Although it has been continuously improved over the years, the seven-speed sequential P1159 version was developed specifically for the 2014 LMP1 regulations. Through the use of a wide range of input bevel and final drive ratios, all engine permutations can be accommodated and this versatility led the Thatcham, England, based company to introduce a lower cost six-speed variant specifically for LMP2 cars ahead of the 2015 season. It is this unit that ORECA eventually chose to adopt.



‘Although parts will have to evolve, the car will be easily updateable’

‘When we designed the chassis, and the engine mounting positions, we had some options for the gearbox, and we felt the best option was the new Xtrac, because it made sense to keep the same general structure between LMP1 and LMP2,’ Guibbal continues. ‘The gearshift system on the LMP2 is quite different to the system on the Rebellion though. It is pneumatic and lighter where on the LMP1 it is electric.’

Adopting the same general transmission and layout for the new car saw ORECA opt to raise the level of safety built into the car above the required standards. Already the monocoque had Zylon anti-intrusion panels built into it

which are not required in LMP2, but the use of the Rebellion’s rear impact structure is also a step forward in terms of safety. ‘It is obviously better in terms of safety, and we believe that in the new 2017 rules it will become mandatory to have rear crash structure in LMP2. At the moment you do not need a rear crash box in LMP2, but you do in LMP1,’ Guibbal points out.

Future proofing the new car against the forthcoming 2017 rule changes will allow ORECA simply to update its existing chassis in order to meet those rules rather than developing an all-new car, something it feels will help it cut costs. As a result, it has pursued a number of avenues with the 05 beyond where

much of its competition has gone to date, including a reduction project across the whole car. ‘The DNA of this car is all about the future,’ Guibbal explains. ‘Weight was not a problem on the ORECA 03, but with all of the change in the rules coming in 2017 we will have to put a lot of additional weight on the car. For us it is really important to be able to accommodate that and give the scope for car setup too.’ ORECA also claims that the weight distribution has been optimised around both the current rules and the new rules.

Despite the fact that the tender process has not yet been formally opened, and the new rules have not been formally agreed, ORECA seems confident that it will be one of the chassis suppliers selected, and that has influenced many elements of the 05’s design, most notably its width. While other LMP2 designs are built to the full 2000mm width allowed by the current regulations, the new ORECA is only 1900mm wide, a feature that will be introduced in the 2017 rules as the ACO tries to bring in commonality across all three LMP classes. It is a move that has raised eyebrows in the design offices of other constructors over just how fast ORECA was able to react to the change.

Developed using CFD

‘Although body parts will probably have to evolve by that time, the car as it is today will be easily updatable to the next regulations,’ ORECA’s sales literature explains. ‘That global decision was a way to take teams’ budgetary issues into account: that investment will not be limited to a two-year period (2015-2016) but potentially spread over six years. That also means that teams will be able to benefit from a higher resale value.’

In terms of the car’s aerodynamic package the new car is, as already mentioned, very similar visually to the Rebellion R1, a car that shows some clear carry over concepts dating back to the ORECA 03 and even the ORECA 01/ Courage LC70, especially around the flanks of the car. ‘The car’s pitch-sensitivity was one of the focus points, allowing customers to easily make the most of a whole range of settings,’ Guibbal explains. Like most new LMP designs, the 05 features a wide flat raised nose supported by pillars from the front splitter and retains the front impact structure used on Rebellion.

‘The front crash structure remains the same between the R1 and the 05, but there is still a lot of potential to develop a different nose between LMP1 and LMP2 because on the crash structure there are some recesses which allow us to put on different shapes,’ Guibbal reveals. ‘You can’t look at the nose in isolation. I think while visually they look similar, in reality the noses of our car, SMP and Ligier are quite different to each other. In our case, during the LMP1 design

The rear impact structure has been adopted from the LMP1 car in anticipation of stricter LMP2 safety rules coming into effect for the 2017 season



The ORECA 05 flies in the face of LMP2 convention and is 100mm narrower than the maximum width allowed

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Slippery aero package saw the ORECA 05 clock an impressive top speed of 262.1kph around Silverstone



process we looked at a lot of different nose shapes and found what we thought was best, and interestingly the 2015 Porsche nose is quite similar in concept to this one.'

While ORECA's main class rivals Ligier, BR Engineering and Dome all used wind tunnels while designing their cars, the 05's aerodynamics have been developed using CFD, something that allowed the car to be designed in a shorter timescale and at a lower cost.

Promising debut

'We used a totally new CAD model for this car. We could not simply adapt the Rebellion model as the internal shapes are so different, as are the demands of the engine packaging. But on the aero side we already had a good basis to start on, with the data from the ORECA 03 and the R1. Of course we did not ignore this, but the regulations between LMP2 and LMP1 are quite different in terms of aerodynamics. This is especially true around the front of the car, and that has an impact on everything else. We don't have the same size or shape of front splitter, but for sure some of the external shapes and concepts were carried over because time was short, and we simply could not design a totally new car in the timescale,' Guibbal admits.

The car made its race debut in the European Le Mans Series at the Silverstone four hours in the hands of the TDS team, then the following day it made its World Championship debut at the six hour race held at the same venue, this time with the KCMG team. In both races it lost out to older cars but showed strong potential,

especially in terms of top speed. Around Silverstone, the ORECA 05 achieved a maximum of 262.1kph, whereas the rival Ligiers only managed 255.9kph. This could suggest that the car is perhaps a lower drag lower downforce design compared to most of the opposition.

'The new car is designed more with Le Mans in mind, but Silverstone is not a great indication of the car's potential because of its layout,' Guibbal admits. 'It was the first race, so our customers TDS and KCMG are still learning the car and they will tell you that there is a lot more to come.' But he also goes on to stress that while the car is designed to be strong on the two prestige tracks for the LMP2 class, it is also designed to be an all-rounder. 'Le Mans is a big target, and Daytona too, and of course we want to win both, but we have to keep in mind the full championships. WEC is getting bigger and bigger while Tudor is an important market in future, in both its important to fight for the titles. You cannot just do a car for Daytona or Le Mans because, if you win Daytona and then nothing else for the next seven or eight months, it's no good for anyone. So while the 05 is a bit more designed for Le Mans than was the case for the ORECA 03, it is still very much a car designed to run strongly on every track.'

The new ORECA is perhaps the design most prepared for the arrival of the controversial new regulations (See P22) but its rivals are working hard on designs to match it – whether those designs will ever see the light of day rather depends on what happens behind closed doors in the coming months.

TECH SPEC

Chassis
Monocoque: Carbonfibre & Honeycomb
Length: 4640mm
Width: 1990mm
Height: 1.045m
Front track: 1570mm
Rear track: 1550mm
Wheelbase: 2950mm
Weight: 900kg
Engine
Power: around 490bhp
Torque: about 55 Kg.m
Max revs: depending on the engine
Lubrication: dry sump / staged oil pump
Engine electronic control unit: depending on the engine
Suspensions: double wishbones with pushrod
Tyres, according to the teams choice:
FRONT: 30-65/R18 , REAR : 31-71/R18
Front rims: 12.5"x18"
Rear rims: 13"x18"
Gearbox
Make: Xtrac
Type: transverse, magnesium casing
Gear change: Steering wheel-mounted paddles / Pneumatic paddle shift system
Speeds: 6 + reverse
Brakes
Ventilated carbon discs
Calipers: Brembo 6-piston in monobloc
Safety
Six-point harness adapted for Hans system
Rubber fuel tank 75L with integrated safety cell
Body
Carbon/kevlar

'Le Mans is a big target, and Daytona too, and of course we want to win both, but we have to keep in mind the full championships'

SIMULATION, NOT ESTIMATION

One of the biggest shifts within motorsport in recent years has been the emergence and reliance on simulation solutions, fuelled by the rapid development of technology and increasing testing restrictions.

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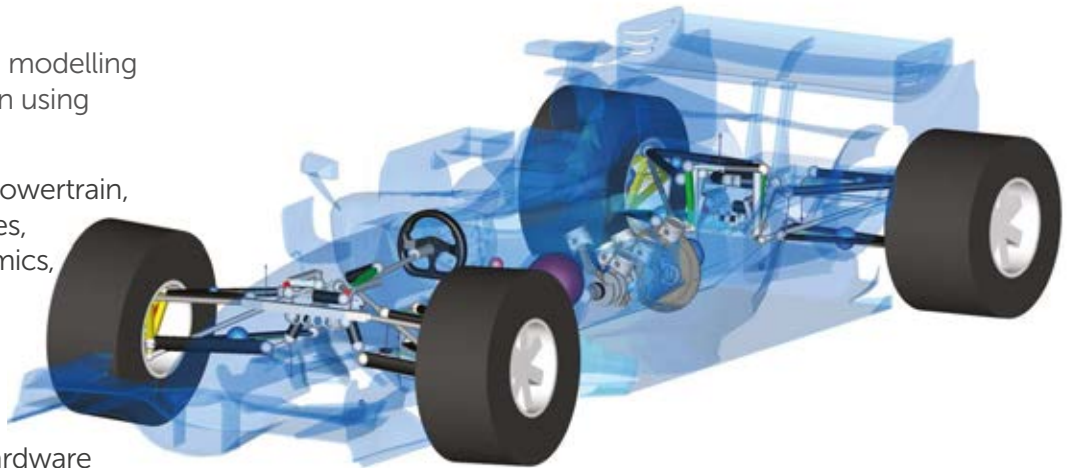


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Standing at the crossroads

Proposals for the future of customer prototype racing are being hotly debated

By ANDREW COTTON

The future of LMP2 is to be decided within the next month, and in the first five of this year there has been significant unsettling as the direction of the regulations takes shape. At the heart of the proposals, discussed with teams and with manufacturers, is cost-cutting and in the March World Motor Sport Council meeting, representatives green-lighted the plan for a single engine supplier to be nominated for the category.

At Daytona in January, representatives from the major organisations including Bentley, Volkswagen, Ford, Riley and Scott, Mazda, General Motors, Coyote, Wirth Research, Engine Development, Lamborghini, Dallara, Nissan, ORECA, Onroak and HPD met with the FIA, ACO and IMSA to discuss the future of LMP2.

There, a plan was presented that unified the three organisations with a single set of

regulations. Four chassis constructors would be nominated, and each would produce a car for a fixed four-year homologation. One of the chassis constructors would be from North America and there is a plan to have several entities create a single chassis. IMSA and the TUSCC would allow styling variants to fit with their philosophy already introduced into the Grand Am series of having manufacturer styling cues.

While Europe will have a single engine supplier, according to the proposal and subsequent announcement, IMSA teams will have multiple engine specifications, and engines will be balanced by a balance of performance process. However, a single ECU would be used around the world, in Europe, Asia and in the US.

Fierce resistance

The performance targets were set at a 10kph increase compared to current WEC cars, and the engines to produce an extra 50bhp, similar to the current TUSCC performance level. Tyres proposed were GT3/GTE specification and the original proposal was to have a single tyre

supplier. Existing LMP2 and Daytona Prototypes would be grandfathered for a year.

This led to an outcry, particularly from manufacturers that had produced cars to the existing formula, including HPD and DOME, whose cars debuted in competition at Daytona in January and Silverstone in April respectively.

'Someone at the end has to be responsible for the package as a whole, not a la carte shopping for bits and throw them together,' says HPD's Stephen Erikson of the proposal for multiple manufacturers to produce the US car. 'When we signed up for this next generation P2 car, we understood that it would be a six-year car; three years, a small adjustment, and then another three years so your investment is secure for six years and the maths suggest that is fine. All of a sudden it is three years, and one of those is grand fathered, so that has turned things on their head, and I don't understand. When you look at how many cars are out there now, and even not out there now but are planned or discussed, what are we doing changing? It is working as it is. I have been advocating since day one that you have a great skeleton. You have FIA crash tested, safety approved monocoques, nose box, crash structure, engines, gearboxes, suspension, uprights. If the important thing

LMP2 manufacturers say that there is enough diversity under current regulations and question the need for change

'The initial concept is to reduce the technical costs by 20 per cent'

is to make the car have a more recognisable reference to production cars, you can do that with the existing car. You don't have to throw it out and start all over again.'

Other chassis constructors with cars unveiled or proposed include BR Engineering, Wolff and Pilbeam, while Ligier, Gibson and ORECA have cars already in use and competitive in the European Le Mans Series. Onroak's Jacques Nicolet confirmed that, should his company not be one of the four nominated chassis constructors, his P2 programme would close and acknowledged that others would have to similarly adapt. ORECA has opened an office in the US to service the anticipated demand in North America, while Dallara is a favourite to land the final position. Engine suppliers submitting a tender are expected to include the Volkswagen Group and a rumour surfaced that the Global Race Engine could be an alternative solution to the engine supply proposed.

Timetable agreed

At a meeting in Paul Ricard at the end of March, a timetable was laid out for the creation of the regulations. On May 1 there will be a call of interest for chassis constructors and the spine of the technical regulations will be specified. The first selection of Chassis Constructors will take place in June, post Le Mans, while the tender for FIA/ACO engines and the electronics will take place by July 10. On July 15, the four chassis constructors will be selected and by September 1, the engine and electronics suppliers will be named. Between August and November, the four selected chassis constructors will form a Technical Working Group to form the regulations, which will be published on December 15. The first cars will debut in September 2016, and will race in January's Daytona 24 hours.

The engine specifications were set at a bespoke race engine, with a 90-degree normally aspirated petrol V8 with Direct Injection, of not

more than four litres and at 140kg. The target cost for running the engine is €1300/hour all-inclusive apart from the electronics. Engines will come with a warranty, maps will be frozen and individual support will be forbidden.

The electronics will be sold to the teams at a cost per kit of €20,000, which includes the Engine Control Unit, Gearbox control unit, Chassis control unit, Logger, Steering dashboard switch panel and power box. The proposed rebuild cost is €2000 and it will be mandatory to support series around the world.

After resistance from the tyre companies, including Dunlop, the tyre formula is to remain open in the European series despite a proposal from Hankook to take over the entire LMP2 supply and with marketing spend behind it. That, and a proposal for a single tyre supply in the European Le Mans Series, may also have cost Pirelli's participation in the series, although the Italian manufacturer has tested already and has further tests planned this year for a P2 tyre.

'Around the table we have the actors of the LMP2 programme and all the family, chassis manufacturers and engine manufacturers. Private teams are involved in a technical group to find a final proposition for this regulation and the philosophy is to pay attention to the running costs and create a sustainable and good business for the future,' said the WEC general manager, Gerard Neveu at Paul Ricard.

Reducing costs

'This is a private team category, we cannot compare with the LMP1-H, so the framework has to be correct to engage for a long-term future of the category because this is in the interests of the ACO, and the last point is to do a harmonisation between the different continents in North America, Europe and Asia to provide a good future for LMP2 worldwide, for the WEC and for Le Mans. I won't give you any final details because we are still waiting for the final copy,' continued Neveu.

At Silverstone in May, the ACO cancelled a press conference planned for Saturday morning to discuss LMP2 and instead issued a press release that only confirmed the limitation of the number of chassis constructors. However, even this has been met with resistance from P2 manufacturers, including DOME which issued a statement confirming that the S103 would be made available to customers, and that the firm remains of the opinion that the market should be left open.

'The LMP2 category has been one of the great motorsport success stories, and the ACO is very proud of what has been achieved,' says the ACO President, Pierre Fillon. 'We are in consultation with the manufacturers and the teams to find the best solution for the new 2017 regulations. We must remember that LMP2 is for teams and drivers, it is not a manufacturer category outside of North America, and we must build a sustainable business model for teams, cars and engine manufacturers.'

'Twenty-one engine manufacturers were consulted about the best way to reduce costs and the universal opinion was that the only effective way forward was to have a single supplier. This was recently announced by the World Motorsport Council and the tender process for this will begin in the summer.'

'The initial objective is to reduce the technical costs in LMP2 by 20 per cent (this figure to be confirmed once the discussions within the technical working groups to define the details of the new regulations are finalised) without affecting the quality of the racing and also to build cars that can be raced in America, Europe and Asia. We are going to make sure the LMP2 category provides the best solution for teams and drivers wishing to compete in a Le Mans Prototype in endurance racing for many more years to come.'



Formula 2 coming 2017!

Stefano Domenicali outlines the final layer of the FIA's pyramid scheme

By SAM COLLINS



The world of junior open wheel racing is a cluttered place. Formula 3, GP3, World Series, Auto GP, GP2 and others all create a complex mass of championships. One man has been tasked with sorting out the mess, namely former Ferrari F1 team boss Stefano Domenicali who was appointed head of the FIA Single Seater Commission last year.

His impact has been immediate. A recent FIA World Council session agreed that an all-new class of open wheel racing would be introduced to complete the FIA's pyramid of open wheel racing, and logically it will be called Formula 2.

The construction of that pyramid started in 2014 with the launch of the FIA F4 class, a formula that has proven to be hugely successful with hundreds of entries around the world in 2015. The redevelopment of Formula 3 above it has proven controversial and has seen a number of national F3 championships collapse, while a pan European championship is booming – but that is all part of the plan apparently.

'From the FIA perspective, F3 is part of a process that has been planned in the last couple of years and now is in action,' says Domenicali. 'The concept is to make sure that there is a path that is starting from the basics after karting and the F4 national championships, then the F3 international championship. Then we will close the gap between Formula 3 and Formula 1,

because we believe that one of the assets and one of the duties of the international federation is to make sure there is a consistent path of growing in which drivers can really perform.'

In a refreshing change from recent years the new FIA pyramid is not solely focussed on driver development and Domenicali is keen to stress that point, suggesting that an end to the proliferation of single spec classes may be coming to an end. 'Just because we are talking about the young generation it is important, not only to give opportunities to the drivers, but also to the teams and to the race engineers, the mechanics, to all of motorsport, to grow,' he explains. 'That was the philosophy that was behind the thinking of the championship, it has to be the part of growth of the sport or all the people that are involved. Sometimes – and it may be correct – we concentrate only on the drivers, but it is important also to have the passion of engineers and the mechanics and it is a great opportunity for them to be involved.'

Open competition

It is clear that the FIA wants multi-chassis and multi-engine competition throughout its pyramid. In F4 this is achieved by having a set of technical regulations globally, but each country can pick its own spec car within those regulations, something that has seen Dome, Mygale and Tatuus all build fleets of cars and

others design chassis looking for business and a range of engines is also in use. 'What we did with F4 seems to be a success. This year we have some championships with a lot of drivers; Germany 42, Japan 40, Italy 38, and Northern Europe 25, it is a very healthy start. The UK is a problem and we need to sort out the situation, but we are working on that,' Domenicali adds.

In Formula 3 the concept has changed little as the impending arrival of a new chassis from ArtLine and Mygale in 2016 proves, and the technical regulations have allowed a large number of tuners to offer engines to the class.

Turbos and hybrids

So what form will FIA Formula 2 take? Well, the question is a matter of debate internally at the FIA currently and externally around the wider industry. Some details are easy to work out – the cars will be a composite monocoque chassis built to at least FIA F1 2011 safety standards, not dissimilar to the current GP2 Dallara, but the engine is rather more difficult to pin down.

'We need to be pragmatic. We are all motorsport fans and motorsport lovers and when you hear the noises of classes like LMP2, it is really great, but at the end of the day, the displacement for the future is smaller. Turbocharging is the future; hybrid technology is the future; so we have to look at those things with a level of cost that the system is able to

‘Turbocharging is the future; hybrid technology is the future; so we have to look at those things with a level of cost that the system is able to accept’



accept – that is the key,’ Domenicali explains. ‘This needs to be thought through carefully in order not to make a mistake, the project of Formula 2 needs to be spot on.’

When Domenicali left Ferrari (apparently not by choice) he joined Audi to work in business development, and it will not have taken long for the engine department of Volkswagen Motorsport to get in touch. When the current F3 regulations were under discussion some time ago Donatus Wichelhaus, Volkswagen Motorsports engine director, proposed that F3 use otherwise redundant engines from the WTCC and WRC, reworked by tuners (and specifically not manufacturers) in order to supply a cost effective, varied and continuous supply of blocks and heads. The idea was rejected as many felt that F3 should remain a naturally aspirated class, but the idea could be resurrected for the F2 championship. The World Rallycross Championship has shown what a WRC specification 1600cc engine can do with the restrictors enlarged and the turbo reworked, and while this has not gone unnoticed it is far from the only proposal on the table.

‘We are open to all the different situations. We are discussing with all the different manufacturers of engines and chassis and so on, and as you know we need to go official with a tender to see what will be the real interest of the major stakeholders. This is the objective

that I really hope, to push the Single Seater Commission to find a good proposal within the next couple of months. I want to be very proactive on that,’ Domenicali continues. ‘You know that in DTM in the next couple of years, there will be a new engine. It is a possibility but I cannot say something because we are in the middle of discussions to understand what others want from this championship.’ With the 2.0-litre four cylinder direct injection NRE (DTM) engines already used in Super Formula and GT500, the case for their deployment is at least as compelling as the case for the WTCC/WRC units. Additionally both Honda and Toyota are known to be evaluating hybrid versions for use in Super Formula, something Domenicali has already highlighted as desirable.


Cost control

Following Domenicali’s statement that an open chassis competition is clearly desirable, in an industry constrained by spec classes there are few beyond Tatuus, Dome, Mygale and Dallara capable of delivering such a design. However, one suggestion is for the teams in F2 to use a year-old F1 chassis which, as the Manor team is currently demonstrating, is clearly possible. It could also be a very cost effective option.

Cost is a major element for the creation of any new FIA class and F2, with open chassis competition and open engine competition, has

the potential to get very expensive very quickly – a fact that the FIA is keenly aware of.

‘If you look now at the cost of Formula 4 globally speaking, it is really a great achievement. We know that motorsport is not only dangerous – it is written on the pass! – but it also expensive; that should be included on the pass too! It’s difficult to say where the level is that it becomes too expensive, and that is what we are trying to find out. The way it was done in Formula 4 was the right one and I’m very optimistic to say that this is right entry basis to driver and car performance with the right power and performance overall,’ Domenicali continues. ‘But in F2 we need to control the teams, for example in testing, that’s part of what the FIA has to make sure to monitor the situation. We have a product that needs to be of a certain quality and that cannot come free of charge. It is the biggest challenge with Formula 2, in order to sit between Formula 3 and Formula 1. That will be a challenge and hopefully I can come back to you with this project very soon, because that’s the target.’

Formula 2 should, according to reports, begin in 2017, leaving a relatively short amount of time for the rules to be formulated and cars constructed. A formal proposal is expected to be agreed or otherwise in July, with tenders opening soon after. *Racecar Engineering* will of course report on any developments. 

Time to think differently?

The time has come for motorsport to think outside the box and embrace mainstream technology companies in order to ensure its very survival

By PETER WRIGHT

While the internal but all-too public wrangling about the future of F1 and how to reclaim its TV audience rages, the news has emerged that Apple is recruiting automotive engineers. What has this to do with motorsport? What it reveals is that, while F1 tries to decide whether or not it is a technical contest, relevant to road cars and therefore those that buy them, or simply an entertainment for those that crave continuous distraction from real life, the world of the car is changing.

The rumours that Apple is planning to recruit 1000 automobile engineers – mainly initiated by Tesla and A123 complaining about Apple tempting their key employees away with “golden-hello” packages – might have passed relatively unnoticed if automobile industry leaders gathered at the Geneva Motor Show, had not insisted they had nothing to fear from Apple; or Google for that matter. Dieter Zetsche, chairman of Daimler, went out of his way to say: ‘I do not know the strategy of Apple; it is not easy for me to understand why they would be interested in entering into the automobile industry.’ Maybe Apple is not planning to enter the automobile industry; maybe it is planning a new industry to eventually replace it. That would be very typical of Apple; and besides, Apple doesn’t make things.

One of the main roles of the automobile has always been to connect people to other people, and to things. Today we are entering into an ever-maturing environment where people are connected to people by media devices, and to things by the likes of Amazon.

Of course, society has a legacy of workplaces and high-street shops and malls, and so we still use cars, but the way people live is changing fast. Already the need for a set of wheels can be fulfilled by Uber and other similar services, or by Car2Go, which just happens to be Daimler owned. ‘A car at the touch of a button’ is a fast-growing reality, freeing people from the burden of car ownership; purchasing and financing, depreciation, parking, garaging, taxing, insuring, servicing, and being fined for driving too fast.

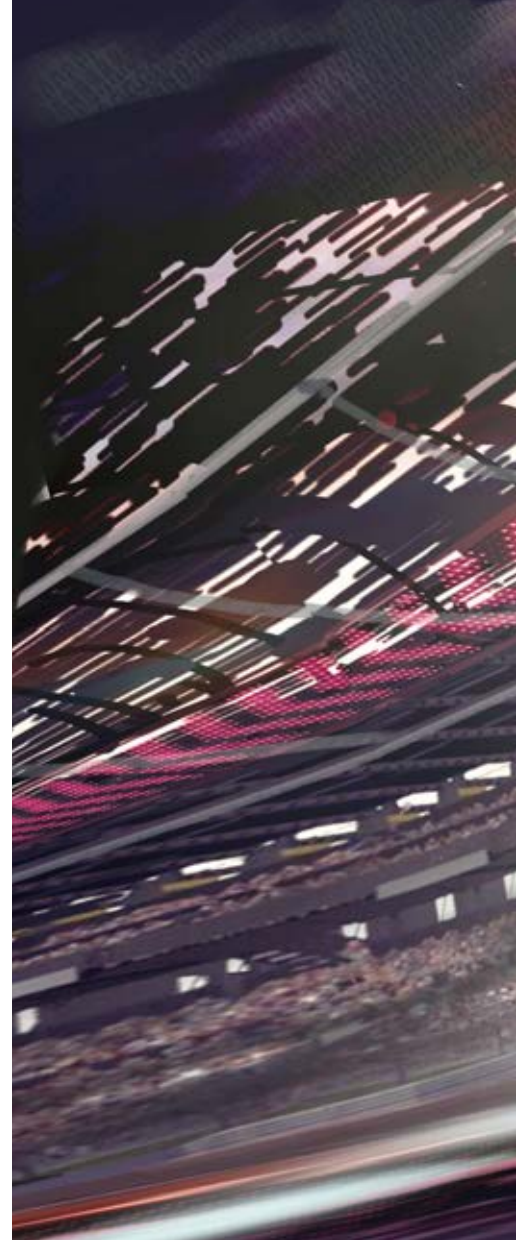
Inevitably it will be the urban and suburban environments where these mobility services first gain a significant foothold displacing private car ownership, and this is where more than 60 per cent of the world’s population will reside. The vehicles supplying these services will still need:

- **Wheels and suspension**
 - **A propulsion system and energy store – probably electric**
 - **Passenger and luggage compartments**
- But the most significant components will be:
- **Communications**
 - **Navigation**
 - **Traffic information**
 - **Media**
 - **Data**
 - **Drive assistance**
 - **Controls, or self driving systems**
 - **Human interfaces**

Of the above electronic systems, six of them are already available on an iPhone.

What I’m sure Apple has discerned is that the value of the electronics content of cars is steadily increasing and that it is a profitable part of the total price of a car and that it has a significant influence on purchasing choices. The iPhone supplies many of these functions in a piece of hardware that costs Apple \$200 to make and sells for around twice that. Electronics options in a Ford Focus add up to more than £3000, and this figure is only going to increase. When self-driving arrives, courtesy of Google or whoever, it will increase substantially.

Apple was among the first to put a computer on people’s desks. When they saw how it was used to communicate, surf for information,



access media and generally become a major part of how people ran their lives, they put it all in those people’s actual hands, and came up with a satisfying interface, and media and applications stores. Now they are putting it on people’s wrists. The one place and time a person cannot, or should not use what Apple has provided is while driving a car. ‘Apple products and services are useful for a third of most people’s day, but it could increase to three quarters by getting into TV and cars,’ says Kate Huberty, an analyst at Morgan Stanley.

So what is stopping them?

I believe what is stopping them is that they believe the right vehicle for future urban/suburban use is an EV, but that the technology does not yet deliver what service providers and users require. A quick look at energy densities tells us why. See **Table 1**.

Using these numbers, and ignoring the potential of nuclear power, we can clearly see the problem if we consider one lap of the 58-lap Australian GP on the Melbourne circuit in an F1 car. One lap uses 76.4 MJ in the form of gasoline, which weighs 1.7kg and occupies 2.4 litres. The best lithium battery would weigh over 30kg and occupy around 12 litres, taking into account the different energy conversion efficiencies. For

‘The value of the electronics content of cars is steadily increasing and that is a profitable part of a car’s total price’



Table 1

Energy store	MJ/kg	MJ/litre
Uranium	80.6 x106	1540x109
Hydrogen	142	5.6
Diesel	48	35.8
Gasoline	44.4	32.4
Ethanol	26.4	20.9
Li battery	0.36-0.88	1.8-5.2

the race, that would equate to: 1.75 tonnes, and almost 700 litres.

Even the new Satki3 lithium battery, in which James Dyson has recently invested £15m (other investors include General Motors and Itochu – the third largest Japanese general trading company), comes to fruition it will only double the energy density of lithium ion. Currently an EV has to be designed around its batteries, while an IC engine-powered car fits the fuel tank in where there is relatively unusable space. Apple’s initial interest is in the EV (Tesla engineers) and batteries (A123 engineers), as these are the key areas to be solved.

Dieter Zetche ended his interview by saying: ‘We have been in the business of making automobiles for 130 years and we think we



Google’s self-driving car has neither a steering wheel or pedals



A fully electric windowless driverless racing car concept, the ED Torq. The software technology war could begin here



The battery system on the Porsche 919 uses cells developed by A123 Systems, who also supply a number of F1 teams

are pretty good at it.' The automobiles he is speaking about are one to two tonne cars burning fossil fuels. The future is half tonne cars using electricity (where that comes from is a whole other issue). Key technologies are lightweight structures, electric motors, batteries, and all the sensors/electronics/displays/interfaces that Apple understands so well. They also know that the batteries in their products must provide the user with a working day's use, and fully recharge overnight.

As for making the parts of a car that are outside Apple's experience, well, it could just about buy any part of the existing automobile industry it wanted. Its current capitalisation is three times greater than Toyota's, six times greater than VW/Audi's, and more than 10


times that of Ford. There is already talk of Apple buying Tesla, which would be a good start, as it would not be encumbered with IC engines and gearboxes, and all that goes with them.

If the Apples and Googles of this world do invent a different approach to mobility and create a whole new automobile industry, they won't do it quickly. However, motorsport is already experiencing a waning interest from the younger generations – the Millennials – and it is not due to Mercedes dominating F1, although some would like us to believe it is. 1000bhp engines are not going to have any influence on most young people. There may be 1000bhp supercars, but they only represent 0.01 per cent of car sales and are declining; they are not so much cars as fashion items, akin to

fancy clothes and expensive watches. EVs are already 0.3 per cent of sales and doubling each year. If maintained at that rate, in less than 10 years they would represent over half of annual car sales. It probably won't happen like that, but they will become a significant segment of the cars people buy and rent.

750-1000bhp hybrid F1 and WEC cars may be relevant for the next decade, but by then will anyone watch motor racing that is not configured for pure entertainment? I know this sounds terribly pessimistic and way out there, but it is not. For motorsport to survive and thrive as an industry, and not just be for the pleasure of those that take part, it must follow the inevitable automotive trend. The industry is full of ingenious, innovative, creative and motivated designers, engineers and scientists, and there will be a large demand for their approach to automotive engineering. Whether motorsport provides an environment in which it makes sense for Apple, Google, and the conventional automotive industry as it evolves to compete, to invest and fund development will depend on how quickly and effectively it can change. At the moment the high-level movers and shakers are not looking good in the way they are dealing with the initial symptoms of the coming evolution in automobiles.

F1, WEC and Formula E have all demonstrated what motorsport can achieve with batteries, high-speed high-efficiency electric machines, control systems, energy recovery, torque-vectoring vehicle dynamics, electrical safety, etc. – all key technologies for future automobiles. Motorsport should be building on this and not talking it down.

As someone, deep inside motorsport said recently: 'This is probably the last generation that will enjoy motorsport.' If the industry doesn't change, he may be proved right. 

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Mini revolution

How JRM's RX MINI hopes to take the Rallycross world by storm

By SAM COLLINS

At the end of the 2014 season JRM made the unexpected announcement that it was going to start competing in Rallycross. The organisation is best known for its sportscar racing projects which include the development of NISMO's GT3 specification GT-Rs and in the past has seen JRM contest the GT1 World Championship as well as the LMP1 class in the World Endurance Championship. It has recently moved into loose surface motorsport with the development of a Group N Subaru rally car.

To move into Rallycross, JRM acquired Prodrive's MINI Countryman JCW RX Supercar project and its technical lead Paul Eastman, who has worked on the project since its inception.

'Technically the car started life as a S2000 rally car,' Eastman explains. 'The RX Supercar technical regulations do not really allow you to take an homologated World Rally Car and use it in Rallycross, but what you can do is convert a car homologated in Group A, which is what the S2000 was. It's a technicality, but we don't want to fall foul of the rules.'

Falling foul of the rules has become a lot easier in 2015 as there has been a significant move by the FIA to enforce the RX Supercar regulations after it was realised that not a single car contesting the 2014 World Championship fully conformed with the rulebook.

'One of the approaches we have is to ensure that we have a clean car as the recent history

of RX has been quite ambiguous as to what the regulations are. But they have been a close knit community and they have done things their own way and found a mutual way forward. Now RX is opening out and becoming a bit more technical and we need to have more controls in place,' Eastman continues.

The S2000 MINI was launched in 2011 as a project between Prodrive and BMW Motorsport but had mixed results. A programme to convert the design into a Rallycross supercar began in 2012 and was completed a year later where the car won on its debut at the Munich X-Games in the hands of Liam Doran.

'The conversion did not take too much as the essence of what we did with the rally car



‘In its rally guise it was not the most powerful car in its class, but it did allow the driver to get good feedback from the car’

was to create a nicely balanced and packaged vehicle that had a couple of main criteria, one of which was allowing the driver to get a good feel for it. In the rally guise it was not the most powerful car in its class, but it did allow the driver to get good feedback from the car,’ Eastman explains.

The changes from S2000 car to RX Supercar saw it stripped of many rallying essentials including the co-driver’s seat and instrumentation, tools, spare wheel, heater and protective undertrays. The headlights have gone too as have many other minor components designed for the stages. The radiator has been moved from the front of the car to the boot area where it is fed by ducts



Top: The cooling fans can clearly be seen – these play a huge role in keeping performance consistent
Above: Fans push air through the radiator and are constantly running for optimum results

in the side of the car. One thing that remains from the rally car is its engine – a turbocharged 1600cc four cylinder BMW with direct injection.

Remapped powerplant

‘The engine has a production block and that’s a key to it,’ says Eastman. ‘The rally project was conceived in partnership with BMW motorsport and they developed the engine. BMW wanted the engine to be designed so that it could be used in both the rally car and the WTCC car. In the touring car it was mounted longitudinally but in the RX car it is transverse, so in its development there were trade offs between some design elements of it. But the regulations the engine was designed for would never

not have a restrictor, or one so large, there was never the thought of running it to these extreme horsepower levels. So for the intended applications the production block and head are suitable, but now in RX we are going to make them work a bit harder. BMW’s official line was ‘we would not recommend it.’ What they did was design an engine to last a season in racing or 1600km in rallying before it needed a rebuild.’

With a production block, the engine in RX trim is performing at levels beyond its original design parameters. During its first phase of development the engine was remapped to deal with the larger restrictor. This, when combined with a larger intercooler and increased boost, raised the power level by about 20 percent.



'In 2016 all RX Supercars have to go to 1300kg, regardless of engine'

'When the car was being developed, all the effort was put into the chassis, but the next phase would have been engine development for WRC,' Eastman continues. 'That never came. In rally use it had restrictors of 29mm-33mm, so it was heavily restricted and never got more than 330bhp maximum. But with a 45mm restrictor we pushed the engine beyond what the rally car was meant to be, so we had to do some work on the chassis as a result.'

The MINI is almost certain to be the only car contesting World Championship with a 1.6-litre engine, but despite being at a clear power deficit, Eastman does not feel that the car is at a disadvantage. 'The beauty of the regulations in 2015 is that a 1600cc engine gets a 90kg weight break over the 2.0-litre cars, so for us it makes a lot more sense to stick with that for now. The question we are now asking as JRM is what to do going forward – do we develop

the 1600cc engine further? As we know, there's still a lot more to come from it; bear in mind F1 engines are 1600cc too. But how much of that performance can be unlocked and at what price? You have to think about the economics,' Eastman explains.

It could be argued that a more cost effective route would be to drop in a developed version of the 2.0-litre engine used in some MINI production car variants, but it is not as straightforward as it seems. The engine bay of the car is already cramped, so fitting a larger capacity engine could be an issue.

Light weight is key

'Installing a 2.0-litre engine is a challenge with the chassis. Not just from fitting it in the space available, but also from accommodating the extra 90kg you would get as a result of going to a 2.0-litre unit. With that 90kg you have to think about stopping it, how it impacts the car when it lands off jumps and even the driveshafts have to be slightly larger to cope. It impacts massively on the whole car,' Eastman admits. But he also goes on to acknowledge that this is a path that JRM will ultimately have to take. 'The decision has been made for us. In 2016 all RX Supercars have to go to 1300kg, regardless of engine, so we will have to do all of that work and get the extra power.'

But for the 2015 season at least the MINI's 1.6-litre engine and resulting weight break is, in Eastman's mind, actually an advantage, as he believes his car to be a much lighter package all-round due to its S2000 roots. 'Fundamentally the whole rally package is a lot lighter than the conventional RX Supercar, as the car was first developed to S2000 there were certain limits. The engine, for example, has to weigh 82kg, so obviously between us and BMW we made sure it was 82kg. The gearbox had to be 55kg, so that's what its weight is. In RX there are no component weight minimums so they tend to have a lot more weight in those parts, and that's a lot of weight to have on the front axle,' Eastman says.

Tyre management

This weight advantage gives the MINI an advantage off the line over its bigger engined and heavier rivals, but testing and the GRC outings it has completed have shown that it does lose out slightly on long straights. However, it makes up time elsewhere on a lap.

Generally it seems that the chassis of the MINI was a very solid basis for a RX Supercar with its roots in stage rallying, and while the demands of Rallycross are obviously different, much of the design has carried over. 'The base geometry of the car, the heart of the car if you like, in its centre of gravity, its geometry, that has not changed,' Eastman claims. 'It is all about



Top: The RX MINI uses conventional brakes on the front and an asphalt braking setup on the rear

Above: Engine bay is already extremely cramped and would struggle to accommodate a 2.0-litre powerplant

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traction and that has already been optimised on this car. Even with more power you won't get any more traction out of that geometry if you have fully maximised it already. The one equalling factor in this series is the tyre, and the cars are under-tyred for the performance they have. You will always have this condition of ultimate power and ultimate torque balanced against having to look after your tyres. In distance terms, the races are not that far but they are very intense on tyres. If you have too much power you will simply eat those tyres, and you do see a drop-off in performance throughout the event.'

Consistency is paramount

Avoiding a performance drop-off as the car is used has been a key part of the MINI's design since its original conception as a rally car. This was something Prodrive wanted in its design in order to ensure that the car was user friendly and consistently competitive.

'If you look at the MINI, the concept was always that it would have consistent performance throughout an event. We still want

the same level of performance as the car starts the final as we had when we arrived and set the car up for free practice,' Eastman continues. 'It's quite tricky to do that throughout a race weekend with mud build up, general wear and getting bashed into by other cars. There are so many factors that can come into play that I think by the time a lot of RX cars get to the final they are simply not as good as they were at the start of the weekend in terms of performance. The MINI can keep its performance consistent and we have seen that in events.'

It is a design philosophy that Eastman is continuing with the car under its new JRM ownership and it is having a clear impact on the car's development. 'It's about having the right strength in the right components in the right places. We are lucky that this chassis has done so many miles as a rally car that we know that it can do the distance. We have all of the data on the brakes, the cooling and all of that. For example, this car has a set of fans pushing air through the radiator, which are on all the time, and another set sucking air through it, and those are on a temperature control. In GRC

events the fans would not come on during the first six laps, they would only come on in the final two laps usually. It was all about keeping the oil and water temperatures in an optimum working range to ensure the engine performance was not reduced in any way, shape or form. Some of the other top cars did not have that and they suffered.'

Breaking convention

This 'no performance drop-off' mentality can also be seen in the braking system, which from the outside appears to be very conventional, mainly because it is, but it is a conventional rallying setup, not a RX setup. Paddock wisdom suggests that the short sharp races in Rallycross favour different friction materials which warm up to their working range faster but can overheat in a much shorter amount of time, but this is not a theory that JRM and Eastman subscribe to.

'So far with the brake friction material we have not seen the need to change, because in rallying, like RX, you don't get the chance to warm up the brakes much. It's all about going from cold to the working range in the shortest possible time – that is as true for RX as it is for rallying. The thing with rallying is that you have a 20-minute stage which means that the brakes must last, so you have brake cooling.'

'We want the same level of performance as the car starts the final as we had when we arrived'

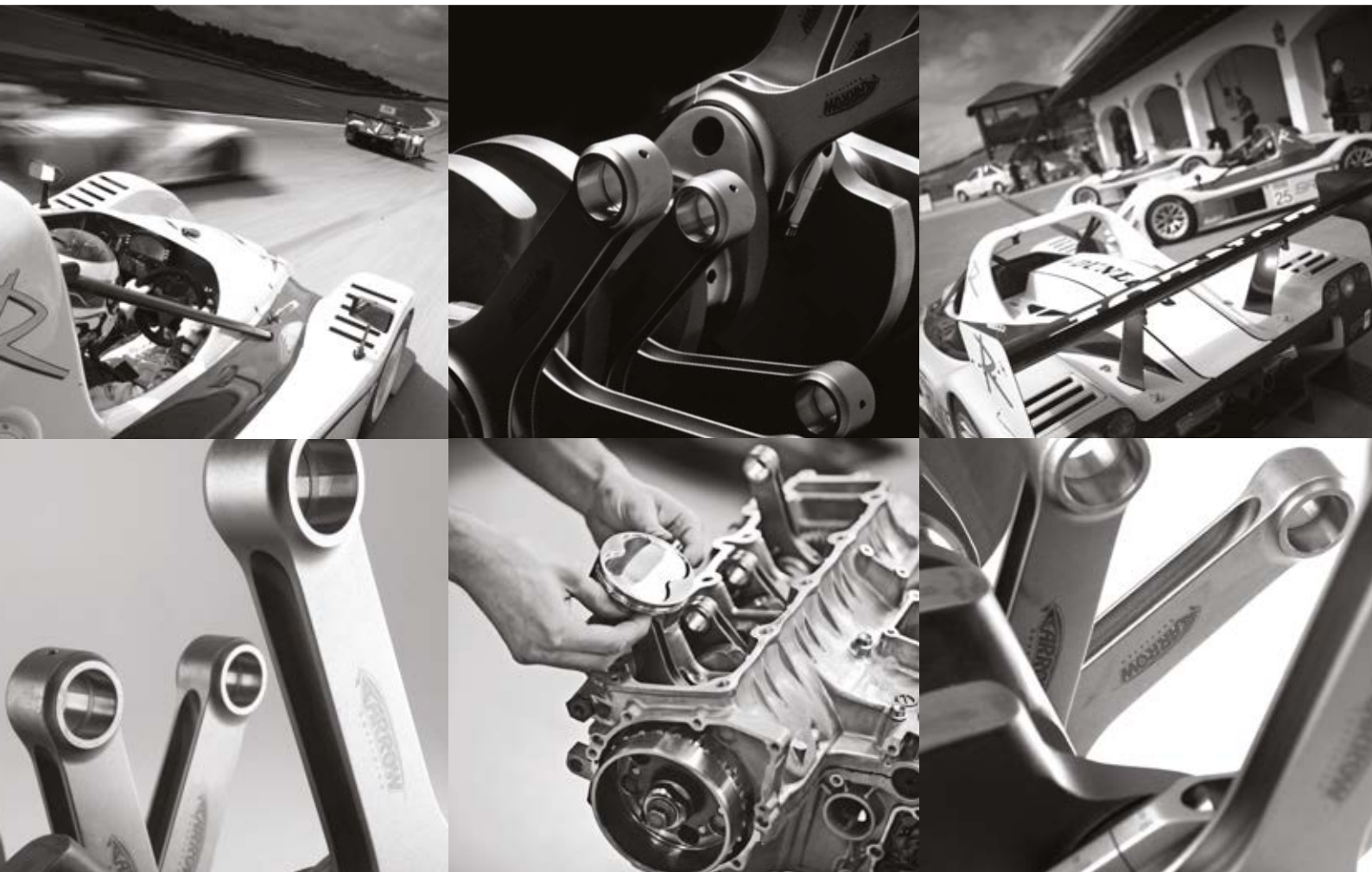
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Yet with the short races in RX you don't need that endurance, but you can also do away with the cooling too,' Eastman explains. 'We use the AP braking system and that has a full suite of discs available for different conditions, so we select what we need from that. So what we use is an S2000 asphalt setup on the car with a gravel brake on the rear, but it's something we can play with and swap around.'

Other lessons that have carried over from Prodrive's rallying experience are clear to see in the way the car is run at the track. Some of the design features are straight out of the 555 Subaru WRC teambook and even the design of the stands the car sits on

in the garage have come from the Prodrive rally team. 'The serviceability of the car is key,' continues Eastman. 'When we sustain damage it's very quick to repair. With this car, the suspension, for example can be swapped out without the driver noticing a difference,' Eastman reveals. 'But in some areas there are RX specific demands. Running the car in GRC we discovered a weak link in the rear suspension from where the drivers lean on each other a lot. All of the load cases of the car running on a stage, both in testing and in reality, were fine. But in Rallycross, where the cars are making frequent contact, we realised it needed strengthening. In a similar way body damage

is a factor so we have used some flexible panels on the car – if you use a brittle composite panel it can get a hole in it and reduce driver comfort. It only takes the smallest distraction to put a driver off in Rallycross and the races are not long enough to recover from mistakes.'

The MINI will make its official World Rallycross Championship debut at Hockenheim, Germany, in round two of the series and will then take in other selected rounds of the series. With as many as five manufacturers looking to enter the championship in 2017 it seems that JRM's RX MINI project is a statement of intent, and perhaps an advert to potential partners. 

Prodrive's 'Value Engineering' approach

Prodrive claims that the 'Value Engineering' approach, adopted from its production car development department, can cut the cost of developing a competitive vehicle by up to 50 per cent. The approach focuses a firm's resources to maximise the benefits of every Euro spent. Prodrive claims that the technique can be applied across any formula and will 'almost guarantee' to deliver a competitive car.

'Automotive engineers have systems to help them meet tough performance and quality targets within specific budgets,' says Prodrive Technical Director David Lapworth. 'Working with colleagues from our automotive technology division helped us understand how to translate their value analysis techniques into a rigorous process that supports design decisions, correlating engineering investment with performance value far more precisely than previously.'

According to Prodrive the heart of the process is a rigorous definition of the sensitivity of the vehicle's performance to incremental changes in the characteristics of each significant component. 'Much of the investment has been focussed on quantifying parameters through which the performance of systems can be defined and then developing

performance factors such as weight, weight distribution, centre of gravity, aerodynamic forces, engine power and so on. The next stage of the analysis is to define the degree of contribution of each component on each of these performance factors, allowing a rigorous definition of the improvement to whole-vehicle performance that will

example, a highly accomplished chassis that you can't fully exploit because of a poor power unit. Our approach ensures that resources are focussed only on the areas that deliver the biggest gain, so the relative performance of every system is balanced across the vehicle.'

The foundations of the process were developed in 2009 as Prodrive prepared a generic rally car for new World Rally Championship regulations in 2011. 'At that stage, we didn't know which car we were going to put the design into, so we spent time ensuring we had a rigorous understanding of every characteristic that affects vehicle performance, then building that knowledge into a model-based process,' says Lapworth. 'In the end we ended up in talks with three vehicle manufacturers about a programme and chose to work with MINI. The result was that the MINI World Rally Car was delivered very quickly, with far less testing than any previous programme, yet the car achieved three podiums in its first seven outings and very nearly won on its third event. The design and development budget for that programme was also a fraction of the norm, indeed less than 50 per cent of what we had previously spent on developing the Subaru Impreza WRC.'

then be generated by incremental improvements in each component.

'At this stage, we have a very precise understanding of the cost of making the car competitive for each performance step, essentially a Euro per second/kilometre in the case of rallying or a second per lap in racing,' says Lapworth. 'This approach allows us to make decisions very quickly and very accurately, ensuring that time and money are only invested where they will deliver most value. Everyone in the design team understands these parameters and therefore does not waste time over engineering a component or endlessly seeking irrelevant incremental performance.'

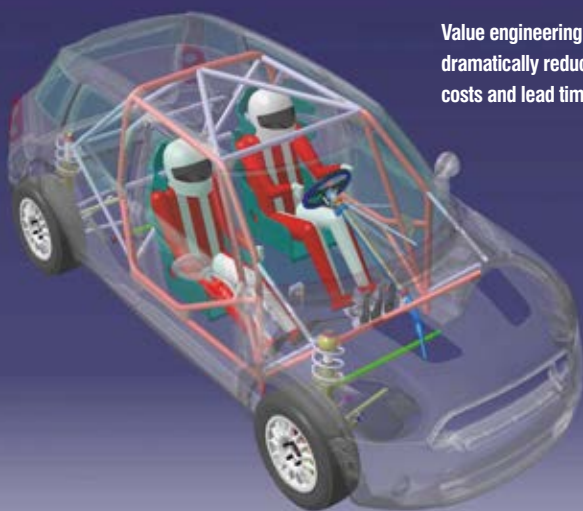
Much of the cost reduction comes from the time saved by Prodrive's engineers, but a significant contribution is also derived from what Lapworth calls 'value balancing'. 'Most constructors are under such time pressures that they base decisions on a combination of experience and what they are good at,' he explains. 'That can mean, for

'Our approach ensures that resources are focussed on areas that deliver the biggest gain'

the models that link changes in those parameters to the degree of change in overall vehicle performance,' explains Lapworth.

The first step in the process is to create a generic model of an ideal vehicle for the formula. Specific targets are then set for key

Value engineering can dramatically reduce both costs and lead times





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By **STEFAN BARTHOLOMEAUS**

Pictures by EAUN CAMERON AND SIMON DARBY



The rebirth of New Zealand's Race to the Sky featured an Australian entry that threatens to change the way the world thinks about gravel hillclimb specials. The car, which features a Ford Focus derived body and Nissan twin-turbo V6 engine, has been built in Queensland, Australia, by Paul Cernich's Pace Innovations for event promoter Tony Quinn.

An amateur racer and multi-millionaire businessman, Quinn has revived the Race to the Sky hillclimb, held in the picturesque Cardrona Valley, after a seven-year absence. It now boasts the honour of being the world's longest gravel hillclimb following the paving of Pikes Peak and lured the legendary Nobuhiro 'Monster' Tajima back for an attempt at a ninth crown.

While Tajima's Toyota GT86 tackled the event in all the powersliding glory for which gravel hillclimbing is known (although ultimately ended spectacularly with a crash when the engine cover came off and took the rear wing with it), Cernich and Quinn planned on negotiating the nine-mile layout differently.

Quinn had last year approached Cernich for advice on buying a hillclimb car for the event, to which the latter enthusiastically suggested a ground-up build. Cernich has added some of his company's own money to Quinn's budget in order to build the car to the level that the engineer desired. The project took just 20 weeks and an estimated \$450,000 from the start of design to the car being dispatched to NZ for the event.


The philosophy

Since opening its doors in 2006, Pace Innovations has established itself as a leader in tin-top chassis design and manufacturing.

Its work has included co-designing and building V8 Supercars' Car of the Future prototypes, while also drawing and manufacturing a full field of cars for New Zealand's equivalent, the V8 SuperTourers.

Cernich, whose engineering career includes a Le Mans victory with Schnitzer's BMW effort in 1999, is keen to expand his business into one-off rally and Time Attack projects and sees Quinn's car as a showcase for Pace's talents.

Although at first glance the wild bodywork appears to fit the bill of a typical gravel hillclimb



‘We decided from the outset that the car would be driven like a circuit car and that we would bring as much circuit racing thinking as we could’

special, the overall design philosophy has the company's circuit racing roots at heart.

‘There's footage of these guys going through these long, sweeping corners with the engine revving and the car sliding,’ explains Cepnich of past Race to the Sky entries.

‘We believe that if you have a car with good tyre grip and a reasonable amount of downforce, you can be quicker around a corner by holding a racing line. So we decided from the outset that the car would be driven like a circuit car and that we would bring as much circuit racing thinking as we could to the project.’

The thought process was partially driven by Cepnich's inspection of the course last year. Tajima's record from the 2006 event stands with an average speed of almost 110km/h.

Cepnich spearheaded the design of the car himself, working alongside recent university graduate and designated project manager Jordan Yeomans, as well as a team of mechanics.

The layout

Although chassis design and fabrication is the hallmark of the Pace business, producing a 985kg car with a near-to-perfect weight distribution was no easy task.

The layout of the spaceframe chassis is dominated by a mid-mounted engine and two large shafts; one taking the power to the front-mounted Holinger transaxle, and the other transferring it back to the rear wheels.

‘The packaging of it was difficult,’ admits Cepnich. ‘The engine is offset and the rear diff is

offset by 20mm just to let the shaft that comes back from the transaxle get around the driver. Everything is really, really close there.

‘We could have packaged it lighter and better with a carbon shaft but we didn't have the budget. Packaging the steel propshaft, because of its size and the centre bearing size, has probably been the biggest challenge.’

The end result is a 47:53 weight distribution which, with the addition of an 80kg driver and 15kg of fuel in the passenger-side mounted tank, delivers what Cepnich describes as perfect corner weights.

The chassis and rollcage were designed and jig-assembled by Pace using 25CrMo4 laser-cut in Germany. The fully welded chassis structure weighs just 128kg.



‘We just wanted to use as many parts on the car as we already had’

While buggies are allowed under the Race to the Sky’s liberal rules, Cepnich and Quinn were both intent on producing a racecar with swinging doors and some semblance to a conventional road vehicle.

The decision to go with the Ford was made due to Pace’s work with the MARC Focus V8 endurance car project that is seen in the Creventic Series races throughout Europe.

‘We already had Focus bodysides and a roof in carbon, as well as the Lexan screens and side windows,’ says Cepnich. ‘We just wanted to use as many parts on the car as we already had.’

The A and B pillar skins are taken directly from the road car, ensuring that the windscreen and side window shapes, as well as the start of the roofline, are also true to the standard production model.

Not one surface on the car, however, is standard Focus thanks to the use carbon fibre bodywork throughout.

Pace in-house designed the body in CFD, which was then manufactured with the help of Adelaide-based Centre Line Patterns and Queensland-based materials specialists Lightning Composites.

Maximum downforce

The aero concept is about keeping the frontal area to a minimum and generating as much downforce from beneath the car as possible.

‘All the hillclimb and Time Attack cars that have big wings need big power just to push their wings along,’ notes Cepnich. ‘We’ve tried to be as efficient as possible with this car, which is why the rear wing is inside the roofline.’

The CFD shows that the car produces over 1000kg of downforce at 200km/h, but how that translates to the real world remains to be seen.

The 120mm high rubber skirts that run the full length of the car are a key part of the package. Although a full ground-effect is not possible on a dirt course, the skirts help channel the air through the diffuser, which starts at the centre of the car.

Pace meanwhile worked closely with world renowned radiator specialists PWR to utilise the engine’s airflow in the aerodynamic package. The top-mounted intercoolers are positioned so as to enjoy a mutually beneficial relationship with the rear wing.

‘We found that the low pressure underneath the wing, while making the downforce, was also extending back towards the rear window and causing a bit of lift on the bootlid,’ says Cepnich.

‘The intercooler position achieves two things. The low pressure on the exit ducts improves their efficiency, sucking the air through at a higher speed. That hot, energised exit air is in turn bled into the airstream over the



The amount of plumbing associated with the turbo, and the amount of heat the unit generates, left Cepnich surprised



The exhaust exits blow directly into the diffuser tunnels in an attempt to further boost downforce

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'The Nissan isn't a big weight saver, but the smaller size is a big benefit'



The 120mm rubber skirts run along the car's entire length and are an integral element of the aero package

bootlid as low as possible. It works to counter the low pressure that the wing is causing on the bootlid itself, increasing the wing's efficiency.'

The exhausts meanwhile blow directly into the diffuser tunnels to further boost downforce. The striking fins that extend from the roof to the rear wing exist to decrease yaw. According to the CFD, the car will lose 50 percent of its downforce at 25 degrees of yaw. The fins have also been designed as part of the contingency plan in case the overall aerodynamic concept proves troublesome in the real world environment. 'We can lift them up into the airstream and generate a more inefficient aero downforce with the wings,' says Ceprnich.

Successful test

The car had a brief shakedown on a tarmac course prior to being dispatched to NZ, where it underwent a two-day test.

Ceprnich drove the car himself at the shakedown and enthused over both the downforce and turbo power, even although he was only running a maximum of 50 percent throttle during the brief hit-out.

With the Race to the Sky course rising from 450m to 1500m above sea level over its 135 turns, a force-fed engine was a must for this car.

Early designs had a supercharged version of the 5.0 litre Ford Coyote V8 used in the MARC Focus endurance cars. While confident that 700bhp could be achieved with that engine, the desire for more power and tighter packaging led the project in a different direction.

Turbo power

Having also assessed the Mitsubishi Evo engine, Nissan's VR38 was eventually decided upon – several weeks into the design stage – as the way to go. The development was contracted out to local firm Cragsted.

Owner Craig Hasted has a long history in V8 Supercars and currently runs the engine parity formula for the series. V8 Supercars is currently in the midst of its own assessment of turbo engines ahead of its new Gen2 rule package coming online in 2017.

'The Nissan isn't a big weight saver over the Coyote, but the smaller size is a real benefit. It's a pity that it doesn't have the same motor as it does body style, but we wanted a turbo and that's just how it worked out,' says Ceprnich.

'I've not been involved in a turbo car before and I was amazed at how complex it is with everything in terms of water cooling, oil cooling,

all the plumbing, how the intercoolers work and the heat that comes out of them. It's mind-boggling. But then when I drove it for the first time I realised it was worth it!'

Without a bellhousing or gearbox directly hanging off the end of it, the engine is effectively free-mounted in the car. A piece of the rollcage can be bolted in and out in order to allow the removal of the engine.

A MoTeC M150 ECU makes up the brain of the engine. Cragsted worked closely with MoTeC on the integration of the ECU and engine, mapping boost levels to the throttle percentage and currently selected gear.

The car utilises the MoTeC's new paddle-shift software, featuring throttle-blip and shift-cut functions. The pneumatic paddle-shift mechanism sports a Shiftec accumulator and compressor, with the package making for rapid-fire changes.

'Rather than a cylinder that shifts a lever, this is an air valve that's directly connected to the gear shifter drum,' explains Ceprnich of the pneumatic arrangement. 'The valve that controls the shift is right inside the same unit, so the air is not going down a hose or anything, it's right there and delivered very, very quickly.'

The drive from the transaxle is a permanent 50:50 front to rear split. If any one element will give the car a crucial advantage at the event, it could well be the decision to use the 15-inch World Rally Championship wheel and tyre package. The relatively small wheel created its own challenges when trying to accelerate and stop an 850bhp rally car, but importantly comes with a wide range of tyre choices.

'Right from the start we wanted to use the WRC wheels so that we could have a choice of what rubber we could use,' says Ceprnich. 'There could be varying conditions across the five runs and having the full scope of the WRC gravel range, is a big part of the design.' The carbon brake rotor, calipers and pads are taken straight off the front of a GP2 car.

No compromise

The need to keep out stones and operate at temperatures of 300 degrees ensures the brakes are fully enclosed with no ducting. The team also brought steel brakes if the stones proved incompatible with the carbon set-up.

The suspension layout is an unequal length double A-arm design on all four corners, with the top wishbones working as bellcranks to activate the locally made King Springs.

The team had progressive springs made following the initial shakedown which, even at relatively low speeds, proved that linear versions would not cope well with the downforce. The springs are fitted around Reiger Racing dampers, which are similar to those in the WRC.

Reach for the sky

The Race to the Sky may not have yielded victory for the Ford Focus V6, but the event left Ceprnich more than confident of the car's potential.

Having toyed with the idea of flying in a star driver, Quinn elected to steer the car himself; an ambitious task for the 58-year-old considering his unfamiliarity with the 139-corner course.

A brief shakedown at the nearby Highlands Park racing circuit on the Thursday before the event provided the only real sign of mechanical weakness experienced by the team throughout the race weekend.

The extent of the front downforce at high speed saw the front spoiler break from its mounts, requiring repairs and a minor rethink of the springs and bump stop set-up.

With the car untested on gravel until the event itself, times improved with each of Quinn's five runs up the mountain.

Quinn took nearly a minute off his initial effort for an eventual best of 9:06s; 48s adrift of the winning time set by Alister McRae in a custom-built, 750bhp, ex-WRC Subaru Impreza.

'From our point of view the event was a big success because what we set out to do definitely worked,' said Ceprnich.

'We were sniggered at a bit when we rolled the car out with its skirts and everything, but we only needed to make very minor changes behind the rear wheels because it was rubbing too much.

'I don't know if Tony is ever going to be fast enough to win the Race to the Sky, but I would go out on a limb and say that if he knew

the road better and had another day of running he could have competed for the win.'

The team opted to keep the car limited to 80 percent throttle due to Quinn's unfamiliarity with the layout, detuning performance by an estimated 100bhp.

'It was an amazing personal challenge for me,' smiled Quinn after the race, laughing that conquering a fear of heights had been his main motivation for tackling the event.

'I was peeling 20 seconds off my time with each run which was a great buzz. I was convinced I was going to get down to the eight minute-mark, but I made a few mistakes on the last run.'

The car will now head back to Ceprnich's workshop in Queensland before a planned return to the event next year.





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‘Being able to hold a line should bridge the gap between race and rally’

As the top wishbones effectively act as rockers operating the suspension, spacers are placed between the wishbones and the uprights for quick 50mm ride height adjustments.

The suspension layout, designed without pushrods in order to keep as much out of the all-important under car airstream as possible, means there’s no anti-dive or anti-squat front or rear. ‘With the amount of travel that we’ve got and on a gravel surface I don’t think it’s effective,’ Cepnich says. ‘I’m not a believer in a lot of anti-geometry when you’re dealing with a varying grip level that’s going to change the way the

car behaves dynamically.’ The steering is a fully electric system from the BMW M3 road car that Cepnich has also used on the MARC V8s.

While marginally heavier than a hydraulic system, removing the need to run lines from the mid-mounted engine to the steering rack made its use an easy decision. The electric system also allows driver adjustment of the steering assistance level.

Although Pace was charged with building the car specifically for the Race to the Sky, Quinn confirmed that he would be the one to drive the car, rather than to insert a professional.

While built to go as fast as possible, regardless of driver, the circuit racing philosophy used proved an even more important edge with Quinn behind the wheel.

‘If Tony does drive, it’ll be much easier and safer for him to do so in this car the way it’s been designed,’ says Cepnich, who travelled to the event alongside Yeomans and Pace mechanic Mark Burns. ‘I think having a car in a four-wheel drift with the rear wheels over the edge of a mountain is probably not where he wants or needs to be.

‘For anyone that’s experienced in circuit racing like Tony, being able to hold a line and use the aero grip sucking the car to the road should really help to bridge that gap between race and rally.’

The car was an interesting solution to the problem of gravel hill climbing. While the Pikes Peak course is now largely tarmac, the Race to the Sky route is off-road. Although Quinn took the wheel of the car himself (see sidebar), the car performed well enough that it could be competitive wherever it runs.



The suspension layout has been designed without pushrods – there’s no anti-dive or anti-squat front or rear



The car acquitted itself well during the race, with Quinn posting a fastest run of 9:06s, 48s behind the eventual winner

TECH SPEC

Engine

Type: V6 Twin Turbo
Capacity: 3799 cc
Position: Mid rear
No of valves: 24
Max Boost: 1.4 bar
Max Power: 850 Hp @ 7100 RPM
Max Torque: 976 Nm @ 5100 RPM
Top Speed: 212 Kph

Transmission

Type: 4 Wheel Drive
Front: Holinger MFT 6 Speed Transaxle with steering mounted paddle shift
Rear: Holinger HFD differential

Chassis

Type: Tubular Steel Space frame 25CrMo4
Bodywork: Carbon

Suspension / Brakes / Steering

Front Susp: Unequal length double wishbone with top wishbone as rocker
Rear Susp: Unequal length double wishbone with top wishbone as rocker
Springs: King Springs - Progressive front and rear
Dampers: Reiger 3 way adjustable with double piston
Travel: 210mm front and rear
Anti roll bars: Adjustable front and rear
Steering: Electrically assisted rack with driver adjustable assistance
Brakes: Hydraulic double circuit system with driver adjustment
discs: 286mm diameter carbon discs front and rear

Callipers: Brembo lightweight 6 pot monoblock front and rear

Tyres: Pirelli 205 65R15 Front and Rear

Rims: Braid Aluminium 15 x 7

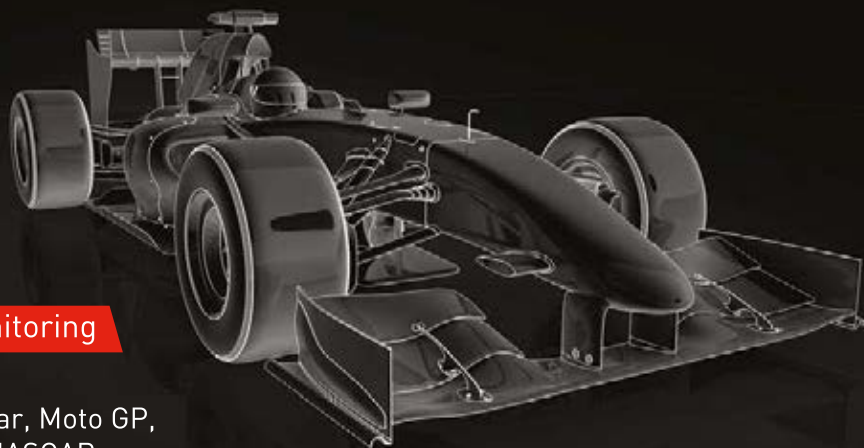
Dimensions

Length: 4920mm
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Wheelbase: 2700mm
Fuel tank: 30 litres
Weight: 989kg



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Off to a flying start

Yuasa's Racing's new Civic Type-R is taking BTCC by storm. Team director Barry Plowman gives us the lowdown on the project

By LEIGH O'GORMAN

Emerging from the opening round of the BTCC at Brands Hatch with Matt Neal leading the points standings – after he and teammate Gordon Shedden took a race win each – was probably more than Barry Plowman had in mind.

This did present Plowman and his team with their first set of sporting challenges of the season. The early big points scores for their two drivers at the Kent opener ensured Neal and Shedden would take success ballast of 66kg and 35kg respectively into the following round at Donington Park. Yet having seen Shedden place his car on the front row for Saturday's first race, Plowman does not appear overly perturbed despite the weight penalty. However, as the curtain raiser developed, the excess baggage designed to penalise Neal helped the former champion chew through his Dunlop tyres.

While this was a disappointing development, it proved as a reminder to the technical director that there is still a lot more performance to be eked out of the Type-R, which may compensate

for future successes. 'It has been a good platform to start from,' says Plowman. 'It is certainly a little bit different to the estate car and we are slowly but surely finding ways to make it better and better all the time and every time we go out, we learn something new with it.'

Yuasa Racing last ran the Civic Type-R in 2004 with privateer entries for Neal and Dan Eaves, taking four race wins before switching to the Integra and further success a year later. Plowman hopes that moving to the Type-R in 2015 can help the team repeat the success of 2005. 'Last year we used the Tourer, which is essentially an estate car; it threw up some very different challenges from what we're used to. Now we have gone back to a more conventional hatchback, but with the new Type-R shape.'

Initial comparisons from the Yuasa Team Technical Director were positive. 'It has leant itself a lot easier to make a racing car, rather than using the estate car. The base model is a little bit longer than the old hatchback car, but in terms of the body it is a lot more refined. Honda has

done a lot of work in Japan getting the drag down for the Type-R with the body extensions, while maintaining downforce and stability.

The new Civic also brings Honda's latest Type-R engine to the fore. Tuned by Neil Brown Engineering, the 2.0-litre unit is the first turbocharged engine to be used in the long history of the Type-R – a factor that has added another dimension to the task faced by Plowman, as he explains: 'This is a new engine. It is, at the moment, a starting point. There will be some more development and there's more to come from that later in the year.' Under the bonnet, the engine position of the Type-R remains unaltered, with Plowman acknowledging, that there was a regulation that governs crank centre-line height and position.

While the engine position has not changed, the placement of the cooling ducts certainly has, with the vents now situated on the wheel arches, as opposed to the bonnet. As the wheel arch vent is a standard feature of the road going version of the Civic Type-R, the team is allowed

'We are slowly but surely finding ways to make the car better'



Honda Yuasa Racing has been working closely with Honda UK, readying the racecar long before the road car's official debut



Time in the windtunnel has created a car with increased downforce and less drag compared to 2014's Tourer

to retain and use them, although an exit duct on the bonnet is permissible.

Where the Team Dynamics entry has been particularly busy is the aerodynamic department, with the team committing resources to CFD design and windtunnel work on the bodywork. It has been key to the team discovering its strengths – and more importantly – its weaknesses. 'We are learning all the time. Come the end of the season, we will investigate the information we have acquired even further and take that to the next level.' Moving from the estate to the hatchback racecar meant previous aerodynamic information was no longer relevant, effectively meaning Plowman's team was back at point zero. However, he is also keen to underline the importance of track time to validate this

data. One element that had to change early was the standard Type-R rear wing, which was removed and replaced by a series standard wing as mandated by TOCA. During the homologation process, teams present the standard road-going version of their cars to TOCA, who place a standard rear wing before placing in a windtunnel for testing. 'The theory is that everybody should get the same amount of downforce at a given speed to start with,' explains Plowman. Following the test, the team is given a wing position and angle set which dictates the starting position of the rear wing.

Unlike a number of other upper-level categories, sporting regulations for the BTCC allow for unlimited testing up until one week prior to the opening round, but following that marker, only four full days of testing are


permitted. It is a limitation that initially proved a stumbling block for the Worcestershire-based team, which missed much pre-season running due to uncertainties surrounding confirmation of the Type-R programme. 'The deal happened very, very late and part of that was because the road car does not actually come out until the middle of the year,' says Plowman. 'It was all a late decision as to which car we were going to use. That held things up a little bit, but now we have it on a good platform.'

Additional testing

Yuasa Racing may have one card up its sleeve. Series regulations do permit newly-designed cars to benefit from an additional five days of testing during the season, but only if a sealed in-season engine is used. Should Yuasa Racing use any extra days, the team will be limited to one set of tyres per day and can only run on circuits that are either not on the calendar or have already hosted that year's BTCC meeting. Naturally Plowman is keen to use as many of those extra days as possible.

Yet for all the new elements in place delivering in spades, Yuasa Racing has not become blind to the opposition, with Plowman particularly acknowledging the step forward made by the independent BMR Volkswagen entry – piloted by reigning champion Colin Turkington and Jason Plato amongst others. However, he admits some surprise that the Triple Eight Racing MG and the West Surrey Racing BMW squads were not challenging quite as consistently. 'BMW looked strong at Brands Hatch but doesn't look strong at Donington Park. MG was strong last year, but it isn't looking quite as strong as it ought to, considering that [Andrew] Jordan had no [success ballast] in,' says Plowman. Despite their early season success, he is also keen not to get ahead of himself. 'We have still yet to understand and find the advantages of the new car. The opposition moves on every year and we have to get to a point where we have got to all the different types of circuits, around the middle of the year, to actually suss out where everybody really is.'

By the conclusion of the Donington meeting, Neal had grabbed another win and added a second place finish to take him to the top of the drivers' standings ahead of Turkington, while Shedden claimed a pair of podium finishes and resides five points adrift of Turkington in third spot in the championship. Honda Team Dynamics has also jumped to the top of the Manufacturers' Championship standings.

For what is effectively a new start for the Yuasa Racing Team and Honda Civic Type-R, things could hardly be going much better and as the combination continues to grow and learn, the team under Plowman's charge may well still be title challengers come the end of 2015. 

The standard Type-R wing was removed and replaced by a series wing

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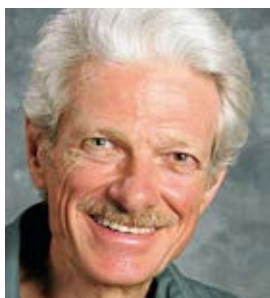
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Weight transfer fundamentals

Investigating spring stiffness and load transfer

Question

I have been confused with some basic weight transfer fundamentals.

1. Assuming there is a 100 per cent smooth surface (no curbs/no bumps) with a rigid enough chassis do I need to have suspension springs in my car?

2. Stiffer springs help to reduce weight transfer. Based on that logic then weight transfer would be minimum with infinite spring rate. Isn't that good if you are assuming 100 per cent smooth surface?

3. Is there any theoretical approach to find correct spring rate/natural frequency when considering bumps?

The consultant says

On a smooth surface, it is definitely possible to run with no suspension other than tyre and frame compliance. Every go kart in the world does exactly that. I even recall somebody long ago trying a full-size sports racecar like that.

This was circa 1964. I don't remember the name of the car but I read about it, I think, in Sports Car Graphic. It was built for the US Road Racing Championship, which was the predecessor of the Can Am series. It was a rear mid-engined V8-powered sports racing car. It was not successful.

In the early 1920s Bugatti tried just having the rear end rigid and a stiffly sprung beam axle in front – that didn't work very well either.

A car's suspension serves to absorb road irregularities but it also has a second function, and it controls the load transfer distribution between the front and rear: what percentage of the total load transfer (weight transfer) occurs at the front, and what percentage occurs at the rear.

For vehicles such as cars, the overall stiffness of the suspension has only a slight effect on total load transfer. Lateral load transfer does not primarily result from roll. Most of it would occur even if there were no roll at all. Roll does result in a small lateral translation of the c.g., but this effect only becomes large enough to be of concern in vehicles where the c.g. height is large relative to the track width, as in trucks and buses.

The real reason for most of the load transfer is that the c.g. is above ground level and the tyre contact patches are at ground

level. When the tyres generate lateral force (centripetal force) and accelerate the car toward the turn centre, the car's mass exerts an equal and opposite inertial reaction force (centrifugal force) away from the turn centre. The tyre forces act at the ground plane while the reaction force acts at c.g. height. All these forces are horizontal with respect to the ground plane. The forces have parallel but offset lines of action, so they create a couple.

This couple tries to overturn the car toward the outside of the turn. The tyres resist this and

each end. It doesn't matter how stiff the whole suspension system is, but it matters how stiff the front is compared to the rear. In this context, stiff springing does not reduce weight transfer; it increases it. If the front has three quarters of the total roll resistance, it gets three quarters of the total weight transfer, assuming equal track width at both ends.


Note that roll resistance has geometric and frictional components as well as elastic (from springs and anti-roll bars), so it's not just springs that determine weight transfer.

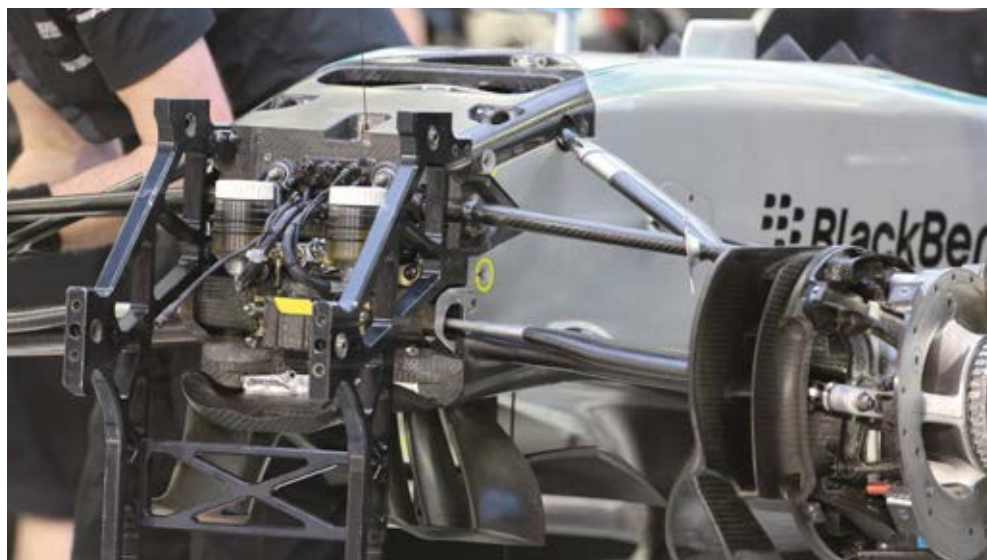
A car's suspension absorbs road irregularities but also controls load transfer distribution

hold the car upright. The outside tyres press harder against the ground and the inside ones less hard. For the car to be in equilibrium, the sum of the moments must be zero, just like the sum of the forces. The total load transfer between the right and left wheel pairs, times the track width, must equal the total lateral force, times the c.g. height.

For fairly low and wide vehicles, the total roll resistance for the front and rear combined has little effect on the total lateral load transfer. However, the relative magnitude of the roll resistance at the front and rear determines the share of the total load transfer that occurs at

Even with very stiff suspension, the relative stiffness front and rear can be used to control load transfer distribution. This makes suspension useful even in cases where it only helps a little in absorbing bumps.

There are ways to calculate what natural frequency you'll get with a particular configuration, but there are only general guidelines regarding what natural frequency you want. It's always a compromise, mainly between the need to absorb road irregularities and the need to keep the tyres upright and keep the c.g. low. In many cases, aerodynamic considerations enter into the compromise too. 



F1 cars are very stiff but still feature significant suspension movement. Could they still perform with no suspension?

Weight transfer with anti-roll bar versus springs

Optimising suspension setup for really rough terrain

Question

My car is a VW Polo 9N3 GTI MY2006 with the same VW/Audi 20V 1.8-litre petrol turbo engine from the VW MK4 Rabbit/Golf GTI. I'm looking to set my car up for Australian east coast national park roads (think British B-roads but rougher). I have the rear end more or less where I want it – the stock height 25 N/mm (142 lb/in) springs have been replaced by slightly lower 22.5 N/mm (130lb/in) linear rate springs. The reasoning behind this was to drop the c.g and rear roll centre. Due to the resultant reduction in rear geometric and elastic roll resistance, a three-way adjustable RARB has been added to bring rear roll stiffness to a level slightly greater than before. It is now softer in ride but stiffer in roll than before.

Predictably, now that I can get the car to unload the inside rear tyre, the front (standard spindles with -0.5 degree of static camber) is not able to cope since it has inadequate roll stiffness to keep the outside front upright. In tight corners, improved turn in still moves into understeer and then wheelspin on exit.

My question therefore concerns the appropriate front end setup. I estimate that the front OEM springs are about 25 N/mm. It runs

a stiffer FARB as opposed to stiffer springs? That is, assuming equal front roll stiffness in each case – in a stiffer FARB car won't the weight transfer onto the outside front tyre be trying to lift the inside front, whereas in the stiffly sprung car won't the spring in the more independent sprung strut still be trying to push the inside front into the ground?

The consultant says


An anti-roll bar is just another kind of spring, but there is a lot of confusion about its action and effects. One often hears it said that if you achieve a given increment of roll stiffness with stiffer springs, the springs plant the inside tyre, whereas an anti-roll bar giving the same roll resistance tries to lift the inside wheel instead. This misconception seems to be especially prevalent in Australia and New Zealand for some reason, but it's pretty common elsewhere as well. I think I recall Carroll Smith saying something like that in one of his books.

No disrespect to Carroll Smith or anybody else, but there simply is no truth to the notion that one source of roll resistance produces a different change in tyre loading than another. All roll resistance has to act through the tyres,

sprung mass and two wheels. So, is an inch of displacement an inch of relative motion between one wheel and the other? Or is it one inch of motion between each wheel and the sprung mass, which is two inches of relative motion of one wheel versus the other? Is an inch of displacement an inch per wheel, or is it an inch per wheel pair?

If we test anti-roll bar rates the same way as ride torsion bar rates, by holding one end stationary and deflecting the other end and measuring the force, we get a rate in pounds per inch per wheel pair. That's half the rate that the bar gives in pounds per inch per wheel. So if we put on a bar that's a hundred pounds per inch stiffer measured that way, and compare the effect to stiffening ride springs with the same motion ratio by a hundred pounds per inch, we will find that the bar change has a lot more effect on the car's handling than the spring change. But that's just because we chose to measure and express the bar's rate in pounds per inch per wheel pair rather than pounds per inch per wheel.

I advise using a generous amount of bar and correspondingly softer ride springing, when the goal is to control roll while still absorbing bumps, provided the car will not bottom or suffer adverse aero effects if large ride motions are permitted.

With the car in question, the rear bar will need to be stiffened along with the front one. To put power down on exit with a front-wheel-drive car, especially one with an open diff, the inside rear wheel needs to be off the ground or at the point of impending lift even when we are feeding power in and releasing the car in terms of cornering force. That means the rear roll resistance needs to be considerably in excess of that required to pick up the inside rear wheel in steady-state cornering. 

To put the power down on exit with a FWD car, the inside rear wheel needs to be off the ground

a 20mm FARB. My lower control arm pivots are already parallel and the steering arms a few degrees up at the tie rod ends, so lowering is out of the question for fear of adversely affecting the front roll centre height, camber gain in roll and bump steer.

I'm torn between upping the front spring rate or upping the FARB to increase front roll stiffness and curb the understeer. My indecision comes from not knowing which method will work better at achieving the front roll stiffness I'll need. I am leaning towards increasing the size of the FARB to keep the car compliant and to make tuning the dampers F:R easier. Any pitching and diving due to the standard springs should be controlled when I install these Koni sport dampers.

So my question is, when a FWD open diff car transitions to putting power down coming out of a tight corner, is it not more likely to lift and spin the inside front when fitted with

and it necessarily changes their loading when it does so. The tyres don't know where the loading on them comes from. The roll resisting moment generated by any front or rear wheel pair is always equal to the lateral load transfer at that pair times the track width.

I've written of this in the past but it probably bears repeating: one origin of the idea that anti-roll bars transfer more weight than ride springs of comparable stiffness is that people get confused about what constitutes comparable stiffness. That confusion results from the fact that there are two ways to express displacement in the case of an anti-roll bar because it connects three things rather than two.

With a ride spring system, we have the sprung mass and the wheel. One inch of vertical motion of one relative to the other is an inch of suspension displacement – simple. But an anti-roll bar system connects the

CONTACT

Mark Ortiz Automotive is a chassis consultancy service primarily serving oval track and road racers. Here Mark answers your chassis setup and handling queries. If you have a question for him, get in touch.

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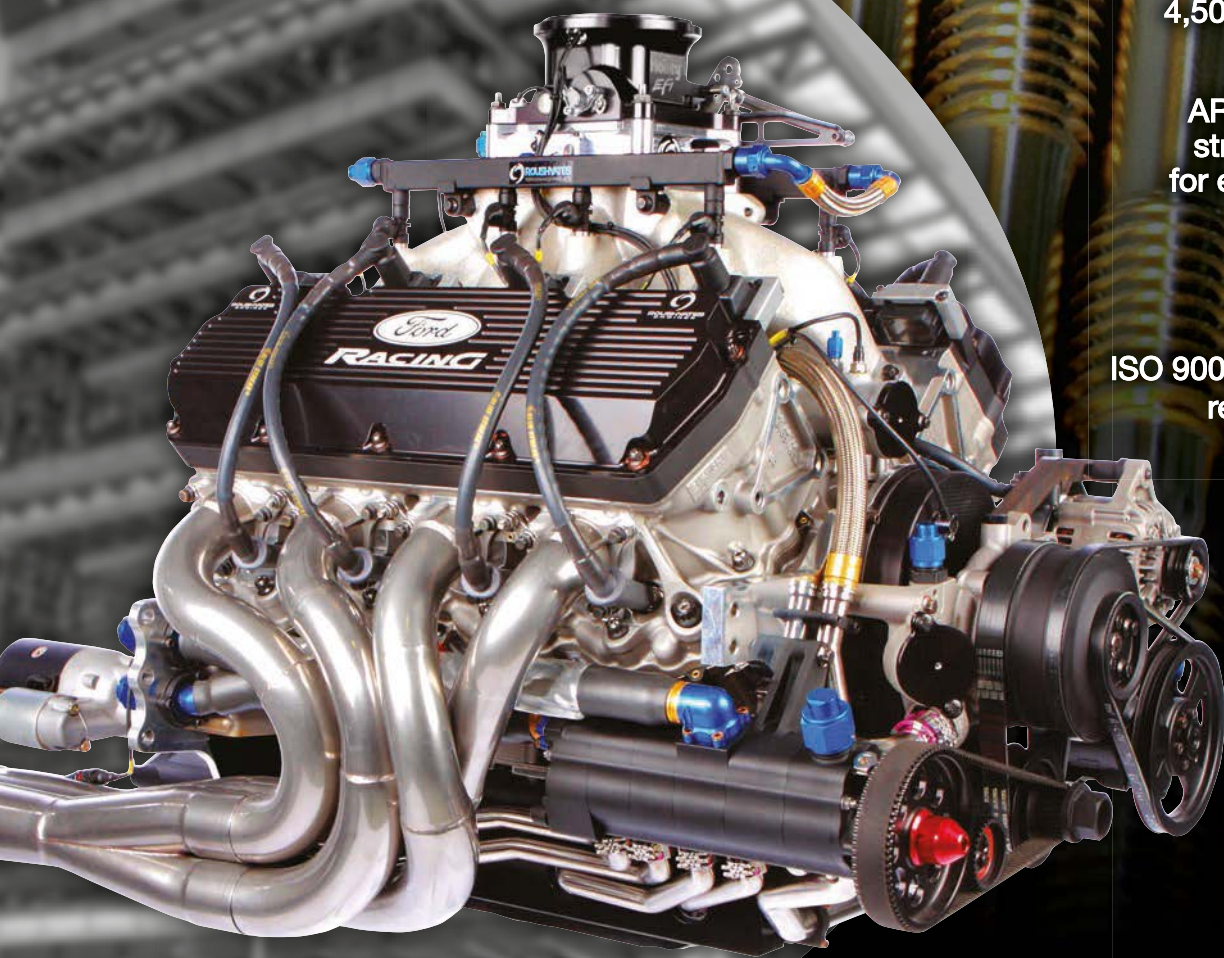
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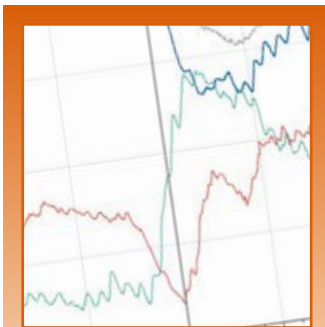
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Speed limiters

The different approaches to managing speed in the pit lane

Being able to set a car up so that it maintains a specific speed under certain circumstances is an extremely useful feature and, in fact, sometimes it's necessary. Most, if not all, of the world's circuits mandate a speed limit in the pit lane to ensure the safety of those working and spectating there. In most racecars this speed limit is automatically governed by the engine control unit of the car, but in some cases the driver needs to monitor and control this unaided. Being able to maintain or limit a car to a set speed can also be useful in other ways – a recent rule change in endurance racing asks drivers to observe a speed limit on track without a safety car being called out. This can be controlled in a similar way to a pit lane speed limit. Another, and perhaps more interesting use of speed limiters is for track aero testing. Setting the car

up for a specific speed on a straight bit of track can gather very useful information on the aerodynamic balance. If the car also has active suspension it is even possible to maintain a set ride height for this type of testing. This would obviously have to be done with special test cars as fully active suspension is rarely allowed these days.

When the pit lane speed limit is active in the ECU, we effectively are asking for a reduction in torque depending on how fast we are going. This normally means cutting the spark or the fuel, which in turn can cause unnecessary stress on the engine, and if done in a crude way can also mean a jerky and seemingly out of control car when cruising down the pit lane. Some ECUs have a much more refined strategy for speed control where some cylinders are shut down completely and the ignition angle reduced on the rest,

significantly reducing the torque of the engine and, just as importantly, also allowing it to run cool. If the engine is also equipped with a drive-by-wire throttle the actual throttle angle can be limited to further enhance the control.

As the pit lane speed limit strategy is based around torque reduction the first thing to look at is which cylinders to cut and how. In order to create a smooth torque reduction it is advisable to use a specific cylinder cut pattern as opposed to a random one most common in traction control and other strategies. Using a specific cylinder cut pattern allows us to choose which cylinders are running, so for example if the engine is a V shape, it is possible to cut out one bank, as shown in **Figure 1**.

If we imagine that the right bank is cylinders 1-4 and the left bank is 5-8, as is typical for a V8, the



All F1 cars are fitted with a steering wheel button that imposes a speed limit on the car. It can only operate in 1st, 2nd and 3rd gears and must be selected by the driver

Matrix: Cut Method Selection By Source

Torque_Reduction_Source	Cut_Type	
	IGNITION_CUT	FUEL_CUT
RPM_LIMIT	RANDOM	RANDOM
MAP_LIMIT	RANDOM	RANDOM
ANTI_LAG	RANDOM	RANDOM
EXTERNAL_REV_LIMIT	RANDOM	RANDOM
PIT_LANE_SPEED	RANDOM	SPECIFIC_CYLINDER
TRACTION_CONTROL	RANDOM	RANDOM
GEAR_CUT	RANDOM	RANDOM
EGCU_CUT	RANDOM	RANDOM
PROTECTION_CUT	RANDOM	RANDOM
OVERRUN_CUT	RANDOM	RANDOM
STUCK_THR_CUT	RANDOM	RANDOM
DTB_CUT	RANDOM	RANDOM

Figure 1: Cut method selection by source

Matrix: Predefined Specific Cylinder Cut Map

PreDefFrgCut (%)

Cylinder_Number	PreDefFrgCut (%)																				
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	-	-	-	-	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT
2	-	-	-	-	-	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT	CUT
3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 2: Predefined specific cylinder cut map

Matrix: FBW Maximum Requested TPS

out_Tps (%)

In_Tps (%)	out_Tps (%)																				
	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0
RPM_LIMIT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
MAP_LIMIT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
ANTI_LAG	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
EXTERNAL_REV_LIMIT	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0	87.0
PIT_LANE_SPEED	80.0	80.0	80.0	22.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0	19.0
TRACTION_CONTROL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
GEAR_CUT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
EGCU_CUT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
PROTECTION_CUT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
OVERRUN_CUT	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
STUCK_THR_CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DTB_CUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Figure 3: Maximum requested TPS

Matrix: Pit Lane Speed Limit (kph)

CAL_POT

	CAL1	CAL2	CAL3	CAL4	CAL5	CAL6	CAL7	CAL8
	60.0	60.0	60.0	60.0	60.0	60.0	60.0	40.0

Figure 4: Pit lane speed limit (kph)

‘It is also possible to have a pit lane speed limit based only on the engine speed. This requires that we are able to calculate the expected speed given an engine rpm vales and the gear position’

cut pattern (Figure 2) would shut down one bank of the engine during optimum engine speed. The target is to be at around 50 per cent torque reduction at the speed limit.

It is worth noting that if the cylinder numbering is different to the above configuration the cut pattern will look different.

Using drive-by-wire throttle control further increases the control we can have over the pit lane speed limit by restricting the amount of throttle opening allowed when the strategy is active or even requesting a specific angle. Using this technique also means the torque reduction will be minimal, which means the pit lane speed limit will be smoother. If an absolute angle is requested it is sensible to set it slightly above

the angle needed to maintain the pit lane speed, just in case the pit lane is at an uphill angle. Another option is to set the throttle request proportional to what the driver is requesting, which essentially allows for partial control.

The maximum throttle position is then configured in a map which looks at the torque cut requested by the strategy, and we set the maximum angle to be used as shown in Figure 3.

There are some obvious inputs needed for the pit lane speed limit strategy to function correctly. First is the actual speed limit. This cannot only be adjusted in the ECU, but also by which map is selected. This means that if the pit lane speed limit is changed for any reason it could be enough to change engine maps to one that is suitable – see Figure 4.

Then there is the source of the actual speed the strategy uses; normally this would be one of the wheel speed sensors or the speed is based on a strategy that selects the appropriate speed at each moment. For example, if a sensor goes down the strategy could choose to ignore this input. It is also possible to have a pit lane speed limit based only on the engine speed. This requires that we are able to calculate the expected speed given an engine rpm value and the gear position.

Some other interesting settings are also available such as the pit lane speed limit catch speed, which means it is possible to set a speed at which the strategy will not activate. Doing this should filter out any accidental presses of the pit lane speed limit button while driving around the track. There can also be a minimum engine speed value to prevent the engine stalling during pit lane control and a stuck switch detection which counts how long the button has been pressed for and after a set amount of time simply ignores the value.

Setting up speed limiters for other things than the pit lane is in most ways similar, but perhaps with fewer fail safes and possibly more driver interaction, if required.

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Blanking and wing position

Continuing our studies on the VUHL 05 sports car

The Mexican-built VUHL 05 sports car comes under the Aerobytes spotlight again. The concept behind the VUHL 05 – in the same 'lightweight sports car for road and track' genre as the Lotus 2-11, the Ariel Atom, the BAC Mono and the Caterham AeroSeven – belongs to the Echeverria brothers, Iker and Guillermo. The car was undergoing development work by UK-based Collins Advanced Engineering, run by brothers Jenner and Jilbruke Collins, enabling *Racecar Engineering* to host the car in one of its MIRA full-scale wind tunnel sessions.

Briefly recapping on last month's introduction, in baseline trim the VUHL 05 was found to have moderate drag commensurate of an open sports car with quite modest, forward-biased downforce, the starting coefficients and balance figure as shown in **Table 1**.

The team wanted to ascertain the contribution to total drag of the car's cooling

systems, which comprised a front mounted water radiator and an intercooler in the right-hand side duct. Inlets were at the front, in the sides and underneath at the rear, and there were through-ducts and exits in various places on the car. **Table 2** shows the changes (deltas or Δ values) from covering all the inlets and outlets.

Downforce and its distribution changed with the cooling system being blanked off, but perhaps the most important number here is the drag contribution of the system. 27 counts

of cooling drag is, according to J. Katz's book *Race Car Aerodynamics*, better than average for a production car, with the average value quoted being 40 counts. Furthermore, the cooling system only contributed a three-count reduction in front downforce, when some production-based racecars suffer much greater front lift from poorly executed cooling systems. The 25-count benefit to rear downforce of having all ducts open was curious but useful, and may indicate that some of the drag



Table 1 – Baseline aerodynamic data on the VUHL 05

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	0.533	0.135	0.102	0.032	75.6	0.253

Table 2 – The effects of blanking all the cooling system inlets and outlets, changes shown in counts (1 count = a coefficient change of 0.001) relative to the baseline data in Table 1

	Δ CD	Δ -CL	Δ -CLfront	Δ -CLrear	Δ %front	Δ -L/D
All ducts blanked off	-27	-23	+3	-25	+18.2%	-31



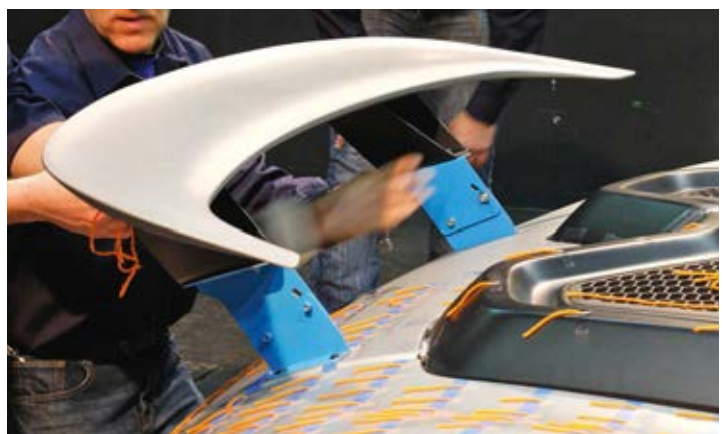
Picture 1: Cooling flows were examined on the VUHL 05 open two-seater sports car



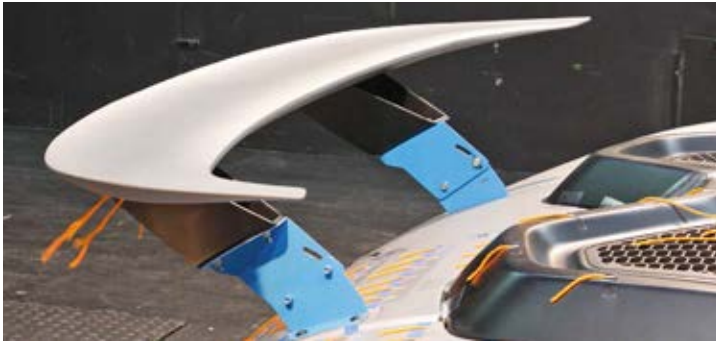
Picture 2: Inlets at the front, side, in the centre next to the driver and underneath at the rear were covered over (in blue for clarity)



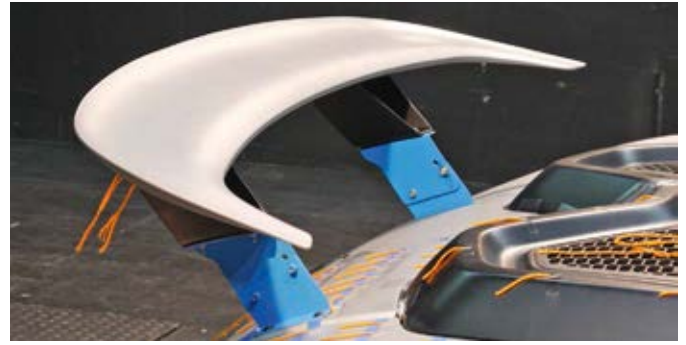
Picture 3: Outlets on the rear deck and in the rear panel were also covered over



Picture 4: The rear wing was raised and moved aft with these spacers



Picture 5: The wing at the minimum angle tested (at the modified location)



Picture 6: The wing at maximum angle tested (at the modified location)

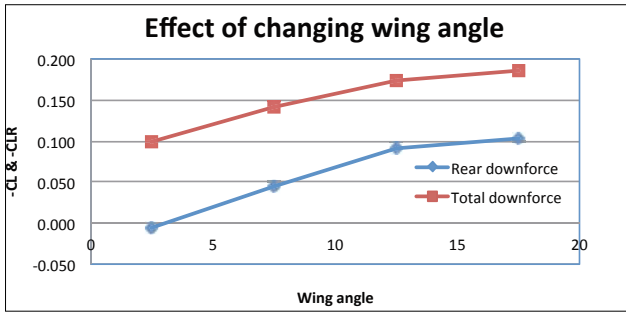


Figure 1: Rear and total downforce versus wing angle at the modified location

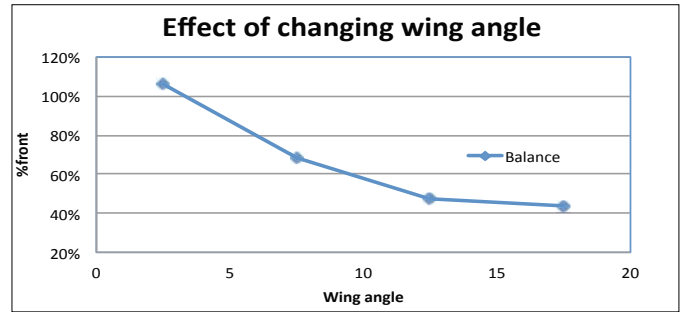


Figure 2: Percentage front versus wing angle at the modified location

Table 3 – The effects of raising the wing by 115mm and moving it 100mm further aft, changes in counts relative to the baseline

	Δ CD	Δ -CL	Δ -CLfront	Δ -CLrear	Δ %front	Δ -L/D
Move wing	+9	+39	-19	+60	-27.9	+68

Table 4 – The effects of altering rear wing angle and fitting a 30mm Gurney; the datum angle was 12.5deg, measured in the centre

Wing angle	CD	-CL	-CLfront	-CLrear	%front	-L/D
2.5deg	0.512	0.099	0.105	+0.006	106.1	0.193
7.5deg	0.524	0.141	0.096	0.045	68.1	0.269
12.5deg	0.542	0.174	0.081	0.092	46.6	0.321
17.5deg	0.553	0.185	0.081	0.104	43.8	0.335
17.5deg + Gurney	0.590	0.233	0.064	0.169	27.5	0.395

attributed here to the cooling system in fact came with this rear downforce increase, with additional induced drag accruing from the wing.

Rear wing

Prior to the session VUHL shipped over some rear wing mounting extensions to evaluate a higher, further aft location. The extensions also allowed some wing angle changes to be made. **Table 3** shows the results of moving the wing up by 115mm and aft by 100mm.

Moving the wing up and back thus produced an efficient rear downforce gain (60 counts of rear downforce for just nine counts of drag, a gain in the ratio of 6.66:1), but also a significant shift in overall balance, this now being 47.7 per cent front. The 19 count drop in front downforce would be the result of the wing's mechanical leverage from its position aft of the rear axle. The flows on the wing's important lower surface exhibited less separation at this raised, further aft location, as evidenced by wool tufts. It was also apparent that the wool tufts in the rear diffuser showed surprisingly well-attached flow with the wing working better in this location.

The wing was then swept through a set of angle changes, and finally a large (30mm) Gurney was installed (along with some 'spill plates' adjacent to the mounts, although it was ascertained in a subsequent run that these had almost negligible effect so the data is shown as the product of the Gurney alone). **Table 4** shows the full data set, and **Figures 1** and **2** plot the effects of the wing angle sweep on rear downforce and balance.

The changes fitted the expected patterns, with drag rising more or less linearly across the wing angle range, while rear (and total) downforce gains started to tail off as the wing got towards its stall angle at this new location, as the plot in **Figure 1** demonstrates.

Figure 2 shows how the balance altered with wing angle at this location, and indicates that in order to achieve a value of around 35 per cent front (to better match the static weight split of 37-39 per cent front) it would be necessary to either trade off some front downforce or increase rear downforce still further. One such method would be to add a Gurney to the wing to enable the stall point to be delayed, and the last line in **Table 4** shows the effect of a large

30mm Gurney. This produced a further 65 count gain in rear downforce, albeit with a not very efficient 37 count increase in drag.

Forces for courses

To put this interpolated 'balanced data' into a more practical context we should examine what the tyre contact forces would be relative to static weight. In rough terms these coefficients would see an additional 4.4 per cent vertical force on the front tyres and 5.3 per cent on the rear tyres at 100mph (44.7m/s). This may sound modest, but from a run in which all the aero devices were removed, the VUHL would generate as much positive lift without its downforce-inducing appendages as it produced in actual downforce with them. In other words, the VUHL would have 9-10 per cent more grip at 100mph with its aero kit.

Next month: We conclude our study on the VUHL 05 by examining the car's front end. *Racecar Engineering's thanks to Iker Echeverria at VUHL, and Jenner and Jilbruke Collins at Collins Advanced Engineering.*

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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MIRA's £2.5m new Suspension Parameter Measuring Machine (SPMM) was officially unveiled in December 2014

The ultimate test

MIRA has invested £2.5m in its Kinematics & Compliance facility with a new twin-axle dynamic Suspension Parameter Measuring Machine

By SIMON McBEATH

MIRA's Nuneaton site has housed the UK's only quasi-static two-axle Suspension Parameter Measuring Machine (SPMM) since 1996, a facility that has been used not only by a large automotive clientele but which has also been put to good use by all of the UK-based Formula 1 teams. Other motorsport categories have also benefited from sessions on the SPMM including GT, touring car and rally teams. A brand new SPMM was officially opened by Bob Joyce, executive director of Jaguar Land Rover, in December bringing enhanced capabilities to MIRA's Kinematics & Compliance department. The new machine features an increased mass and wheelbase capacity, and its state-of-the-art high speed actuators allow measurement of both quasi-static and dynamic kinematic and compliance characteristics. This dynamic

capability also enables the measurement of vehicle mass properties, centre of gravity and moments of inertia – crucial data for vehicle dynamics and simulation studies. So, what exactly does it do, how does it do it and how could it be of benefit? *Racecar Engineering* has been to check out Europe's only independent, 'high speed' twin-axle K&C rig.

First, let's look at some fundamental definitions to help explain what MIRA's latest investment actually enables. 'Kinematics' in this context describes the changes in orientation of the road wheels arising from the particular suspension and steering geometries as the vehicle is subjected to heave, roll and pitch motions. And 'Compliance' in this instance refers to changes in the orientation of the road wheels caused by the application of loads at the tyre contacts and arising from the use of

elastic elements within the suspension system. 'Elastic elements' should perhaps be regarded as anything less than completely rigid in the tyre/wheel/suspension/steering system. In essence then, MIRA's SPMMs enable measurements of a vehicle's K&C characteristics producing data that greatly enhances the understanding of ride, handling and steering performance. This data can be used for target setting for a new car programme, benchmarking an existing car, developing and problem-solving prototypes and current vehicles, validating new designs and supporting CAE simulation activities.

The SPMM rigs function by applying individual or combined motions or forces to the vehicle. The body/chassis can be held in a fixed attitude or it can be displaced in heave, roll or pitch while cornering, braking or traction forces are applied, as appropriate. The steering

'The new rig is superb for racecars because its exceptional accuracy is very appropriate for high stiffness vehicles'

'Accurate simulation requires the use of good mass property data, which the new SPMM is also capable of measuring'

system can also be independently controlled to either turn to pre-determined angles or controlled to a given steering torque. And more than 220 individual data channels are logged to provide output covering a wide range of parameters including wheel rates, steer and camber changes plus lateral and longitudinal suspension swingarm vectors.

Racecar Engineering visited the new SPMM machine and spoke to vehicle dynamics consultant Ian Willows, a member of the MIRA Vehicle Dynamics team for some 26 years, to delve deeper into the detail. At the start of a session the test car is raised on a lift and rolled onto the SPMM machine. The chassis is firmly attached to the centre table of the rig using clamps fastened to the sills of production-based vehicles (bespoke engineered solutions are used for non-production based racecar chassis). The centre table is controlled by six electric actuators that move the body/chassis in heave, roll, pitch and yaw and also generate full body position

data. 'The higher speed actuators on the new SPMM allow measurement of suspension characteristics at frequencies up to around 4Hz, frequency here referring to input frequency rather than suspension frequency, as well as in the normal quasi-static regime,' says Willows.

Accuracy is key

Meanwhile the tyres sit on four x-y tables, each of which measures the forces and moments at the tyre/ground interface. These x-y tables can be controlled to zero force, allowing unrestrained wheelbase, track and steer changes during the kinematic tests, or driven to apply lateral and longitudinal forces or aligning torques during the compliance tests. In addition, four high resolution 'dynamic arm' encoder systems, accurate to less than 0.1mm (~0.004in) attach to the wheels at the hub centreline, either via machined plates that bolt to the wheel studs or via a centre lock adapter in the case of race wheels. These dynamic arms

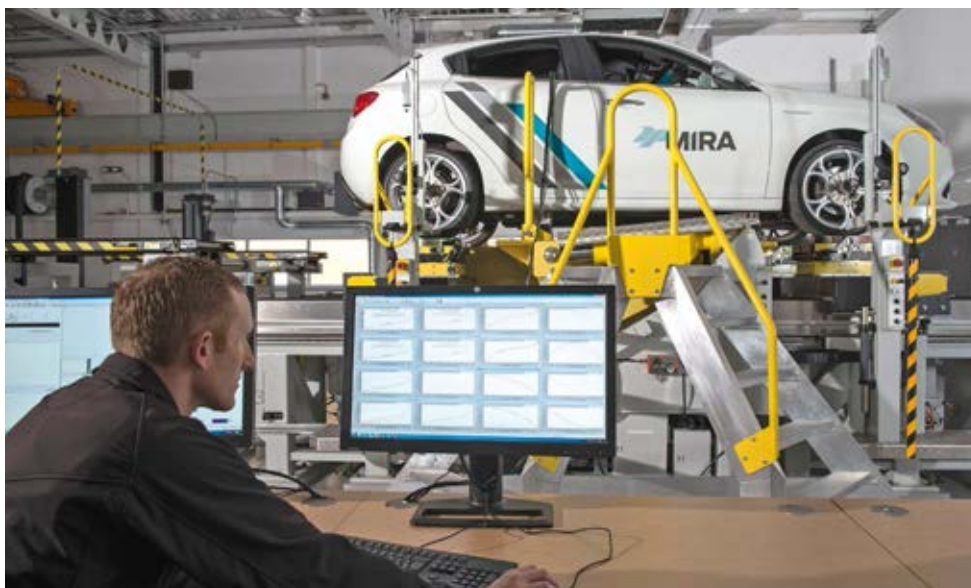
measure the road wheel x, y and z coordinates and steering, camber and spin angles.

So what can we learn from this? Willows again: 'We post process the raw data channels to derive a characteristic data set that completely describes the kinematic and compliance behaviour of the suspension and steering systems. Parameters such as tyre stiffness, wheel rate, bump steer and camber, roll stiffness and roll centre migration and anti-dive and squat characteristics are all captured together with the basic road-wheel geometry and force information. The kinematics of the steering system; ratio and Ackermann, how camber varies, and the relationship of the steering axis to the tyre contact centre are all defined.'

This information can then be used in a variety of ways, for example, to:

- Assess variations between design and reality; do the suspension characteristics meet the design intent?
- Determine the effect of component changes; new parts can be compared to previous parts and/or to simulation
- Correlate multi-body simulation models, such as those assembled using ADAMS or similar software,
- Create parametric models that perform handling simulations where insufficient data exists for detailed multi-body simulations

Willows expands on the use of the SPMM to generate the data required for simulations: 'Accurate simulation also requires the use of good mass property data, which the new SPMM is also capable of measuring. To generate this, four load platforms are inserted at the points where the vehicle body is attached to the centre table to measure body reaction forces. The car is then excited in the vertical direction to determine the total mass and its x-y distribution. Subsequent roll and pitch movements enable the z-location of the centre of mass, that is, the centre of gravity height to be calculated. The



Acquiring data from the SPMM on MIRA's test mule



Chassis clamps fore and aft of the front and rear wheels, dynamic arms attached to the wheel hubs, and x-y tables under the tyres interface with the vehicle

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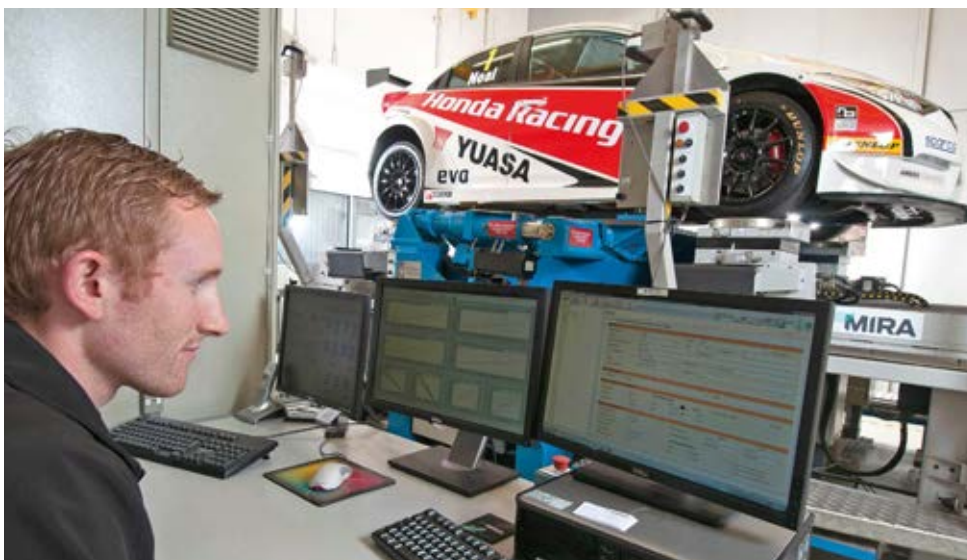
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Fixing one of the dynamic arms to the wheel hub



Team Dynamics' Honda BTCC racecar under test on the old SPMM

MIRA's Vehicle Dynamics group and the new SPMM



Right to left: MIRA vehicle dynamics consultant Ian Willows, Dynamics Group managing director Anthony Best and founder and director Tony Best with the SPMM

Comprising around 14 people in the test group and four simulation engineers the Vehicle Dynamics Group at MIRA operates across automotive and military sectors as well as motorsport and can carry out full vehicle development as well as test and development of cars in production.

The new £2.5M SPMM was designed and built by AB (Anthony Best) Dynamics, as was MIRA's original machine, installed in 1996. The original design was based on a machine at Goodyear's Akron, Ohio base, and has a four-tonne capacity, whereas MIRA's new machine has a six-tonne capacity. The wheelbase capacity has also gone up from 4m (13ft 1½in) to 4.5m (14ft 9in). High speed actuators on the new machine enable higher frequency movements of up to 4 to 5Hz, while the dynamic arm encoder system measures wheel position data to twice the accuracy of the original draw wire encoder system. The new machine is also CAN-capable, enabling communication with vehicle on-board systems allowing, for example, interaction with EPAS inputs.

vehicle is then oscillated in roll, pitch and yaw about an axis system through the centre of gravity to measure the moments of inertia and determine the principal moments of inertia, vital inputs for all dynamic simulation software.'

So how appropriate is the rig for competition vehicles? 'The new rig is superb for racecars because its exceptional accuracy is very appropriate for high stiffness vehicles. In terms of mounting a car to the rig, most F1 teams have developed their own mounting plates, and MIRA provides a drawing of the SPMM centre table to facilitate this. MIRA can also provide bespoke engineering services to manufacture mounting clamps for a specific car, and this initial set-up cost is modest,' says Willows.

Value for money

A typical session on the SPMM depends on the client's requirements. 'For example an F1 team would generally require an extensive test programme on a new car and might spend two to three days quantifying the effects of different anti-roll bars, springs and dampers, and studying the suspension installation stiffness (substituting solid links for the normal spring damper arrangement). We can load a racecar to simulate the effects of downforce via changes in ride height. And we're often requested to install extra sensors and also to log data from the team's own sensors on the car. It would probably take a day to mount the car onto the SPMM and set up for such a scenario. More typically though, a team wanting to fully categorise a car should consider that a two day session is the minimum to both mount the car to the rig and perform the necessary test schedule. The cost for this is currently £12,400 (€16,800 or US\$18,500), with an extra £3000 (€4065 or US\$4475) for moment of inertia and CoG data derivation. Obviously, additional tests would attract a pro rata additional cost.

'Production car manufacturers have been gathering and using this type of data for over 20 years whereas the first motorsport clients started coming to MIRA about 15 or 16 years ago. Now we're encouraging others to come and use these facilities,' says Willows.

If this service sounds expensive then consider that as well as characterising a vehicle's suspension behaviour, MIRA has also been able to spot some simple yet fundamental deficiencies in racecars it has run on its SPMMs, including defective components, high friction levels within suspensions, low suspension stiffnesses, compliant steering systems and inefficient anti roll bars. In relation to the cost of track testing time and the difficulty of actually diagnosing such problems in that context, a couple of days' benchmarking and analysis on the SPMM looks like good value.

Check out this MIRA video at www.youtube.com/watch?v=EoNkn-cRgZc or search the web on 'MIRA vehicle dynamics development full length youtube.'



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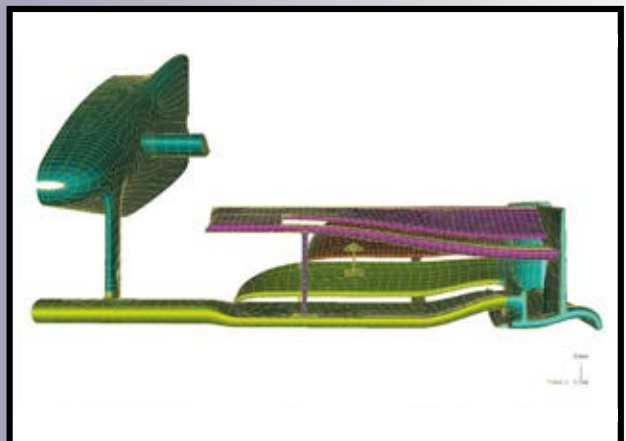
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Laser scanning

The technology behind metrology is now so advanced that it plays a major role within any racing team

By GEMMA HATTON

There are 100,000 components on a Formula One car, 7500 of which are unique in their design. With the average team completing 30,000 design changes per season, this means there are a phenomenal one million parts that are manufactured per season, per team. Yet, the most impressive statistic is that every one of these components is inspected fully, such as the demands for Formula One's quest for perfection.

Teams are constantly under pressure to improve the quality of their manufactured parts and achieve faster production times, and this requires responsiveness and flexibility. This gave birth to the concept of 'data driven manufacturing', where highly-advanced metrology equipment such as laser trackers are used to measure data at various points throughout the production cycle. This data can then be analysed and used to base decisions on, as well as preventing potentially disastrous and expensive situations where a component may not have been properly manufactured. Therefore, dimensional inspection has been revolutionised from an end of the line process to a real time process, where the quality can actively be improved during manufacture. This capability is invaluable to a team like Infiniti Red Bull Racing which has only five months between starting with clean sheet of paper and getting a Formula One car on track. Yet production flexibility is only one of the many advantages the metrology technology of today can bring to F1 teams.


Dynamic measuring

For motorsport applications, laser trackers are the metrology tool of choice and were originally launched in the 1990s – laser trackers are essentially portable CMM machines that use a laser beam and a reflector to measure the co-ordinates of an object in 3D space. The basis of any laser tracker is an interferometer (IFM) and/or an absolute distance meter (ADM). The former determines the change in distance from one point to the next and can achieve accuracies to the micron. As **Figure 1** demonstrates, the laser beam that is projected to the reflector and the laser beam reflected back are both monitored – the red waves – and as the position of the reflector is changed, the reflected beam also changes. This results in the wave peaks crossing each other and therefore generating

a superposition wave. Consequently, each peak of this superposition wave represents a change in distance of half a wavelength, or 0.32 microns, and as the direction of movement is known, the number of peaks can be counted and then multiplied by half of the wavelength to determine the exact change in distance. This method is highly accurate and as the speed at which the reflector is moved at determines the update rate, the change in location is known regardless of how quickly the target is moved – making it the perfect for dynamic measuring.

However, an IFM is only useful for changes in distance and thus requires a known starting point in 3D space, whereas an ADM has the capability to measure absolute distances. Unfortunately, ADMs have to deal with integration times – the time taken for the system to obtain the target's position – and the longer this integration time, the increased likelihood of introducing error.

The Leica Absolute Tracker AT960 from Hexagon Metrology combines

these technologies to create the Absolute Interferometer (AIFM) to measure the distance of a moving target without the error associated with the target moving during the integration time. 

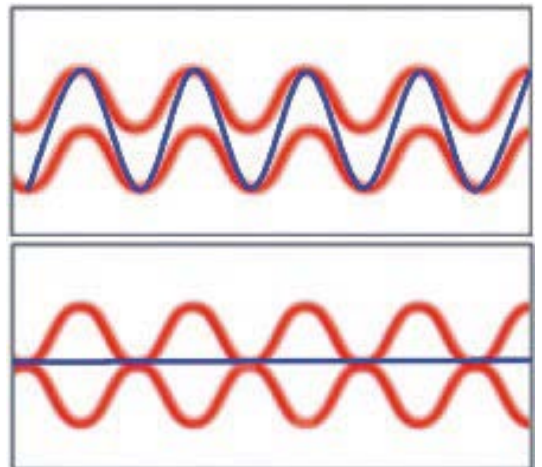


Figure 1: The superposition wave generated from the laser beam sent from the laser and the reflected beam



Measuring the engine cover using a Leica Absolute Tracker AT960



The portable system being set up in the Red Bull Racing garage

Clever stuff, but what does this actually mean for motorsport? The innovation of AIFM technology offers the speed and accuracy of measurement required by teams and so Leica Absolute Trackers were first utilised to reduce bottlenecks within the manufacture process often associated with CMM machines. Now that their measurement time has been reduced from two hours to 20 minutes using these trackers, parts can be efficiently checked and thus be rejected before they are integrated onto the car, reducing the cost of any mistakes. In 2014 Chris Charnley, quality Manager at Infiniti Red Bull Racing, conducted a demonstration to show the team's engineers the benefits of laser trackers. 'I measured the car using the Leica Absolute Tracker system and the results were astonishing,' he explains. 'We detected errors in the region of 2mm on various areas of the car, which the engineers just could not believe. After that, they used measurement data to inform the car setup process, he says.

This is where Hexagon Metrology's latest innovation, the Leica Absolute Tracker AT960, comes into its own. With its ability to conduct single-point measurements to a reflector or use the handheld Leica T-Probe to measure 1000 points per second, the AT960 is being used extensively in both the factory and the pit lane. 'Racing teams are trying to get their perfect design as close as possible to the standards laid out by the sport's governing body. Almost all of the teams in F1 have CMM systems. However, the team at Infiniti Red Bull Racing are implementing our products to their full extreme,' explains Duncan Redgewell, vice resident of Hexagon Metrology – Laser Tracker and Portable Measuring Arms. 'This is why they are taking the Leica Absolute Tracker AT960 to race weekends, because this new system is small and portable enough to be used to help adjust aerodynamic setup to an accuracy on the micron scale.'

The handheld Leica T-Probe is used at the racetrack to set up the car using single point

measurement. The system can also be used back at base for reverse engineering, which is where other teams are likely to be utilising this technology. 'Alongside CFD, teams use trial and error in wind tunnel tests to improve aerodynamic performance. This is where engineers could potentially use the AT960 and the Leica T-Scan handheld laser scanner to scan millions of points and then import it into CAD software, ready for manufacture,' says Redgewell.

Unlimited use

The main goal when designing the AT960 was to make it highly portable, yet retain the high accuracy while being battery powered. The jet-setting lifestyle of F1 emphasises the need to have a reliable system which can be transported from one race to the next without having to recalibrate it every time it is used. In fact, the reliability of the system means that it only takes five minutes to take it out of the box and start measuring. This ease of setup allows anyone to use this equipment, meaning no specific laser tracker operator is required. 'The AT960 is a new replacement product built from the ground up, there are no components from the old product,' highlights Redgewell.

The most challenging aspect of laser scanning is dealing with shiny, reflective, black surfaces, so carbon fibre components present a major problem. 'Carbon fibre almost has a glaze over the top surface, so are you actually measuring the top surface or slightly underneath the surface,' Redgewell continues. 'This is an issue which we can allow an offset for. Other scanning technology requires putting a white powder on the top surface to reduce reflections, but this struggles to scan a large range of colours and backgrounds. The AT960 has the ability to scan almost any colour and any surface.'

As this technology continues to advance, the question that springs to mind is can these handheld scanning units be used as an espionage tool to scan competitor's cars? According to Redgewell this is highly unlikely as the Leica T-Probe and Leica T-Scan need line of sight to the laser tracker unit to record its measurements. Therefore, despite the attractive speed of the operation, laser tracker measurements are not particularly covert.

'For F1, the future is more about how teams change their processes to use this data. Suddenly they have the ability to aid fault diagnosis without having to return all of the associated parts to the factory for checks, which has proved enormously valuable,' highlights Redgewell.

'This is the first season that Infiniti Red Bull Racing is able to take a system like this to the racetrack. There's already a lot of interest now that people are starting to see it being used in the garage, so in the future I imagine it will start to become a fundamental part of an F1 team's race weekend.'

'The AT960 has the ability to scan almost any colour and any surface'



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Measuring up

Case Study: 3D scanning

By GEMMA HATTON

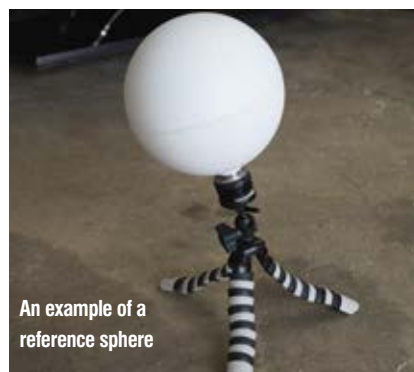


Figure 2



The black and shiny suspension arms need to be covered in a white chalk based powder spray to make the surface appear matt to ensure that the whole component can be seen by the scanner

‘Only when we are satisfied with the accuracy of the scan will we use techniques to minimise cumulative errors’



An example of a reference sphere

As the capabilities of 3D scanning continue to become more relevant to motorsport, one interesting area which this technology is revolutionising is the restoration of historic vehicles. 3D Engineers is the perfect example of a company which is applying modern scanning equipment to reverse engineer and bring these ancient vehicles back to life.

To fully demonstrate all the processes behind reverse engineering a complete racecar using scanning equipment, 3D Engineers came to Cranfield University and completed a full car scan on a Formula BMW.

The first stage was to ensure that there was enough space around the car to match the scanners ideal range. Next, the types of surfaces that were being scanned had to be analysed, explains Stuart Brown, Owner of 3D Engineers. ‘Scanners generally hate shiny surfaces due to their reflectivity, but also dark colours such as blacks and blues and then you have to deal with transparency such as the windscreen. This is why with the windscreen and the suspension arms we used a chalk based powder spray to matt the surfaces down so that they could be seen more easily by the scanner.’

Figure 2 illustrates what happens without this chalk based powder spray. This is a single scan which was completed without the chalk spray, and as you can see none of the suspension arms have been seen by the scanner, and thus they appear invisible.

Increased accuracy

Once all the surfaces have been matted, the next step is to place ‘spheres’ around the vehicle, which are used as reference points. A test scan is then run to allow the scanner to idle so that all the internals can get up to temperature. Otherwise an issue can occur where the scanner ‘ramps up’ during the first few scans, which increases likely errors.

Essentially, the scanner completes a scan at different points around the Formula BMW, and in the software all of these different scans are combined together. However, to increase the accuracy of this process, rather than just assigning reference points by eye, these spheres are used as Brown explains. ‘We use the spheres to ensure our reference points are a known piece of geometry rather than just a freeform shape. There is a lot of data on the outside surface of the sphere which the software uses to extract the centre point of each sphere from. We use eight spheres placed at different locations and heights around the vehicle so that each scan will capture at least three or four spheres, and some of those will overlap with the next scan. The software then compares the centre points of the overlapped spheres between two scans and then brings these points together, and therefore the two scans.’

This process can be illustrated as in Figure 3, where two scans from different positions



The scanner is mounted on a tripod so that each scan is 'global' – this improves accuracy when the multiple scans are brought together, rather than focusing on a small area

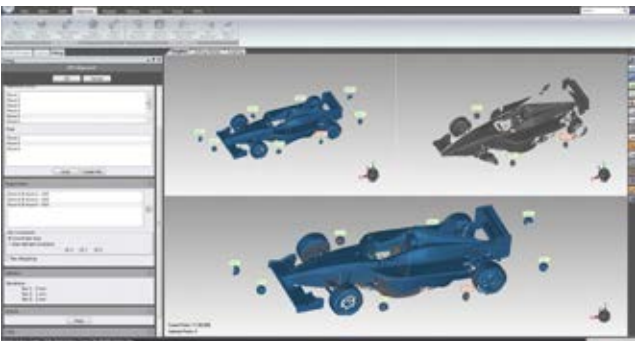


Figure 3

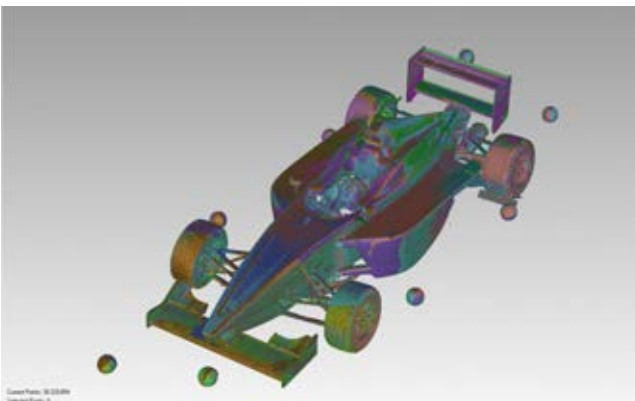


Figure 4

around the car (blue and grey) have been combined together using the spheres as reference points. This process is repeated with each scan integrated into the previous one and therefore a 3D model of the car is built up.

Each scan is imported into the software as a point cloud and once all the multiple scans have been joined together, as illustrated in **Figure 4**, the point cloud consisted of 38million points. Here the different shades represent all the different scans.

Minimising errors

To generate a surface from these point clouds, a polygon approach is used as illustrated in **Figure 5**. The different colours represent the differences in distance, with green representing 0mm difference from the surface and thus ideal. Extra polygons have been added to areas which show a larger offset, similar to refining a mesh

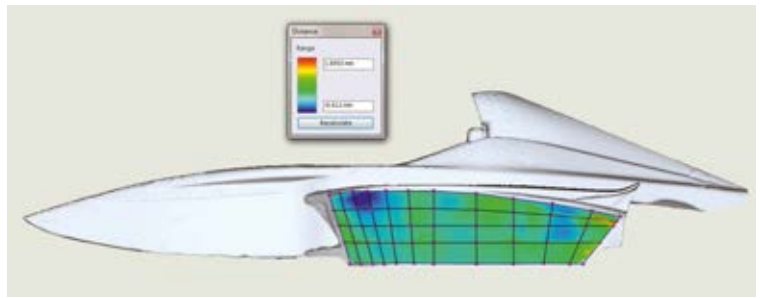


Figure 5

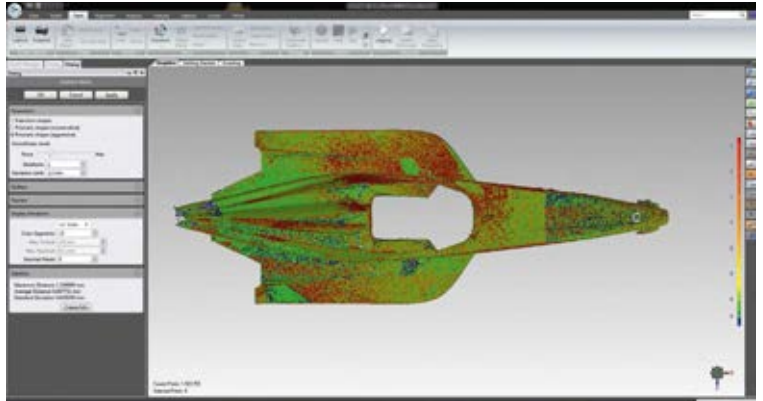


Figure 6

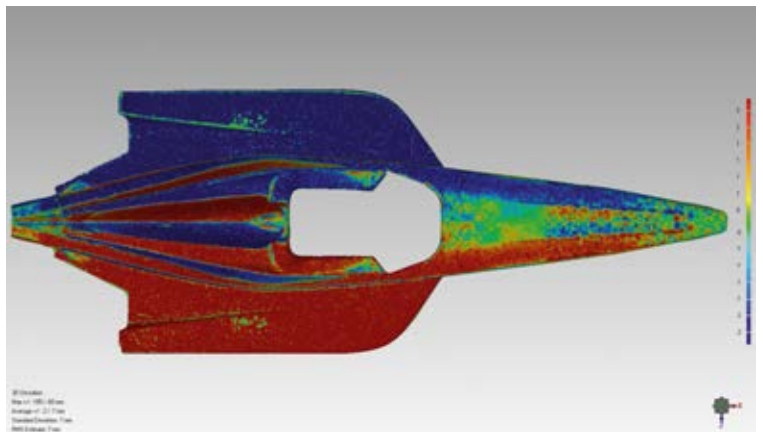



Figure 7

in CFD or FEA. Once all the surfaces have been generated and re-meshed, the 3D CAD model is finally created.

As with any repeatable process, maintaining reliability and accuracy is vital and the joining together of multiple scans can lead to large stacking errors. This is illustrated in **Figure 6** where the red and blue points are some distance away from the true value and therefore need to be moved to the statistically correct positions. 'You have the natural error of the scanner, the error induced when you re-jig the points to the correct position, the error as you join the scans together and then errors throughout the polygon and CAD surface phase,' explains Brown. 'Only when we are satisfied with the accuracy of the scan will we use techniques to minimise cumulative errors.'

Another interesting aspect of 3D scanning is the fact that most vehicles are

to a greater or lesser extent unsymmetrical along the centreline of the vehicle. **Figure 7** demonstrates this, where the original scan has been mirrored and the blue points illustrate areas that are below the surface, red is above the surface and green shows where the two scans match exactly – as you can see there is not much green. This however, can be refined by reducing the scale.

A very important aspect throughout the entire process was data management. When you are dealing with numerous scans, all of which transform into point clouds in the millions, it is important to cut out any excess data such as the floor or nearby surroundings which will dramatically reduce the processing and simulation time. This technique is continued throughout the whole process to try and ensure that only the required shapes are analysed to speed up productivity. 



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Setup sensitivity and how to deal with it

How to quantify and maximise sensitivity through 2D and 3D tyre models

By DANNY NOWLAN



One of the greatest debates you'll see in racecar vehicle dynamics is setup sensitivity. You'll have some old engineers swear black and blue that if you change the rear springs by 100 lbf/in on a high downforce open wheeler it will make you 0.7s per lap faster. However, you will also deal with racecars that are sensitive for reasons that aren't initially obvious. Also, as a simulator principal, when your product doesn't reproduce these results you are usually the first in the firing line. The truth is somewhere in the middle and this is what we'll be exploring in this article.

What we'll be discussing in this article is how to quantify setup sensitivity for a 2D tyre model and the steps you need to take to maximise this. What we mean by a 2D tyre model is traction circle radius as a function of load only.

In particular we'll discuss the mathematical basis and how you can put hard numbers to this. Then if the tyre model requires more sensitivity I'm going to introduce you to the thermo exponential tyre model. It's a buried feature within ChassisSim and I recently had to use it for a customer and it got me out of a tight spot. Some very useful lessons were learnt and we'll discuss both of these in depth.

Before we discuss this in detail I need to make it clear there is no way a lap time simulation package will be as sensitive as the actual racecar. It all comes down to the way the car is driven. The primary reason is the simulator knows exactly where the grip is and it has no concept of its own mortality. In total contrast, a racecar driver is like a box of chocolates. You have no idea what you are going to get. The skill

levels vary and they are acutely aware of their own mortality and the bills they have to pay for a crash. They also don't know exactly what the grip levels are. Consequently you are going to see much bigger variations in the data. It's that simple. However, the simulator when set up correctly will point you in the right direction, albeit the lap time deltas will not be as large.

The first step to understanding setup sensitivity is understanding what a parabolic fit of the traction circle (TC) radius vs load characteristic tells you. Mathematically this is what we are talking, see **Equation 1**.

Equation 1 is the building block of tyre analysis. It's also the D term you get back from the Pacejka equation so it's worth your while getting your head around it. Some typical racing numbers for this are presented in **Table 1**.

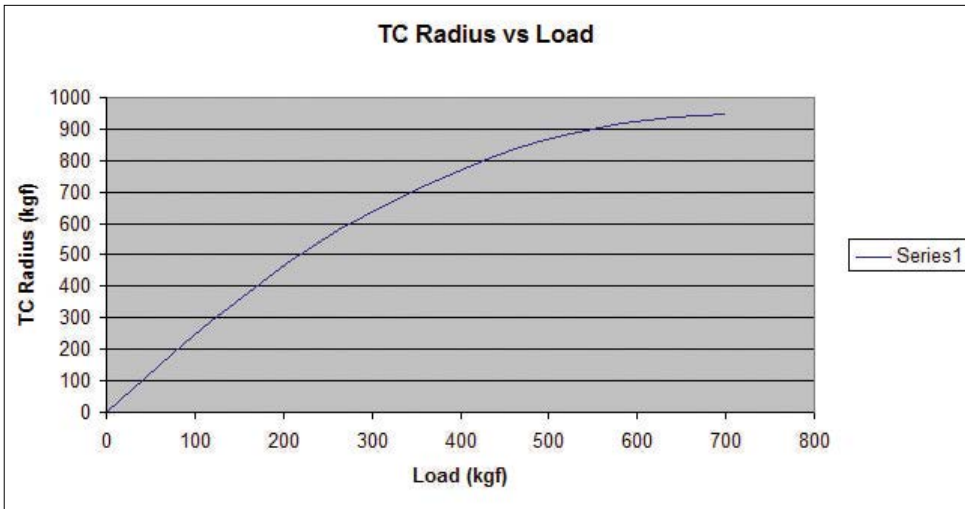


Figure 1: Plot of 2D function of the traction circle

Table 1 – 2D Tyre model numbers for a high downforce open wheeler

Quantity	Value
K_a (Initial co-efficient of friction)	2.7
L_p (Peak load)	700 kg
K_b (Load drop off / N)	7.3×10^{-6} /N

Table 2 – Open wheeler parameters

Quantity	Value
Car Mass	700 kg
Weight distribution at the front	0.43
CLA	3
Rear Bar range	0-70N/mm
c.g height	0.3m
Corner speed	120 km/h
Corner acceleration	1.8g
Mean track	1.57m
Lateral Load transfer range at the front	51.6 - 44.7%

EQUATIONS

Equation 1

$$F_y = k_a (1 - k_b \cdot F_z) \cdot F_z$$

$$L_p = \frac{1}{2 \cdot k_b}$$

where

F_y = Maximum possible force (N)
 k_a = initial coefficient of friction
 k_b = drop off of coefficient with load (1/N)
 F_z = load on the tyre (N)
 L_p = Load at which maximum grip is generated

Equation 2

$$F_{yT} = k_a (1 - k_b \cdot (L_S + \Delta L)) \cdot (L_S + \Delta L) + k_a (1 - k_b \cdot (L_S - \Delta L)) \cdot (L_S - \Delta L)$$

$$\therefore F_{yT} = 2 \cdot k_a \cdot (1 - k_b \cdot L_S) \cdot L_S - 2 \cdot k_a \cdot k_b \cdot \Delta L^2$$

Equation 3

$$F_{yT} = k_a (1 - k_b \cdot (L_S + \Delta L)) \cdot (L_S + \Delta L) + k_a (1 - k_b \cdot (L_S + \Delta L)) \cdot (L_S + \Delta L)$$

$$\therefore F_{yT} = 2 \cdot k_a \cdot (1 - k_b \cdot L_S) \cdot L_S + 2 \cdot k_a \cdot \Delta L \cdot (1 - k_b \cdot (2 \cdot L_S + \Delta L))$$

Equation 4

$$\Delta F_{yT} = 2 \cdot k_a \cdot k_b \cdot \Delta L^2$$

Equation 5

$$\Delta F_{yT} = 2 \cdot k_a \cdot \Delta L \cdot (1 - k_b \cdot (2 \cdot L_S + \Delta L))$$

Figure 1 illustrates this graphically. As we can see, it goes up non-linearly and has a peak value of half the initial coefficient of friction multiplied by the peak load. As I mentioned before, this is not the full story but it gives you a good approximation of what the tyre is capable of.

The power of Equation 1 is that we now have the tools to get a first pass of setup sensitivity. Laterally, let's say we have a delta load of +/- ΔL N and a static load of L_S N. From Equation 1 we see Equation 2.

Longitudinally, for a uniform change of load of ΔL N per tyre we see Equation 3.

What all this means in plain English is that we can calculate the lateral forces as function of static load and differential load. In terms of the differentials laterally we have Equation 4, longitudinally we have Equation 5.

The full significance of this will become apparent once we put numbers to this.

Front tyre force

To quantify this discussion, let's consider an open wheeler running in a moderate to high downforce set up. The parameters for this car are shown in Table 2.

For clarity we'll focus our discussion at the front using the parameters from Table 1. So, let's consider when the front bar is disconnected.

The change in load will be given by Equation 6, the change in lateral force for this change will be Equation 7.

Let's now consider the case where the rear bar is at 70 N/mm. The load transfer in this case will be given by Equation 8, so the change in lateral force for this case will be Equation 9.

Here is where the rubber meets the road. From Equation 2 all we need to figure out the differential force, and hence differential corner speed, is to subtract the two differentials in lateral force. We have Equation 10 since cornering speed is given by Equation 11.

It surmises that the differences in speed will be the square root of these changes. So, in this case, we have Equation 12.

What this is telling us is that disconnecting the rear bar will lead to a 1.2km/h change in front cornering speed. There will be drivers and race engineers who will tell you that this change in speed is far too small. Yet the front tyre force curve I have presented will give good correlation throughout the speed range.

To complete this section of this discussion let's evaluate a longitudinal load change. Let's say we make a ride height change and it leads to a CLA change of 0.1. So, at our quoted speed of 120km/h, assuming this is distributed with weight distribution we have a change in load of Equation 13, so the static load is given by Equation 14.

So, the differential change in lateral force can be evaluated using Equation 5. Working the numbers we see Equation 15, so this will be a change of 0.0165g. This will lead to a cornering speed change of Equation 16.

Table 3 – Typical temperature numbers for the ChassisSim v3 exp function

Parameter	Value
T_{opt}	100°C
k_{pre}	4
k_{post}	4
k_{PRE_MULT}	0.7
k_{POST_MULT}	0.8
T_{scale}	50

In order to produce a CLA change of 0.1, you are looking at a 2-4 mm change in front/rear ride height or 2 deg of front/rear wing. Again there are some engineers who will claim this change is simply too small.

Corner speed

The tyre curve we have presented above is the typical initial result that will get you good initial correlation throughout the speed range. Also given that most racecars work in a bandwidth of load change in the order of +/- 20kgf at best, to claim a small setup change will give you 0.5s -1.0s a lap is just complete nonsense. That being said the examples we presented here were relatively big setup changes. However, they produced a 1 km/h change in corner speed. What this illustrates is that the initial 2D traction circle radius curve, while giving good correlation, will at times struggle with setup sensitivity.

The way we solve this dilemma is to use a TC radius model that is a function of both load and temperature, and uses an exponential function. You pull this out of the box where you are confronted with the following circumstances:

- You work through equations (4) - (5) and you have poor setup sensitivity.
- Your testing indicates you have a sensitive racecar.

Both of these questions must be answered before you go down this road. Do not pass go and do not collect £200. This is not up for negotiation. One of the powers of ChassisSim is that it features a thermo mechanical tyre model. This was added to deal with tyres that are razor sensitive to adjustment and this exponential function brings this to its full potential.

The exponential temperature function plots tyre force variation vs temperature as a bell curve as shown in **Equation 17**.

This is a function that is scaled between 0 and 1 and some typical values for this for racing tyres are shown in **Table 3**. Graphically the function will look something like **Figure 2**.

The reason this function is so sensitive is that any change in temperature, particular below the peaks is amplified considerably. That's the nature of the exponential function and this can be readily seen by the slopes before and after the peak traction circle radius value.

EQUATIONS

Equation 6

$$\Delta L = \frac{LLTF \cdot m_t \cdot a_y \cdot h}{tm} = \frac{(51.6/100) \cdot 700 \cdot 1.8 \cdot 9.8 \cdot 0.3}{1.57} = 1217.5N$$

Equation 7

$$\Delta F_{yT} = 2 \cdot k_a \cdot k_b \cdot \Delta L^2 = 2 \cdot 2.7 \cdot (7.3 \times 10^{-5}) \cdot (1217.5)^2 = 584.3N$$

Equation 8

$$\Delta L = \frac{LLTF \cdot m_t \cdot a_y \cdot h}{tm} = \frac{(44.7/100) \cdot 700 \cdot 1.8 \cdot 9.8 \cdot 0.3}{1.57} = 1054.7N$$

Equation 9

$$\Delta F_{yT} = 2 \cdot k_a \cdot k_b \cdot \Delta L^2 = 2 \cdot 2.7 \cdot (7.3 \times 10^{-5}) \cdot (1054.7)^2 = 438.5N$$

Equation 10

$$\Delta F_y = 584.3 - 438.5 = 145.8N$$

$$\therefore \Delta F_y = 145.8N / (m_t \cdot g) = 145.8 / (720 \cdot 9.8) = 0.02g$$

Equation 11

$$F_{yt} = \frac{m_t \cdot V_x^2}{R}$$

Equation 12

$$V_{x_new} = V_x \sqrt{0.98} = 120 \cdot 0.989 = 118.8km/h$$

Equation 13

$$\Delta L = wdf \cdot 0.1 \cdot 0.5 \cdot \rho \cdot V^2 = 0.43 \times 0.1 \times 0.5 \times 1.225 \times (120/3.6)^2 = 29.26N$$

Equation 14

$$\begin{aligned} L_S &= L_{CW} + L_{AERO} \\ &= 0.43 \times (700 \times 9.8 + 3 \times 0.5 \times 1.225 \times (120/3.6)^2) / 2 \\ &= 1913.86N \end{aligned}$$

Equation 15

$$\begin{aligned} \Delta F_{yT} &= 2 \cdot k_a \cdot \Delta L \cdot (1 - k_b \cdot (2 \cdot L_S + \Delta L)) \\ &= 2 \times 2.7 \times 29.26 \times (1 - (7.3 \times 10^{-5}) \times (2 \times 1913 + 29.26)) \\ &= 113.5N \end{aligned}$$

Equation 16

$$V_{x_new} = 120 \times \sqrt{(1 + 0.0165)} = 120.98km/h$$

Equation 17

$$fn(T_t) = k_{MULT} + (1 - k_{MULT}) e^{k \cdot \left(\frac{T - T_{OPT}}{T_{SCALE}} \right)^2}$$

$$T \leq T_{OPT} \rightarrow k = k_{pre}, k_{MULT} = k_{exp_pre}$$

$$T \geq T_{OPT} \rightarrow k = k_{post}, k_{MULT} = k_{exp_post}$$

One of the powers of ChassisSim is that it features a thermo mechanical tyre model

It's worth pointing out that there is no way a lap time simulation package will be as sensitive as the actual racecar

However, before you use this you first need to dial in your temperature parameters of the tyres using the 2D tyre model. The reason you use a 2D tyre model first is that it is not sensitive to temperature. This ensures you don't chase your tail. The first method is to correlate to logged data. You do this on the middle infrared temperature sensor. Remember you are not going to get it perfect everywhere but it gets you in the ball park.

The second method is that you need to take some educated guesses. Based on the logged data we have seen this is what you are aiming for:

- Temperature peaks + 30-40deg from the pit lane or straight running conditions.
- The peak occurring just after peak lateral g.

While this is not perfect, sometimes you will be in a position where you have to make something from nothing. This is the nature of engineering a racecar in the modern era and if you can't make your peace with this then O.P.B (other professions beckon).

Once this is dialled it is time to run the ChassisSim tyre optimisation toolbox that will fill this in from race data. Effectively the way the tyre force optimisation works is it changes the tyre model to minimise the error between actual and simulated g. The rough rules of thumb to get you going are illustrated below in **Table 4**.

What is presented in **Table 4** are the numbers you fill in for the tyre force optimisation toolbox. The value is your start point and the delta is what you put as your

search space. The origin of the numbers presented here were derived from modelling tyres as diverse as V8 Supercars to open wheelers. That being said treat these as a start point only and be guided by the cost functions and the results you obtain.

When you are done, you should have a tyre model that is more accurate and more sensitive than its 2D cousin. To illustrate this, allow me to present some numbers from some customer modelling. Please note this is deliberately vague since this is being used in anger right now. The results are summarised in **Table 5**.

3D vs 2D tyre models

The cost function measures the average error between actual and simulated lateral acceleration. Please note this is the end result of the tyre force optimisation. As can be seen, the 3D exponential function shows an improvement of at least 12 per cent so we are definitely on the right track. I should also add that I took a number of different starting points with this model and it still finished up in the same point, which was a good sign. However, more significantly the lap time delta improved from 0.2s to 0.3s. This also showed up per corner and the fine changes as well, which is what we were after in the first place.

One thing worth noting is that while the exponential tyre function will improve sensitivity, it is definitely not a magic wand. It will certainly improve the deltas and point you in the right direction more so than it's 2D cousin, but it will not replicate the full sensitivity of the car for two key reasons. The first is the fact that the simulator is the perfect driver since it knows where the grip is and is not subject to massive mood swings induced by a potential forthcoming accident. The second reason I'm going to keep my powder dry on because this is still an ongoing area of research. The results are interesting and something I'll be returning to at some point in the future.

In closing we have discussed a number of useful things in this article. Firstly, we have discussed the tools needed to quantify setup sensitivity. These will prove to be very useful to see whether tyre rig test results make sense and it will form some useful rules of thumb to make sense of the 2D results of the ChassisSim tyre modelling toolbox. Secondly, when presented with a highly sensitive racecar, the thermo exponential tyre model we have discussed should bridge the gap between what the simulator says and what you see on the track. It won't be perfect, but it will get you in the ball park and that, combined with looking at your data, will get you a considerable way down the road.

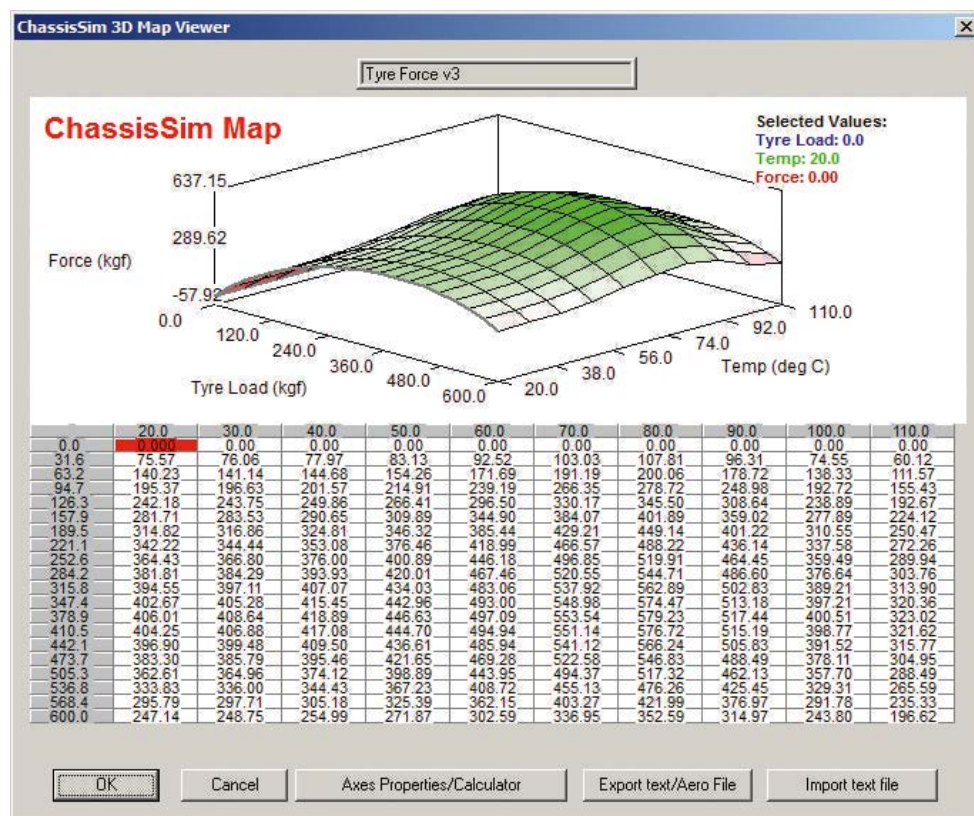


Figure 2: Exponential function TC radius load and temperature.

Table 4: Initial start points and deltas		
Parameter	Value	Delta
Topt	100degC	10degC
kpre	4	2
kpost	6	2
kPRE_MULT	0.7	0.15
kPOST_MULT	0.7	0.15
Tscale	50	10

Table 5: 2D Tyre model vs 3D exponential function		
Parameter	2D tyre model	3D expo function
Cost function	0.27	0.24
Roll bar sweep lap time delta	0.2s	0.3s

Finally some curves worth discussing.



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Bleeding tyres

We look at the issue of tyre bleeding in NASCAR

By DR DIANDRA LESLIE-PELECKY

There are three things teams simply don't mess with in NASCAR – engines, fuel and tyres.

NASCAR came down hard on the Richard Childress Racing 31 team after finding unauthorised modifications to tyres confiscated after the March race at the Auto Club Speedway of California. While the exact nature of the violation wasn't specified, tyre bleeding has been a constant source of rumours in the NASCAR paddock this year.

NASCAR made its feelings about tyre tampering clear by levelling a P5 plus (the second harshest) penalty. Crew chief Luke Lambert was suspended for six races and fined \$125,000. Driver Ryan Newman and owner Richard Childress were each docked 75 points (a little more than two races' worth) and the tyre specialist and team engineer were suspended for six races. RCR is appealing against the penalty, but they'll have an uphill battle. Upon appeal, the penalty was knocked down to the minimum for a P5: a \$75,000 fine, 50 owner's point and 50 driver's points. The team's race engineer will not be suspended. The appeals panel argued that there is no written explanation for what "post-race inspection is" and thus NASCAR wasn't justified in upping the penalties as the tyres were taken mid-race.

Why bleed tyres?

According to the ideal gas law, the hotter the gas inside a tyre, the higher the tyre pressure. This is shown in the following equation:

$$\frac{\text{Pressure} \times \text{Volume}}{\text{Temperature}} = \text{Constant}$$

A tyre's volume does change a little with temperature and pressure, but it's small enough that (for the purposes of a qualitative argument) we can take it to be constant. The ideal gas law then tells us that the ratio of pressure to temperature has to stay the same. If the temperature increases, the pressure will increase, and vice-versa.

Grip depends on tyre pressure. Too low a tyre pressure means that the tyre flexes a lot and energy that could be used for speed is used to overcome rolling resistance. If the tyre pressure is too high, the sides of the tread pull away from the track, giving you a smaller contact patch and less grip. Teams use practice runs and simulations to determine the ideal pressure for each tyre at a given track.

A tyre is filled (with dry nitrogen, in the case of NASCAR) to a specified pressure, but the pressure build up can be anywhere from 10 to 45psi, depending on the track and track conditions. If the ideal tyre pressure is 30psi and you get a 20psi build up as the tyres reach operating temperature, you have to start your tyres off at a much lower pressure. Tyres on cars waiting to head onto the track at a place like Martinsville look almost flat, which means the sidewalls are forced to support much more of the car's weight than they were designed to.

In many lower-level stock car series, teams are allowed to use tyre bleeder valves that limit

tyre build up by releasing some of the gas once the tyre pressure reaches a preset value.

A tyre bleeder valve works on the same principle as the pop-off valve in a radiator. A radiator is essentially a closed length of tubing. When the water inside heats and turns to steam, the pressure inside increases. The technical term for this is "a bomb" and when the pressure inside the tubing exceeds the tubing strength, the tube will burst.

Bleeder valves

To prevent this type of catastrophe, a pop-off valve is inserted in the radiator system. When the pressure reaches a critical value, the pop-off valve opens and allows some of the steam to escape. The steam is released through a tube near the windshield so the driver can tell when he or she is overheating the engine.

A tyre pressure bleeder valve works in exactly the same way: it provides a way for the tyre to release excess pressure. Most devices are easily installed in the valve stem of the tyre and allow you to dial in the exact pressure you want the valve to open at.

Tyre bleeder valves are fairly straightforward. An O-ring sits atop a spring. At low pressure, the spring is relaxed and the O-ring seals on the valve seat. When the tyre pressure increases past the trigger value, the higher pressure compresses the spring and unseats the O-ring. Air then leaks out until the pressure returns to below the trigger value. Then the spring relaxes, allowing the valve to close.

Rubber is flexible enough that a tiny puncture can self-heal at lower pressure, but leak when the pressure rises

The harder the driver pushes the tyre, the hotter the gas gets and the higher the tyre pressure becomes. Having a way to relieve pressure gives the driver the option of pushing the car harder than a driver who is limited by the building tyre pressure.

A bleeder valve seems like a perfect solution – except bleeder valves aren't legal in NASCAR. Steve O'Donnell, NASCAR's chief racing development officer, says NASCAR isn't likely to legalise tyre bleed valves anytime soon, despite the very public urging of high-profile racing personalities such as Darrell Waltrip.

O'Donnell told SiriusXM's The Morning Drive: 'We wish Darrell would talk to some of the team owners and some of the other folks in the garage.' NASCAR is more interested in using tyre pressure monitoring to provide information directly to the driver via the 'digital dash' being tested for possible future implementation.

One reason O'Donnell gave for not using bleeder valves is safety. A pop-off valve decreases the pressure in the radiator, but the cooling power of the radiator is reduced because there's less water to carry away heat. Once the bleeder valve allows gas out of the tyre, the pressure may be at the target value, but there's less gas in the tyre.

Let's say a red flag causes the cars to stop for ten minutes and the tyres cool to ambient temperature. If they started cold at 10psi and then return to the same temperature (after losing gas via the bleeder valve), their pressures will be even less than 10psi when the race re-

starts. Running on those very low tyre pressures increases the stresses on the sidewall and (especially at bumpy tracks) could increase the chance of tyre failure.

A second issue is the delicate balance between keeping drivers happy and keeping the tyre supplier satisfied. When a tyre fails, the first response of a frustrated driver is often to criticise Goodyear.

Tyre enforcement

Although there have been times where Goodyear admitted missing the mark (Indianapolis, 2008 and Charlotte, 2005), there are many more cases in which the responsibility for tyre failure isn't so clear. Goodyear has been much more vocal recently about teams pushing the limits of camber and/or recommended tyre pressures. Tyre pressure monitoring shifts the responsibility for tyre management more toward the teams, and would likely provide additional data for analysing tyre performance.

Another reason NASCAR may be averse to allowing tyre bleeder valves is the need for enforcement. NASCAR's inspection procedures have become increasingly more complex, with laser measuring rigs now being brought to the track. At last year's 600-mile Charlotte race, teams got five sets of tyres for practice/qualifying and 13 sets for the race. That's 774 tyres to monitor over the 43 teams.

NASCAR doesn't announce the specifics of violations, but the scuttlebutt is that the 31-team's tyres had small holes poked in the

sidewalls, where the rubber is thinner than on the tread. Rubber is flexible enough that a tiny puncture can self-seal at lower pressure, but leak when the pressure rises.

The disadvantage of the pinprick method is that it's not very accurate. A bleeder valve set to open at 35psi will not let any air out until the tyre pressure reaches 35psi – poking holes in the rubber doesn't give you anywhere near that level of precision.

Beyond reasonable doubt

Tyre bleeding via small holes is easy to detect – if you're looking for it. The easiest way to check is to overpressure the tyre, then submerge it in water. Gas escaping from the tyre will form bubbles. You can also try squirting a little soapy water on the suspicious areas of an overpressured tyre. If gas is escaping, it will form bubbles from the soap near the holes.

Once you have reasonable suspicion, there's reason to do a more formal forensic materials investigation. Looking at the holes under a microscope gives you additional information about the size and shape of the holes, as well as if they were arranged in a pattern.

Given the magnitude of the penalty and the knowledge that the team would likely appeal, NASCAR had to be very certain that there was a purposeful tampering of the tyre. Once it had satisfied itself that this was the case, it took the opportunity to send a loud and clear message to the rest of the garage. Fuel, engines and tyres: do not touch.



Everything must go

Open auctions offer a valuable insight into the secret world of Formula 1 and tell us much about what could have been for two now defunct teams

By SAM COLLINS



Caterham's CT05 chassis could compete in the 2015 F1 season with minor mods



The rear wishbone from Marussia's MR03 uses a 'mushroom' suspension blocker



This assortment of 2014 and 2015 parts eventually sold for less than £1000

The demise of the Caterham F1 team and the near demise of the Marussia team have opened up the books to many intriguing stories of what really happened and what might have been with Formula 1's smallest outfits. Many of those tales are fascinating and are still developing, and in time the full stories will come out.

With both organisations collapsing financially late last season the administrators moved in and sold off the assets of both operations to the highest bidders in open auctions. The Marussia team's assets were the first to go, including the team's 2015 wind tunnel model (see RCE V25N2), and as *Racecar Engineering* closed for press the Caterham assets were going under the hammer. Included in one of the sales held by English company Wyles Hardy were

followed the twin tusk layout as seen on the 2014 Lotus. Caterham had planned to introduce one of these variants at the Spanish Grand Prix but it seems that development on the design stopped short of them going into production. Many in the paddock claimed that these twin noses made cars more aerodynamically sensitive and were not a good avenue to go down, despite the fact that in certain conditions they did show gains in terms of airflow under the front of the chassis.


Tantalisingly one of the Caterham concepts appears to feature a front with open-ended tusks, although quite what the purpose of these would have been is unclear. It may be that the nose is simply missing some end caps as twin noses such as these were banned ahead of the 2015 season.

The complete Caterham 2014 wind tunnel model sold for just £12,600

two 2014 Caterham CT05 chassis with assorted spare parts – these cars could be used in the 2015 Formula 1 season with some light modification (as is the case with the Marussia MR03). As such the final hammer price for one chassis of £27,200 (with a buyers premium and purchase tax to be added) was perhaps surprisingly low. The second chassis made £40,600, but this is still very cheap for a near current specification Formula 1 chassis. A third CT05 tub went under the hammer for just £3,150, but this had been written off by Kamui Kobayashi in testing.

The complete Caterham 2014 wind tunnel model sold for just £12,600 (with buyers premium and VAT the total was £17,388), but what was more interesting than the price was what lay among the piles of old wind tunnel components that came with the model. Along with parts relating to a number of other Caterham F1 cars were three alternate nose shapes for the CT05 and all three

Another set of wind tunnel model parts was sold off in late 2014. These were listed as a collection of obsolete aerodynamic test parts in the catalogue, although further investigations have revealed that the parts (sold for less than £1000) contained a significant number of 2014 and 2015 model parts. Included among them were more tales of what might have been including a rear wishbone from the MR03 model. It appears to be a McLaren style 'mushroom' suspension blocker – these were used exclusively by the Woking team during 2014 but a number of rival teams were also known to have tested them.

As time passes it's likely that the collapse of those two teams and the later resurrection of one them will result in a lot more detailed technical information becoming available. More detailed analysis of the Caterham CT05, Marussia MR03 and Manor MNR1 can be found on the *Racecar Engineering* website. 

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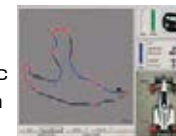
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Formula 1 tech chiefs reject calls for wind tunnel ban



Ferrari technical boss James Allison believes banning wind tunnels would be a mistake

F1 technical directors have questioned the wisdom of a ban on wind tunnels and the placing of more emphasis on CFD as a route to driving down costs.

The idea of a ban has recently been mooted by Red Bull Racing team principal Christian Horner as part of F1's continuing debate on cutting costs. However, F1 technical heads have raised doubts about the benefits of such a move.

James Allison, the technical director at Ferrari, says: 'I don't think it's the best direction for us to take as a sport. At the moment, you wouldn't find too many engineers who work in aerodynamics of any hue who would recommend developing the type of thing we've got, using just CFD. It's just too error-prone and you need to have the wind tunnel to keep dragging you back to reality. Without that you are at very high risk of spending your investors' money foolishly and not delivering a car with the performance you thought you would have. That doesn't really save any money or do anyone in the sport any good.'

Pat Symonds, chief technical officer at Williams, says: 'I disagree with the proposal to ban wind tunnels. We've invested an awful lot of

money in wind tunnels, we've invested an awful lot of money in CFD – it's not as cheap as some people might think. I think we have quite a good balance at the moment and I'm pretty happy with the way things are.'

Tech bosses have also questioned the practicalities of working without wind tunnels. James Key, technical director at Toro Rosso, says: 'There's stuff in CFD you can do which you just couldn't do in a wind tunnel and it's the same in reverse so they complement each other very well. And to just take one of them in isolation right now for any team, if you were forced to do it, would be quite tricky.'

Wind tunnels were also stoutly defended by tech chiefs after remarks by Force India deputy team principal Bob Fernley, in favour of a ban, who referred to it as 'dinosaur technology'. Symonds says: 'I think it's a clearly ridiculous and provocative statement. Our wind tunnels are anything but dinosaurs. Just because a technology has been around for a while doesn't mean that it becomes obsolete and joins those reptiles of old. Cars have been around for a long while. Are cars dinosaur technology?'

IndyCar ramps up Leaders Circle team payments

IndyCar teams have seen the payments they receive from the series increased to \$1.25m this season.

The payments, which will only be made to so-called Leaders Circle teams – the pre-selected entries who will be paid provided they qualify for every race – have increased by \$250,000 per team over the 2014 figure.

Derrick Walker, IndyCar's president of competition and operations, said: 'IndyCar is investing in the

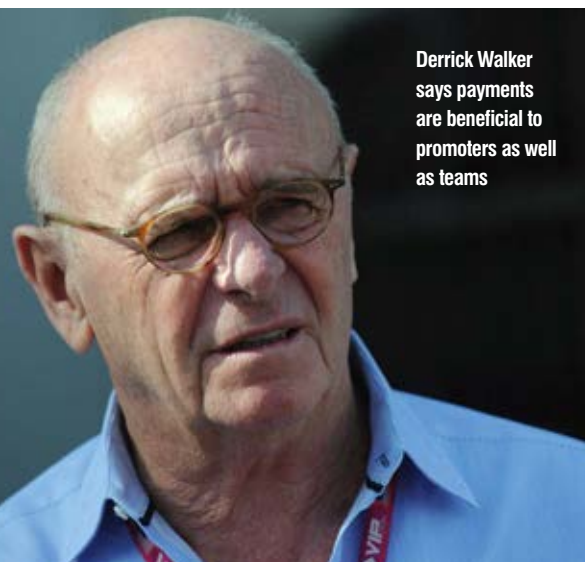
continued support of its teams. The Leaders Circle programme rewards IndyCar teams for full-season participation and helps each of them with an additional source of funding.'

Walker added that the scheme also benefited race promoters: 'The programme is also an asset to our promoters as it guarantees more than 20 cars at each Verizon IndyCar Series event. As IndyCar continues to grow we're excited about opportunities like this that are beneficial to the teams that compete in our series.'

The Leaders Circle programme was established in 2002 to provide incentives to teams that participate full-time in the IndyCar Series. Each Leaders Circle member is now assured a minimum of \$1.25m if an entry successfully qualifies for all of the 16 IndyCar races in 2015, including the Indianapolis 500. The 21 entrants were selected based on the final 2014 IndyCar Series entrant points.

Eligible teams will also compete for race-by-race bonuses, which will be issued to the top 12 this year – it was restricted to the top 10 in 2014. The race bonuses are \$30,000 (first place), \$20,000 (second), \$15,000 (third), \$11,000 (fourth), \$10,000 (fifth), \$9,000 (sixth), \$8,000 (seventh), \$6,000 (eighth), \$5,000 (ninth), \$4,000 (10th), \$3,000 (11th), and \$2,000 (12th).

Non-eligible teams can also compete for payouts given to the top three finishers, although race-by-race reward schemes exclude the Indy 500.



Derrick Walker says payments are beneficial to promoters as well as teams

IN BRIEF

Le monster grid

The Automobile Club de l'Ouest (ACO), the organiser of the Le Mans 24 Hour race, has said it's on course to complete work on the extra pit garages that will allow the entry for the classic event to expand from 56 to 60 cars by next year. It plans to build the four extra garages in early 2016, and has said that while the pit lane will not have to be extended to accommodate the new buildings, the paddock and the parc ferme will have to be reorganised. The Le Mans 24 Hours previously boasted grids of 60 cars back in the 1950s.

Entente Cordiale

IMSA and the Automobile Club de l'Ouest (ACO), organisers of the United SportsCar Championship (USC) and the Le Mans 24 Hours respectively, have extended their alliance until the end of the 2020 season. This new agreement comes after a two-year deal, that covered the American Le Mans Series (ALMS) and GrandAm, was signed in 2013 – both series merged last season to become USC. The relationship between IMSA and the ACO stretches back to 1998 and the start of the Petit Le Mans race at Road Atlanta. The ALMS began in 1999.



Chinese acquisition will not affect F1 commitment says Pirelli

Formula 1 tyre supplier Pirelli has said that the recent announcement of the planned purchase of the company by Chinese National Chemical will have no impact on its F1 motorsport tyre supply deal.

The Chinese state owned company, which is better known as ChemChina, is set to buy the Italian tyre manufacturer in a deal said to be worth €7.1bn. The mechanics of the deal will see ChemChina's tyre-making concern China National Tire & Rubber first

buying the 26.2 per cent that Italian holding firm Camfin owns in Pirelli.

ChemChina will then make a bid for the rest of the company, launched by a group it controls which is part-owned by Camfin investors, which include current Pirelli chief executive Tronchetti Provera (who is to remain in his post after the buyout), Italian banks UniCredit and Intesa Sanpaolo, and Russian oil company Rosneft.

Pirelli will ultimately be indirectly controlled by the Chinese Government, but the company's

motorsport boss, Paul Hembery, does not believe that the news will have an impact on its Formula 1 activities: 'For us, it's business as normal,' Hembery said. 'Our view is as before, nothing changes. We see F1 as a medium to long-term involvement for us and we will be very happy to continue in the sport.'

'Mr Tronchetti will remain for another five years as our CEO. They've bought into the management team that we have in Pirelli and an integral part of our vision and our work is also Formula

1, so from that point of view, no change,' Hembery added.

Pirelli is the world's fifth-largest tyre manufacturer behind Bridgestone, Michelin, Continental and Goodyear. It has a presence in over 160 countries with 19 manufacturing sites around the world and a network of around 10,000 distributors and retailers. Its motorsport arm currently supplies rubber to F1 (the sole supplier since 2011), GP2, GP3 and WRC. In total Pirelli is involved in 250 motorsport championships in 54 countries.

Australian race track scoops extra state funding

Hidden Valley Motor Sports Complex, a circuit situated in the Northern Territory in Australia, has been granted A\$8m (£4.2m) of local government money for its ongoing programme of infrastructure improvements.

The venue, which is situated six miles from Darwin, hosts Australia's V8 Supercars on its 1.7-mile track once a year, while it also has a drag strip, kart track and various off-road circuits.

Northern Territory Sports Minister Gary Higgins said the

aim of the investment was to help grow the motorsport industry in the area: 'The Government's investment in Hidden Valley is an investment in helping ensure a vibrant and growing motorsport industry in the Northern Territory,' he said.

Adam Giles, Northern Territories Chief Minister, said of the grant: 'The Territory is fast building a reputation as a haven for motorsports and this significant investment will help ensure events like the

V8 Supercars are here to stay. Motorsports fans have a lot to look forward to in Budget 2015 (in which the investment was announced) with a multi-million dollar package of sports infrastructure spending right across the Territory. We are proud to offer first class facilities to motorsports and Hidden Valley is the jewel in the Territory's crown,' Giles said.

Giles added that the new money will help the venue to build upon upgrades made with

previous grants totalling A\$9m (£4.7m) over the past 18 months. This has enabled Hidden Valley to upgrade its pit garages, resurface the track, add pit wall gates, re-seal the paddock, install concrete barriers and debris fencing, and redesign its Turn 1.

Higgins added: 'We are ensuring Hidden Valley remains in peak condition and offers competitors, officials, support crew and spectators the best possible environment for some great racing.'



Hyundai delays debut of new WRC car until next season



Hyundai has ditched plans to switch to a three-door i20 and will now campaign this five-door version, which it was already using as its test prototype, in 2016

The debut of the all-new Hyundai i20 has been pushed back to 2016 as its planned three-door configuration has now been dropped due to problems with the production of the new road car on which it was to be based.

Hyundai had planned to debut its new three-door coupé i20 at Rallye Deutschland later this year, but now it has revealed that it was unable to homologate the car due to production schedule issues. Instead it now intends to compete with a new five-door i20, which Hyundai plans to launch in time for the opening round of next year's WRC, the Monte Carlo Rally.

Hyundai team principal Michel Nandan said: 'We had hoped to introduce the car later this season but an issue with the homologation schedule – related to production of the three-door road version – will delay our programme.

'We have therefore opted to continue focus on the five-door version of the new generation

i20 WRC which will compete at Rally Monte Carlo 2016. This revised schedule gives us extra time to ensure the car is where we want it to be performance-wise. At the same time, the current Hyundai i20 WRC will undergo a number of important updates which we hope will keep us in the fight for podiums this season.'

Work has been ongoing on the new five-door car for some months, Nandan telling *Racecar Engineering* earlier this year (March issue) that it was still waiting for the new bodyshell to switch to the three-door version, and that the car that will now actually be its new WRC challenger was simply a prototype for testing. He said then that he had expected the three-door bodyshell to be ready by February of this year.

Hyundai returned to the WRC after a nine-year break last year, winning an event, the Rallye Deutschland, with its i20 during its first season back in competition.

National Guard sponsorship case thrown out of court

Panther Racing's lawsuit against rival Indycar operation Rahal Letterman Lanigan Racing (RLL) has been dismissed by a US court.

The lawsuit was initially filed after RLL was awarded sponsorship from the US Army National Guard for the 2014 season, thereby taking the backing from Panther – RLL's bid was said to be close to \$5m less than that pitched by Panther.

Panther's boss, John Barnes, appealed against the decision, going through the US Government Accountability Office. However, the Panther appeal was rejected so it then sued both RLL and IndyCar, claiming that Panther had lost a possible \$13.1m in sponsorship as a result of what it called 'bid-rigging'.

As far as IndyCar's part in all this was concerned, Panther accused the series of a breach of contract, claiming Panther had exclusive rights to provide access to the National Guard for the IndyCar Fan Village at events. The suit charged IndyCar with interfering with its contract with

the National Guard, and it claimed that IndyCar CEO Mark Miles wrote a letter in November 2013 – when RLL was chasing the sponsorship deal – saying RLL had the right to provide access to the Fan Village.

The lawsuit also alleged RLL was aware of Panther Racing's exclusive rights to provide access to the Fan Village and that it falsely claimed ownership of the contractual right.

However, Judge Tanya Walton Pratt of the US District Court rejected Panther's claims: 'The Miles letter merely stated what IndyCar believed it had a right to do, which was to grant another race team, Rahal, space in the Fan Village for its potential sponsor, the National Guard,' she said.

The Guard dropped its IndyCar and NASCAR sponsorship at the end of 2014, partly due to the publicity generated by this legal action, but also because of political pressure as figures showed the sponsorship had been less than effective in drumming up recruits. Panther Racing shut up shop last year.

Panther Racing closed its doors at the end of the 2014 season after losing its National Guard sponsorship to RLL



CAUGHT

Richard 'Slugger' Labbe, a crew chief on the No.33 Circle Sport Racing entry in the NASCAR Sprint Cup, was fined \$50,000 and suspended for three races after the Chevrolet he tends was found to be running with an illegal truck trailing arm at Fontana's Auto Club Speedway. Specifically, the suspension piece was made of aluminium rather than the mandated magnetic steel, while it was also not bolted on correctly. The car's owner Joe Falk – who runs the team in a tie-up deal with RCR – was docked 25 owners' championship points for the infraction. The fine was reduced to \$20,000 and the penalty to 10 points on appeal.

FINE: \$20,000
PENALTY: 10 points

For the first time crew members have been penalised for behavioral issues prior to the Xfinity Series race at Auto Club Speedway, California where they failed to take directive from track personnel. JR Motorsports crew members, Mark Armstrong was fined \$1,500 suspended from NASCAR until April 21 and placed on NASCAR probation through the end of the year. While Tyler Bullard, Nathaniel House, Jeremy Howard and Ryan Mulder have all been placed on NASCAR probation until December 31.

FINE: \$1,500

The Williams Formula 1 team was given a suspended €10,000 fine after Felipe Massa was found to have used a set of tyres outside the permitted window during practice for the Malaysian Grand Prix. 'The competitor admitted the infringement and sought to mitigate,' said the FIA in a statement. 'Having considered the facts, the stewards accept the infringement was inadvertent and no advantage was gained as a result. In the circumstances, the stewards decided that a suspended penalty was most appropriate for the infringement.'

FINE: €10,000 (suspended)

The Extreme Speed Motorsports (ESM) HPD-Honda ARX-03b was disqualified from third place in the World Endurance Championship opening round at Silverstone at the beginning of April after it was found to have raced with front and rear underfloor skid planks which were under the regulation 20mm thickness. ESM, which debuted the HPD ARX-04B coupé at the opening round of the TUSCC at Daytona in January, said the rules infraction was, ironically, 'a result of chassis modifications to comply with the rules' after the car's outing in the second round of the United SportsCar Championship race at Sebring mid-March.

PENALTY: disqualification

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SEEN: Hyundai RM15 concept racecar



While the new Hyundai i20 WRC car will not now make its stage debut until 2016 (see separate story) the Korean company has at least kept itself busy with this racy concept, revealed at its home motor show in Seoul. The 'RM15' (Racing Midship 2015) features an aluminium spaceframe with a covering of light, stiff body panels formed in carbon-fibre reinforced plastic (CFRP), which together help to achieve a significant weight saving, we're told. Meanwhile, weight distribution is quite evenly balanced (43 per cent front, 57 per cent rear),

and the centre of gravity is just 491mm from the ground, while aerodynamic downforce is 24kg at 120mph. Power comes from Hyundai's Theta 2.0-litre engine mounted transversely behind the two-seater cabin and ahead of the rear axle. Vertical air-intake slots in the flanks of the car, ahead of the rear wheel arches, increase cooling airflow within the engine bay and enhance powertrain efficiency. The four-cylinder turbocharged petrol engine generates 300bhp at 6000rpm and drives the rear wheels through a six-speed manual transmission.

NASCAR round-up

City officials have given permission for a developer to demolish Irwindale Speedway in California and replace it with a 700,000 sq ft shopping mall on the 63-acre site. Built on a former quarry and landfill in 1999, Irwindale is one of the premiere short ovals in the US and holds NASCAR local and K&N Series events. The facility also houses a NHRA sanctioned drag strip.

Several tracks are making upgrades following the accident at Daytona Speedway in which Kyle Busch sustained injuries to both his legs in the Xfinity Series race when he hit a part of the inside wall that was not equipped with a Safer Barrier. Bristol Motor Speedway, Michigan Speedway, Indianapolis Motor Speedway and Talladega Speedway are all adding areas of the energy absorbing Safer Barrier to their facilities.

Texas World Speedway in College Station, Texas, will close its doors in mid-June and be demolished to make way for a \$55 million housing development including 1400 homes on the 400 acre tract of land. Built in 1968 the two-mile oval and circuit has held IndyCar, NASCAR, USAC and SCCA events over the years before becoming essentially a test track.

NASCAR has re-aligned some of its TV purse money within the three top division it sanctions, allocating funds normally used in the Sprint Cup Series to be spread into the second the third tier XFINITY and Trucks Series.

NASCAR has again modified the qualifying format at the superspeedways of Daytona and Talladega with now just two rounds of qualifying with an on-track order determined by draw and then one timed lap per car. Cars will be released onto the track using a predetermined interval set by NASCAR. Following a ten minute break the fastest 12 cars will post a second timed lap, the format will be used across all three national series.



F1 cooling company acquires US market leader

Australian-based motorsport cooling solutions company PWR Group has purchased the American manufacturer C&R Racing to form what's described as 'the most powerful high performance cooling company in the world'.

PWR, based in Queensland, provides cooling systems for many top motorsport disciplines, including Formula 1, WEC, WRC, NASCAR, IndyCar and DTM, while it is also an OEM supplier to Porsche and Aston Martin, and supplies the top tier high performance automotive aftermarket sector the world over.

C&R Racing, Inc. was founded by its owner Chris Paulsen, a former IndyCar Series chief mechanic, in 1988 in Indianapolis. It supplies cooling systems, specialised chassis components, and drivetrain packages for professional motorsports in the USA. The C&R brand has dominated NASCAR for the past 24 years, while C&R has also moved into the high performance aftermarket with its high-end cooling systems.

Paulsen said: 'We have watched PWR rapidly grow into the premier performance cooling system manufacturing company in the world. Their world class engineering and incredible flexibility is unlike any company we've ever done business with. Joining our two companies will create the most powerful, high performance cooling system company in the world.'

Kees Weel, PWR's co-owner, said of the acquisition: 'We have supplied C&R with PWR product for a number of years. We see this acquisition as bringing together two like-minded, dominant businesses to create a much larger footprint in the USA. The opportunities available to the combined PWR/C&R group in USA are significant.'

PWR will use the well-established C&R Racing brand for its USA operations only, while retaining the PWR brand throughout the rest of the world. Paulsen will be nominated as president of a rebranded C&R Racing, Inc.

IN BRIEF

Road runner

New primary legislation which will allow closed-road events on mainland Britain has been approved by the UK government. The Deregulation Bill contains a framework for running motorsport on closed public roads without needing an Act of Parliament to suspend the Road Traffic Act. This marks the culmination of a long campaign by the Motor Sports Association (MSA) that began in 2010. But before the primary legislation can become available to event organisers secondary legislation – in the form of a statutory instrument detailing the enabling powers – is still required.

Malaysia deal

Sepang, the home of the Malaysian Grand Prix since its inaugural race in 1999, has extended its contract with Formula 1 for a further three years, cementing its place on the F1 calendar until 2018 at least. Malaysian state-owned oil company Petronas has also extended its title sponsorship deal with the Malaysian GP for the duration of the new contract.

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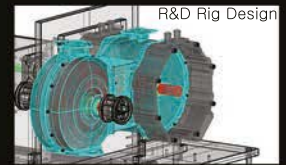


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INTERVIEW – Bruno Famin

Famin relief

Since the plug was pulled on its LMP project three years ago, Peugeot Sport has had to reinvent itself as a value for money operation. Its boss tells us how

By MIKE BRESLIN



‘Pikes Peak was an incredible return on investment. Everything was exceptional: the place, the driver, the car, the record’

Bruno Famin’s love of motorsport was sparked when he was 10 with a trip to Le Mans in 1972, the year a French firm, Matra, chalked up a famous victory. In 2012, 40 years on from that first visit to the 24 hours, Famin was technical director at another French outfit, Peugeot Sport, where he had worked since 1989. Its race team was set to take up where it had left off in 2011, duking it out with Audi in LMP1. Peugeot was confident the car was good and Famin was hopeful of repeating Peugeot’s Le Mans win of 2009. For a Frenchman it just didn’t get much better than this.

Sadly, that proved to be so right. In January of 2012 PSA (the group that encapsulates both Peugeot and Citroën) announced that in the wake of a woeful sales performance in 2011 it had decided to cut 6000 jobs and €800m of its spending. The Le Mans project was finished. ‘It was a great disappointment for me and for all the team,’ says Famin, who was promoted to director of Peugeot Sport later that year. ‘But the decision was purely down to the financial situation at the PSA Group. The end of that programme was a shock, and it was a disappointment not to have raced Le Mans in 2012 at least, because everything was ready, but it was among the big decisions that the top management had to take at that time, and it was understandable. When I see the WEC now, and the level of budget manufacturers have, frankly speaking I am not sure that we would have been able to continue, because their return on investment is just a disaster. I don’t know how they manage.’

Thinking outside the box

That phrase, ‘return on investment’, has become something of a mantra at Peugeot Sport, and it has led to an involvement in a succession of non-mainstream motorsport ventures. But before all that there was much head scratching as the team tried to find its place within the new austerity-driven PSA. ‘It was very difficult,’ Famin says. ‘But Peugeot Sport still had the customer activities, which is the only programme we have never stopped in our 30 years, so we focussed on that.’ Indeed, Peugeot has now sold more than 170 of its rally-bred Peugeot 208 R2, and 30 of its 208 T16 R5 rally cars.

But the sport department also diversified and worked on a series of road car and non-motorsport projects such as the 208 Hybrid FE concept, in which it placed much of the technology developed with the 908 Hybrid LMP1.

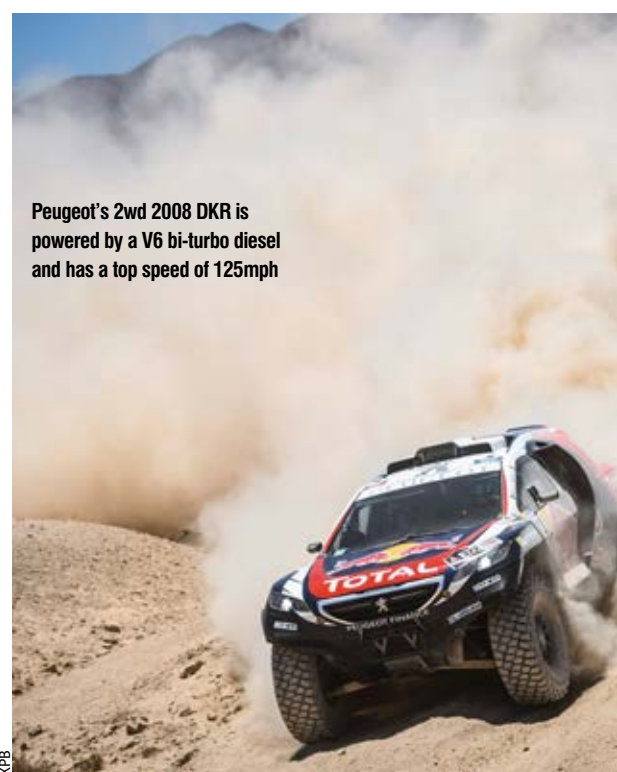
However, while the Hybrid 208 might be seen as a futuristic project, it was in looking to its past that Peugeot Sport began to see a future, harking back to the success it had achieved at Pikes Peak in the late 1980s with the 405 T16, and trying to replicate that success in the modern era. ‘Pikes Peak was part of our heritage, and it was a one shot programme. Not expensive at all, very little money, with a good potential in terms of marketing and communication,’ Famin explains. ‘It was an incredible return on investment. Everything was exceptional: the place, the driver, Sebastien Loeb, the car, the 208 T16, the record. I think the record will stand for some decades.’

But, as Famin admits, whatever the marketing rewards, Pikes Peak in 2013 won’t be repeated any time soon. You can’t have a comeback every year, after all. What Peugeot Sport really needed was a long-term factory project. It found it in cross country, better known as Rally Raid, or simply Dakar, after the category’s most famous event.

Return to Dakar

This, too, was an echo of the past, for Peugeot had dominated the then Paris-Dakar from 1987 to 1990, winning it every year during this period. Yet Famin says this return was not driven by heritage, just pure business reasoning. ‘It had nothing to do with heritage. It is to do with brand strategy. The fact that we have done it before gives us some opportunity to talk about it, but the reason we chose the cross country programme is not just Dakar. We are also targeting other events: the China Rally, if it is confirmed, and hopefully one day the Silk Way Rally in Russia will come back. So, South America, Russia, China; three strategically important areas for the development of the Peugeot brand. We also race with the 2008, which is sold in all those countries, which is not the case for example with the 208. It is a crossover, too, to add something more to the image of the 2008 with the cross country programme. It makes a lot of sense.’

The other difference between Peugeot’s return to Pikes Peak and its return to the deserts of the Dakar is the results, with a disappointing best placing of 11th for the radical 2wd 2008



Peugeot’s 2wd 2008 DKR is powered by a V6 bi-turbo diesel and has a top speed of 125mph

on its debut in January. Yet that's not something that overly fazes Famin for the time being. 'The Dakar 2015 and the Dakar 1990 are two totally different races. We perfectly knew that the Dakar is a very tough race, in a very difficult place. We knew that competitors were very strong with a lot of experience, and we knew that we would not be in a position to win for the first year. The planning of the project was very tight, we had only 12 months to design, build and test the car. And on the team, almost nobody knew the Dakar; it's a very specific race, you have to learn how it works, you have to learn how it is.'

He's also confident there's more to come from the 2008. 'When we started the race the three cars were new – testing in 2014 focussed on reliability and we hadn't worked on performance. So the car still has its full potential and when we look at all the items we are able to improve I'm quite optimistic.'

Rallycross is the future

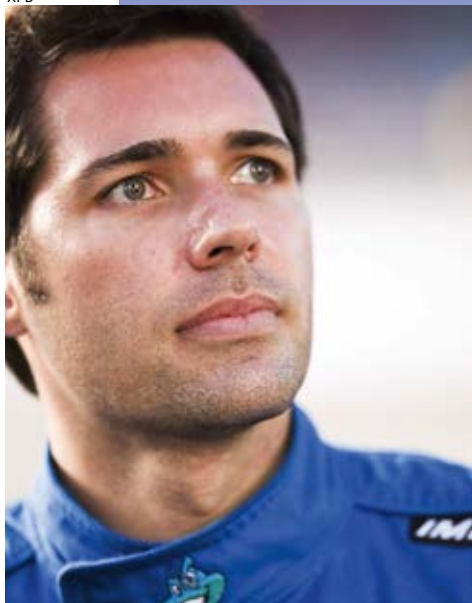
While the Dakar presents a fine opportunity to show off Peugeot's 2008 crossover, its 208 cousin has also been seeing action on the rough stuff, this time in the resurgent rallycross discipline. Thus far Famin is pleased with Peugeot's involvement. 'We are officially involved with Team Peugeot Hansen in World Rallycross. We are quite happy with that, because we believe that rallycross has a good future, it matches quite well with the era and with today's expectation of young people: it's short, fast, it's easy to see by web or television, it is very easy for inviting VIPs, and it's a very good spectacle. It's non-stop activity over the weekend, and for the time being the costs are reasonable. We believe that there is big potential there.'

As for other motorsport programmes Famin says that Peugeot Sport is busy enough right now. But while he says – as motorsport department heads invariably do – 'never say never', when it comes to a return to WEC the reality is that for some years that's very unlikely. As is WRC or an involvement in WTCC – simply because Citroën is already in both and it's now PSA policy not to pit one of its arms against another. So just what is the future for Peugeot Sport, then? 'Whatever it is, first we should always have two key points to consider: the brand strategy, and the potential return on investment,' Famin says. Which, while it might not mean a return to WEC, should at least ensure Peugeot stays in motorsport.



RACE MOVES

XPB



Larry Foyt is now president of Indycar outfit AJ Foyt Enterprises. Foyt, who is the biological grandson and adopted son of IndyCar legend and team founder AJ, will be aided in the team by Mitch Davis, who joined as team manager over the winter.

Paul McNamara has joined Williams Advanced Engineering, the engineering services and technology division of the Williams Group, as its technical director. Before joining Williams Paul worked as an executive director at Shanghai Automotive Industries, and prior to that he spent more than 20 years at Ricardo, five of those as UK managing director.

Former British F3 champion **Marc Hynes** has taken a year off from his driving comeback in the British Touring Car Championship (BTCC) in order to concentrate on his driver development and management position at the Manor (Marussia) F1 team.

Stuart Pringle is now sporting director at Silverstone Circuits Ltd, the wholly owned subsidiary of the British Racing Drivers' Club (BRDC). Pringle has spent the last eight years as club secretary at the BRDC.

Gillian Carr is now club secretary at the British Racing Drivers' Club (BRDC), filling the position vacated by **Stuart Pringle**. Carr comes to the club from the Historic Grand Prix Association.

Earl Baltes, the founder of Eldorado Speedway in Ohio, has died at the age of 93. Baltes built the track in 1954 and Eldora became one of the premier

dirt tracks in the USA in the years that followed. Baltes sold the venue to **Tony Stewart** in 2004. For the past two years El Dorado has hosted a NASCAR Camping World Truck Series event.

Rob Smedley, the head of vehicle performance at the Williams F1 team, is to host a charity gala dinner for the Zoe's Place Baby Hospice on Saturday, August 1. Smedley and wife Lucy are patrons of the charity. For more details contact elaine@zoes-place.org.uk

Dick Harvey, the man who created the ultra-successful Darvi Formula 750 cars with his brother **Jon** and **Mick Harris**, has died. Harvey championed the introduction of the Fiat 1108cc engine in F750, a move that's widely credited with saving the highly-respected club series.

JD Gibbs, president of NASCAR operation Joe Gibbs Racing and son of the team's founder, Joe, has cut down his involvement in the organisation as he starts treatment for a brain-related illness. The team has said that Gibbs, a former driver, will now limit his presence at the track, but he will continue with many of his other day-to-day activities.

Steve Oseth is now vice president and general manager of SCCA Pro Racing, the for-profit subsidiary of the Sports Car Club of America. Oseth comes from a general business background but he is also a successful Formula Vee racer and has acted as a technical coordinator for the SCCA.

DC Electronics has appointed F1 specialist **Mark Cornell** to bolster their award winning team of motorsport experts. Mark has more than 16 years of experience designing and manufacturing wiring harnesses for Formula 1, Le Mans, Indycar and the European Le Mans Series, as well as World Championships including the WTCC, WEC and WRC.

Gary Terry, 36, the senior operations manager at the Richard Petty Exotic Driving Experience at Walt Disney World Speedway, was killed when the Lamborghini Gallardo in which he was a passenger while instructing a customer crashed in to a guardrail at the Florida track in April. The oval, which is operated by Petty Holdings, is due to be demolished later this year and the driving experience was already set to be shut down in August.

Prodrive apprentices complete UK's largest scheme

Twenty-five apprentices have completed their level 2 NVQ in composite engineering at Prodrive, marking a successful conclusion to the largest composite industry apprenticeship scheme in the UK.

The newly-qualified group are now working on programmes at Prodrive Composite's factory in Milton Keynes, ranging from the manufacture of components for a number of British sports and supercars to the construction of the European Space Agency's new Mars Rover.

Prodrive says that it took the decision to recruit and train its own young talent in 2013, when it was faced with a dramatic growth in business and a general lack of skilled composite technicians in what is an expanding global industry.

The company worked with the Milton Keynes-based TXM Academy to deliver the programme and through a combination of work-based and classroom training the apprentices have now gained a nationally

recognised qualification and the skills for a career in composite engineering.

Chris Smith, Prodrive Composites operations director, who oversaw the apprenticeship programme, said: 'Back in 2013 we employed about 70 staff, but with major programmes coming on stream we realised we would soon need nearly 200. There just aren't that many skilled composite technicians in the UK yet, because it is such a new and growing sector, so our only option was to train our own. It has turned out to be the best decision we could have made and we have a great group of enthusiastic technicians.'

The apprenticeship programme has proved so successful that the company has already begun recruiting another 15 apprentices for 2015, who should be qualified in the next year.

Prodrive Composites is part of motorsport and advanced engineering giant Prodrive Group, which is based in Banbury, Oxfordshire.



Prodrive's cadre of apprentices have passed with flying colours

SPONSORSHIP

NASCAR has reached a five-year agreement with **K&N Filters** for the latter to continue its title sponsorship of the **NASCAR K&N Pro Series**, one of NASCAR's main junior feeder formulae. The new deal will see the filter manufacturer remain on-board with the series until the end of 2021 at least. This will mean K&N will have sponsored the series for 12 consecutive years by the end of this new agreement.

The World Touring Car Championship has signed what it describes as a 'significant new partnership' with **Rosneft**, the petroleum giant which is owned by the Russian Government and which already sponsors the **Lada Sport** works team in the championship. The tie-up will see Rosneft sponsoring the Russian and Chinese rounds of the WTCC later this year.

RACE MOVES – continued



XPB

Kenny Handkammer (left), who was chief mechanic for **Sebastian Vettel** at Red Bull until the end of last season, has now turned his back on F1 to take up a position at electric road car manufacturer Tesla. Handkammer worked in Formula 1 for 25 years, starting out at Benetton.

Specialist and motorsport insurance broker **Ellis Clowes** has appointed **Ann Roughead** as its CEO. Roughead has had a career in investment and finance that spans 30 years and has held senior posts at LV Asset Management and Citigroup, among others.

SCCA Pro Racing has named **Mike Pasquale** as its BFGoodrich Worker of the Year for 2014. Pasquale works in the Battery Tender Mazda MX-5 Cup. The award was instigated to honour the hard work the SCCA Pro Racing staff put in to support the many professional racing series that the organisation sanctions.

According to reports Red Bull Racing's driver development adviser **Helmet Marko** won €400 after betting that his former driver **Sebastian Vettel** would win the Malaysian Grand Prix for Ferrari. His own team had a torrid race, finally coming home 9th and 10th after suffering with brake issues.

Anthony Scrivener QC, one of the UK's most prominent barristers, has died at the age of 79. Scrivener had a passion for

motorsport and motoring and was acknowledged as a sports law expert. He was a steward of the RAC and was appointed by the MSA to represent the UK at the FIA International Court.

Former Chrysler motorsport boss **Ralph Gilles** has been appointed global head of design at Fiat Chrysler Automobiles. Gilles was most recently the senior vice president of the company's North American design office after overseeing its competition programmes while heading SRT (Street and Racing Technology).

Nick Rogers has succeeded **Dr Wolfgang Ziebart** as engineering director at Jaguar Land Rover (JLR). Rogers has now assumed board-level responsibilities for JLR's global engineering operations. Ziebart will continue to work with JLR, focusing on technology development.

David Lowe, who has previously worked for the FIA in Formula 1 and as team manager for Carlin in Formula 3, is now the series coordinator for the Indian MRF Challenge, a single seater series.

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All change at the top?

Bright lights may be attractive, but they may blind you, says our business expert

So the race is on to find a new Formula One World Champion and also a new government for Motorsport Valley UK – both will have significant effect on the supply chain of motorsport.

Last year, the leaders of F1 missed their chance to promote the energy efficient technology used in their engines, proving the exceptional engineering talent in F1. This year, we are beset by endless coverage of the financial security of the series, and some of the teams. It won't be long, as can be seen from social media, that fans will tire of this and we will see the effects on the audience figures.

When reading of the financial difficulties of F1 teams, we should remember they rely on many good suppliers. Although "F1" and "credit control" seem strange bed fellows, entering this season the credit position of suppliers to F1 teams reached meltdown. These are mostly small specialist companies, which cannot afford to give the amount of credit demanded by the F1 teams. Past history shows that unless payment is secured in full prior to the first race, then they are likely to suffer from the obscure machinations of the F1 finances, and wait for many months.

More attention should be given to the vital generosity of these suppliers, and to their plight following poor treatment from some F1 teams. The F1 series owners talk in multi-millions, but some of these hard-pressed innovative workshops, for the sake of a few hundred thousand pounds, are being lost for ever.

Diversify to survive

The slow, drawn out closure of Caterham and Marussia hit suppliers badly. Several excellent businesses were caught out, some having not been paid since the previous season, yet facing a new season with a stack of unpaid debts. Leaders of the F1 series need to recognise the importance of this supply chain and understand that each time it is savaged in this way, difficulties in supplying new technologies gets greater. The wealthier teams can survive, but the less wealthy find life almost impossible, as do their suppliers – it must be time for a change.

Much of the work we do at the MIA involves helping our members carefully monitor their motorsport credit risk, and so avoid bad debts. In most cases, by working together, we succeed, but the system is not foolproof.

To spread their risk, I recommend companies find business in other race series and other countries, moving away, to some degree, from the apparently lucrative, but potentially dangerous, F1 market to reduce their exposure. The US market, for example, continues to grow strongly and soundly, as does business in rallying, particularly Rallycross. I know of many companies which were relying on F1 for 80 per cent of the business, and are now reducing that to below 40 per cent and are still happy with the results.

A move to supply sectors such as defence and automotive can help too. While payments may be slow and margins squeezed, these customers are generally far more financially secure. They counterbalance the extreme financial difficulties

It's good to see Silverstone, under new management, taking a significantly different approach to their customers, both fans and competitors. They report ticket sales for MotoGP and the British Grand Prix are at record levels already. We all benefit if our premier circuit, home of the British Grand Prix, has a more settled and positive future and such improvements will help our other great circuits, such as Donington Park, to increase attendance figures too.

Fans must be our future priority, without whom there will be no sponsors. I watch improvements of the fan experience in the US carefully, and reckon they could teach European circuit owners a great deal in the area of customer loyalty and entertainment. I encourage all circuit operators to visit the USA and see what they do.

Investment into the automotive and motorsport industry has now exceeded £7bn in the last four years



Rallycross is one discipline that continues to see decent levels of growth

caused by the F1 series management and their outdated financial model.

The MIA actively helps companies to diversify their business risk portfolio in this way. For example, we are taking some 20 companies to the USA in May to meet buyers from the Global Rally Challenge and United SportsCar teams, as well as NASCAR and IndyCar. Although the currency rate is challenging to exporters, winning solutions will always command a good price, so quality and innovation is the export message for 2015 and the years beyond.

The future's bright

With Formula E overlapping with Goodwood the weekend before the British Grand Prix, National Motorsport Week has a great chance to promote the joys of motorsport to the wider world. During that special week, during which over 400,000 fans will attend a race, many other business and club events are being held. For *Racecar Engineering* readers wanting to get motorsport into their local press, then that's the week in which to capture the mood of the nation. Go on the MIA's website for National Motorsport Week (<http://www.the-mia.com/National-Motorsport-Week>) to register your event, large or small, to help get maximum publicity to attract new audiences, new competitors and new sponsors.

By the time you read this, the UK General Election will be over and we will face the future under a new government. The clear message from UK business, to whoever wins, is "please don't meddle with a winning formula". The UK economy is currently leading most developing nations; employment

and wages are rising and investment into the automotive and motorsport industry has now exceeded £7billion in the last four years with more to come. Motorsport benefits from this activity. I expect to see more international motorsport companies locating in the UK during 2015, to gain benefit from this positive economic success and government support. It would be foolish of any new government not to realise the value of our motorsport industry.

Good luck with the 2015 season and I hope you get who you voted for in the Election.



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B-G Racing has introduced a new set of turn plates which are useful for measuring castor, camber and kingpin inclination angles. The plates can be placed either on the floor or directly on top of scale pads.

The turn plates are constructed from lightweight aluminium and feature steel ball bearings to ensure they are free floating and do not bind. They provide up to 25 degrees of rotation and come with a laser etched dial that can be zeroed when a vehicle is on the Turn Plates.

www.bg-racing.co.uk



Ignition wire protectors Protect and survive

DEI has introduced a new silicone based protection sleeve for high voltage ignition wires. The Protect-A-Wire™ Kit provides everything you need to protect ignition wires using the latest silicone coated, annealed, fiberglass technology. This process provides a flexible, abrasion and

chemical resistant cover which is ideal for high voltage ignition wires.

The kit includes 25 feet (7.62 metres) of 3/8" (3.75mm) ID annealed, silicone coated, fiberglass sleeving that is heat resistance to 400°F (205°C).

Also included in the kit are eight DEI branded tube ends, and eight consecutively numbered (1-8) tube ends to label the plug wires to ensure they are connected to the correct spark plug.

www.designengineering.com



Refuelling kit ATL fuel equipment



ATL has released a number of new products suitable for endurance racing teams, including its new Jet Pump.

The concept utilises high pressure flow to feed two Venturi's, each scavenging up to 200 litres per hour to the collector. The collector is of known volume with a level switch located in the top face within a baffled

compartment inside the collector to ensure "bouncing" is minimised. The collector is primed using a specially developed valve in the base.

The system is low cost but has all the same benefits as a typical high end LMP / GT reserve tank system.

It has also introduced a new refuelling bowser in response to recent regulation changes and the new zero-vapour bowser is designed to make the motorsport safer for drivers, teams and spectators alike.

The bowser connects to the car or fuel drum using two hoses, one for the fuel and one for the displaced air, and has been designed to do four specific things in a totally closed loop system:

1. Empty a race car and measure the amount of fuel removed, without risking running the on-board pump dry.
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4. Fill or empty a refuelling tower in pit lane quickly and safely

The bowser is available in two sizes – 100 litres and 170 litres – and features an integrated display of fuel weight. Both are capable of pumping 35 litres per minute.

www.atfuelcells.com

Tyres Hill climbers

Pirelli has launched a new range of hillclimb tyres. The new rubber comes in two versions: slick (with soft and supersoft compounds available) and Cinturato rain tyres. These new hoops have been developed with the help of Simone Faggioli, a multiple Italian and European hillclimb champion.

The tyres are suitable for use in the top category of sports prototype in hillclimbs (weighing 560kg and producing 500bhp) as well as the medium category (weighing 470kg and producing 350bhp). The tyres come in 250/575-13 and 315/660-13 sizes and feature some of the techniques carried over from Formula One.

The new tyres have already proven successful, winning the opening round of the European Hillclimb Championship fitted to a Norma M20 FC.

www.pirelli.com



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The World Touring Car Championship, labelled by some as the World Touring Citroën Championship after a season of dominance in 2014, which shows no sign of changing after the first races of 2015, remains optimistic about its chances of securing a coveted fourth manufacturer alongside Citroën, Honda and Lada. Two, apparently, are close to a decision (which could still be 'no') but at the second round in Marrakech, there was some discontent at the prospect of having more competition, and discontent if there wasn't.

With the advent of the new TC1 regulations in 2014, Citroën came into the championship with a fully developed car having built the C-Elysées and then negotiated the regulations around it. So good was last year's car that very little was needed to improve it for 2015. 'We made a big improvement for the downforce of the car and we worked a lot on the suspension, especially the front kinematics,'

said Xavier Mastelon-Pinon after watching his C-Elysées finish first to fifth in the first race in Marrakech, and filled the podium in the second. 'It is not a revolution of the car but it is a good improvement.' Good enough to be 1.5s faster than the Hondas in race two!

Certainly the performance in Morocco was enough to slightly demoralise the chasing pack, led by Honda although the JAS team knew that the Marrakech circuit would be the worst on the calendar for them, and the Ladas had power steering issues, which slowed the drivers on the narrow street track. The balance of performance will kick in for the next race in Hungary at the beginning of May, where Honda hopes that the new aero kit developed over the winter will be enough to make up the rest of the substantial gap to the Citroëns.

Yet, while the manufacturers are busy pushing each other, the privateers are being left further behind, and new manufacturers could push them even further away from a potential podium. And, they are spending money on engine and aerodynamic upgrades in a bid to stay ahead of each other. As one observer put it, this is not balance of performance racing, this is competition and the privateers now have a cash incentive at the end of the season.

In the offices at the circuits there seems to be a lack of common thinking. One manufacturer says that the privateers will be priced out of the WTCC, probably at the end of this season, and that they will be replaced by one or two new manufacturers, which are seriously considering joining the series in 2016. However, series promoter Francois Ribeiro says that the privateers are here to stay,

and that he will do everything he can to keep them in the championship. A manufacturer can walk away at any point, says Ribeiro, but the privateers are the ones that stay.

The potential new manufacturers are, apparently, happy with the existing calendar (Ribeiro said that there would be no need to add a Korean round, for example), and are talking about customer programmes similar to that of Citroën and Honda. For Dutchman Tom Coronel, the only driver to have competed in the ETCC and WTCC every year since 2001, the answer is simple – the manufacturers competing swallow the development costs and sell the upgrades to privateers at cost. That keeps the privateers in business and in the championship, but it is hard to see the manufacturers supporting such a proposal.

The TC1 cars are now as expensive as the Super Touring cars of the 1990s. Back then they were considered too expensive and were outlawed. A privateer budget in the

WTCC is almost one million Euros per season (a rumour banded around in the paddock in Morocco was that one customer managed to lease his car for €1.6 million, which would set an eye watering new record if it was true).

I thought back to a conversation I had at Sebring while discussing the advent of the GT3 cars into the GTD category of the Tudor United Sports

Car Championship, and the interest of manufacturers in GT3. One manufacturer pointed out that, once you identify what is manufacturer racing and what is customer racing, all things become simple. There are a good few series that could apply that theory, and the WTCC is among them.

Even if the €1.6m rumour was true, with a budget of €12m for three factory cars the privateer would still be far off the spending power needed to compete for outright race wins. With the increase in performance year-on-year, particularly of the manufacturer cars, the privateers are now further away from the podium than ever before. The return on investment is therefore lower than it was even last year and that needs to change if Ribeiro is to keep his privateers, particularly if he goes hunting for new manufacturers to push Citroën.

The WTCC show may need to make more of the fact that it is an FIA World Championship, one of only five alongside Formula 1, the World Rally Championship, the World Endurance Championship and the World Rallycross Championship. Everyone needs to show a return on investment or the series will collapse.

ANDREW COTTON Editor

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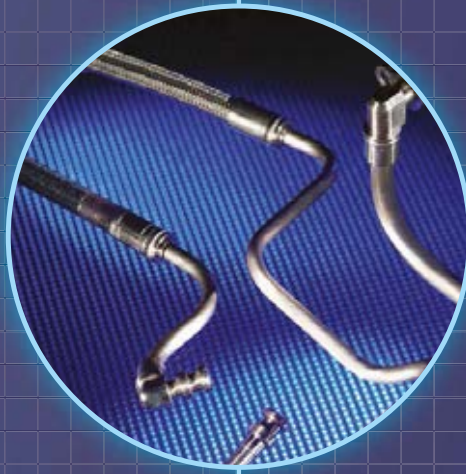
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