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Alternative realities

Our columnist ponders the age-old issue of simulation versus reality

The ancient Greek philosopher Plato wrestled with reality, and posed the interesting example of reality perceived being by the shadow cast on the wall of the cave by the light of the flickering fire. True reality would be only grasped by leaving the cave and seeing the real world. One interpretation of the allegory of the cave is about human ignorance and a people who are unable or unwilling to seek truth and wisdom. But there was another philosopher that looked at the world another way, Aristotle, Plato's chief disciple.

Against Plato's belief in mysterious entities called Forms, available only to the intellect and whose presence provides the foundation for all material beings, Aristotle eschewed the Forms for an empiricism that begins with particular material beings as the most real beings and then proceeds toward generalisations, not unlike the inductive method scientists employ today.

So you can espouse the idealism of Plato or the empiricism of Aristotle. Plato asks: 'How do you want your world to be?' Aristotle, on the other hand, asks: 'How do you fit into the world that already exists?' The two philosophies have repeated themselves through Western history, waxing and waning and remaining in tension with each other to the present day.

Back to reality

In engineering, reality will be the driving force behind decisions. One cannot wish for a result without taking in account the laws of physics and what we observe. Simulating what happens can be done for a variety of useful reasons, for example cost, time, or the need to be able to tweak one variable at a time.

It is not a new idea, being used from time immemorial to think out what would be the result of a particular action or combination of factors in the light of the knowledge you have; used in politics, economics, and generally in any situation where the outcome is simulated in your mind before engaging in any action. Armies have war games, either in the field or on paper, the algorithms developed to weight the inputs, disposition and number of resources. Simulations can also be a mathematical model constructed according to empirical evidence.

Lap time simulation is one of the interesting uses of it. The first LTS I am aware of was created at Mercedes Benz in 1954 to hand calculate sectors of a track before summing them up for a complete lap time once the laborious process was finished. The advent of computers made life a lot easier, computers being rather good at churning through

algorithms. So the tool is to use our knowledge of physics and maths to create an experimental world where we can change the parameters and see what differing results we would have with different inputs. It can be run as a computer simulation to reproduce behaviour of a system. The simulation uses an abstract model to simulate the system. They've become a useful part of mathematical modelling of many natural systems in physics, astrophysics, climatology, chemistry and biology; and human systems in economics, psychology, social science and engineering.

When laying out a car, it is interesting to play around with wheelbases, track widths, weight distribution, cg height, roll centres, aero distribution, as many parameters as we want, with the added bonus of highlighting, via result, the sensitivity of each input for the result. That in itself already highlights the areas that will give the most returns.

For motor racing, apart from lap times, there are several other areas of interest for simulation;

The trap in some simulation is the wrong assumption of weights or inputs



Is this motorsport's version of Plato's cave? Modern simulators get fairly close to reality but lap time simulations can be fudged

race strategy, Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD), for instance.

There was once a Frenchman and an Irishman: Claude-Louis Navier and Sir George Gabriel Stokes. Navier formulated the general theory of elasticity in a mathematically usable form in 1821, and in 1826 he established the elastic modulus as a property of materials independent of the second moment of area. Navier is therefore often considered to be the founder of modern structural analysis. Stokes made seminal contributions to fluid dynamics (including the Navier-Stokes equations), optics, and

mathematical physics (including the first version of what is now known as Stokes' theorem). Between them they nailed FEA and CFD, the Navier-Stokes equations being the cornerstone of CFD and Navier's work the basis of FEA.

The first paper on three-dimensional modelling was published by John Hess and AMO Smith of Douglas Aircraft in 1967. This method discretized the surface of the geometry with panels, giving rise to this class of programs being called Panel Methods. Their method itself was simplified, in that it did not include lifting flows and hence was mainly applied to ship hulls and aircraft fuselages.

Lap time simulation

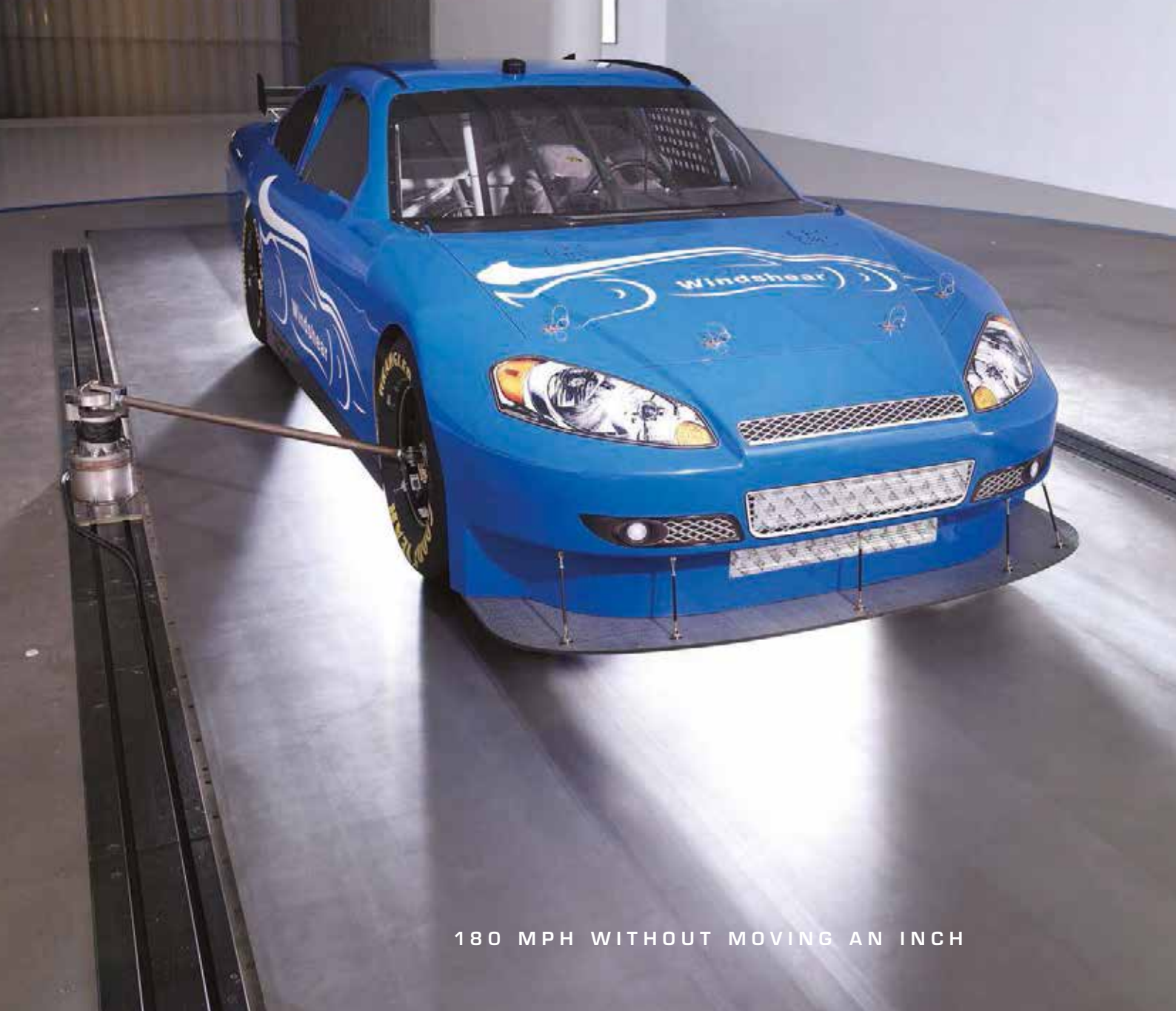
Back to LTS, Cornell university was doing work in the late '60s, but now on computers, and we probably had the first LTS in F1 in 1977, run on a 12kB HP 9821... a lap could be simulated in roughly two hours as the simple bicycle model was run. It was a great boon for design choices, as the major characteristics could be optimised.

The trap in some simulation is the wrong assumption of weights or inputs. Francis Bacon warned us of this in *Of Simulation and Dissimulation, 1597*... therefore a general custom of simulation (which is this last degree) is a vice, using either of a natural falseness or fearfulness.'

The simplification of some assumptions can be fiddled in the general simulation by the very useful fudge-factors embedded in most LTS to make them fit the track data. Too liberal a use of the fudge knob might turn the whole exercise into a mere Disneyland simulacra, as quoted by Jean Baudrillard (the high priest of postmodernism). His key ideas include two that are often used in discussing postmodernism in the arts: 'simulation' and 'the hyperreal'. The hyperreal is 'more real than real': something fake and artificial comes to be more definitive of the real than reality itself. Examples include high fashion (which is more beautiful than beauty), the news (sound bites determine outcomes of political contests), and then there's Disneyland.

A 'simulation' is a copy or imitation that substitutes for reality. There we have it. There is so much more to be written about all this, but I will abstain from simulacra and head for a real coffee now, unless we exist as in the thesis set out in a 2003 paper by Nick Bostrom, in which he argues that the simulated reality scenario is correct, and that the world that we see around us is very likely merely a computer simulation.





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The show goes on

When Renault said it was to ditch FR3.5 many mourned its loss, but now it's to live on

Following Silverstone's recent round of the World Series by Renault, there must be many people relieved to hear that Formula Renault 3.5 is to continue, despite being dropped by the French manufacturer after 11 years' support and promotion. Jaime Alguersuari Sr's company, RPM, will continue to promote and organise the championship in 2016, with only technical involvement from Renault. This news has, not surprisingly, been welcomed by the teams, given the investment in chassis, together with engine leases etc., that they have made.

More than that, though, is that the formula has been a very successful one, with Sebastian Vettel, Daniel Ricciardo and Carlos Sainz just some of the former FR3.5 stars currently driving in Formula 1. This makes Renault's decision a little difficult to understand. Maybe it's because of the anticipated return of the manufacturer to Formula 1 as a works team with the consequent big ramp-up in budget required. Or maybe it's because it views the forthcoming FIA Formula 2 as a potential threat to its own senior single-seater category. Most likely it's a combination of the two.

Great racecars

These are cracking racing cars, built to a high standard by Dallara, incorporating the key technologies expected in a route-to-F1 category, and operated by first-class teams. Watching on-track at Silverstone, like all downforce-dependent cars running on radial racing tyres, the 3.5 litre machines looked a bit slow and clumsy through Luffield – although this is an awkward corner at the best of times. However, in comparison, they looked mightily impressive through the following Copse corner, with the quickest drivers appearing to take it flat in sixth gear, as F1 cars used to do before they morphed into their current blind-alley configuration. They also sound gorgeous, with that urgent and unfettered normally-aspirated V8 bark.

However, how can it succeed as a stand-alone championship without the full backing of the Regie? Will it still have the Renault identity, as a condition of the ongoing technical back-up, or will the naming rights be open? This could be key to the financial input that will be needed to run the operation, along with a television deal, in particular.

Sharing the programme mostly with GT Open, as this currently appears to be the available option, is not going to create the greatest media and fan exposure, nor the prestige and credibility that upcoming grand prix drivers crave. On the plus side, the circuits concerned mainly also host F1, so there is a benefit to drivers in learning these tracks should their aspirations be realised.

Running alongside WEC would be better, but so far this extends to one weekend only at the Nurburgring, unhappily no longer an F1 track. In 2016, after July, all the remaining WEC rounds will be outside Europe, making logistical costs for joining these untenable for FR3.5. ELMS has been taken up already, ironically by Renault's remaining classes – it would have been an ideal partnership. Supporting WTCC at least means being on a World

fastest lap was less than a second quicker. GP2's current closeness to F1 around most circuits (too close, to the embarrassment of a number of F1 teams) is not needed. There should be more of a challenge when a driver steps up to Formula 1 than is currently the case. When F1 speeds-up as planned, a move by FR3.5 to low-profile Michelin tyres on 18 inch diameter wheels, plus some added sophistication to the aero, should be all that is necessary to achieve a sensible performance gap.

The F2 question

So technically there is no reason why FR3.5 should not challenge GP2 as the basis for the new FIA F2 Championship, starting in 2017. Cost-wise, there is every reason why it should, and this would

appear to be a no-brainer. Of course, it is not as simple as that. A seven-year commitment is required by the FIA (which Renault reportedly did consider but balked at). FR3.5 cars are designed around Michelin tyres, GP2 around Pirelli. If F2 has to run tyres supplied by the same manufacturer as Formula 1 (almost certainly so) then, depending on which supplier Bernie Ecclestone decides upon for 2017, this could affect the FIA's choice between the two categories (although of course it might want to start completely from scratch anyway). Then again, GP2's Bruno Michel and Bernie have business ties going back some way, so this could

influence matters a tad as well.

The likelihood of FR3.5 – or whatever it might be called – surviving after 2016 without a replacement for Renault's major investment, or alternatively as the new F2, has to be doubtful. A lot could depend on the required budgets of F2, if indeed it is not FR3.5-derived. If set high, then maybe there is room for a less expensive alternative single seater championship for teams and drivers more concerned with racing for its own sake than with a Formula 1-or-nothing agenda. A little like ELMS/LMP2, although unlike with sportscars, gentlemen drivers and single seater racing is not a cocktail that works. It would be a shame to see FR3.5 disappear. But I still wonder where the money will come from.



Formula Renault 3.5 is to race on in 2016, but without the French manufacturer's backing

Championship stage, even though this is bound to be very much in a supporting role. And here of course comes the rub with its rival series, GP2, which is almost always in a supporting status but – key point – with F1 grands prix.

Nonetheless, judged on performance and chassis/engine sophistication alone, there isn't sufficient difference between the two championships for GP2 to justify its much higher budget, reportedly at least 50 per cent more than Renault 3.5. In fact, the fastest pole time (of two races) for GP2 at Silverstone back in July was actually fractionally slower, by around a tenth of a second, than the equivalent FR3.5 mark, set in similar track conditions in September at the same circuit. In the following races, the GP2

They looked mightily impressive through Silverstone's Copse corner

Swiss movement

The 2015 season promised much for Sauber and yet the team has yet to deliver on track. So where has it all gone wrong?

By SAM COLLINS



The 2015 Formula 1 season looked like it was going to be a good one for Sauber. Pre-season testing had gone well and the Swiss team arrived at Melbourne with some optimism and, despite a high profile dispute over driver contracts, it walked away with a strong finish in the race – a fifth and an eighth. A couple of races later it again had two cars in the points. But that was the last time (up to the Japanese Grand Prix) that it managed the feat. In Singapore, Felipe Nasr finished tenth, Marcus Ericsson 11th.


Sauber's C34 was in evolutionary design by Eric Gandelin, who had learned many lessons with last year's C33. Visually, aside from the bright paint job, the biggest difference between the Swiss team's 2014 and 2015 cars was the nose and the front on the monocoque chassis; due to a rule change the newer car features a much longer and lower front impact structure, Sauber following a different route to much of the Formula 1 field.

Those nose regulation changes actually have a considerable impact on the aerodynamics of the

entire car, especially around the front wheels, and for this reason Sauber was one of a number of teams in 2015 to start the season with a new design of rim, in order to get the best out of the airflow in this region. But biggest changes come at the rear of the car, with Ferrari's substantially upgraded power unit and transmission (covered in more detail on page 16).

Bright start

Giampaolo Dall'Ara, Sauber's head of track engineering said: 'Using last year as a reference the



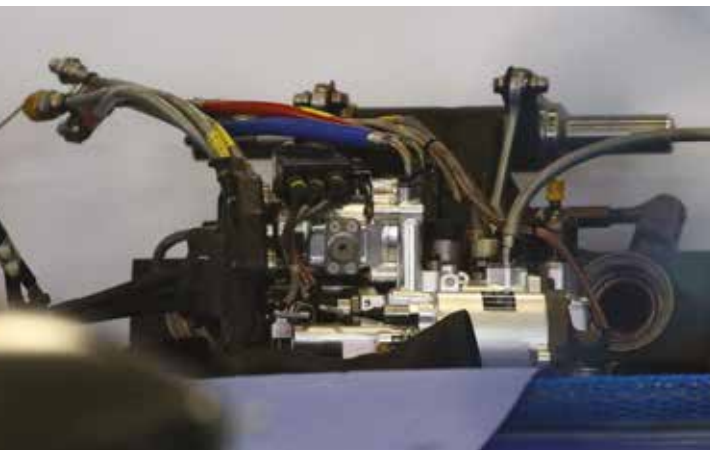
‘We had a reliable car from the start and we thought we had caught up on a lot of things we did not do so well last year’

With rear stability problems carried over from the C33 and also understeer, the Sauber C34 has struggled to be competitive so far this year, but updates are on their way

beginning of this year was really good, we had a bit of a reset on the car design and Ferrari did a mega job on the power unit. We had a reliable car from the start and we thought we had caught up on a lot of things we did not do so well last year, especially in terms of set up and tyres, but the power unit was the biggest step. This year the power is really good, the energy management in the race is sorted where it was not last year, and the speeds we can get on the straights is much better than it was and that has improved the raceability of the car all round.’

The new Ferrari unit in the back of the car led to a fairly substantial rework of the cooling concept for Sauber. The C33 featured vertically mounted coolers, something only a couple of other teams attempted, but in 2015 the C34 features more conventional horizontal radiators, allowing the sidepods, which were already small on the C33, to be even tighter despite the 2015 Ferrari having a higher cooling demand than the 2014 version (according to Sauber). Ferrari’s works cars use a different cooling solution to the Saubers with a louvred cooler layout,

something Sauber is not really able to consider for a number of reasons. ‘In terms of cooling they can go more extreme on performance than we can because we have to keep an eye on reliability more, because we don’t get the replacement bits for free,’ Dall’Ara says. ‘As a result you end up with a bigger car because you have to use a bigger radiator. So these constraints are not purely technical. We have very different coolers to Ferrari, and the heat rejection we accept is different because we have to play safe with PU [power unit] life.’



Above and right: The clever carbon fibre bellhousing accommodates the turbo and the exhaust collectors; the exhaust tailpipes exit out of the rear of the casing



Also inside the bellhousing are a number of hydraulic components, plus dampers and torsion bars. All of these parts are exposed to very high temperatures and yet still perform as required



The Ferrari transmission is very different from 2014, which has meant Sauber had to mount damper elements in bellhousing and use pullrods to actuate them



Some radical and innovative packaging solutions have been used in the C34. Sauber has also switched to horizontal mounted radiators, allowing for even tighter sidepods than nimble C33

Sauber again utilises the same transmission as the works Ferrari, and like Ferrari the 2015 version is also very different to the version used in 2014 (and still used by Manor). A new exhaust and turbocharger layout sees the twin entry turbocharger mounted in the bellhousing along with the collectors and the tailpipe which exits via a hole in the top of the carbon fibre transmission casing. Packaged into this small volume are the car's hydraulics and dampers, operating in a very hostile environment.

'The tighter the packaging the harder it is but it's down to us engineers to make it work,' Dall'Ara continues. 'I think it's wrong to compromise the packaging too much just because you think that there may be cooling issues. Last year we were expecting fires all the time and everything just kind of worked on track so it's now more extreme and still working. With Ferrari we have a very open exchange, but we do get what we are given. If there is a problem on track that happens to us and not to

them then it is up to us to resolve it, but if it happens to both then they give a lot of help and we can work together.'

Downstream of where the tailpipe leaves the bellhousing it encounters the rear wing supports which, as with the C33, have two mountings on the rear of the car, though on the 2015 design these pick up on the transmission casing rather than the rear impact structure.

Steering feel

The spring and damper elements, which are mounted in the bellhousing, as mentioned, are again pullrod-actuated, something Sauber had to do due to use of the Ferrari gearbox, but in general the design was new with separate lower wishbone legs. Much of the suspension work was aimed at improving the rear end of the car and getting better traction and improving stability. At the front little has changed year on year, with pushrod actuated torsion bars, but work has been done on improving the steering feel for the drivers. Indeed, the driver feel for the car has been something of an issue both in 2014 and to a lesser extent in 2015.

'Last year the drivers lacked confidence in the rear of the car,' Dall'Ara says. 'The tyres have helped a bit in this respect with the new rear construction from Pirelli. It was not a big step

but it was enough for us and worked well with our chassis, it let the rear become more stable.'

Stability is a word often heard used by engineers in the paddock but it is something that is very hard to quantify, and it is something some drivers can be very sensitive to while others are not so sensitive. It is, according to Dall'Ara, a matter which blurs the lines between engineering performance and human performance. 'Stability, or the lack of it, is the best way to kill a driver's confidence. When I talk about stability I mainly mean in the phase between the entry and braking to a corner, and the late entry to a corner. If a driver feels he is losing a car at this point, even if he is not, then it is a killer because they then brake with more margin and keep the car straight for longer, as they lack the confidence to negotiate the corner. This in turn results in a low apex speed which carries to the next braking point so it kills performance all round. You should not confuse this with oversteer. There are drivers that like to talk about how they like an oversteering car, but that is a case of entering a corner well and sliding out of it. Stability comes before; it's the feeling of losing the rear before turn in. Last year it was an issue we never got on top of.'

Despite largely being based on driver feel and difficult to see in data, it is possible

'Stability, or the lack of it, is the best way to kill a driver's confidence'



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Due to the sheer amount of mechanical and electrical systems it has to pack, the modern F1 car is a long piece of kit and this has led to understeer problems, Sauber tells us

to engineer solutions to this fairly complex problem. Indeed, at one point Sauber did feel that it had mastered it, but then the rules changed. 'It was probably the biggest performance thing for us in recent seasons. With the old exhaust rules we had it really well sorted and had a good season in 2012 because we did not have this issue,' Dall'Ara says.

Now Sauber is working on ways to try to improve the performance of the rear of the car, and some of the fruits of this work will not be seen until 2016. 'It's a big issue as it's all about what you can do with the set-up and what the car can do. Power management also adds to this, not just at entry but also through the corner too, so that has to be right. If the BBW [brake by wire] is not smooth enough it can be an issue, but that's been much better this year. Also, there can be other factors, it can be something like track conditions, so that can be fixed with a bit more temperature in the blankets at the start of a session or going slightly softer at the rear. But the biggest issue is the car losing too much rear load when the front dives and the rear lifts under braking,' Dall'Ara says. 'You can design

around this to some extent, but it impacts how much rear ride height you can run. I remember when James Key arrived in the team in 2010 and tried to eliminate this issue. So we set a target of a softer and higher car, and we got that working. So you can design around it, we know that and we are trying to do it. We have been working hard on the suspension kinematics, too, and we have made some steps there, but the next steps will come next year because there is no point in changing the suspension again now.'

Understeer

In general then, Dall'Ara indicated that the rear end stability is one of the weaker elements of the C34, but it is not the only one, and it is perhaps the symptom, not the underlying cause. 'We need more load on the rear, right through the ride height range as the rear lifts through braking, that increase in height, this transition, we don't feel we are really there yet with it, that hits the stability of the car. The fact is that the car understeers, too. I think you will find it is common to the paddock; these cars are just too long for the tracks we use. You can't get rid of the mid corner and low speed understeer. At Monaco and Montreal, which are radically different tracks where you have low speed change of direction, we really have struggled. [At] tracks with flowing corners like Silverstone and Austria we are reasonably strong. In terms of braking we are okay but we lack downforce so we have to brake a bit earlier. Aero is the biggest contributor, but the suspension is still important but with a 13in rim you lose a lot with the tyre. Brake balance and migration can also be worked on to improve the stability.'

Indeed, it is the car's aerodynamic development that seems to have been holding back the C34 and rather masking its real potential. Few visible upgrades have been made during the season and some of the aerodynamic concepts trialled have not fully delivered.

'One issue here is correlation between CFD, wind tunnel and track. Some years you get it right and some years you don't, sometimes you can fix it, but sometimes not, Dall'Ara says. 'This year we are okay on it but we have lost momentum a bit. I think that is down to the limited development we have compared with some of our competitors. We never got near the front of the grid but we should be scoring points regularly, so we are bit frustrated at the moment.'

Sauber has a strong aerodynamic development capability at its factory in Switzerland. It is so strong in fact that a number of other major organisations are using it. Indeed, Audi Sport is reputed to have booked 3000 hours of wind tunnel running in 2015, and the amount of paid external use is actually limiting how much the F1 team can use its own facility. 'We are restricted in the use of our wind tunnel because it is used by others a lot and all money goes in the same pot and we need it. So we use more CFD than tunnel, as that is how it has to be,' Dall'Ara says.

This restriction in tunnel time for commercial reasons could be partly responsible for the lack of updates on the C34, but the biggest factor was that the last major development simply did not deliver as expected. 'At Melbourne we were quite competitive and reliable, but after that we ended up in a similar situation to last year. The first aero update we brought in didn't really

'I think it's wrong to compromise the packaging too much just because you think that there may be cooling issues'

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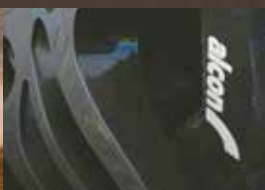
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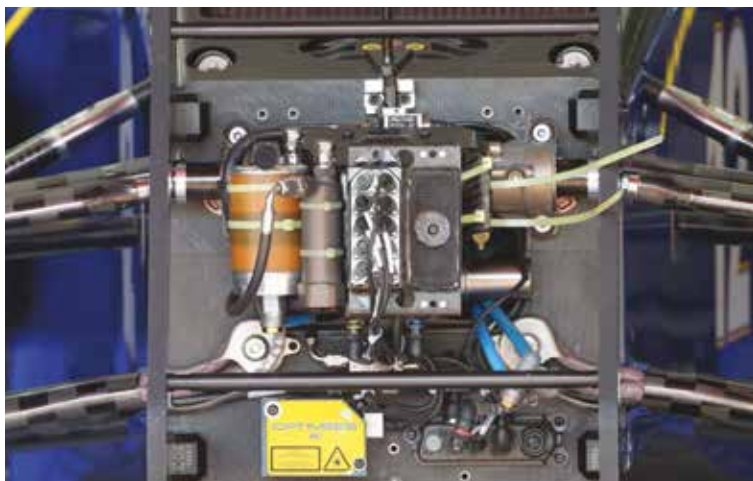
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Much work has been done on improving the steering feel for the drivers with this year's car and, while this issue has not been completely sorted, it has been pretty successful thus far



As always cooling is a major design consideration but Sauber made a decision not to be too conservative this year after learning lessons with 2014 C33



Much of the suspension work on the C34 has been focussed on improving the rear end of the car for better traction and stability. The rear wing supports pick up on the transmission casing



The roll hoop structure is a direct carry over from the 2014 Sauber and follows a concept first used in Formula 1 by the Force India team a number of years ago

work all that well; the front wing we tried didn't have a good balance so we couldn't really use that update. From that point we have not really been able to update the car too much, and that has hit relative performance. But we do have another upgrade, a big one, to come, and that includes a lot of lessons learnt from failing with the first update,' Dall'Ara admits. The upgrade he mentions was expected to feature on the C34s in Singapore and Japan, just as *Racecar Engineering* closed for press.

As Sauber is reliant on Ferrari for a great deal of the mechanical layout of its car the engineers at Sauber rightly often feel a little bit constrained in what they can do. But it is clear that using Ferrari parts has raised the performance level for Sauber this year.


'From the nose tip to the back of the tank we are fully free as engineers, but from the tank back we don't have much freedom at all,' Dall'Ara says. 'Sometimes there are some rough discussions at the factory, I want to have a shorter car and the designers come back and say like an excuse, "you have to allow for all of these things in the car"; of course it's not an excuse. It's a fact, but it is very frustrating.

Frustrations

'One of the frustrations we have is the understeer and there is not much we can do about that,' Dall'Ara says. 'It's the wheelbase you want to change but ultimately that is constrained by the amount of stuff we have to put in the car, so you can only be so short. So that is annoying as an engineer, but you just can't do it. You'd like to do your own thing but we are not in the position to do that. I'm glad we can have the current specification parts from Ferrari, they are very good parts, so that's good and we try to do the best we can. The only constraint really is the inboard suspension pick up point but, if we want a shorter wheelbase we move the wheels where we want and you end up with the suspension sweeping forward and you can't really do it.'

While the overall mood in the Sauber camp may at first seem a little low, it is really not the case, and actually there seems to be a sense of optimism around the organisation and the direction it is taking. The arrival of Mark Smith as technical director is seen by Dall'Ara as a very positive step and a good start to building a strong future for the team.

'Overall we need a stronger car all round, it's clear. We want to be back racing Force India, Toro Rosso and Lotus. We want to be in the points every race. One of the things is that there was a lot of carry-over from 2014 into this car partly because of need and partly because of will. From my perspective the car has grown too much. Maybe we need to go a bit more radical in 2016. We need to go smaller and tighter. You can only develop around the same concept for a while, so we have to find some new ideas and I think Mark Smith will bring that.'

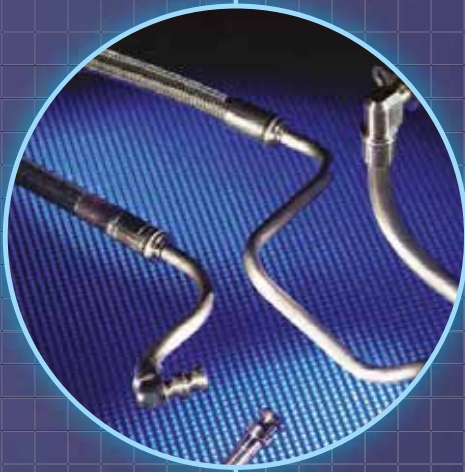
With Sauber looking to the future it still has a fight on its hands to stay ahead of McLaren in the constructors' championship and catch up to Toro Rosso, which narrowly held seventh position ahead of the introduction of the updated Sauber in Singapore. It will be interesting to see if Sauber can bounce back to finish the season as well as it started it. 

'The car understeers. I think you will find it is common to the paddock; these cars are just too long for the tracks we use'

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‘We started with last year’s power unit as a basis, but we developed it into a much better product’

Ferrari staged a special launch event for its new Formula 1 power unit, the 059/3, in late 2013. It was the first new F1 engine from the famous Italian constructor since 2006, so perhaps it was not surprising that its arrival was met with such fanfare. At the launch the bare V6 engine was shown lacking exhausts, turbo, hybrid system and many other parts, but once the power unit was fitted to a car, initially a one-off GT car test

bed and later the 2014 Ferrari, Marussia and Sauber chassis, it took on a very different appearance.

The exhaust manifolds took a tight route curving upwards around the cylinder head in a three-into-one layout on each bank of the engine with a curiously large wastegate sat above the turbocharger. The turbo itself did cause some consternation when it first appeared as it did not feature a separate ballistic cover like that of the

Mercedes and Renault, rather it was built into the main turbo housing instead. Overall the concept of the Ferrari 059/3 was clearly heavily influenced by the demands of other departments and Ferrari technical director James Allison admitted as much at the roll out of the 2014 Ferrari: ‘Our engine department have been aggressive and bent over backwards for us on the chassis side to produce an engine that can be packaged tightly and can

Prancing horsepower

The 2015 version of Ferrari's V6 power unit has shown itself to be a great improvement over its predecessor. *Racecar* uncovers some of the secrets of its success

By SAM COLLINS

be cooled with radiators that are not too big. Our car has quite a neat bodywork package and the radiators are quite small and that is a result of what the engine guys have done. The engines are incredibly busy compared to the V8s, and the Ferrari has been rather exquisitely packaged.

Its tight packaging came as the result of a few unconventional design decisions: the charge air cooler was mounted in the V of the engine, and the

oil tank was mounted in the transmission rather than in the more conventional location at the front of the block. The MGU-K was also mounted at the rear of the block.

In races, the Ferrari 059/3 seemed to be a reliable unit but it was also said to be overweight and underpowered and the Italian manufacturer reacted with not a little aggression. The head of the engine programme Luca Marmorini was forced out, as were

two team principals. A new focus was placed on improving the power unit for 2015, and from the very first test at Jerez it had clearly paid off.

'The power unit has, along with the rest of the car, been an area of extremely high effort to improve,' Allison says. 'We had a number of issues with last year's engine and power unit. Early on in the season the power delivery was not particularly sophisticated, and it was quite tough for the drivers

to get the type of throttle response that they wanted. It was improved a lot during the season and we take that a step further this year.'

The hybrid system was also highlighted as a weakness by Allison and was another area that was fundamentally revised for 2015. 'The amount of electrical energy that we were able to recover from the turbo was not really good enough for producing competitive power levels during the race. That's one of the reasons why Ferrari's qualifying performance was relatively strong compared with the race performance last year. That's an area where we've tried to change the architecture of the engine to make it a better compromise between qualifying and racing performance', he says.

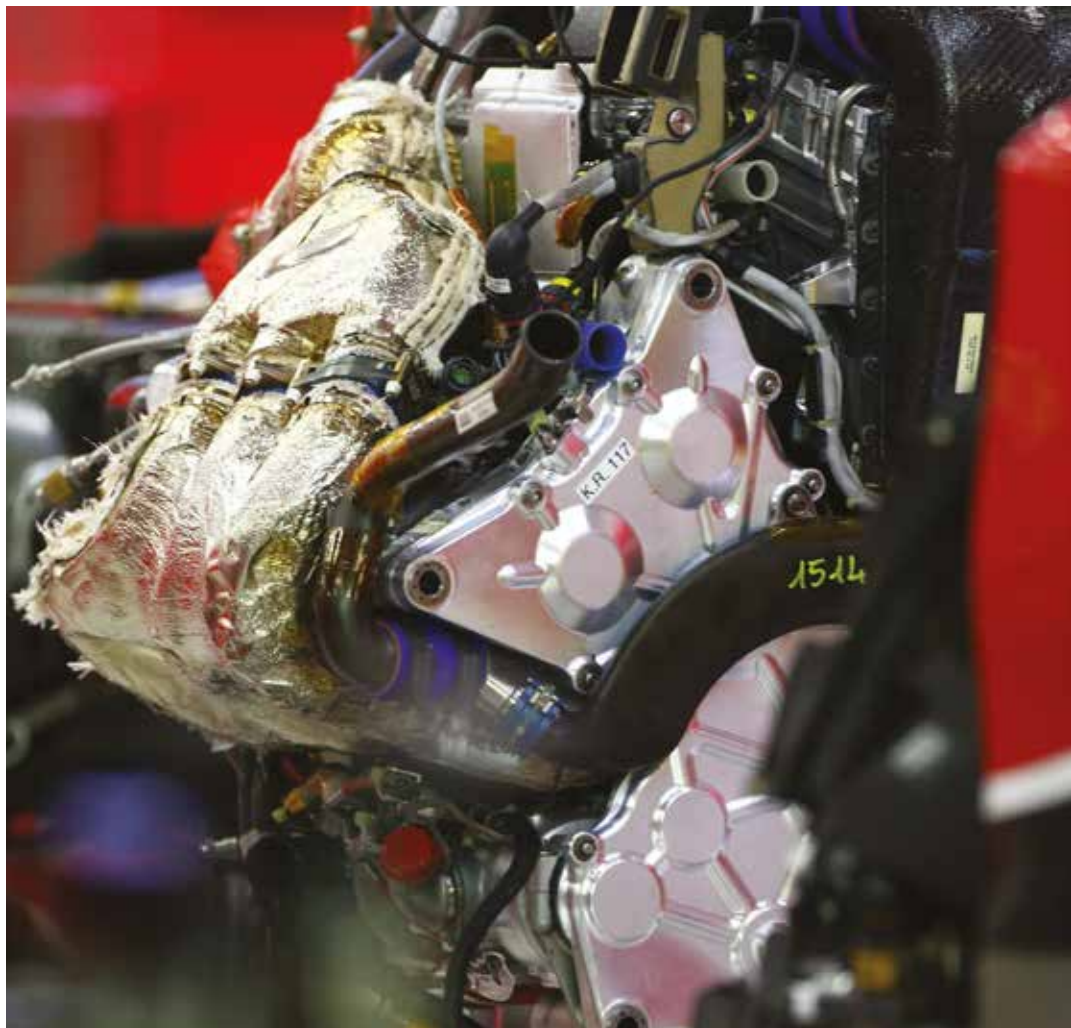
'Then, there is plain simple horsepower. A tremendous amount of work has gone into all aspects of our combustion efficiency to try and make sure that in this fuel limited formula, where every team is only allowed to burn the same amount of fuel, that every single compression stroke, every single ignition stroke, is extracting the maximum amount of horsepower and putting it on the road.'

New power unit

While not stated by any Ferrari engineers, it seems that the compromises made on the power unit to favour the chassis and aerodynamic demands went too far. But Ferrari was clearly minded to move away from the concept in 2015. The new power unit (PU) did not have the big launch of the 2014 variant and only a subtle name change. But the Ferrari 059/4 was a very different machine, according to Luigi Fraboni, Ferrari's head of engine operations. 'We started with last year's power unit as a basis, but we developed it to a much better product, but we realised that there were others better than us so we reworked everything. A big effort went into combustion, we looked at the turbo, getting the most out of the energy recovery and we did a lot on the oil system. We looked at better knock control too, and we had to get better correlation between the software and how the engine worked in reality. In the end, we ended up with basically what is a completely new engine.'

The 059/4 saw a number of visually obvious changes, most notably an all new exhaust layout with the manifolds now running low along the flanks of the engine block to the twin entry turbine, which now appears to be mounted in a lower position in the bellhousing. Returning to convention the oil tank appears at the front face of the block in common with the layouts used by other PU manufacturers.

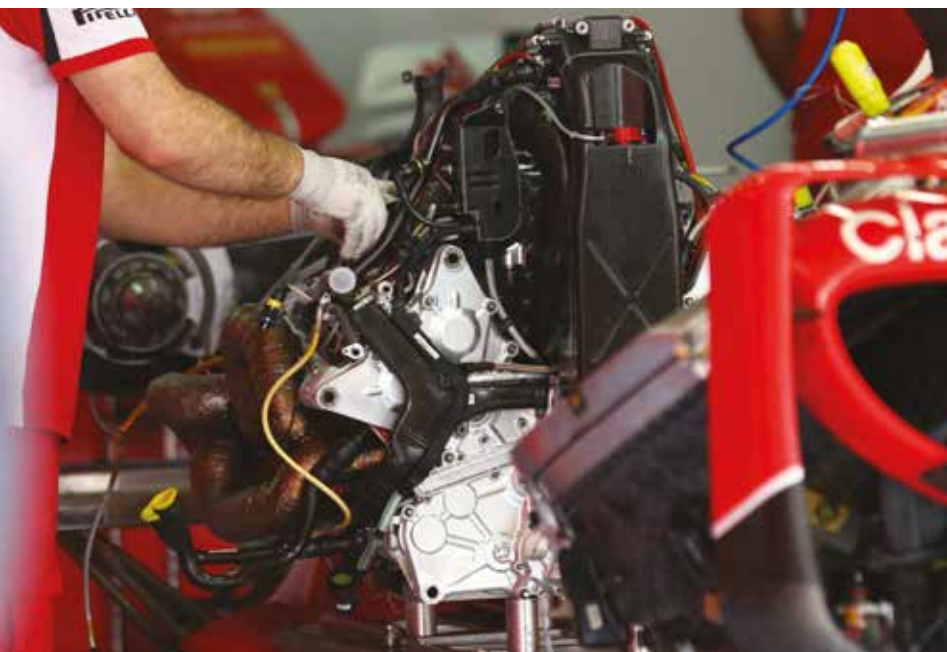
However, it is the changes that cannot be seen from the outside that seem to have brought the biggest impact on performance, especially in terms of combustion. The work here is not just limited to the shape of the piston crown and combustion chamber itself but has seen Ferrari rely on two long term



Top: 2014 power unit (the 059/3). Picture shows the exhausts swathed in thermal protection, something that Ferrari did not do for much of the season, baffling many as this meant it lost heat which reduced the recoverable energy of the MGU-H
Above: Another shot of the 2014 unit; the intake and charge cooler in the V of the block can be seen here. A feature of last year's engine was the tight path taken by the exhaust manifolds, curling upwards into a three-into-one layout on each bank



The 2015 power unit (059/4) has a relocated oil tank, now mounted at the front of the block as per convention



The exhausts have been re-routed for the 2015 version and they are now *always* swathed in thermal barrier



These Magneti Marelli injectors are the same as used in the 059/4, though they may differ in appearance

technical partnerships. The introduction of direct injection in 2014 was something of a step into the unknown for Ferrari and it turned to electronic specialists at Magneti Marelli to help, but even for them it was a steep learning curve.

Roberto Dalla, motorsport director at Magneti Marelli, said: 'We started on the project using the experience of our production car products, they were way ahead of us in terms of experience and technologies as we had not done a GDI system for motorsport. So we took onboard their experience, but not their product, as a basis. We decided to start over and build a brand new 500bar injector for F1 V6 engines.'

The injector pictured below is the same as that used on the Ferrari V6, though likely not in the exact configuration used currently.

Bespoke injectors

'It is very customisable by design as we know every customer wants its own solution,' Dalla says. 'They want different nose lengths, larger or smaller sizes, things like that. It's not only the nozzle section that changes a lot it's the whole thing because it all interacts, the whole dynamic of the injector has big influence on combustion.'

Ferrari is not the only PU manufacturer to use the Marelli injector, and this has seen many variations of the design being developed. 'There are different types of developments going on, the mechanical developments can take some time but the customisation of the nozzles and other related parts to change the fuel spray can be done very quickly, in perhaps two weeks from concept to delivery, and that's really important for the engine builders,' Dalla says. 'They are doing so many variations, in the last two years we have done maybe 70 or 80 different nose configurations and perhaps even more nozzles. Now we are passing the experience from the F1 project back to production cars.'

The fuel injected by the Marelli injectors is also a key area of development, and Ferrari is working as it has done for many years with Shell to develop the ideal fuel for the V6 engine. But here too some of the working practices of 2014 have changed to improve performance.

'We have done a lot of fuel work on these power units, it's a big area because you can change it as often as you like without using any tokens, and developments in that area make some things possible in terms of combustion that would not be otherwise doable,' Fraboni explains. 'Last year we were developing in parallel with Shell, but this year we have set targets to them in terms of performance and especially knock. They now know where we want to go and what we want to achieve with the engine and they have to get there. So each time we go to the dyno they will bring a number of candidate fuels to test to make sure we have the best for the races. I think now it is a very close relationship.'



The significance of fuel development has increased substantially

The significance of fuel development has increased substantially with the introduction of the new V6 engines and this can be seen by how closely the manufacturers are working with suppliers, Mercedes with Petronas and Renault with Total. Says Guy Lovett, innovation manager at Shell Motorsport: 'The fuel development has been an intense area of activity since 2013 for us. That is not to say that we have not done anything with the oils but the proportional gains have been greater in terms of the fuel.'

The possibility to improve performance with the V8s was always there with the fuel, but the opportunities then were probably that much greater with the oils. 'We have seen with the new power units that the balance has significantly shifted, the new V6s are incredibly responsive to fuel, they have a different appetite for fuel to the V8s and that is an area where we have exploited our experience with turbo engines from other areas of motorsport.'

Technology also transferred from production

cars into the racing fuel for Ferrari as well as the expertise from other series such as WRC and WEC. 'We have benefited from some of the road car fuel development for GDI engines, though the applications are a bit different,' continues Lovett. 'The temperatures are a bit higher in the racing engines tip temperatures, but the detergent technologies are the same in the road fuel as the race fuel. It's actually much easier in F1 where we are developing a product for a single engine. We have intimate details of every aspect of the engine and we have complete information sharing. It's a one team approach now. That lets us get into the minute details of the formulation to let us optimise to the design, on production cars you can't do that. But there is some commonality between the applications so the motorsport technologies are extracted and applied back to the road car products at the pump. It's why Shell is in Formula 1, it's not just marketing, it's real technology development.'

Fuel flow

One technology not a major feature on the road but increasingly so on the race track is the use of fuel flow limits, either by restrictors such as in GT500 racing in Japan, or by flow sensors in WEC and Formula 1.

'I think the challenge with flow meters is an interesting one,' Lovett says. 'The balance of how we formulate the different fuels does subtly change, so parameters like anti knock and flame speed, which are good for performance, are typically not so good for energy density, so we need to continuously optimise the fuel to get a good calorific performance within the given flow and consumption limits. The same is true for the WEC. The challenge there is that the fuel works across all the different demands of the different manufacturers, so they all had to work together with us to get an optimum fuel.'

Shell does not only supply Ferrari with its fuel, but also other bespoke products. Indeed, according to Lovett it supplies every fluid apart from brake fluid to the Scuderia and its customer teams, Sauber and Manor. Interestingly the latter retained the older 059/3 power unit for 2015 and Shell still supplies it (via Ferrari) with its 2014 product.

Lubricants are clearly still a major area of engine development and not just in terms of reducing friction, Fraboni explains: 'The oil also has an effect on the detonation so it's very important not only for friction reduction and performance but also reliability. If you want to reduce the cooling on the car then there is a lot to do with the oils, the flow rate, things like that, you can use the oil formulation to close up the radiators a bit too.'

With only four complete power units allowed per car per season in F1 each engine has to operate in a variety of conditions, from



Plenum is smallest in F1, suggesting 059/4 does not feature variable inlet. Wastegate configuration has changed from 2014



059/4 power unit installation – this picture graphically illustrates the mind-boggling complexity of a modern Formula 1 car



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Shell works very closely with Ferrari and says it supplies all the F1 car's fluids except for the brake fluid. Ferrari says Shell's input into the engine's development has been vital

the high speed tracks at Monza and Spa, to the heat of Singapore and the high altitude of Mexico City. Rather than using a bespoke oil for each venue, though, as was once the case in F1 (during the V10 era) Ferrari and Shell claim to stick to roughly the same spec for a number of venues. 'We tell Shell what we want to do and then we try things out on the dyno,' Fraboni says. 'Sometimes you take something that you know is marginal to see if it is worth risking it. Basically though we run the same oils, for quite some time, the engines have to do a lot of races so we don't change it too much each year. We need an oil that can survive all the conditions.'

But the fuel flow and fuel consumption limited formula of modern Formula 1 (and LMP1) places a serious emphasis on increasing efficiency, and that does mean that reductions in friction do result in big rewards on track. 'We are always hunting friction reductions because of that,' Lovett says. 'With a finite amount of fuel going in [100kg], any efficiency gain you can make is heavily rewarded in lap time. It's a big win, that remains our key drive for lubrication. We want to reduce the viscosity of the oil as much as we can, as long as we avoid metal to metal contact we can reduce friction. But it's

not that easy as every component has differing demands. It's not just about viscosity; there are other parameters to look at. We have to protect these engines. If we take viscosity down too far we get into issues with durability and wear, and ultimately an expiration of the engine before its design life.'

Surface coatings

In recent years much has been made of the development of surface coatings and they have now become an essential part of a racing engine's design and construction, the Ferrari V6 included, according to Lovett: 'We are right with Ferrari working on the coatings,' he says. 'We like to call it co-engineering, so we optimise our lubricants around the latest surface coatings and surface finishes. A DLC [coating] contact is very different to a metal-metal contact, ideally we would like to have six different lubricants in the engine for different areas but you can't really do that!'

One new area where Shell is making a bespoke product for Ferrari, but is unwilling to disclose details, is in the energy recovery system, which requires a special cooling fluid. As said, information on this is not available.

The 059/3 was not the first hybrid power unit for Ferrari, the 056 V8 also featured a hybrid system in 2009, 2011, 2012 and 2013, and one of the key suppliers to that project was once again Magneti Marelli.

'We started in 2009 with a solution on the MGU-K,' Dalla says. 'We understood then that the voltage was very important so the evolution of that 2009 solution saw us go down in voltage because under those regulations, at that time with the experience we had then, going down

in voltage allowed you to reduce the battery size and improve overall car performance. In 2011 we were able to use a battery that was less than half the weight of the battery we used in 2009, because of the pursuit of that voltage reduction.'

The 2009-2013 MGU-K was a 60kW device and proved popular, and a variant of it was believed to have been fitted to Peugeot Sports stillborn 908 LMP1 hybrid. But in 2014 the importance of the hybrid system on overall car performance increased drastically with the new power unit rules.

'In 2014 with the introduction of the MGU-H there was a paradigm shift, the way the MGU-K was used changed completely and we moved in the opposite direction as a result and increased the voltage to over 450v because the overall car package would be better with a higher voltage,' Dalla continues. 'Going up in voltage and the higher power motor [120kw as opposed to 60kw] and the different type of usage. But we had to develop a highly customisable solution again, both for the motor and the control electronics.'

As you might expect with the increase in both voltage and power the 2015 specification MGU is much larger and heavier than the 2009-2013 version, but tipping the scales at 10kg its weight has certainly not increased in proportion to its potency.

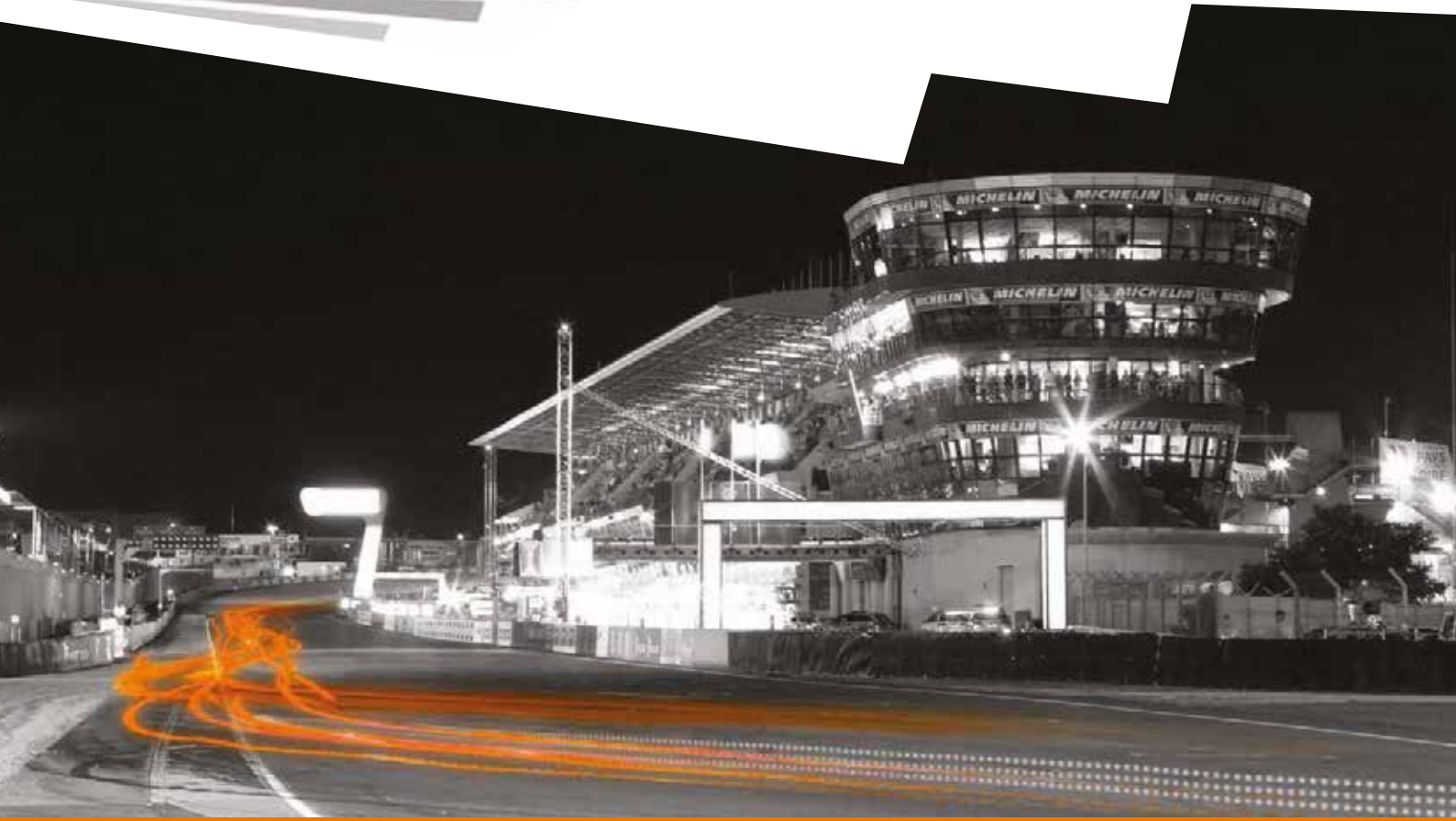
'The biggest step has come in the control electronics, and here there are still big gains to come in that area,' Dalla says. 'At the moment the weight is about 3kg. We have a big constraint with this part, the capacitor. From 2014 to today it is an area we have plans to improve and we have some clever ideas to come which will reduce the weight substantially. The power

The fuel flow and fuel consumption limited formula of modern F1 places an emphasis on increasing efficiency



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Cooling is vital with new breed of power units and Ferrari has crafted louvred coolers to help with heat efficiency on 059/4



Magneti Marelli MGU-K can pack 120kW and 450v and weighs 10kg – which seems a fair trade off when all's said and done



Magneti Marelli is trying to reduce the weight of the capacitors, which are housed in the black section of the inverter

modules will be completely revised, so I think we will show a very big step in the near future.' Dalla goes on to point out that the developing technologies in motorsport energy recovery systems are rapidly becoming a great area of focus for all concerned, not just for their on track performance, but also their wider relevance.

'In the current regulations there is this wonderful element, the link between MGU-H and MGU-K which is a very open door and there are very few constraints in this area.

'These electric motors have more than 95 per cent efficiency. Introducing this technology to road cars will take time but it will happen, with 95 per cent efficiency you will see its importance in series production grow and grow, as focus on fuel consumption intensifies,' he states with detectable excitement.

'What really excites me is the ERS-H because there is the potential to recover so much waste energy, you will see it tomorrow in Formula 1 and down the road in series production, but you can reduce the importance of the battery in a hybrid car, because right now the battery is the weak point,' Dalla adds.

Work in progress

While Dalla enthuses about the potential of ERS-H his company does not supply the full system to Ferrari. The MGU-H often shown on the internet as being Ferrari's solution, with the MGU-H mounted between the compressor and turbine, is in fact just a demonstration part from Marelli and not the Ferrari solution at all. Indeed, in general the design of MGU-Hs in Formula 1 remain largely secret.

But Dalla stresses that the importance of them and indeed the MGU-K is likely to grow in the very near future, perhaps even by 2017 as Formula 1 contemplates its own existence. 'The power units have moved from 32 per cent efficiency with the V8s to 40 to 45 per cent efficiency. That's wonderful, now Formula 1 is looking to what comes next, and the idea of a more powerful power unit, 1000bhp or more easily, is an interesting idea.

'I'm pretty sure that will come, but the big question in meetings now is how to reach it. If you reach it with the fuel it's easy, but you lose that efficiency which you have worked hard for, and it's bad in terms of image, so I feel sure that the power increase will come from the ERS. It's the only way to do it,' Dalla concludes.

Ferrari's power unit is still very much a work in progress. Even in 2015, new fuel and oil specifications are still to be introduced, and some of the development tokens will be spent on combustion and reportedly a new MGU-K, as the Italians try to continue to close the gap to the seemingly less dominant Mercedes. 'The engine is still at the beginning of its development and we are still having new ideas each week, there is still much more to come,' Fraboni says. Which is surely a warning the Scuderia's rivals will take very seriously. 



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Three into 16

With a desire for safer and roomier racecars GP3 took the decision to switch to a brand new car in 2016. The GP3/16 is the result

By **SAM COLLINS**

When GP3 was first introduced five years ago it was not quite clear how it would position itself within the messy ranks of European open wheel racing classes. But with its regular slot on the Formula 1 support package and good media coverage the class has now become a key rung on the ladder to Formula 1 for many young drivers.

In 2016, the series will welcome a new car designed by Dallara. Launched at the Italian Grand Prix the Dallara G316 (officially called the GP3/16) is the third iteration of GP3 car, though strictly speaking only the second chassis, as the 2010 and 2013 versions shared a large amount of commonality.

GP3 and GP2 series technical director, Didier Perrin, gave Dallara's engineering team, headed by Luca Pignacca, a set of criteria for the new design. 'We had three targets: improve the safety, so the car meets F1 2015 front and rear impact standards, the second target was to improve the show with more overtaking, then the third target was to keep the costs as low as possible,' Perrin says. 'In addition to that we took the opportunity to make a chassis to

accommodate taller drivers, because year after year we are finding that the drivers are getting taller and fatter.' These requirements also meant that the GP3/10 and GP3/13 chassis simply could not be further upgraded, and therefore an all new design would be required.

'Overall the new monocoque is built to the F1 2010 safety specifications,' Pignacca explains, 'with the nose built to the 2015 F1 technical regulations with the low nose box. We have adopted torsion bar suspension at the front which is a little bit more modern, too. Really this work has benefitted a lot from the other cars we are doing from GP2 to F1 in terms of understanding the safety specifications and things like that.'

Keeping the costs under control was also one of Perrin's key criteria and in order to go some way towards achieving this, Dallara has not reworked every part of the design. 'We have made it possible for teams to upgrade from the existing car so we have carried over some components,' Pignacca says. 'The gearbox carries over, you just need a new bellhousing, the rear suspension carries over entirely and the uprights also carry over all round.'

The reason the teams need a new bellhousing is that the 2016 car is fitted with a new 3.4-litre normally aspirated V6 engine from Mecachrome. But even with the bodywork fitted to the car it's obvious that this power unit is not a conventional installation, with additional ducts on top of the sidepods. With the bodywork removed it's clear to see that the layout is in fact similar to that of the Audi R18 V6 diesel, just without the turbocharger.

Bespoke engine

'The new engine is a pure race engine dedicated to us, it's bespoke,' Perrin says. 'The layout is the way it is because we have in mind the next generation of car, and we want a family design, using the engine as a basis. Next year we will produce a new GP2 car. This is a turbocharged architecture, and the layout is similar to what we have in Formula 1 because we have something in mind with that.'

The engine output in the normally-aspirated GP3 guise is the same as the well regarded AER engine currently used in the class, at about 400bhp, but it is clear from the design of the Mecachrome that Perrin hopes that this will be

'We had three targets: improve the safety to meet front and rear F1 impact standards; improve the show with more overtaking, then the third target was to keep costs as low as possible'



the basis of the new FIA Formula 2 power unit. The GP2 organisation is currently the favourite to secure the rights to run the new F2 championship on behalf of the FIA. That would require probably an engine of around 600bhp fitted with a single turbo, as well as an exhaust energy recovery system and a kinetic ERS. Though this has not been formally announced, a number of GP2 insiders have been dropping heavy hints that this is indeed the case.

Design challenges

'The biggest challenge while designing the new GP3 was installing the new powertrain,' Pignacca says. 'Actually it was really good fun doing that, it was something new, a bit different. I was actually really happy with the old AER engine, that was a good package, but Didier [Perrin] wanted something new.'

'The exhausts are mounted in the centre of the V of the engine with the air inlets mounted on the side where the exhausts normally are, so the engine has two airboxes rather than one. We just designed two airboxes fed by the ducts on top of the sidepods, the roll hoop duct which would normally give you combustion air now just provides some airflow through the engine bay,' Pignacca says.

With the combustion air now entering the engine bay via ducts above the sidepod mounted heat exchangers it could be something of a challenge to ensure that the airflow to the plenum remains cool but Pignacca claims that it was not too difficult: 'Having the airboxes where they are means you have to be a bit careful not to feed hot air into the engine, but using common sense and a bit of CFD you find something that works.'

The final objective for the Dallara engineers was to provide a car that would be able to

overtake more easily, something which is far from straightforward to design into a package. 'That last element is something of a black art,' Pignacca says. 'Nobody really knows what makes a car good for overtaking. I personally think its a combination of the aerodynamics, the tyres, the tracks and the format of the races.'

With this in mind the Dallara engineers decided to follow the lead set by their own GP2 car design, which does seem to race well (though is aided by DRS). The aerodynamic development was largely carried out in the virtual environment rather than in the wind tunnel for budgetary reasons. 'This GP3 car is much closer in design concept to that of the current GP2 car, especially when you look at the floor and front end,' Pignacca says.

Overall the pace of the new car will be about the same as that of the old car, but this is by design, Perrin explains: 'I think the speed is similar, we did not want to be much faster, the positioning of this car on the ladder to F1 is quite precise, it has to be a bit faster than F3, but not so fast as GP2.'

The development of the GP3/16 is ongoing. Ahead of its launch, it underwent five days of testing at Magny Cours and Barcelona, but Pignacca feels that it is too early to make any comparisons or draw many conclusions about the cars overall characteristics.

Delivery of the complete cars, or the components to allow teams to upgrade from the existing package, is set to begin in early 2016.



Above: Word in the paddock is that the new 3.4-litre normally-aspirated Mecachrome V6 in the GP3/16 could also power the new Formula 2 car in turbocharged form. Exhausts are mounted in the V of the engine, with the air inlets on the side

Below: The design concept of the new GP3 car is close to that of its GP2 big brother, especially the front end and the floor



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Unplugged

Formula E will have a degree of technical freedom in its second season – but just how are the manufacturers and teams adapting to the new regulations?

By **SAM SMITH**



Citroen's DS sub-brand has tied up with Virgin Racing as FE goes into season two while other manufacturers are also taking an interest

The FIA Formula E Championship enters a brave new world for its second season, which runs until summer 2016 and kicks off in Beijing on October 24 this year. For season two, the all-electric series takes the step from spec chassis and powertrain to a melting pot of freed-up technical solutions – which has been embraced by all but two of its 10 teams.

The technical road map implemented by the FIA, in conjunction with founding organiser and promoter Formula E Holdings (FEH), will see a diversity of packages this season as the series works toward its 'one car/one driver' plan for the fifth season in 2018/19; as opposed to drivers changing car mid race as is now the case.

The freedom in the powertrain development for teams in season two revolves around the motors, gearbox and inverter, but there are knock-on freedoms, too, which could prove telling. The rear suspension and damping is freed up, as is the cooling systems for the cars, meaning that re-packaging around the rear of the manufacturer cars has been embraced.

Meanwhile, the Dallara built SRT_01E chassis itself, and the mechanical running-gear, has a number of upgrades for 2015/16. A new brake

disc has been introduced, as has an aluminium blanking plate. New brake pad geometries have also been mandated with supplier Alcon.

Bulky and re-enforced lower ball joints have been added to the front wishbone in an effort to improve durability after some high-profile race ending issues in season one. An updated spec cooling system has also been unveiled. This sees a reduction in the size of the radiators and cooling pipes linked to the intercoolers.

Overall, the emphasis in season two will be focused on efficiency as the teams are playing with the exact same amount of energy that was available in season one. The ultimate performance from the cars will depend upon the efficiency that the teams can muster from the new powertrains. The energy of the Williams Advanced Engineering-provided batteries stays at 28kW, but the overall race power from the lithium-ion unit has been somewhat controversially upped from 150kW to 170kW (see below).

Additional changes for the sophomore year of Formula E will include real-time Fan Boost voting. This is set to be controlled by the Leeds-based media technology company Telescope Media. A re-jigged qualifying format

was also set to be announced as *Racecar Engineering* went to press.

Battery row

Plans for a power increase in season two races of the FIA Formula E Championship will go ahead, but this has split paddock opinion. Each of the 10 teams tested one upgraded Williams Advanced Engineering (WAE) designed and supplied battery at the final two days of testing in August before the cars were shipped to China for the first race on October 24. The increase from 150kW to 170kW is for the races only and the cars are set to have 200kW at their disposal for qualifying.

The upgrade in power was at the centre of a considerable and often contentious debate between the FIA, FEH and WAE, which initially resisted a wholesale increase to 170kW in race power output. WAE has now increased cells in the unit and improved aspects of the cooling in response to the demands from the FIA and FEH.

The FIA drove through the plans to make the cars faster in the second year of competition after it was deemed that the single seaters were too slow in season one. Talks between the FIA, FEH and WAE were on-going throughout the

The emphasis in season two will be placed on efficiency



The upgrade in power was at the centre of a considerable debate

summer period, and were initially deadlocked before breakthroughs were made just before the commencement of testing in early August. *Racecar* has learned that the teams agreed to a specific set of conditions with FEH and WAE for the power increase this season. However, strict guidelines within the agreement are believed to cover potential cost implications if the agreed conditions of use are breached.

WAE initially designed the batteries to a spec provided by the FIA before the start of the inaugural season. The race power was originally set at 133kW but then increased to 150kW just before the first race in Beijing last September. With the cars now at 170kW from the first race of season two onwards, it means that the batteries are set to perform 30 per cent beyond the initial specification and design.

WAE worked with teams during the Donington testing in August to gauge the reliability and performance of the batteries at 170kW. But, although modifications have been made to the units, there is still concern that it exceeds the original specification and the capability of the RESS (Rechargeable Energy Storage System), which is the original item. Reliability will be closely observed in Beijing and especially at the second round in Malaysia, where temperatures are so extreme.

But Adrian Campos, whose eponymous team runs the NEXTEV squad which won the inaugural Formula E Championship, believes that the bigger picture for Formula E's technological road map is paramount for the image of the nascent series. 'You have to understand that the aim of the championship

is very important and we need to push the innovations and be quicker every season,' said Campos. 'The test for all us manufacturers is to improve with new technology but we also need to control the costs too. We have to go as fast as the rules permit. Yes, there might be problems but we have to solve those in order that we develop these kind of cars and the public sees they can get faster.'

However, one leading engineer in the paddock, who preferred not to be named, believed that the changes were not necessary and stated his 'sympathy for the difficult position WAE has been in since the start of the championship' and that it had been 'railroaded in to going beyond the original spec.'

An additional problem was the tight time-frame for supplying the new spec batteries to all racecars in time for the Beijing opener. The cars, including the powertrains and most of the batteries, had to be shipped first to Gdansk and then go via train across Russia to China. Like many of the teams, WAE was completely at the mercy of FEH's generally unpopular yet necessary 'bigger picture green credential' logistical arrangements for the opening race.

Varied solutions

The solutions chosen by the seven manufacturers for season two range from the complicated twin-motor set-up of reigning champions NEXTEV TCR (formerly known as China Racing) and the conservative upgrades on the initial McLaren-Hewland package sported by Mahindra.

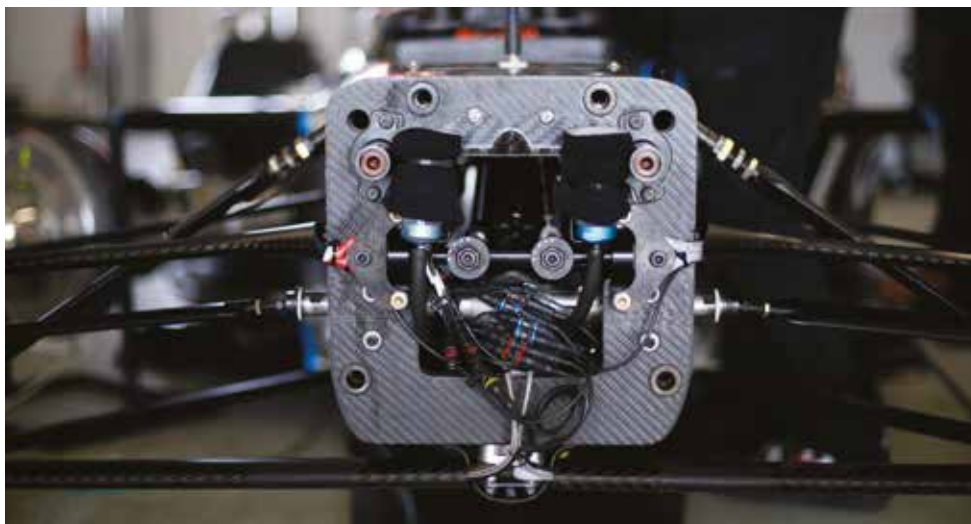
The season two Formula E rules state that the motor or motors have to drive the rear axle through a conventional mechanical differential. This means that, in theory, running without a conventional gearbox would not be beneficial. This passive/aggressive move by the FIA was made to stop the exploitation of controlling the amount of power being allocated to each rear wheel through torque vectoring from a dual motor design.

The challenges faced by the seven manufacturers for season two (Abt, Renault, DS Virgin, Mahindra, NEXTEV, Venturi and Trulli) centred on what would fit best in to the original confines of the Dallara built SRT_01E car. Essentially the teams had to evaluate exhaustively on simulation tools. The big over-arching questions were whether to run a high speed motor with gears, with the gears weighing extra but the motor being lighter, or run a high-torque motor but with no gears, but the motor weighing more.

The teams have also been toying with and planning on how to enhance efficiency in their systems, particularly electrical efficiency gains, and thus try to exploit more of the power through the RESS. Designing in more



Williams Advanced Engineering-supplied batteries were originally designed for race power of 133kW but this rose to 150kW before first season and for season two it's to go up to 170kW in the races. This move has proved controversial in FE paddock



A major challenge for the seven manufacturers going into season two was how to fit their new technology into the confines of the Dallara-built racecar and this was the subject of much simulation as the teams decided on final concepts for 2015/16



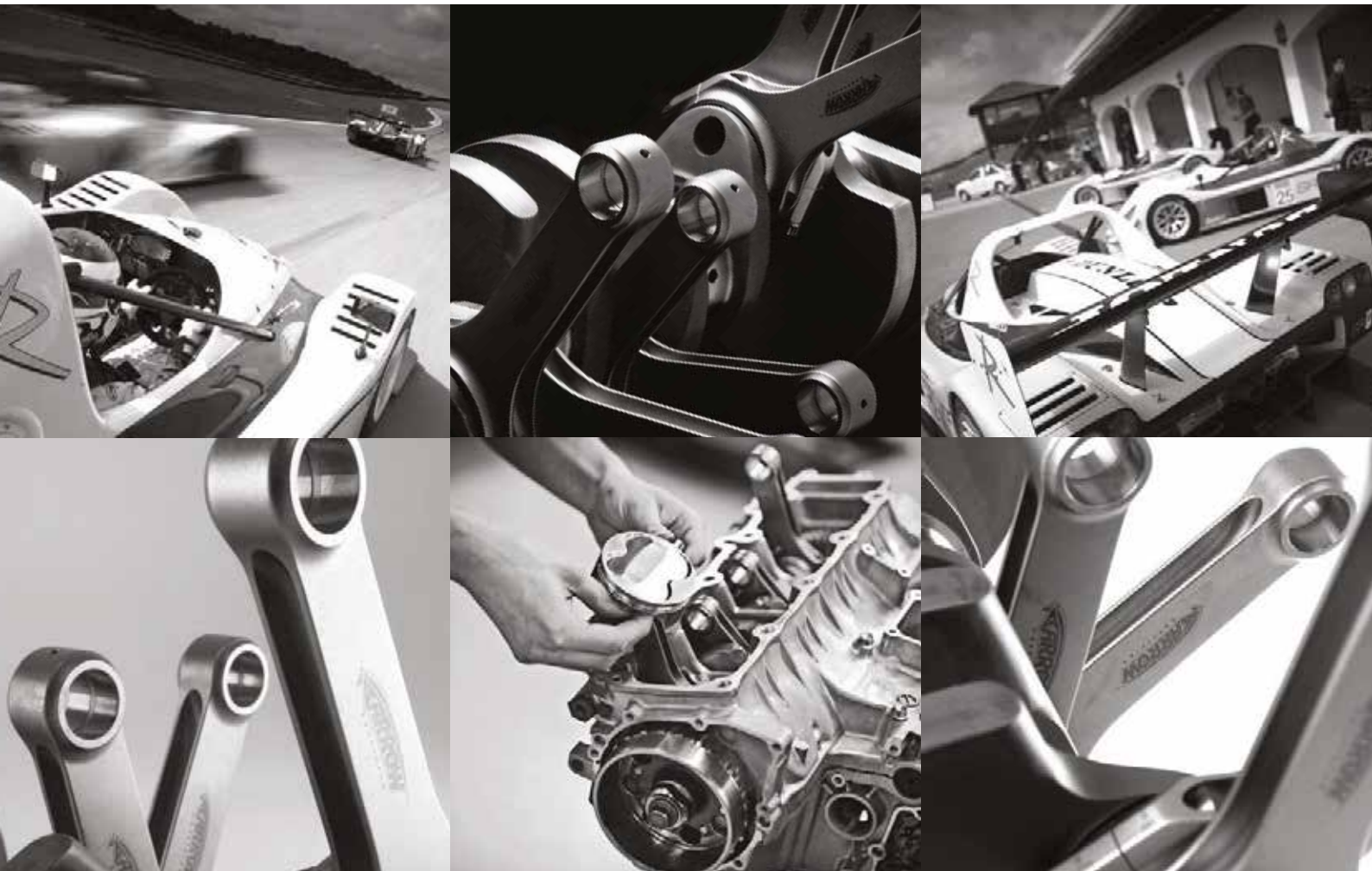
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Reigning champion NEXTEV TCR has gone for the most radical set-up

temperature tolerance and then being able to run at higher temperatures will be vital, as will drag-reduction from optimising the cooling system, and the rear suspension geometry changes that will undoubtedly come from the modifications. Weight reduction and improved centre of gravity will also be key areas where the manufacturer teams aim to gain in season two.

Before the August tests at Donington the teams had 15 private days at their disposal. Few completed all 15; others didn't get off their simulation tools or test benches. The vast majority of them were in a whirring, agitated race against time to get in to shape with their

single specially provided test chassis for the public days. The overriding feeling at Donington was of the teams playing cards very close to their collective chests. Little was given away in terms of detail on the options and solutions embraced by the seven manufacturer teams.

That said, some things were clear. For example, reigning champion NEXTEV TCR has gone for perhaps the most radical set-up. Little detail is confirmed but Campos told *Racecar Engineering* that it has a dual-motor and a single gear set-up. What else is known is that the team has partnered with Rational Motion GmbH. This company is headed by former Toyota employees

Robert Marusic and Benoit Vareille, and is based within TMG (Toyota Motorsport GmbH) workspace at Cologne.

Solutions used by NEXTEV include an 'in-series' layout, utilising two different spec motors which use a mechanism linked to a mechanical differential. This has been created and developed by another partner, American agricultural technology equipment giant Omnigear. The gearbox housing itself is believed to be tiny and it sits between one of the motors and the wheel itself to manage the large levels of torque.

Testing times

So far the NEXTEV car has been beset by reliability problems thought to have been centred around cooling, generating power to the wheels effectively, and the entire structure initially being too flexible. There was also some conflict within the team about whether or not the powertrain needed to be a structural unit, *Racecar* has learnt. However, NEXTEV seemed to make a breakthrough in the final test and should make rapid progress. Factory McLaren driver Oliver Turvey will join Nelson Piquet in the team after an impressive debut at the final meeting in London last season.

One of two teams that has shown the most pace and promise in testing is the Abt Schaeffler Audi Sport team, re-named in deference to Schaeffler, which has provided technical development and integration of the motor for season two. The new Abt-Schaeffler FE01 features a single motor and three gears for Formula E driver pioneer and original tester Lucas di Grassi, and his team mate Daniel Abt, to utilise for season two.

'Our calculations indicated that three gears was the best solution, as you have so many complex things to consider with the torque management,' said team boss Hans-Jurgen Abt. 'From what we know, running just one gear is not the way to go because you have one central differential and this influences the whole package. With the speed and torque behaviour our calculations [showed] we felt three was the optimum for torque and efficiency during a race. The thermal behaviour is important too and we have worked closely with Schaeffler on this for the last year or so.'

The other early team which could stake a claim to being a pre-season favourite is the Renault e-DAMS concern, which has seen the previously obtuse Regie connection come to the fore this season as the French manufacturer co-ordinates the whole powertrain package. Early indications are that the retained Sebastien Buemi and Nicolas Prost will be right in the championship hunt, with the Swiss driver particularly keen to banish the memory of his title losing spin at Battersea, London, in June.



The suspension has been beefed up for season two with the addition of bulky and reinforced lower ball joints, which have been added to the front wishbone. FE made this change because of some high profile crash damage issues in season one



A new brake disc is among the changes to the Dallara-built SRT_01E racecar for season two of the Formula E Championship while new brake pad geometries have been introduced by the championship's brake supplier, Tamworth UK-based Alcon





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The Mahindra team went through considerable change in the off season

Renault e-DAMS has a partnership with Zytek Automotive which has previously worked with the French manufacturer on several electric engineering projects. Zytek has been instrumental in finding the best solution for the inverter as well as other electrical housing

systems. The team will run a single motor with a two-gear set-up through a new in-house developed carbon gearbox.

'We have a lot of know-how on electrical systems from what we have done in F1, and it was my previous work over a decade to build a

complete team to develop electrical technology,' said Renault's engineering chief, Vincent Gaillardot, adding: 'How I would specify the way we work with Zytek is really in co-development, and we are close to each other. It is a very smart collaboration.'

The Virgin Racing team has scooped a significant partnership with PSA and Citroen sub-brand DS, and will thus now be known as DS Virgin Racing. A new competitions department has been formed called DS Performance, headed by WTCC Citroen boss Yves Matton and long-time PSA strategy guru, Yves Bonnefot. This new operation was the first to track test back in May.

Chasing efficiency

As with most of the teams, excavating any detail of the DS Virgin tech has been especially tricky, but *Racecar* believes that the team is likely to be using two Yasa 400 motors. Although not confirmed, these proven motors will be a significant boost to Virgin in terms of reliability and torque control. DS Virgin Racing has majored on chasing efficiency with its single gear approach and so far has been well in the ballpark with multiple season one race winner Sam Bird and new recruit Jean-Eric Vergne.

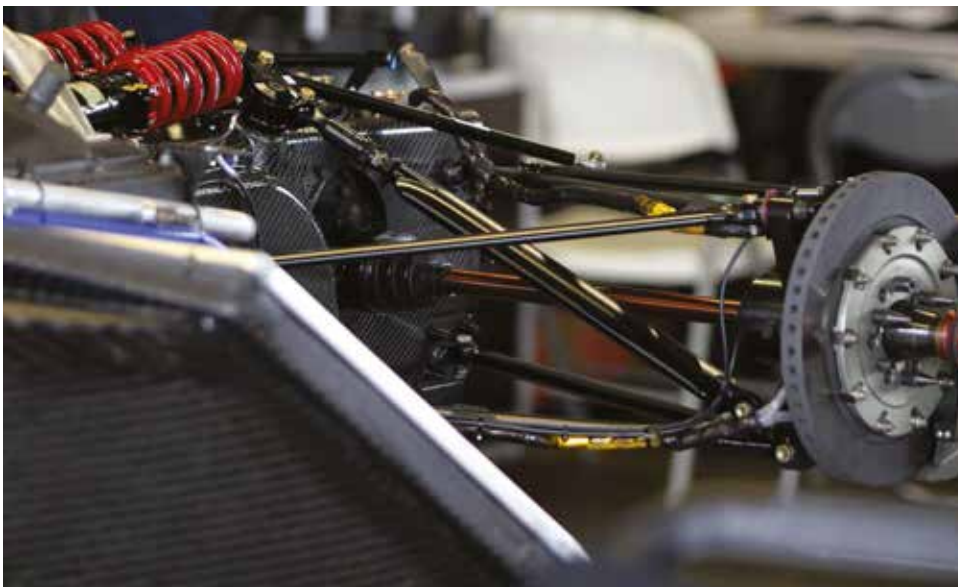
The Mahindra team went through considerable change in the summer off-season. Gone is Carlin Motorsport, replaced by Campos Racing, which runs the team in conjunction with Mahindra engineers. Karun Chandhok has been traded for Nick Heidfeld, while a partnership with McLaren Electronics has seen an upgraded powertrain using a single motor and four gears (in a modified Hewland box). It is a conservative evolution, but so far reliable, quick and effective on efficiency gains.

Like most of the manufacturer teams, Mahindra has put a lot of its focus on the re-packaging of the rear suspension, with pushrods and wishbones redesigned for weight-saving. Interestingly the team has developed a 'total loss gear shift' which is a pneumatic system using a high pressure air reservoir to supply the air needed to change gear. This high pressure reservoir will be recharged between sessions.

The Venturi operation, which has utilised its knowledge and expertise in electric projects that have included the world land speed record-holding VBB3 concept, has the smallest motor on the grid with the 'pocket-rocket' VM200. Delivering 20,000rpm peak revs and 145Nm max torque the unit has so far, along with its tweaked McLaren inverter and four-speed Hewland gearbox, been the surprise package, with no serious reliability issues and a good initial turn of pace in the hands of season one returnee Stephane Sarrazin and high-profile new signing Jacques Villeneuve.



Formula E has opened up the rule book in terms of the motors, gearboxes and inverters. But it could be a while before FE's a fully open formula, as there is caution over freeing up chassis design because of the cost implications of aero development



With scope for rear suspension and damper work, and changes to cooling now allowed, the re-packaging of the rear of the racecar has received a lot of attention from the teams in the run-up to the Chinese season-opener at the end of October

Formula E runners and riders

Team	Car	Drivers
Abt Schaeffler Audi Sport	Abt Schaeffler FE01	Lucas Di Grassi, Daniel Abt
Andretti Formula E Team	Andretti ATEC-01	Simona De Silvestro, TBA
Dragon Racing	Venturi VM200-FE-01	Jerome D'Ambrosio, Loic Duval
DS Virgin Racing Formula E Team	Virgin DSV-01	Sam Bird, Jean-Eric Vergne
Mahindra Racing Formula E	Team Mahindra M2ELECTRO	Bruno Senna, Nick Heidfeld
NEXTEV TCR Formula E Team	NEXTEV TCR FormulaE 001	Nelson Piquet Jnr, Oliver Turvey
Renault e.Dams	Renault Z.E.15	Sebastien Buemi, Nicolas Prost
Team Aguri	Spark SRT_01E	TBA, TBA
Trulli Formula E Team	Motomatica JT-01	Vitantonio Iuizzi, Salvador Duran
Venturi Formula E Team	Venturi VM200-FE-01	Stephane Sarrazin, Jacques Villeneuve

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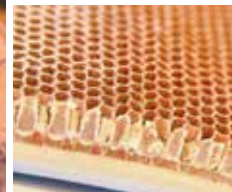
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FE is set to be under increased scrutiny during its second season



The all-electric championship sparked into life last year and was generally considered a success. The long term aims of FE are to attract further manufacturers and to get to the point where the drivers do not need to change their cars mid-race



Formula E technical regulations state that the motor or motors have to drive the rear axle through a conventional mechanical differential, which means running without the original spec Hewland gearbox would not, in theory at least, benefit the teams

Formula E calendar

- Beijing, China – 24 October
- Putrajaya, Malaysia – 7 November
- Punta Del Este, Uruguay – 19 December
- Buenos Aires, Argentina – 6 February
- TBA – 19 March
- Long Beach, USA – 2 April
- Paris, France – 23 April
- Berlin, Germany – 21 May
- Moscow, Russia – 4 June
- London, UK – TBA



An updated spec cooling system has been fitted to the base SRT_01E car, this features a reduction in the radiator size. Teams have also been given some freedom when it comes to the cooling

Venturi has also supplied its systems to Dragon Racing, which had second thoughts on its original decision to stick with the season one kit. Dragon therefore has become the first genuine customer of a manufacturer in the championship and keeps an unchanged driver line-up of Jerome D'Ambrosio and Loic Duval.

Going in the opposite direction is the Andretti Formula E Team, which suffered a tough testing programme. After developing its own package in conjunction with partners TE Connectivity and Houston Mechatronics, the team decided to revert to the original Spark-Renault package. Houston Mechatronics featured ex-NASA engineers, but the Formula E stratosphere will have to wait, as the project was put on hold after a series of fundamental issues hit the team, including coolant leaks shorting out the motors and software glitches.

The Andretti team had also developed the Hewland gearbox and had built its own carbon unit which will now also be shelved for a potential re-emergence once testing is allowed again at the start of 2016.

Spark life

While Andretti's hand was forced in reverting to the season one tech, the Trulli Formula E team has stuck with its home-grown package despite only completing a handful of laps in testing. The design and integration of the Trulli systems has been undertaken by the team in conjunction with partners Technomatic under a newly formed alliance between the two called Motomatica. The single-motor, four speed powertrain will be raced by confirmed drivers Vitantonio Liuzzi and Salvador Duran, who moves across from Aguri.

Before Andretti made the switch back, Team Aguri was the only team to have chosen to stick with the original Spark-Renault kit. This was a joint sporting and commercial decision by the team which believes that optimising the initial technology with new software will ensure a competitive proposition for season two.

This season the technical team will be headed by experienced former Jordan, Cosworth and Caterham engineer Gerry Hughes, who takes over from Peter McCool, who has moved away from the team to concentrate on his composites company SHAPE machining.

With variety and diversity now ingrained in the FIA Formula E Championship, the series is set to be under increased scrutiny to see if it can consolidate upon an impressive first season. What is more, a manufacturers group was formed earlier this year, and this will be becoming more and more active in trying to entice additional OEM's on board; ready for when the first tentative technology steps of season two expand to the anticipated giant leaps of season five.



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Buck shot

When Venturi's latest electric land speed record car was unveiled two years ago records were expected to fall at its feet. But the road has not been smooth for the Buckeye Bullet

By LEIGH O'GORMAN



The Venturi Buckeye Bullet record car fell short of the electric LSR after bad weather in the run-up to August's Speed Week at Bonneville Salt Flats meant the surface was too bumpy

There is definitely pride in the voice of Delphine Biscay as she says: 'The car was designed to have the best penetration of the air. We call it "the bullet", because it is what it looks like.' As project manager of Venturi Buckeye Bullet Racing, and with a background in research and development engineering, Biscay has every right to be proud of the latest version of the Buckeye Bullet – the VBB-3 – even if circumstances beyond the team's control has meant the streamlined machine missed its target – this time.

Continuing on a programme in conjunction with Ohio State University's Centre of Automotive Research that began toward the end of the previous decade, Venturi Automobiles produced the VBB-3 electric record car in 2013 to supersede the record breaking VBB-2 (303mph, 2009) and the VBB-2.5 (307mph; 2010). Yet while the new car is capable of smashing both of those records, the weather gods have not been kind to the project.

Repeating the now tiresome pattern of recent years, heavy rain over Utah's famed Bonneville Salt

Flats in the lead up to August's Speed Week ensured any running was going to be compromised in the extreme, as Biscay explains: 'It's different than the last two years [when conditions were poorer], but for three years, it has been wet. When that happens, the salt becomes wet and bumpy and can make for poor traction.' International land speed record attempts – which are certified by the FIA – are timed over the middle mile and kilometre of the 12-mile course. However, with the salt flats declared wet, the course was also shortened to 10 miles for safety reasons, thereby reducing the distance used for acceleration.

Consolation prize

Biscay admitted that such conditions meant the potential top speed could not be reached, but there were additional obstacles. The wet weather had prompted mud slides in the weeks before the meeting, creating a violently bumpy surface along the course thereafter. '[The bumps] affected the driver, the electronics and other instruments,'

Biscay says, adding that: 'This also affected return runs – for example, it was so bumpy we had to check that nothing had switched off [because of the severe vibrations].'

Although it missed out on the overall target of breaking the 400mph barrier, the VBB-3 still broke one record – its 240.32mph effort set a new benchmark for electric vehicles that weigh over 3.5-tonnes (FIA Category A Group VIII Class 8 – still subject to confirmation by the FIA) and in one run, the VBB-3 exited the flying mile at a speed of 288mph. On the one hand, it is a mightily impressive speed to achieve, but for Biscay, it was not the outcome she knows the VBB-3 is capable of.

There is little doubt that the previous iteration of the Buckeye Bullet (the VBB-2.5) was a phenomenal success, but while the 800hp VBB-2.5 was indeed an extremely impressive machine, the VBB-3 goes several steps further. 'In late 2010, we decided to build a car to break the world record and show that electric is as fast, powerful and efficient as an ICE,' says Biscay.

The VBB-3 produces about 3000hp (2800kW), with torque measuring up to 2800Nm



Once again Venturi's relationship with Ohio State University proved a fruitful one. While some 30 people operate at Venturi Automobile's Monaco research unit, up to 20 engineering and PhD students in Ohio lend their skills to a project that Giorgio Rizzoni, director of the Centre for Automotive Research, says is 'a project of great importance' which sees these young engineers provided with 'a unique experience to add to their resume.' As such, portions of the car were split between the two entities with the chassis, powertrain, electric and batteries constructed from the ground up in a joint effort.

While the bodywork dimensions between the VBB-2 and the 2.5 were reasonably similar, the VBB-3 required a complete rethink, due to a significant increase in power output. Venturi estimates that the VBB-3 produces approximately 3000hp (2200kW) from the batteries and electric motors, with torque measuring up to 2800Nm. Biscay says: 'Nearly everything has changed. There is much more energy in the car, so the car had to be redesigned to carry it.

The batteries needed for that amount of power are huge – they weigh 1.6 tonnes!

The VBB-3 uses four ATS PML-7-600 inverters, which are synchronised to produce the impressive power figures above. The VBB-3 also continues to utilise Lithium iron phosphate (LiFePO₄) battery packs. However, Venturi opted for pouch type cells over the cylindrical units, with packs hosting a total of 2000 cells thanks to improved stacking characteristics. Lacking a metal enclosure also ensures pouch cells are a lightweight alternative to cylinders, although exposure to excessive heat can shorten durability and dampen output.

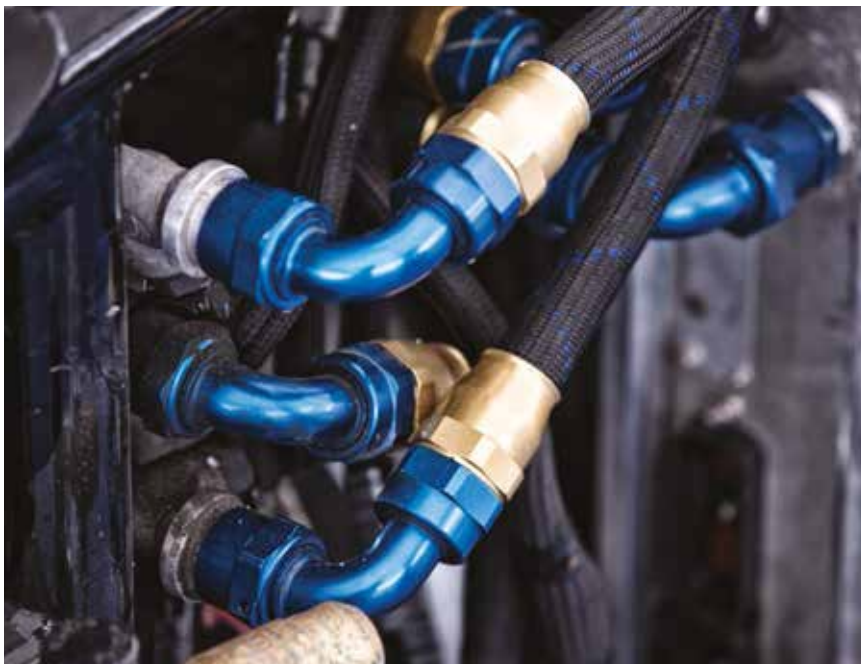
Bigger Bullet

Like its predecessors, the VBB-3 utilises a carbon fibre skin, while the cockpit – roughly situated just behind the central point of the chassis – is a prepreg carbon fibre/aluminium honeycomb composite tub. However, unlike Venturi's previous Buckeye Bullet entries, the VBB-3 enjoys somewhat enlarged dimensions to accommodate the increase of battery

packs. 'In the VBB-3, there is one electric motor and battery driving the front wheels and an electric motor and battery driving the rear wheels. We have also changed from two-wheel-drive to four-wheel-drive,' Biscay says.

This latest Buckeye iteration is 11.35m in length (0.35m longer than the VBB-2), has a tail fin with a height of 1.57m (0.07m higher) and has a width of 1.06m (0.06m wider), ensuring the VBB-3 enjoys a slight reduction in drag coefficient (from 0.14cd to 0.13 cd). 'The biggest challenge was to have power and good aerodynamics and also be compact. The total weight [of the VBB-3] is 3.5 tonnes, so we had to find a compromise between power and weight, as well as make sure of the security and comfort of the driver. It is still a compromise; everything needs to fit inside,' Biscay says. 'The first stage was to make sure everything could work together and then we reshaped it in simulation to make an improvement with the body and increase stability.'

The design team at Venturi also focused on making the cockpit as reasonable an environment as



Cooling is vital on high-powered electric vehicles and it was actually a puncture in the front cooling tank, caused by the excessively bumpy track, that finally ended the Venturi Buckeye Bullet team's record attempt



Sturdy switches are needed on record cars and the team had to make sure that everything was still switched on after each run



The cockpit of the VBB-3 has a real F1 look about it and is a self-contained tub built of prepreg carbon fibre/aluminium honeycomb composite. The 'pilot' is Roger Schroer, who is one of only 60 drivers to have broken the 300mph barrier



Parachute was there to slow the projectile from a hoped-for 400mph – an incredible speed for an EV

possible. VBB-3 is piloted by Roger Schroer, who is an instructor at the Transport Research Centre in Ohio and the official pilot of Venturi Buckeye Bullet Racing. The American is one of only 60 drivers in the world to have broken the 300mph barrier, but as Schroer revealed, the conditions this time made for a very rough ride. 'In 11 years, I have never driven such a difficult track. The car was sliding on the surface from one side to the other due to the soft spots and bumps,' he says.

Considering the potential for an excessively bumpy ride, Biscay explained that the cockpit received additional attention to compensate for the added violence of the runs. 'We needed to make it more comfortable for the driver. The cockpit has increased visibility, as the driver couldn't see short distances [in the VBB-2.5] –


now he can at least see the marker boards along the track during the run.'

At the Salt Flats, the team of engineers monitoring the runs were in place to evaluate the condition of the car following its first run; however, due to the limited time allotted between runs, these checks were implemented with speed. 'During the two runs, we remove the bodywork to access the internals to check the tyres and electronics, for example. We access the computer to retrieve data and also we replace fluids and coolants. In the second run, the car has to reach the timing mile within 60 minutes of the first run,' Biscay tells us.

In the end, such was the violence of the attempt on the return leg, the VBB-3 suffered a puncture in its front cooling tank, ending

its participation early. Practice runs were also hampered by electronics issues brought on by the excessive vibrations.

Yet while this year's attempt at the land speed record for electric vehicles may have left Biscay disappointed, she is already looking ahead to its 2016 entry – and indeed is planning on breaking records beyond that. 'The next goal is the same as this year. We want to go back and go 400mph and when we have achieved that, we will push to do a run at 460mph.'

For Schroer, should he help the VBB-3 break the 400mph marker at the next attempt, he will become only the eighth recorded driver in the world to do so in a ground vehicle and the first to pass that target in a purely electric vehicle. Now that would be some achievement. 

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Strike a **light**

While Lada's replacement for the Granta has not quite set the WTCC alight, the Vesta has proved a match for many. We took a close look at the Russian racer

By ANDREW COTTON



Lada's dramatic weight loss is to be envied, but the entire car is new and optimised

The return of Lada to the World Touring Car Championship with its Granta model was not heralded as a spectacular success. The car was too small, and did not have the technology to challenge the Citroen C-Elysees that went on to dominate the championship ahead of the Hondas and Chevrolets.

The competition does not look so different in 2015, with Citroen continuing to dominate the championship, but at least Lada's new Vesta has taken a vast step forwards compared to its predecessor. This is partly down to a spectacular weight drop of an estimated 75kg from model to model, which can be explained with a 5kg drop in engine weight and extensive use of

carbon in the bodywork and shell. The crash box, to give one example, is no longer metallic, but made of carbon.

Of course, it is not really fair to say that the Granta did not have success. Rob Huff won twice, in China and in Macau, to end the 2014 season in some style on the street circuit. But by that stage French team ORECA, which had in the past run a SEAT diesel in the WTCC with Yvan Muller, was involved and advising the Russian team on how best to set up the car while simultaneously working on the new model.

It produced results, but in September of 2014, all eyes were turned towards making a success of the Vesta, but even that was no easy task. A short time-frame to develop the car, plus a tight homologation deadline, meant that items such as the roll cage were developed in Europe rather than in Russia due to the need to physically crash test it, and this was just one minor problem on a long list.

CAD developed

ORECA was charged with developing the engine for the new car, and also the aerodynamic package, but that was slightly complicated by the fact that the road car was not yet launched. So, ORECA's design team, led by David Floury,



PHOTO: XPB



XPB

In early races the Vesta suffered with steering problems but this issue was partly fixed in time for the Nurburgring round, held on the mighty Nordschleife



'The CAD release of the bodywork for the production car was October 2014, and we had to have a running car in January'

The gearbox in the Vesta is an Xtrac unit (pictured), while its predecessor, the Granta, used a Hewland. Lada says Xtrac 'box is more touring car focussed



to be able to balance the aero and drag and downforce of the car according to the track. Within the WTCC rules, which are quite strict, you have to homologate everything. It is quite tough to adjust, but within this margin we wanted to achieve the best adjustability for the race engineer at the track.'

had a short time-frame to deliver an effective and efficient package in time for the Vesta's homologation in January.

'It was quite a challenge from a timing point of view because the CAD release of the bodywork for the production car was October 2014, and we had to have a running car in the second half of January 2015 to homologate the car just at the end of January,' says Flourey. 'It was okay. We had a good CAD model, but we didn't have a long time to develop the car aerodynamically, so we couldn't concentrate on all the areas, but overall the result is not bad compared to the time we had to develop.'

Lada's Vesta didn't go to the wind tunnel before homologation, ORECA continuing the practice that it started in 2009 of developing in CAD only. That process includes all of the company's LMP programmes, including the

ORECA 03, 05 and the Rebellion R-One. ORECA was also in charge of producing the composite panels and parts, while all the mechanical components, including the bodyshell, were produced by Lada Sport in Togliatti, Russia.

The first car was assembled in Magny Cours at ORECA's engine factory, as the company also designed and produced the engine.

'First we did some lap time simulation on all the tracks, to define the targets because we had different targets for the different tracks,' says Flourey. 'Some tracks have a target that is more oriented towards reducing drag, and some others are towards downforce. We defined an average target taking the work from the different tracks, and the target was to develop the aero of the car accordingly. This was the average target, and then from this average target we had a secondary target, which was

Race testing

With such a short time-frame to design, build, assemble and homologate the car, and with shipping time for the first race in Argentina approaching, the team did not have time to build up a third car scheduled to complete a test programme in preparation for 2016. ORECA and Lada Sport worked flat out in order to produce the third car, but crashes in races meant that this was often needed in the races, and to date the team has yet to put together a full test programme with a spare car.

'The plan was to have a development car to do some testing in Europe, but due to the crashes, it was difficult to achieve this target,' says Flourey. 'Every time the development car was needed to race. It [had] been quite a tough start to the season for all the teams, but [there is] still some potential to extract.'



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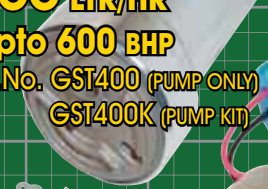
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The Vesta's damper supplier, Ohlins, had its own specific development programme for the car, while work has been undertaken to improve tangent stiffness of the shock absorbers

Since the start of the season, the team has worked on the suspension geometry and increasing the effectiveness of the engine control system. Damper supplier Ohlins had its own development programme for the car, and the team now has new dampers that have helped the drivers. Work has also been undertaken to improve the tangent stiffness of the shock absorbers to improve the car on slow speed circuits, such as Portugal's Vila Real, and some corners on the Paul Ricard circuit.

Lada's dramatic weight loss is to be envied, but the entire car is new and optimised. 'The weight of the engine is much lighter,

says Victor Shapovalov, Lada team principal. 'We have different exhaust line, for example. The engine is 5kg lighter. It was okay [with Granta], reliability was not the biggest issue. Today we are working very hard to develop the performance, but last year it was almost impossible to work with the development of the engine.

'We had more time in the beginning of the season, then the racing started and we didn't have a test car. Now, we completed a programme for development of the engine over the winter, testing with the old car, but we planned to have produced our test car for May and continue the engine development in that. Now, we are just going to the races, we start working hard doing the testing programme.'

Parallel dimension

The Vesta is now similar in dimensions to its opposition, which is a major step forwards for the manufacturer, as it allowed it to work better on roll centre and aero balance. There were some ideas carried over from the Granta, but very little hardware was adaptable.

'We tried to improve everything which we had on the Granta,' says Shapovalov. The gearbox was switched from Hewland to Xtrac, which produced a 'more progressive gearbox,' according to Lada's team principal. 'Hewland are not focussed on the touring cars so it was difficult for them. Xtrac has a different differential, the one from Hewland was old style and difficult to operate. It was very basic.

'For the brakes, the caliper was carried over from the Granta. The brakes were okay on the old car. They were one of the things that was okay! The discs are changed a bit, and we try to improve the braking performance.'

The suspension was far easier to work on with the Vesta. 'In the Granta we found that the basic car didn't give the possibility to make it better,' says Shapovalov. 'It was not possible to fix normal design of the suspension, roll centre and so on. It was a very small car. This car is okay, it gives us a lot of possibilities to make it better, so now at least there we are happy. We have consulted ORECA for their ideas but the design of the suspension is like usual.'

One of the big problems with the Vesta in the early races was with the steering. At both Argentina, the opening round, and in Morocco, the team experienced problems with the electro-hydraulic system and for the Nurburgring reverted to an hydraulic-only system previously used on the Granta. It was not a permanent solution, however, and the team had to perfect its steering system ahead of the street races on the calendar.

Every bit of performance helps as the field has actually closed up. Citroen continues to be the fastest and best developed, while the others are struggling to catch up, but at least the Vesta is holding its own. A podium on home turf in Russia, and another one in Japan, has shown that the Vesta has the potential to be successful, particularly against the customer Chevrolets and the factory Honda Civics.

With a balance of performance system which is largely weight dependent, the Granta's base weight was already over the minimum weight limit and therefore any help offered could not be accommodated. With the Vesta it can. It may still require a lot more work to be very competitive, but the team is on the right track, and a development programme over the winter 2015/16 could see the Vesta at the front of the grid at some races in 2016.

TECH SPEC

Name: Lada Vesta WTCC

Body

Type of body: sedan with in-welded safety bodyshell

Number of doors: 4

Weight and dimensions

Minimum weight: 1100kg (driver included)

Wheelbase: 2685mm

Length: 4628mm

Width: 1950mm

Engine: Global Engine LADA

Displacement volume: 1.6-litre (turbo) **Power:** 380bhp

Max torque (Nm @ rpm): 440/4000

Transmission

Configuration: Front wheel drive

Gearbox: 6-speed sequential gearbox, Xtrac

Chassis: Front and rear suspension. McPherson, specially designed springs, adjustable gas shock absorbers; adjustable stabilizer: all designed by LADA Sport and Ohlins

Brake system

Front brake caliper: 4-piston, AP Racing

Front brake discs: Ventilated, 380mm in diameter

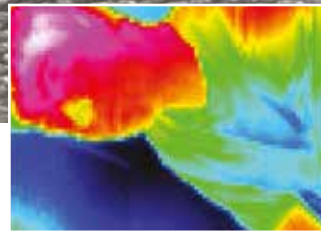
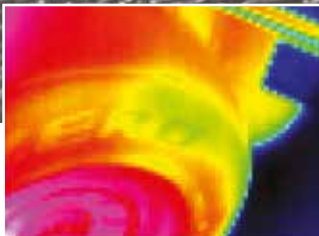
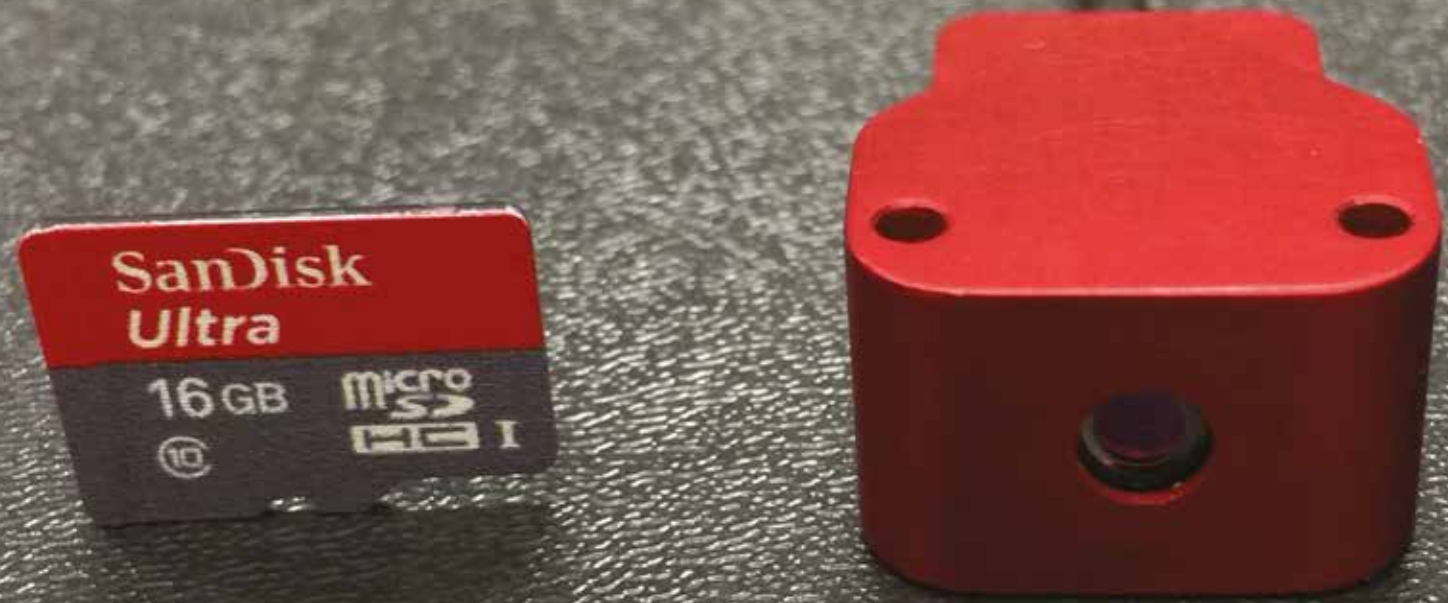
Rear brake caliper: 2-piston, AP Racing

Rear brake discs: Ventilated, 280mm in diameter

Wheels

Dimensions: 10x18

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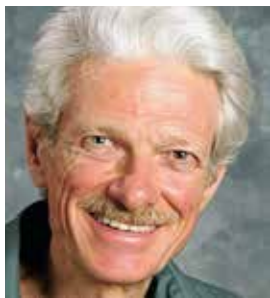
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2D or not 2D? That is the question

Do drawing boards still have a place in suspension design?

Question

I have been reviewing several of your past newsletters on live axle suspension design, in particular, the one from September 2007 on the design of the Satchell Link rear suspension with comments from Terry Satchell.

It occurs to me in reading many of your writings, coupled with Satchell's comments in your newsletter mentioned above as well as his other writings on suspension geometry, that what is commonly referred to as the 2x2D graphical approach can be used very effectively in designing a 3D suspension linkage. I have read elsewhere many comments that disparage this approach with the naysayers claiming this is a 3D problem and should only be solved using either 3D graphic or 3D analytical methods.

I use Solidworks 3D modelling in my daily work as a tool and model maker. But as an amateur racecar engineer software packages such as this are simply out of reach due to their very high cost, the same is true of any really good kinematics software.

I was trained at the drawing board, have a good knowledge of descriptive geometry and have come to believe that my 2x2D drawing board or 2D CAD solutions are accurate enough for most purposes.

So I have a number of questions based on this theme. First, what is your opinion of the 2x2D graphical approach to designing and analysing suspension kinematic motion?

In plotting solid rear axle displacement in heave or roll when using a Panhard bar how would you handle axle scrub? This seems to be one area that must be iterated to be exact. However, the longitudinal link movements caused by scrub seem, in 2D CAD, to be rather small.

What parameters would you track other than the usual movement of: right and left instant centres, roll centre, axle roll axis and wheel path?

Realising that the axle roll axis is an engineering approximation and becomes more so as the suspension moves, would

you consider your approach of averaging the divergence of link intersection points in side view adequate over the full bump/droop range of rear axle travel to fix points to construct the axle roll axis?

I am not adverse to, or uncomfortable with, using analytical methods. I just find a graphic approach seems to get at a suspension design quicker and with a better *feel* for how it works.

Also, does Terry Satchell work primarily graphically in laying out and then analysing his suspension designs? On the same point, do you work more graphically?

Finally, is it simply a romantic notion that Adrian Newey still works at the drawing board, even though we know he is backed up by a small army of engineers and designers using the most state of the art computing and software. Is it just a good PR story?

The consultant says

I don't know Adrian Newey, although of course I know who he is and have likewise read that he prefers to design manually. I did put the question to Terry Satchell, although I know that he's officially retired. This is what he had to say: 'I would be glad to answer this guy's question. And to confirm, I am fully retired. I go to the gym in the morning and ride my horse in the afternoon. I am enjoying that schedule.

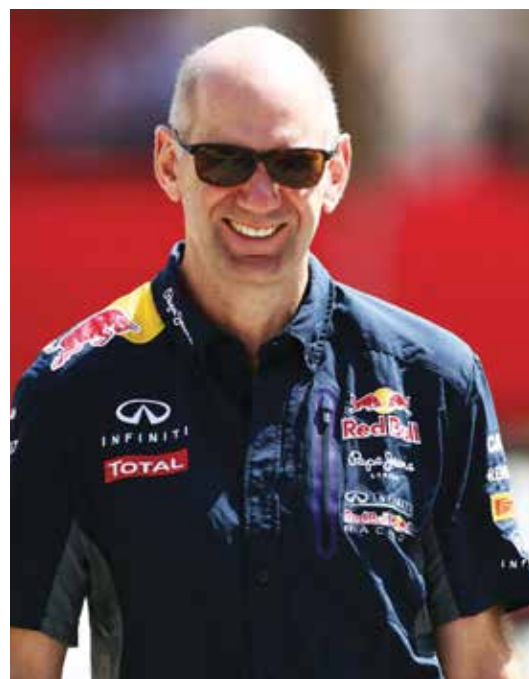
'I would have to say that what I do is analytical rather than graphic. I have developed some Excel spreadsheets that quickly solve for suspension parameters from pivot points I put in. And I also use the iterative solver in Excel to synthesise the geometry points from the desired static design factors at layout position. Once I have that the way I want it, I then transfer to a bespoke 3D geometry program that gives me the factors through suspension travel up and down. I then fine tune from there by modifying the appropriate pivot in the appropriate direction to get what I want. This is for independent suspensions.

'For live axles I have another bespoke four-bar link analysis program. To get started with

this type of suspension I do some simple hand calculations to get the starting points then iterate the 3D geometry program.

'In all these cases I am assuming I have knowledge of some of the pivots, for example the knuckle in an independent and the axle end for a live axle rear. I get them from drawings, or previous usage of the same parts, or we would CMM [coordinate measuring machine] the particular part. When needed, I have taken CMM points of a component, and had a CAD friend help me put the component in car position at layout design. Then I use the process I outlined above,' Satchell says.

In my own consulting work I am seldom called upon to design a suspension, or to model or simulate an existing one. I am mostly asked to answer specific questions, solve specific problems, or make specific recommendations. Sometimes these are for cars in the design stage, but more often they are for cars that already exist. The inputs I get vary a great deal, and so do the outputs the client needs from me. In the vast majority of cases, the car is either a purchased racecar or one that the client race prepared or built without drawing or CAD modelling it first.



Adrian Newey is famous for using a drawing board when designing, but is it practical for 3D suspension linkages?

Is it simply a romantic notion that Adrian Newey still works at a drawing board?

I have a 72in by 42in drafting table, I've owned it since 1982. There are things it can't do, but it's 100 per cent reliable and it never crashes

Sometimes I get called in by engineers for major teams, but mostly I serve hobbyists and lower-level professionals who don't have in-house engineering staffs. Accordingly, they generally don't have drawings or CAD models of their cars, nor do they have surface plates, height gauges, or CMMs. They are generally at a remote location and are working with me by phone and email. Sometimes they have purchased geometry programs. Sometimes they can tell me where their instant centres are or what their camber gain is. Most times I have no way of verifying their numbers. It is not uncommon for their measurements or observations to contradict each other. In many cases I can get what's needed from verbal descriptions and photographs.

I call what I do brain-aided engineering. I understand suspension in depth and consequently am able to ask the right questions to address a client's specific question or need without having to know everything about the car or comprehensively model it. I am not constrained by a set method or software package.

I do sometimes work with students who are doing designs. They generally use Solidworks. For SLA suspension, I generally have them start with static force lines and instant centres. If we are trying to use existing uprights, we use the

existing ball joint locations and the desired instant centres to establish control arm planes, and then see what we can come up with that packages with the rest of the car.

Back to drawing board

When I do design myself, I work manually. I have a 72in by 42in drafting table with a Vemco V-track drafting machine. I've owned it since 1982. There are things it can't do, but it's 100 per cent reliable and it never crashes. It has no compatibility problems. It's paid for. There are no licensing fees. I don't need to hire anybody to help me.

I can use my drafting table not only for drawings and geometry studies, but also for small part layout and making cardboard templates. If mistakes are made, they're my mistakes, and I can find them and fix them. I can live with that kind of world.

Where computers are needed the most is for suspensions with multiple links where no links are in a common plane and nothing looks like a control arm. If you are intent on designing something like that, you pretty much have to do it iteratively with a computer. Once you have an iteration to analyse, you can find instant centres and force lines analytically.

However, be aware that computer analysis is only as good as whoever wrote the program.

If you see a commercially available program whose originator makes serious errors when conversationally discussing the systems at issue, you can be pretty sure their simulations will be inaccurate.

I can't help noticing that despite the availability of ready-made simulation programs, I am constantly seeing ads from big-name teams for engineers to write proprietary simulation programs just for them, which they then guard closely as trade secrets. Nature is trying to tell us something here.

You need to be able to sanity check the outputs. For example, one time I was working with a widely used and well respected geometry program and looking at its outputs for bump steer. This was for an SLA front end with a front mounted steering rack. When I moved the rack up, the program told me I was increasing toe-in with suspension compression. Basic mechanical reasoning tells us that's impossible.

It is important to be able to do basic mechanical reasoning and not just blindly trust the computer. The computer may give you answers to five decimal places, but if you can't check the outputs with your own intelligence, the truth is that you really don't know if the computer output is truly correct or not.

More thoughts on camber gain and trikes . . .

Last month I was discussing camber gain. In response to a question I said that camber gain is generally considered positive when camber goes toward negative as the suspension compresses. I also introduced the concept of camber acceleration, which is the rate of change of camber gain with respect to suspension displacement, and I said this would be positive if camber gain increases as the suspension compresses.

It should be understood that the term 'camber gain' originated with racers taking measurements on a car in the shop, not engineers creating math models. To make the sign conventions really make mathematical sense requires some thought.

Far as I know, there are no official SAE or ISO sign conventions for camber gain or camber acceleration, but there are for suspension displacement (or 'jounce') and for camber. Per ISO convention, suspension displacement is positive in compression and camber is negative when the top of the tyre is inboard of the bottom. To be consistent with these conventions, camber gain as we use the term, would properly be called absolute camber gain, and camber gain as a signed quantity would be negative for most suspension systems.

Correspondingly, camber acceleration would be negative for most SLA suspensions. Camber gain would decrease (i.e. increase negative) with respect to displacement (compression being positive). Camber acceleration would be positive for a MacPherson strut.

Trikes and sidecars

Last month, when discussing trikes, I mentioned the Trihawk as an example of the right way to do a three-wheeler and said whoever designed it knew what they were doing and got it right. Turns out credit should go to Bob McKee for this. I've known about McKee since the 1960s, but either forgot or never knew about his involvement with the Trihawk. Thanks and a hat tip to Doug Milliken for filling me in on that.

Bob McKee is still around, and appears in a recent *Petrolicious* YouTube video (www.youtube.com/watch?v=GAgLSy371us) about one of his better known designs, the Howmet turbine car.

Also, Peter Olsson had some information on those intriguing leaning sidecars we showed in the last issue: 'The passenger is indeed controlling the lean of the motorcycle,' Olsson says. 'Note that the

sidecar is on the right side of the motorcycle, not the left as is the norm. These racing outfits were 500cc, usually British single cylinder engines.

'The rider had no control over the lean; the right foot is being used purely for bracing. These machines would all have had right hand gear-changes; once off the start line there was no requirement for gear-changes, so the right foot could be used for anything else. Whether these leaning sidecars were outlawed, or simply fell out of fashion, I do not know. The photo appears to have been taken pre-war.'

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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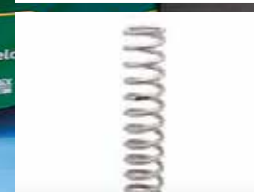
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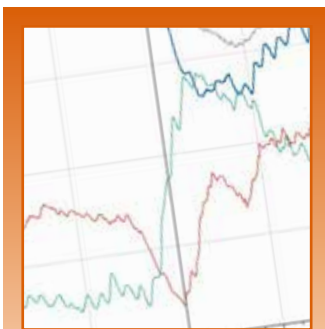
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Map for the lap

Your engine needs to be mapped to suit a whole range of conditions and situations – which is where Cal Pots come into their own

Motorsport is a dynamic environment, and as such, the ability to alter a car's behaviour on-the-fly is essential to maintaining a competitive edge. The use of rotary calibration potentiometers (known as 'Cal Pots') allows instant alterations to an engine's behaviour, meaning that the car can be optimised for changing conditions.

Before exploring the functionality of the Cal Pot, the base engine calibrations must be understood. Most ECUs will provide a degree of flexibility for setting multiple fuel and spark maps (as well as others) in a single calibration file, and applying these calibration settings effectively can assist with optimising engine performance, driveability and reliability.

Fig 1 shows the availability of four base calibration groups which provide multiple calibration maps for different engine functions. Knowing

the engine behaviour induced by the different calibration maps and the way in which they interact with each other is something that should be fully explored under controlled conditions on an engine dynamometer. The time invested to generate the combinations will pay dividends at the track. It is important to remember that Base Fuel Map 1 is not necessarily used with Base Ignition Map 1. This is explored in greater detail below.

Once the different base calibrations are populated satisfactorily, the Cal Pot combinations can be defined. Firstly, the Cal Pot source the ECU will use in order to select the correct base calibration must be defined. This is required where multiple Cal Pots are present which provides an even greater degree of flexibility, but an added degree of complexity (Fig 2).

Next, the base calibrations for each group are assigned to the strategies according to the Cal Pot position. Note that there is no restriction on the combination of base calibrations for the strategies;

as an example, any base calibration fuel map can be used with any base calibration spark map. Incompatible combinations can lead to poor engine performance or even engine damage so extensive dynamometer testing of the chosen combinations should be performed in order to set up the map in Fig 3.

There are four Cal Pot positions available in this example, however rotary switches with eight and 12 positions are also common. The four Cal Pot positions can be utilised in several different ways, but for the sake of example, they could be used as:

- CAL1 = Dry Race Settings
- CAL2 = Wet Race Settings
- CAL3 = Safe Settings
- CAL4 = Qualifying Settings

Dry race settings

Dry race conditions put a lot of demands on the engine and the calibration engineer. The balance of engine performance, hardware reliability, driver fatigue and fuel consumption will all play a role in defining the optimum base

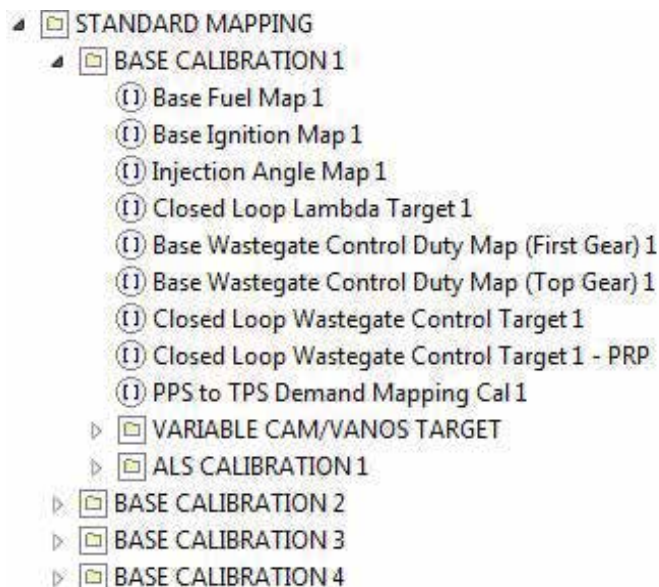


Fig 1: Base calibrations allow multiple instances of maps with different values and behaviours

CAL_POT		CAL1	CAL2	CAL3	CAL4
Base_Map	INJ/LAM	BASE_CAL1	BASE_CAL2	BASE_CAL3	BASE_CAL4
	IGN	BASE_CAL2	BASE_CAL3	BASE_CAL4	BASE_CAL1
	REV_LIMIT	BASE_CAL3	BASE_CAL4	BASE_CAL1	BASE_CAL2
	BOOST	BASE_CAL4	BASE_CAL1	BASE_CAL2	BASE_CAL3
	ALS	BASE_CAL1	BASE_CAL2	BASE_CAL3	BASE_CAL4
	VCAM	BASE_CAL2	BASE_CAL3	BASE_CAL4	BASE_CAL1
	ORFC	BASE_CAL3	BASE_CAL4	BASE_CAL1	BASE_CAL2
	INJ_END_ANGLE	BASE_CAL4	BASE_CAL1	BASE_CAL2	BASE_CAL3
	PPS_TO_TPS	BASE_CAL1	BASE_CAL2	BASE_CAL3	BASE_CAL4
	AUX_PWM1	BASE_CAL2	BASE_CAL3	BASE_CAL4	BASE_CAL1
	AUX_PWM2	BASE_CAL3	BASE_CAL4	BASE_CAL1	BASE_CAL2
	PIT_SPD	BASE_CAL4	BASE_CAL1	BASE_CAL2	BASE_CAL3

Fig 3: The combinations of base calibrations work together to build up a specific engine behaviour



Fig 2: Defining the source to use for each strategy is critical when more than one Cal Pot is available

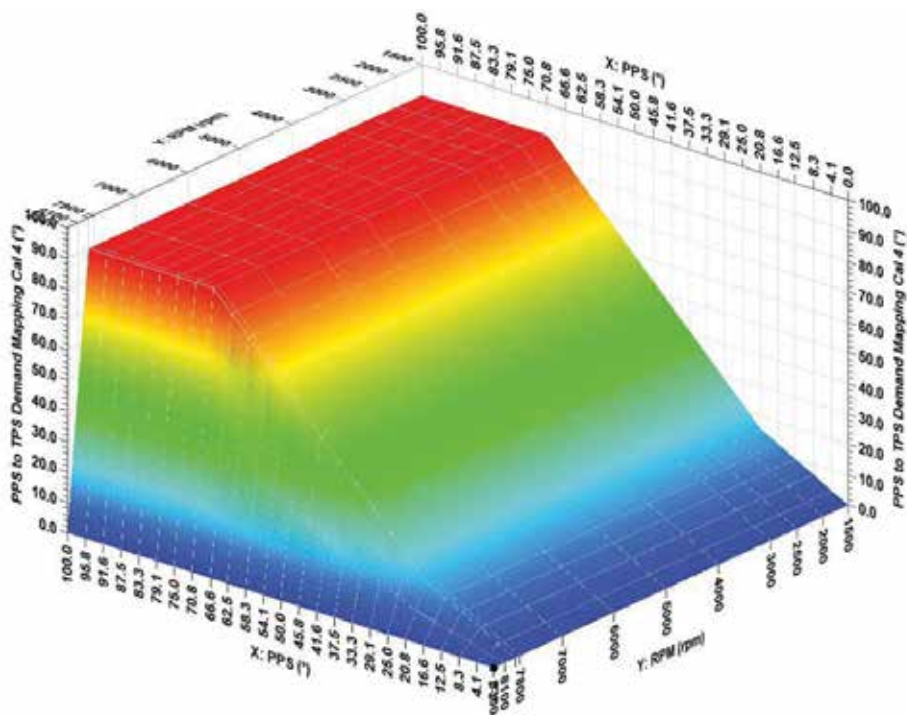


Fig 4: An aggressive PPS to TPS map can be used in the dry to allow fast application of torque

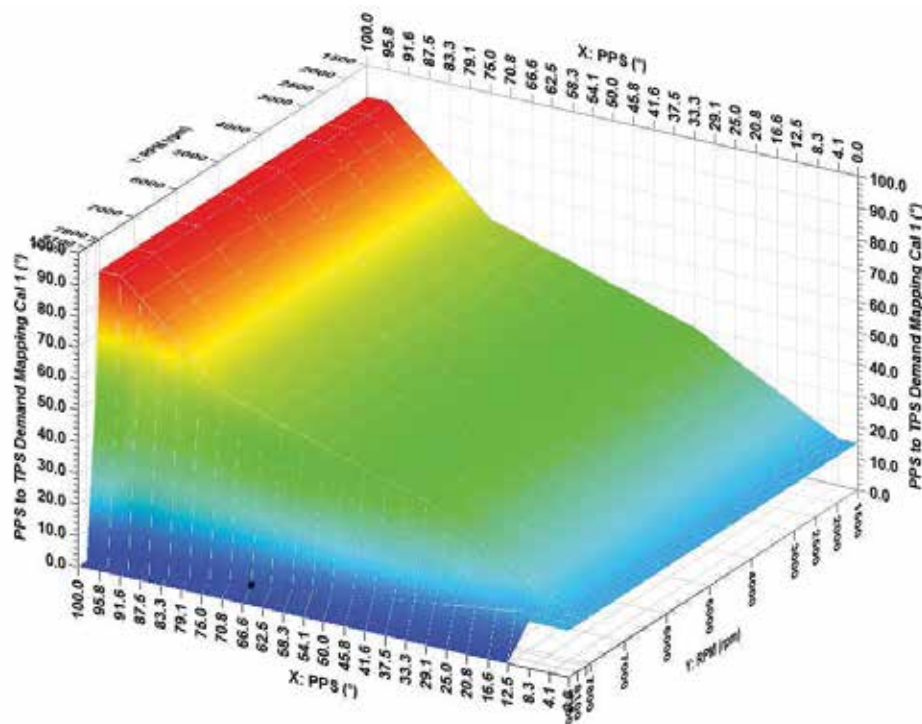


Fig 5: A gentler slope is used in the wet PPS to TPS map to aid in maintaining traction on torque application

Modern race engines are prone to damage if they are driven outside of their prescribed operating window

calibration combination. Proven fuel and spark maps will deliver required performance and efficiency; and smooth, progressive torque delivery will make long stints easier on a driver (Fig 4).

Wet race map

Similar to the dry race setting, the duration for which the engine will be running and the performance demanded from it must be carefully considered when defining wet race settings. A wet race will, in general, require smoother torque delivery than in a dry race. This will prevent wheel spin and can be achieved by reducing the available torque at lower engine speeds (less fuel, later spark) as well as more progressive boost calibration on turbocharged or supercharged engines. To tune the set-up to the driver, more forgiving Pedal Position to Throttle Position (PPS to TPS) maps can be used in fly-by-wire applications (Fig 5).

Safety car settings

Modern race engines are prone to damage if they are driven outside of their prescribed operating window. Simply using less throttle, lap after lap, under a safety car or yellow flag conditions can cause the engine temperatures to increase significantly.

A safe map allows fuelling, spark and throttle to all be reconfigured for the slower pace of a safety car without damaging the engine. This map could also be used during cool down laps after sessions.

Qualifying map

During qualifying, every last bit of performance is required from the engine. The engine will be run closer to the knock limit and closer to the boost limit, which will push the engine to its mechanical and thermodynamic limit.

The qualifying settings allow for higher performance to be easily accessible for the few flying laps required during qualifying, and can then be switched off for the in-lap and during the race. However, the qualifying map might also be used for short periods during a race to gain position, although should not be used for extended periods of time.

Other base calibration combinations might be utilised depending on the application. In endurance racing there may be maps that take into consideration engine wear during a 12 or 24 hour race. Fuel save maps are prevalent in F1 in order to make pit strategies work to a team's advantage. Other disciplines will have a pit lane cool down map that creates maximum air flow for minimum output, cooling the valves and combustion chambers as quickly as possible.

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Ginetta LMP3 aerodynamic study

How will one of the new baby prototypes fare in the MIRA tunnel?

The latest rung on the endurance racing ladder, LMP3, became a reality this year, and the challenges of constructing cars to cost caps and weight limits were discussed in detail in our September issue (V25N9). The category also has its own aerodynamic limitations, with somewhat smaller diffuser volume than in LMP2 and a rear wing limited to a single element of 300mm maximum chord and 1600mm maximum span. Thus, although the front end package is not dissimilar to that of an LMP2 car, total downforce is obviously short of that produced in P2.

Ginetta's technical director, Ewan Baldry, commented that at the end of a CFD development programme carried out by TMG (Toyota Motorsport) in Cologne, Germany, the Ginetta was producing around 1050kg (10,400N) of downforce at 150mph. This would equate to a CL.A (lift coefficient multiplied by frontal area) value of around -3.78. Assuming that drag will also be slightly less than an LMP2 car with a dual element wing, then from our 2012 session with the Greaves Motorsport Zytek LMP2, we might estimate that the L/D value of the Ginetta LMP3 will be well in excess of -4, that rough estimate confirmed by Baldry.

This preamble on virtual numbers is because the Ginetta LMP3 was being finalised prior to full homologation at the time of our test, so we cannot reproduce the measured absolute downforce and drag data from our session in MIRA's full-scale wind tunnel on this occasion. Suffice to say the Ginetta compared well with the CN and LMP2 racecars we have previously tested in MIRA. However, our session provided ample configurations from which we can examine the changes to coefficients, or 'delta (Δ) values', and still glean a better understanding of not only this car but, in a generic sense, the devices used on it.


First let's take a brief tour around the car with the help of photos and the MIRA smoke plume. The front of the car features an LMP2-style splitter, of the 'open' variety on the Ginetta, with twin dive planes, generating a potent vortex in our photo, outriggered on the front wheel pontoons.

Meanwhile, mandatory openings are visible in the tops of the front and rear wheel arches, and can be seen allowing air to escape. The area between the front wheel pods and the chassis is shaped to provide a side exit for air that has passed over and under the splitter. The lower edges of the sides are not raised as on the car's

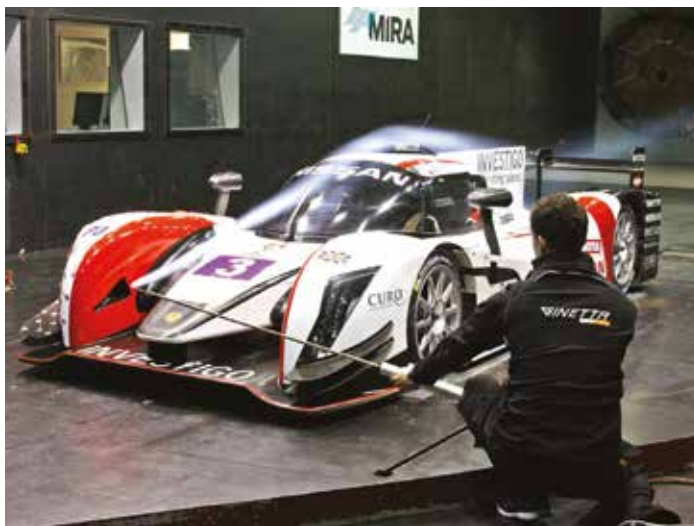
elder cousins in LMP1 and P2. The rear end features the aforementioned single element rear wing and although the diffuser and rear panel configuration looks similar to LMP1/2 the diffuser is in fact shorter.

The eternal quest for balance

Baldry commented in our September article that the Ginetta featured a strong front end. And once the car took to the track it became clear that more rear downforce was required to obtain a good balance. Thus the first few configurations in the wind tunnel revisited the modifications that had been made in track testing in order to quantify the changes that had been made. The first change was to add a bigger Gurney to the rear wing, followed by increases in rear wing angle, and **Table 1** shows the delta values found with the bigger Gurney while **Table 2** shows the incremental effects of wing angle increases.

Looking first at the effect of the Gurney in **Table 1**, a useful balance shift was obtained and the 52 counts of extra downforce was actually comprised of 63 counts more rear downforce and 11 counts less front downforce at the tyre contacts. There was a drag penalty of course (25mm is large for a rear wing Gurney) 

The LMP3 category has its own aerodynamic limitations, with a somewhat smaller diffuser volume than you would find on an LMP2



Ginetta-Nissan LMP3 and other LMP3s look every inch the sports prototype coupe. P3 offers LMP racing on a relatively low budget for both teams and racecar constructors



The front features an LMP2 style splitter and twin dive planes, the latter of which generated a powerful vortex when the smoke plume was put to work at MIRA

Table 1 – coefficient and balance changes from fitting a 25mm Gurney instead of 10mm (expressed in ‘counts’ where one count = a coefficient change of 0.001)

Gurney	Δ CD	Δ -CL	Δ %front	Δ -L/D
25mm Gurney	+22	+52	-3.35%	-1

Note: a positive Δ -CL value represents an increase in downforce; and per cent front changes are absolute, not relative.

Table 2 – incremental coefficient and balance changes with wing angle increases

Wing angle	Δ CD	Δ -CL	Δ %front	Δ -L/D
+1.5 degree	+2	+3	-0.37%	-5
+3 degree	+5	-8	+0.58%	-39

Table 3 – incremental coefficient and balance changes with rear deck Gurney changes

RDG	Δ CD	Δ -CL	Δ %front	Δ -L/D
+15mm	+11	+61	-2.74%	+74
+30mm	+9	+38	-1.65%	+33



Mandatory wheel arch top apertures on front and rear of car allowed the air to escape


Although they looked large the rear deck Gurneys were pretty efficient

but the car's overall efficiency (-L/D) was not adversely affected.

The wing angle changes were interesting too, as seen in **Table 2**. We had already run the smoke plume over the car and suspected that the wing was near its peak angle in relation to the onset flow coming off parts of the back of the car, and this was borne out with the small angle changes made, which do appear to have put the wing past its peak downforce angle; rear downforce increased by six counts at the first angle increase but reduced by 10 counts with the second. So, because the wing was at or about its peak angle the changes here were almost negligible, although the 39 count reduction in -L/D at +3.0 degree would represent about one per cent if our estimate of the car's overall -L/D of 4.0 is reasonable.

The next thing the team changed to gain more rear downforce was the rear deck Gurney (RDG). We have seen these previously in Aerobytes; they can be surprisingly effective

and, despite the sizes often used, even more surprisingly efficient. Two incremental changes were made and the results are shown in **Table 3**.

In terms of balance shift the first additional 15mm on the rear deck Gurney height produced the largest effect, and it was also the most efficient, generating 61 counts of extra total downforce (65 counts on the rear) for just 11 counts of drag. However, taken overall, the downforce gain from both RDG increments was 99 counts (107 on the rear) for 20 counts of drag, with -L/D increasing by 107 counts. Once again then, although they superficially looked like excessively large devices the rear deck Gurneys were in reality pretty efficient. By now the car was in the desired balance range. It was also at this stage in the same configuration that had been arrived at in the previous track test, creating a nice correlation on balance between track and wind tunnel, despite the latter's non-moving floor! 



Air emerging from the rear wheel arch top apertures clearly interacts with the rear wing's flow field. The rear wing is limited to a single element of 1600mm span



A 25mm wing Gurney in place of original 10mm item made a useful contribution



Baseline rear deck Gurney was increased in height by two 15mm increments to good effect; the first of the changes producing the largest effect in terms of balance

Next month we'll look at some combinations of dive planes we have not previously examined, as well as other fascinating details from the session on the Ginetta LMP3.

Thanks to all at Ginetta for their cooperation and hard work in enabling this session to take place.

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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Brembo magic

The brake company celebrated 40 years in Formula 1 by giving *Racecar* an insight into the mysteries of F1 brakes and telling us about its other motorsport activities

By SAM COLLINS

Under the current Formula 1 aerodynamic regulations, the importance of the region around the wheels of the cars has become very pronounced. Teams spend a vast amount of time and money on optimising the components used in this area and at the heart of it is the brake system. Currently the market is dominated by two companies: Brembo of Italy and AP Racing of England, though the former owns the latter. Between them they supply every team on grid bar one with calipers (McLaren uses Akebono), and the engineering and development which goes into the brakes is usually a closely guarded secret. But in 2015, to celebrate its 40th anniversary in F1, Brembo decided to reveal much about the process behind its brake systems.

'Every team has its own bespoke design, there is no off the shelf product,' says Mauro Piccoli, Brembo's racing director. 'We share a lot of information to develop the products with the team, each system is bespoke, so we get involved in brake ducts as well as calipers

and friction material. Every year there is a new caliper design, front and rear. The caliper will generally remain the same for all circuits but with different discs and different ducting.'

Brembo estimates that it supplies each team with around 10 sets of calipers each season, plus up to 240 discs and 480 pads. Creating each caliper is a predictably involved process. 'Compared to our other calipers, those used in F1 and LMP1 use a slightly different technology with an aluminium lithium alloy material,' Piccoli says. 'The rules limit you to using materials which have a Young's modulus of less than 80GPa, so we are as close as we can be to this limit. Every year we have to sign a document to say that the calipers are fully compliant with the rules. We won't supply an illegal caliper, even if the teams ask us to.'

Tough brake

'The material is cast, then machined,' Piccoli says. 'Then the calipers are nickel plated, which offers improvements in durability and weight, as less material has to be used. In other classes

of racing – NASCAR, GT, or rally – the calipers are either machined from billet or forged.'

Brembo carries out all of its own machining in house at a vast facility near Bergamo, Italy, and it machines more than just its brake calipers. 'To machine just the body of a F1 caliper can take six hours, with many tooling changes, then you have to do the surface treatments and assembly, and sometimes the numbers are so small, perhaps just four in a batch,' Piccoli says. 'It really is very bespoke. We do all the machining in house, the caliper, the carbon disc, and for some teams we even machine the whole upright. In future we are working towards a fully integrated upright and caliper, a single piece. It is very stiff like that but if there is a problem then the team has to change everything and that is quite expensive.'

The life of calipers is relatively limited. The top teams send each set back after every race for checking and servicing, while the less well funded of the teams only send them back every three or four races. It seems that an integrated upright and caliper may still be some way off.

'We do all the machining in-house, the caliper, the carbon disc, and for some teams we even machine the whole upright'



Beyond working towards making the calipers ever stiffer and lighter, there is also the very competitive world of Formula 1 friction material. Here Brembo is up against American company Hitco, and Messier Bugatti Dowty of France. All of them offer carbon-carbon brake discs and pads. The teams are known to swap between suppliers frequently, often based on driver preference and feel.

Brembo offers a single material for brake discs and another for pads. The CER 300 material was introduced in 2013 for use in discs and the CCR 700 pad material dates back a little further. While only a single material is offered, the teams each choose to use it in a different way.

'Every team has at least a couple of solutions for discs. In terms of cooling the teams work with us and develop many different drillings, some with over 1000 holes. Each team has its own pattern, shapes and number of holes,' Piccoli says.

Braking out

Brembo also operates beyond the world of Formula 1 and is in many other markets, both racing and mass production. Piccoli points out that the way friction materials are used by teams in lower level series is changing noticeably.

'Most teams want discs and pads bedded in before delivery, so we do that on our bedding machine,' he explains. 'It is much better to do that than bedding in brakes on track, which is really expensive as you are basically using the car engine and all the chassis parts, plus track time, as a bedding machine.'


'So, sometimes we bed in other companies' pads if that is the team's preference. This bedding process is becoming far more popular now; it only used to be NASCAR, which is all bedded, F3 teams and rally teams that wanted it, but now GT3 teams are asking for it more

and more. I think more and more people will realise the advantage. It's a higher up-front cost but it's cheaper overall.'

Elsewhere in the Brembo organisation its joint venture with SGL to produce carbon ceramic braking systems is now beginning to have an impact on the racing department, which is developing new products for the future. 'We have the new CCM-R material which is a mix of the traditional carbon ceramic process and that of carbon-carbon in racing,' Piccoli says. 'Normally when braking you can see the wear, reducing the thickness of the disc, but with CCM the only way to check is to dismantle it all and weigh it. On OEM cars they use electronics to calculate the number of braking events through a car's life and calculate when it is time to change. This is why CCM discs should not be used for aftermarket upgrades. If I take a disc built for a Ferrari and fit it to a Golf I have no way to check that it is okay. It's dangerous to do that. Initially it probably works very well, but one day it will fail without warning.'

One of the main reasons that Brembo developed the CCM-R was to allow some aftermarket tuners to get the benefits of CCM but without the uncertainty over wear. Piccoli

says: 'The CCM-R uses the F1 brake material but infused with ceramic, why do that?' Well the F1 material is fantastic but only when it is at temperature. The ceramic infiltration means the brakes work from cold basically, so we are now offering this product. But the problem at the moment is the price, it is three times the price of carbon ceramic at the moment. The ideal application for this is one-make classes like the Ferrari challenge. At first, the brakes cost more but overall they save money as you can race on them for up to 7000km, so that disc will last the season. DTM or GT3 type cars could also benefit from this technology.'

Brembo, its subsidiary AP, and Akebono are all facing a busy time in the next 12 months, as the 2017 rules for Formula 1 could see some significant changes to the brake system. With wider wheels and higher top speeds the design of the calipers is almost certain to be very different, but without a full set of technical regulations it's hard for much work to be done on this now. So, in some cases, including some of the staff at Brembo, R&D people are exploring new avenues for brake systems, including a brake disc that is capable of recovering kinetic energy directly and converting it to electricity. But that's another story ... 

Main picture: Brembo's calipers are cast in an aluminium lithium alloy material then machined, then they are nickel plated, which brings better durability. The company tells us it supplies around 10 sets of calipers to each team during an F1 season
Below: These days braking systems in F1 are an important part of the aero package and each team has a bespoke design



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The joy of hand calculations revisited

Racecar's number cruncher returns to a favourite theme – the decline of pencil and paper maths in motorsport engineering

By **DANNY NOWLAN**

One of the most talked about articles I ever wrote for *Racecar Engineering* was entitled 'The joy of hand calculations'. It was motivated by an alarming trend I was starting to see in junior engineers; a lack of ability to solve technical problems without a computer. Time has moved on and as I have been involved in mentoring upper level undergraduates, postgraduates and junior data engineers, I have noted that things have been getting worse, and not better.


The purpose of this article is to discuss how we got here, but more importantly what can be done to fix it. The big thing that has changed since I wrote the first piece on this subject is that

the students I have been dealing with this year are very capable. They are intelligent men and women. Unfortunately, there are holes in their education. Fortunately, the fix is easy and we are going to be illustrating this through a number of case studies. We'll present the first principles and then apply the numbers. It is an essential skill that any practicing engineer, with a degree or otherwise, must be able to master.

The reason we got into this mess was the belief that emerged in the late '90s through to the 2000s that computer aided engineering tools could replace hand calculations. At the time of writing I am 43 and I finished my undergraduate training in 1995. Computer

aided engineering tools were then just starting to emerge, so I was still trained to engineer using a pen, a calculator and a piece of paper.

A mentor of mine who was raised in the slide rule era described this situation very well: 'When using a slide rule you had to know within an order of magnitude what the answer was. Consequently it forced you to be on your game.' The introduction of computer aided engineering tools has bypassed this important lesson.

But for all those junior engineers reading this and recoiling in horror at what I am writing let us do a before and after shot to see what's changed. Let's wind the clock back to the 1960s and look at some of the engineering highlights. 

You can get a handle on many of the performance parameters of a Formula 3 car through good old hand calculations says our numbers man



Figure 1: Beam pogo stick visualisation of the racecar with just aero forces

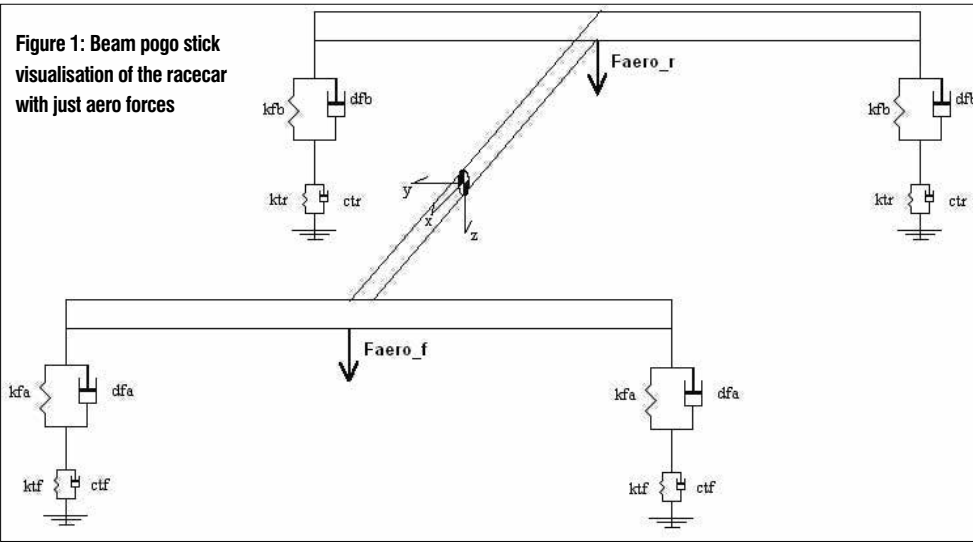


Table 1 – sample F3 car values for an aero hand calculation.

Item	Quantity
Front Motion Ratio	0.9
Rear Motion Ratio	0.8
FL Damper/FR Damper	10mm/10mm
RL Damper/RR Damper	15mm/15mm
Front spring	140.1N/mm (800 lbf/in)
Rear spring	140.1N/mm (800 lbf/in)
Torque at RPM	200Nm
Rolling tyre radius	0.28m
a_x	0g
V_x	220kmh
Gear ratio value	3
mt	500kg
h	0.3m
wb	2.6m

EQUATIONS

EQUATION 1

$$F_s = (k(x_s) + c(\dot{x}_s)) \cdot MR$$

EQUATION 2

$$\begin{aligned} FtDownforce &= MR_f \cdot k_f \cdot (FL_Damp + FR_Damp) \\ &= 0.9 * 140.1 * (10 + 10) \\ &= 2521.8N \end{aligned}$$

$$\begin{aligned} RrDownforce &= MR_r \cdot k_r \cdot (RL_Damp + RR_Damp) \\ &= 0.8 * 140.1 * (15 + 15) \\ &= 3362.4N \end{aligned}$$

$$\begin{aligned} C_{LA} &= \frac{FtDownforce + RrDownforce}{0.5 * 1.225 * (220/3.6)^2} \\ &= 2.57 \end{aligned}$$

$$\begin{aligned} AeroBal &= 100 \cdot \left(\frac{FtDownforce + \frac{mt \cdot g \cdot a_x \cdot h}{wb}}{FtDownforce + RrDownforce} \right) \\ &= 100 \cdot \left(\frac{2521.8 + \frac{500 \cdot 9.8 \cdot 0 \cdot 0.3}{2.6}}{2521.8 + 3362.4} \right) \\ &= 42.9\% \end{aligned}$$

$$\begin{aligned} C_{DA} &= \frac{gr * T / r_t - m_t \cdot g \cdot a_x}{0.5 * 1.225 * (220/3.6)^2} \\ &= \frac{3 * 200 / 0.28 - 550 \cdot 9.8 \cdot 0}{0.5 * 1.225 * (220/3.6)^2} \\ &= 0.937 \end{aligned}$$

- The Mach 3+ SR71 Blackbird spy plane was designed by 40 men using slide rules.
- We went to the moon and back using computers with less processing power than a smart phone.

So then, bearing the above in mind, with all the computational power we now have on tap we should be performing miracles. But let's have a look at some recent examples.

- It takes hundreds of people and hundreds of millions of dollars to run a championship winning Formula 1 car.
- The A380 airliner was two years late and over budget.
- The F-35 Joint Strike Fighter. This is the grand-daddy debacle of them all. It started in 2001 as a project to replace the F-16, F-18 and A-10, but it has gone drastically over budget and we will be lucky to see battle-ready aircraft by 2020. To put this in perspective it was supposed to be operational by 2010 ...

As you can see, things didn't quite pan out quite as expected with these projects in the age of the computer.

Hand-sum man

But before the red necks start squealing in glee, let me state that computer aided engineering tools have a very important and necessary role. Where computer aided engineering tools come into their own is with their ability to minimise the testing you need to do and to explore options you never thought possible. As the principal of ChassisSim I've seen this happen time and again within the ChassisSim community.

However, what must underpin this is a thorough knowledge of the basics and the ability to hand calculate your key metrics. This is critical for two key reasons. Firstly, the millisecond you have to calculate something it teaches you a lot about the problem you are dealing with. The second critical reason is

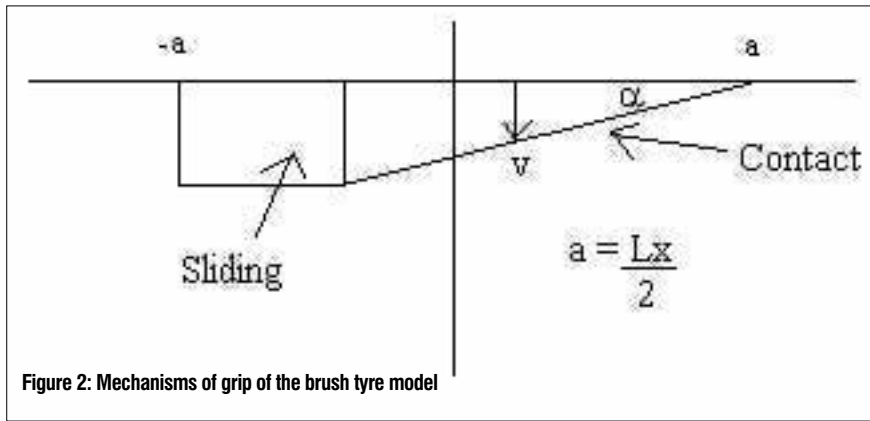


Figure 2: Mechanisms of grip of the brush tyre model

that it develops an awareness of the numbers. Consequently it's a brilliant sanity check and makes the time you spend using computer aided engineering tools even more valuable.

The first case study to illustrate the importance of hand calculations is how to calculate downforce from race data. I realise it is an example I repeat *ad nauseam* but I do this because it is such a critical metric in classifying racecar performance, while the principles and execution behind it are easy.

The reason we can calculate downforce from race data is that at its core it is a simple force balance equation. To illustrate this consider **Figure 1**, the beam pogo stick visualisation of the racecar. Here we have the downforce visualised as a force vector acting on the front and the rear of the car.

Given that the racecar isn't sinking beneath the ground and headed towards the earth's core there must be an equal and opposite force acting on it. This is provided by the car springs

As can be seen, what we are talking about here is some pretty simple high school level maths that will tell you so much about what the car is doing. I realise I have repeated this example, but if you are serious about being a competitive race engineer, it's about reaching a standard and not pandering to the lowest common denominator. What we have discussed here is what I would expect from a junior data or assistant race engineer. If you don't want to learn how to do this then other professions beckon.

Clean sweep

The next example we are going to discuss is the brush tyre model and what that can tell us about the fundamentals of what a tyre can do. The brush tyre model is one of the first models that was postulated to quantify tyre performance. Most tyre models can trace their origins to the brush tyre model. While you would not use the base brush tyre model to predict car performance to the nearest 0.1kmh or 0.01g it

EQUATIONS

EQUATION 3

$$\frac{k \cdot \alpha}{\mu} \cdot (a - x_{CIS}) = \frac{3 \cdot F_z}{4 \cdot a} \cdot \left(1 - \left(\frac{x_{CIS}}{a} \right)^2 \right)$$

We have

k = Shear modulus of the tyre (Pa)

α = Slip angle of the tyre (radians)

x_{CIS} = Transition point measured from the centre of the contact patch

a = Half contact patch length in the x direction of the tyre.

μ = Friction coefficient of the tyre

EQUATION 4

$$\frac{k \cdot \alpha}{\mu} \cdot (a - x_{CIS}) = \frac{3 \cdot F_z}{4 \cdot a^3} \cdot (a - x_{CIS}) \cdot (a + x_{CIS})$$

EQUATION 5

$$\frac{k \cdot \alpha}{\mu} = \frac{3 \cdot F_z}{4 \cdot a^3} \cdot (a + x_{CIS})$$

$$\therefore x_{CIS} = \frac{k \cdot \alpha \cdot 4 \cdot a^3}{\mu \cdot 3 \cdot F_z} - a$$

Here we have,

P_T = Pressure of the tyre (Pa)

F_z = Vertical load on the tyre (N)

a = Half x contact patch length (m)

L_y = Lateral length of the contact patch

Table 2 - typical F3 tyre parameters

Parameter	Value
Tyre Pressure	20 p.s.i (137.9 kPa)
Load	1000 N (100 kgf)
Co-efficient of friction	2
Shear Modulus (Force/Area)	100 MPa
Lateral contact patch length	0.2m

Hand calculating develops an awareness of the numbers. Consequently it's a brilliant sanity check

and is eloquently summarised in **Equation 1**, where F_s is the force of the spring damper unit at the wheel, x_s and ẋ_s is the movement and velocity of the spring, k is the spring rate or function and c is the damper rate or damper function specified at the damper, and MR is the motion ratio of the spring expressed as damper/wheel movement. You can even make this simply by zeroing the dampers on the ground. All you need to do is add up these forces at the end of the longest straight and you have a good idea what the aero on the car is doing. It's that simple.

The best way to illustrate this is by example. Let's consider some typical numbers from a Formula 3 car, see **Table 1**.

Here all motion ratios are damper on wheel, and the gear ratio is engine/wheel velocity and for simplicity I've omitted bump rubbers. Crunching the numbers we see **Equation 2**.

can still tell us a lot about a tyre. Also, as we are about to see, under the surface it's not that scary. The basis of the brush tyre model is it resolves tyre grip into a shear grip section and a sliding/friction generating grip section. These processes are illustrated in **Figure 2**.

The brush tyre model breaks down the grip generation by a series of bristles over the length of the contact patch. The first section is grip produced by the shear stiffness of the tyre. To further visualise this think of it as the lateral spring rate of the tyre. As can be seen, this acts on the slip angle and can be thought of as the linear component of the tyre grip. The second mechanism is pure friction, which is termed sliding. When these two terms are equal this is called the transition point. We will go into the significance of this shortly.

As much as I wanted to present a full derivation of the brush tyre model this ultimately

would distract us. However, there is a thesis by Jacob Svendenius from Lund University written in April 2007. The title of the thesis is *Tire Modelling and Friction Estimation*. The derivation of the brush tyre model presented in Chapter Four is excellent. Also, all of the base results we are presenting here can be derived on a piece of paper working from first principles.

The big thing we can derive from the brush tyre model is an approximation of what we can expect the peak slip angle of the tyre to be. This will be given to us when the sliding friction is the same as the friction given by the shear modulus of the tyre. This can be described by the following relation in **Equation 3**. When the tyre is pure sliding x_{CIS} = a.

However, at first glance if we substitute this in **Equation 3** the equation collapses. Fortunately a little bit of algebra will help us solve generically for x_{CIS} and ultimately for



EQUATIONS

EQUATION 6

$$\alpha = \frac{\mu \cdot 3 \cdot F_z}{k \cdot 2 \cdot a^2}$$

EQUATION 7

$$P_T = \frac{F_z}{2 \cdot a \cdot L_y}$$

EQUATION 8

$$a = \frac{F_z}{2 \cdot P_T \cdot L_y} = \frac{1000}{2 \cdot 137900 \cdot 0.2} = 1.81 \times 10^{-2} m$$

EQUATION 9

$$\alpha = \frac{3 \cdot F_z \cdot \mu}{2 \cdot a^2 \cdot k} = \frac{3 \cdot 1000 \cdot 2}{2 \cdot (1.81 \times 10^{-2})^2 \cdot 100 \times 10^6} = 0.0915 rad$$

EQUATION 10

$$C_y = -2 \cdot k \cdot a^2$$

the slip angle when it is sliding. Doing a bit of manipulation on **Equation 3** we see **Equation 4**. Doing a bit more manipulation we see **Equation 5**. As we stated above, when the tyre is sliding we have $x_{cis} = a$. Putting this into **Equation 5** and manipulating shows **Equation 6**.

The only unresolved question we have here is solving the half contact patch length, a, but we have a trump card to play. Our trump card is that tyre pressure is related to load by **Equation 7** (where P_T is pressure of the tyre (Pa), F_z is Vertical load on the tyre (N), a is half x contact patch length (m), L_y is Lateral length of the contact patch). The tyre pressure is easily given by the hot pressure you take when the car has been on track. The lateral contact patch is measured by the width of the tyre hitting the road.

Slip angles


We are now in a position to estimate what the peak slip angle is going to be. We'll present some typical F3 numbers, **Table 2**. The first step is to calculate the half contact patch length. From **Equation 7** we see **Equation 8**. Subbing this into **Equation 6** we see **Equation 9**.

So our approximation of peak slip angle is 0.0915rad or 5.24 degrees. Most F3 tyres will come in the order of five to seven degrees, so as a ballpark figure we aren't doing too badly.

Also, for those of you concerned with the large value of the shear modulus, this can be cross referenced by the brush tyre model

result as seen in **Equation 10** where C_y is the initial force vs slip angle curve for the tyre at zero slip angle. The unit for this measure is F/rad . You can cross reference this from any supplied tyre force rig measured result.

One thing that is necessary to state from the outset is that these hand calculations are approximations. What we have discussed is not a replacement for computer aided engineering tools or doing a thorough data driven analysis. However, as we can see in both the aero and peak slip angle approximation, it gives us a feel of where the numbers should be. This will be an instant red flag if the numbers you have entered into your computer tools are wrong. A classic example of this is when NASA lost a probe on entry to the Mars atmosphere when someone screwed up the conversion from metric to imperial. This skill set is totally invaluable if you are serious about being an engineer.

In closing, the ability to do hand calculations is a must for any serious racecar engineer. It is a skill set I have seen on the decline and I shudder to think of the long term consequences if this continues unabated. However, the positive news is that this is very easily solved. As we discussed in both the aero and tyre example a few elementary hand calculations, and first principles derivation, allowed us to approximate many important vehicle performance parameters. All that is now required is for you to put it into practice. 

The ability to do hand calculations is a must for any serious racecar engineer



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Can-Am coalition

Two of North America's best-known racecar producers have teamed up to build and supply LMP2 cars for the new-for-2017 regulations. Riley gave us the low down on both this project and its new LMP3

By SAM COLLINS



In 2017, the second tier of world sports prototype racing will undergo a drastic change. New rules will aim to cut costs and most controversially the number of chassis constructors in LMP2 will be cut to just four. While some eyebrows have been more than a little raised about the process of selecting the four manufacturers the requirement that one of them must be based in North America was understood by most. As IMSA phases out the never loved Daytona Prototypes in favour of cars built to LMP2 regulations it needed a familiar partner, and that partner was clearly most likely to be the company that for years had already dominated the DP market, Riley Technologies of Mooresville (NC). But when the four 2017 chassis makers were announced there was something

of a surprise. Ligier, ORECA and Dallara in Europe would be joined by Riley-Multimatic, as the North Carolina company had teamed up with Larry Holt's giant Canadian organisation in order to deliver the new cars.

'A few years ago we had dinner with Larry Holt, we talked about working together in future rather than competing against each other,' Bill Riley, co-founder and head of Riley Technologies, explains. 'We did some work together on the Viper programme, they did some of our driver in the loop simulation. So we knew we were developing a good working and engineering relationship with them.'

Multimatic has in recent years been on something of a recruitment drive and it has expanded its capabilities in the wake of

the collapse of Lola Cars, hiring many of its key design staff. The now Anglo-Canadian organisation could have put together a serious bid to rival that of Riley.

'When the tender came out it was clear we were going to go for it, and we thought that they would probably go for it too, so we thought that it would be a good time to start working together,' Riley says. 'It's a good fit over who will do what on the car and so we created Multimatic-Riley together. The car will be primarily designed by us, but we will use their CFD capabilities, they will do all the higher end composites work and the car will be assembled here in North Carolina. Riley will also be the point of sale, and manage parts distribution.'

While Multimatic has experienced Le Mans Prototype designers such as Julian Sole on its books, many of them are fully occupied with work on the new Ford GT, and while the Riley side of the partnership will doubtless call on the Multimatic engineers at some times the

Riley has opted for an all-new design rather than a version of its existing LMP2 coupe concept



LMP2 will start a new era in 2017 with just four manufacturers allowed to build chassis for the second-tier Le Mans prototype category. One of these will be a Riley and Multimatic collaboration



With Daytona Prototypes it's a relatively simple matter to run an off-the-shelf racecar with a 'works' body, as seen with this Ford-clothed Riley, but with an LMP2 car this process will be complicated hugely, largely because of its coupe type chassis



Riley says it will do most of the design work on the new LMP2 while Multimatic will do the higher end composites and will offer its impressive CFD capabilities. Riley will build the cars and it will also sell them and manage the parts business

core of the design of the new car will come from the mind of the other company co-founder, Bill's father, Bob.

Despite Bob Riley's advanced years he is not behind the times in terms of prototype design. Indeed on the wall of his office is a constantly updated gallery of detailed pictures of features on the latest generation of LMP1 and LMP2 cars. Alongside these are a range of renderings of less familiar LMP designs – the series of stillborn Riley Tech LMPs of recent years – and taking clear cues from all of them is an early rendering of the 2017 car, with a low and wide nose.

But Bill Riley stresses that the rendering of the 2017 car really is just a first impression: 'The tender said that we had to include renders of the design so we did these, but the car will be a fair bit different. [But] the nose concept is likely to be similar,' he says.

Riley has opted for an all-new design rather than a version of its existing LMP2 or LMP1 coupe concepts. 'Bob has never really stopped

working on the LMP designs, in fact he never really stops working,' Bill Riley says. 'The most recent one had a really neat front suspension layout that was very neatly packaged, and some other nice features but really that design overall was just a bit too old.

'The new P2 car will have a very nice and simple front suspension layout, but different to the one [on the old design]. The car is taking shape a little bit, it has come on further than the renderings in the tender,' Riley adds.

American focus

The appearance of the new Riley LMP as it is being designed may differ from final design. Multimatic-Riley is focussed on the North American market and with the works backed teams of the United Sports Car Championship (or IMSA Championship as it will be from next year) the car will likely be significantly different to the version which could race at Le Mans or in the wider World Endurance Championship.

Under the IMSA regulations manufacturers will be able to re-body and re-engine the LMP2 cars, which will then be performance balanced by NASCAR R&D in Concord, NC. The IMSA spec engines will be allowed to contest the Le Mans 24 Hours but not the other WEC, ALMS (Asian) or ELMS races, where all cars must use the newly mandated Gibson V8 engine and Cosworth Electronics.

'The WEC bodies have to be defined at some point in 2016, but the IMSA bodies will not need to be defined until a bit later than that. The car manufacturers will have to get through their fiscal years then allocate budgets before the work really starts on those IMSA bodies properly,' Bill Riley explains.

This approach of placing new bodies on existing chassis is similar in theory to that of the most recent generation of Daytona Prototypes, but in practice it is much harder to do with an LMP2 coupe with its composite monocoque defining many areas of the external shape.



SEEN: ADESS-03



The ADESS-03 LMP3 has run for the first time. The German-designed and built car is the third car built to the new ACO junior prototype rules to run on track. AAI Motorsports, one of the 03's first customers, shook the car down at Hockenheim.

Stephane Chosse, CEO ADESS AG, said: 'I'm very proud to see the ADESS-03 on track today. It was a very good team effort from all ADESS members and partners and I like to express my gratitude for

the hard work we put into the car build over the last weeks. I am looking forward to the next test sessions, where we will concentrate on car reliability and performance.

'I think we are proposing to our customers a high quality product which respects the cost cap defined by the ACO. We are putting a customer support service in place at the moment, so we are looking to the future with confidence.'

'We can't change the windshield surround and door shape for each manufacturer, the leading edge of the engine cover too is defined by the shape of the chassis. So I think what you will see is one manufacturer picking a chassis to work with and developing their body around that, otherwise they will have to double up on a lot of work.

'In DP you did have that with the Ford body on multiple chassis, but to do that there were a lot of little add-on panels here and there to make it all fit. You could not make it perfect, and that was a tube frame car,' Bill Riley says.

Unless there is extensive use of Formula 1 style 'vanity panels' it seems unlikely that, for example, a Ford-bodied Riley will be found racing against a Ford-bodied Ligier, but it does seem likely that a Ford-bodied Riley could race against a Chevrolet-bodied Riley, raising the slightly difficult scenario where a chassis builder will have to work with two rival auto makers, but here the North American coalition has an advantage over its three European rivals.

'Actually we do expect to work with multiple manufacturers,' Bill Riley explains. 'On the last generation DP on our chassis we had our body, the Corvette body and a Ford nose and tail. This is an area where we can double up a bit, Multimatic can deal with OEMS and we can deal with OEMS. We have enough history to show that we can deal with multiple OEMS too. So the Multimatic guys could do a body for an OEM and we could do a body for another, or we could do them all. I think there are different ways to work with it. For example, we could work with

our stylist and come up with a design, and do all the aero and validation here, or we could just give them all the CAD data for the chassis and mechanical parts and they could design and make the body.

'So it's a bit up to the manufacturer, we will have to wait and see. It's quite different to the DP cars, I think it's going to be cool, and the manufacturers are going to have some freedom and IMSA will balance them all out,' Riley says.

Le Mans lock out

Many European fans will be keen to see the IMSA bodied LMP2 cars racing but the ACO and FIA have stated that while the IMSA engine can race at Le Mans under a special BoP, the bodies will not be welcome, meaning all of the cars will have to revert to the standard homologated Multimatic-Riley WEC body.

'I guess you can't have the IMSA bodies at Le Mans because they do not aero balance the cars there and the performance could be quite different,' says Riley. 'I guess if people want to see these bodies race they can come over. There are plenty of flights each day!'

Riley Technologies is not only in partnership with Multimatic to create a new Le Mans Prototype but it is also in partnership with long term Trans-Am collaborator Tony Ave to deliver a new LMP3 class car, though this does face a rather less certain future in terms of racing.

'I don't know if the current LMPC owners want to go to LMP3, I can't figure out why they wouldn't as their cars are getting pretty old now.

But if they don't want it it is hard to force it down their throats,' Bill Riley says.

'I think IMSA knows that LMP3 is a great class, but they need to look at the relative class speeds. The PC is slightly faster than a GT car but they do not race well together. [The P3] is a dynamite little car, LMP3 is a great class for competitors as it is so affordable, and it's going to be fast so it's really good. You can race in things like the ELMS, which is a great series too.'

Riley has already completed the design of its 2016 LMP3, and the build of the first car was underway as *Racecar* closed for press. 'The tub is being done by Panoz along with the crash structure. We will build the first here then all of the subsequent cars will be put together by Tony Ave.

'After that we will make a few components like the wiring harness and some suspension components but he is really very capable of everything. We did the same business model in Trans-Am with him before and he sold 19 cars. Really we will have done the design work, but we will be doing some track support, I think,' Bill Riley says.

Different track

Already the Riley design has captured the attention of customers and it is understood some sales have already been made, but these are not from the expected direction.

'It will be a great track day car too, its better value than our current track day car and we have already had interest from that market, they are attracted by the value and the cost of parts,' Bill Riley says. 'With a car like this at the price it is the parts can't be expensive, the splitter, the nose, they all have to be affordable. For that reason we have a lot of wet lay-up in the parts. It's not so much the materials you use but the process you use with them where the cost savings are. The cost of carbon compared to the cost of fibreglass is not that different in the overall scheme of things.'

While Riley is building its first car, Ligier is already testing its LMP3 and Ginetta-Juno has completed a full season with its design. Address has also now tested its first chassis (see box out top of page). 'I've never been too worried about being a bit late to the party, you lose some of the customer share, like we did with the Daytona prototypes, but we got them all in the end,' Bill Riley says.

But with no clear indication from IMSA about how the new LMP3 cars will fit in with its championship in the future the prospects for the new Riley-Ave are not at all certain.

'In LMP3 they will try to keep the cars close together but IMSA is really the key for that design. I think it depends what people want to do with it. If IMSA embraces LMP3 we will have a huge advantage, if they don't we will be at a bit of a disadvantage being away from the core market in Europe,' Bill Riley concludes. Many will be hoping IMSA does embrace it.

'If people want to see these bodies race they can come to the US. There are plenty of flights!'

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Spirits in the sky

New bodywork and a controversial tweak to its 919 Hybrid's refuelling system has given Porsche the edge in the WEC

By ANDREW COTTON



Porsche introduced a controversial high downforce aero kit at the Nurburgring. The inboard winglets were designed to increase downforce at the rear to better balance the car. Audi believes that Porsche is using the exhaust gasses to blow air through the gaps

Porsche has introduced updates to its 919 hybrid that have, according to its rivals, redefined the spirit of the regulations, after the FIA and the ACO found the car to be completely legal following a lengthy investigation after the Nurburgring six-hour race at the end of August.

The key concern in Germany was the speed of the refuelling compared to Audi and Toyota. Estimates were that the Porsche's refuelling time was between four to five seconds faster than its rivals, despite efforts from the organising body at the start of the year through the Equivalence of Technology to keep refuelling times the same by restricting the flow of fuel into the car.

After the Nurburgring race, the car was found to conform with the regulations completely, but Porsche's rivals believe that,

after extensive work at the start of the season to ensure the cars refuel in times within a tenth of a second of each other through a refuelling valve restrictor, that such an advantage is outside the spirit of the regulations.

Audi's head of LMP1, Chris Reinke, said: 'We are not believing someone should be less quick, but to our best knowledge it has been adjusted and readjusted by the rule makers to have equal refuelling times and when we see what is happening there, we obviously failed badly with that philosophy. I don't say that the Porsche is an illegal car. We honestly believe that the car is in the regulation, but for us it is not in the spirit. We adjusted restrictors at the beginning of the season to within a tenth of a second, and now we accept these systems, and that is not what we expected.'

Porsche explained that it had optimised not only refuelling, but also the pit stop choreography to improve efficiency in the pits. 'It is a combination of everything,' says Porsche's technical director Alex Hitzinger. 'Pretty much everything that you are allowed to modify, the restrictor and so on, is all defined, and the nozzle, but after that from the hose through the valve, through the tank inlet, the internals in the tank, this is all free, this is all your design.'

'We do two-phase flow CFD, correlation with a physical tank with a glass window [a transparent fuel tank] so we can see what is going on, CFD of individual components, it's a development just like every other part of the car, just like engines and gearboxes. It is everything.'

Extensive work takes place to improve the refuelling times as every second lost in the pits



To ensure the volume of the gap inside the rear wheel arch met regulations, Porsche introduced a legality panel through the opening. At the Circuit of the Americas the FIA said the panel should be shortened and Porsche did this. Audi says that the cut out is a safety feature and that it would never touch this area



The thickness of the inboard winglets and their shape were considered to be outside the regulations and Porsche had to make some detail modifications, although ultimately the concept was allowed to stand

has to be made up on the track. For Audi and Toyota, that means an extra 30 seconds on track to make up for the deficit in refuelling over a six-hour race. However, fuel optimisation is a key part of refuelling in racing. 'Exactly,' says Reinke. 'That is why we are not protesting, not saying that they are illegal or wrong, but we share a different philosophy on this item. It was our own target to have equal refuelling times. This is a route that we cancel the commitment of equal refuelling times, we have to accept that and go down that route too.'

Audi had expected that the advantage found by Porsche in Le Mans would be negated for the Nurburgring race but, without a technical bulletin informing them of a change, they went to their home event with some trepidation. 'Porsche had an advantage [in

refuelling] in Le Mans that I don't think they will have again this season,' said Audi's motorsport director Dr Wolfgang Ullrich at the Spa 24 hours at the end of July. That change never came, and Porsche ran in Germany with the same refuelling advantage. 'We didn't cheat, or do anything that is not allowed, or even what is grey area,' said Hitzinger. 'All we did, we had a clever strategy and optimised everything down to the last detail. We just did a better job than everyone else. If people say that this is not possible, that is just a compliment. That means that they need to do their homework better. The restrictor diameter is fixed by the regulations. You have a restrictor that is fixed, and anything after that, that is where you can optimise.'

Toyota, the only other hybrid manufacturer to run with gasoline, was equally sure that this

'We didn't cheat, or do anything that was not allowed'

was not within the spirit of the regulations. 'According to the FIA after Le Mans, because immediately after Le Mans we raised the question of whether it was possible to have a pump sucking the fuel through, the answer was "no," says Toyota's technical director Pascal Vasselon. 'You can only use gravity energy. According to this clarification, we are looking for solutions, and at the moment we have not found the solution.

'The clarification is very clear. I am sure that the FIA did a proper job [investigating] in the Nurburgring. They were strong in the investigation so their conclusion is clear so that is it. We have to go back and do our homework.'

Wheel wonder

Porsche also introduced a high downforce aero kit that, according to Audi, has also stretched the spirit of the regulations. The 919 hybrid features a wheel arch extrusion similar to that used by Toyota in 2012 to generate downforce at the rear of the car.

Porsche's interpretation meant that the wheel arch extension ran inboard, over the rear deck, but was of such volume that it had to also run a shaft down the inside of the rear wheels to remain legal. 'The patch is there to achieve the right areas, it is not doing anything, there is

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Toyota used a similar wheel arch extension on its TS030 back in the 2012 season. It tested a similar concept for its 2015 LMP1 car, but it found the effect to be negligible and so did not go ahead with running with it on this year's TS040

no advantage at all,' says Hitzinger. 'It is a clever way of using the wording of the regulations. It is shorter here [at the American round in Austin, Texas] because the FIA wanted us to shorten it a bit and have a bigger gap at the bottom, they think it was better for lift-off. We have done CFD on it and it is better in terms of lift-off than what we have run in Le Mans, and we have given them all the results. The effect is peanuts. We adjusted the panel and it is all fine.'

Some say the thinking behind the 'wings' at the rear of the car is that the exhaust gas is blowing through the gap, but Porsche denies that this is the case. 'The exhaust gap is mainly going on the centre of the car. Where you have the bodywork, it is passing through the middle. It is not going underneath the plates, but more inboard. We are not blowing it. That is not the purpose. In fact we have checked the influence because we can do it in CFD having exhaust on and off, and in the wind tunnel having the exhaust on and off and the effect is peanuts.'

'The effect of the exhaust on the rear of the car is negligible, and we can see this when we run in the wind tunnel when we turn the exhaust gasses on or off. We see directly the downforce effect. It is not designed for using the exhaust gas effect, and therefore it would be absolutely crazy to do off-throttle blowing; it would be stupid to do that. We have never done it and not even tried.'

However, Audi was happy to go on record and declare that this, too, was against the spirit of the regulations. The rear wheel cut outs were designed to reduce air pressure around the wheels and consequently the chance of cars flipping in instances of high yaw angles. 'For sure there are parts of it that are very creative, there are parts that are controversial


and there are parts of it in areas where we thought from Audi we would never go and we won't follow,' says Reinke. 'For us, safety items are not to be touched and the wheel house ventilation is a safety item. It is a legal part, we are not saying it is illegal.'

'[Porsche] went down a path that we are not going to follow. The wheel house ventilation holes are there for a reason and therefore not for design features. But that is an Audi thing. Porsche is not a dangerous car, is not outside the regulation. I can see a performance increase had priority at Porsche, otherwise they wouldn't have done it like that.'

Pushing the boundary

Porsche also used inboard flaps around the crash structure that it said were part of the engine cover, designed to increase rear downforce and for Porsche to be better able to balance the car. 'The boundary has been pushed through this interpretation,' says Reinke. 'We have concepts that are sometimes beyond legality in the wind tunnel to see the effect, and then turn them down to be legal so there are extremes. What we see at the moment is that the boundary has been pushed. We have more formal investigated areas that we use. It opens a wider range for us as well.'

'A blown diffuser used the exhaust gasses to speed up the air on top of the diffuser, and therefore that made the diffuser more efficient. For us it is a blown diffuser system tweaked into the legal words of the regulations.'

Porsche is clearly pushing the technical development hard. It has been declared legal in all areas by the organisers, but the indications are that the regulations will be much tighter in the future. 

Audi was happy to go on record and declare that this was against the spirit of the regulations



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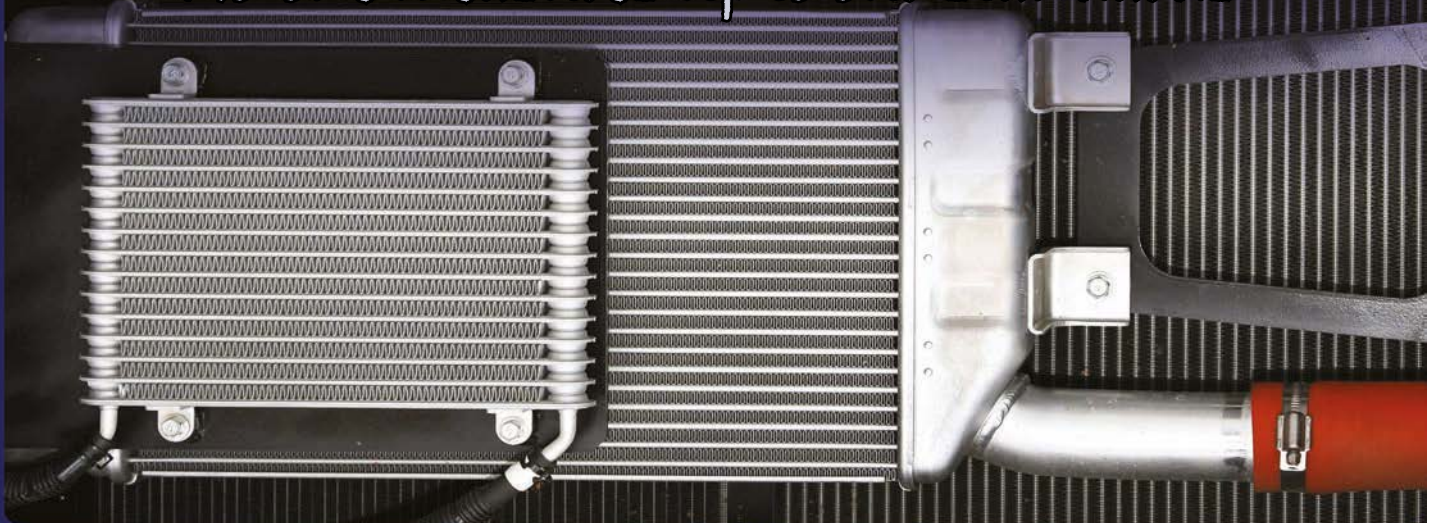
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At what cost?

It's simple enough to say that costs must be controlled, but just how do you go about doing so? *Racecar* asked the top WEC teams for their take on the issue

By ANDREW COTTON



Toyota's technical director Pascal Vasselon has proposed a token system for the drivetrain, as is used in Formula 1, to keep spiralling costs in the World Endurance Championship in check



Porsche's technical director Alex Hitzinger favours an outright cost cap, similar to that suggested by Max Mosley for F1, and says it could also add an engineering challenge that's road car relevant

Cost saving is a concept that should be alien to motor racing, particularly in the engineering departments, yet today it sits at the very core of the sport. Expensive racing is that in which more money is paid out than is being recouped, or that the money being spent is not seen as good value. That value can be seen in a variety of ways: be it transfer of technology, good racing, or in the case of series such as the Blancpain Endurance Series, racing GT3 cars on great circuits.

In Formula 1, Mercedes is clearly seeing the value and is comfortable with what it is achieving; Ferrari likewise, having closed the performance gap and increased its global brand value. Renault sees the value in competing, but has to change strategy slightly as its 'lead' team Red Bull seeks a different partner for 2016. Renault needs to win, or at least be more competitive than it is now. Honda clearly saw the value of a return to Formula 1 under the new hybrid regulations, and although this season is a baptism of fire for the Japanese company, it won't give up until it's winning again.

Meanwhile, in the WEC the regulations allow for different technologies, fuels and car design, but after a winter of incredible development between 2014 and 2015, costs are under the spotlight. The return on investment has been there for Toyota, Audi and Porsche so far, but to encourage a new manufacturer to join is likely to take another change in regulation to level the playing field. Before then, the current manufacturers need to prevent a cost explosion for themselves. Finding a solution is not as easy as it sounds among a clearly close-knit group.

Toyota's tokens

Toyota has made a proposal to Audi and Porsche that it adopts Formula 1's token system in the drivetrain to keep a lid on the incredible development programmes currently underway. Toyota's super capacitor hybrid system in the TS040 costs an estimated €300,000 per system and, in 2014, it was thought to be going through one system per race. By the end of the weekend, the pace of the TS040 had dropped as the super capacitors were spent. This year, the one-lap hit taken by the super capacitors in qualifying

has been compromised in order to make the systems last better through the weekend. The Toyota is so much faster than it was in 2014, but Porsche and Audi have stepped up by an incredible margin. Toyota is, in 2016, targeting something like an eight second per lap improvement at Le Mans, like for like, although the ACO will slow the cars by reducing the energy in the fuel by around 10 mega Joules. 'Without a change in regulation, to see such a big increase is fantastic but it is frightening because of the cost explosion,' says Toyota's technical director Pascal Vasselon. 'What we see in F1, what we see here, is that not everyone will be able to follow this cost explosion.'

'The token system is good in principle to put under control the development costs,' Vasselon says. 'Within our new regulations, which are fantastic because they give a lot of room to several technologies, the negative side is the costs. This is the danger that is facing F1 and WEC. If we don't control the costs I don't think so many people will still be there in five years' time.'

With Toyota's proposal so recently made, Porsche didn't want to comment until it had digested all the implications. However, technical director Alex Hitzinger favours an outright cost cap, similar to that suggested by Max Mosley for Formula 1. 'With this whole cost containment thing, it is a very difficult topic because you cannot stop people from spending money,' says Hitzinger. 'Everyone will always spend as much as they can have. Even with a very restrictive regulation, people can still spend a lot of money, and still get the benefit from it. If a manufacturer comes in and says 'I want to win whatever it costs', you have a problem. What you can do is reduce the impact of what money has on performance gain. I would be in favour of a budget cap. It needs to be done properly, but I am convinced that it can be done. For me, that would add another engineering challenge, which is road relevant. In a road car, you get a budget, and you have to develop in that budget, and hit that target. In motorsport we also have a budget, and you do the best you can with it. If you have someone who has an infinite budget, it is almost not a fair playing field.'

'If you say long-term you want to increase the hybridisation, and we go the same speed,



Toyota struggled at this year's Le Mans in terms of pace and is now targeting an improvement of around eight seconds per lap for 2016 – but how can the costs that come hand in hand with such ambitious development plans be controlled?

the same lap time with less fuel, that's the perfect message, but if I want to do that, I have to invest in hybrid development,' Hitzinger continues. 'If I save the money on aero testing because I am not allowed to do so much, I put it in to hybrid. It is the same budget. From that point of view, some of these things make sense.'

'Another thing is to drive for 10 years with the same technology, and reduce costs by closing development doors, but to do the same thing for five years is not interesting. We have to look where we open up, where can we save the money and keep the same budgets. The ideal thing is if the budget is fixed, it is not variable.'

Budget secrecy

Audi's thinking is interesting, particularly in relation to the famously clandestine cost of competing in DTM. Like Porsche, Audi also did not want to comment on the issue of cost control, as the talks take place behind closed doors and there is an agreement not to discuss them publicly, apparently. However, Audi's head of motorsport, Dr Wolfgang Ullrich, did say that he believed an outright budget cap would not work as manufacturers all have different ideas on value. 'We have to find solutions, and there are many possible solutions,' he said. 'Our favourite is that all the technologies can be competitive and we know that we can keep the budgets more or less constant, and that is the target. It is not easy stuff.'

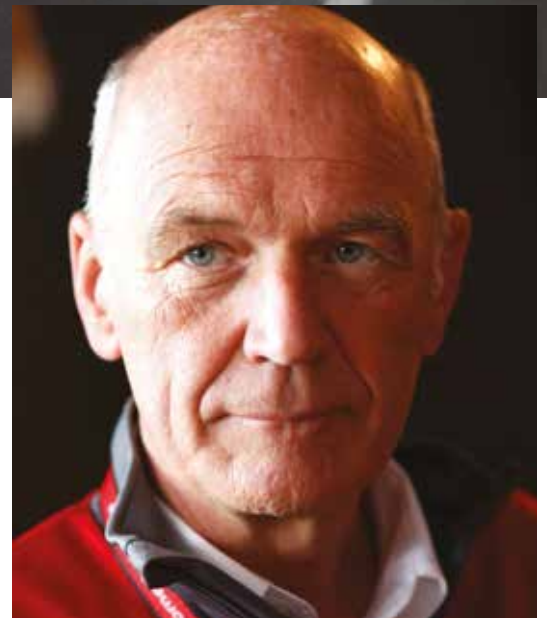
'You need to find a solution to control several things. If you reduce wind tunnel time, then what are you going to do? First you try to optimise the use of the wind tunnel. The second

is that if there is nothing against it, you try to do more simulation work and then you make the wind tunnel again more efficient, but it is something that, if you take these rules, it pushes you to investigate in stuff to bring more or less the same result with less money or less activity, which is the right solution.'

As mentioned above, as far as a budget cap is concerned Ullrich was unequivocal: 'You can't do [a budget cap] because the systems of the manufacturers are organised to be so difficult that if you compare budgets you are completely in trouble. The system of how budgets are built up, and what you have as base costs, is so different in the manufacturer houses, that the real money available for development is too different to the teams themselves. No manufacturer will be happy to give an official number for a budget, because you won't get an official number for other budgets of a big company either.'


'Even without that, if you have completely different structures, and you give them the same money, the money that is available for pure development is completely different. We favour solutions that are given by a rule book where we are all convinced that what comes out of reducing something is not more expensive than what we are producing. That is not easy, but it is possible. We have already done some [of this] and if you continue this way, I think that it is good,' Ullrich concluded.

Cost control is not easy. But perhaps the simplest way to solve the problem of costs is to increase returns, and this is where those who are not successful are struggling. The base cost



Wolfgang Ullrich, Audi's head of motorsport, believes an outright budget cap would not work as manufacturers are unlikely to want to go public with figures, while it would also be difficult to police

of competition is now so high, particularly in F1 where even the customer teams have to run hybrid engines, that there is a real pressure on finances. With this, it could be argued that customer teams in F1, as is the case in the WEC, might be allowed to run without hybrids.

As for the WEC, it needs to increase its value to the competing manufacturers. How it does that, with the clearly different approaches, is a matter of debate. Key to the regulations is how to maintain the variety they need to return the investment. Toyota will move to batteries and an 8MJ system next year. Porsche will continue with what it has, Audi was tight-lipped about its plans beyond 2017. One thing's for certain: the future will be interesting. 

Perhaps the simplest way to solve the problem is to increase returns



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Return of Austrian Grand Prix has helped to boost F1's average revenue per race

Formula 1 rakes in over a billion dollars during 2014 season

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Formula 1 turned over a whopping \$1.35bn during the 2014 season, five per cent up on the previous year.

The figures were revealed in the filings for Formula One World Championship Ltd (FOWC), a member of the Formula One Group and the company responsible for exploiting the F1 championship's commercial rights. The accounts also state that EBITA (earnings before income tax, depreciation and amortisation) was \$260m in the same period.

FOWC explained that turnover was boosted by revised TV deals and other factors. The increase in revenue was driven by strong growth in revised TV

rights agreements in Spain and the Middle East, along with underlying contractual uplifts in other TV contracts, plus growth in logistics revenue and race promotion agreements,' it stated.

Average revenue per race rose from \$57.1m to \$59.4m, the accounts also reveal, thanks largely to the replacement of cash-strapped events such as Korea and India with well-funded new grands prix in Russia and Austria which are willing to pay larger fees.

The accounts also show that the sport increased its payment to the teams in 2014, the total team prize fund increasing by \$66m (eight per cent) in 2014 to \$863m (in 2013 it was \$797m).

Meanwhile, with Ferrari's flotation on the New York Stock Exchange due in the next few months, details of its F1 spend have come into the public domain – Ferrari, along with Sauber and Toro Rosso, are not based in the UK, and hence are not required to file publicly available financial statements each year.

According to well-respected Wall Street institution Bernstein Research, Ferrari spent around \$440m on its 2014 F1 campaign, a figure that is actually close to the estimated budget many have quoted for the Scuderia. Bernstein said this budget comprised \$220m in sponsorship, \$180m in FOM revenues and \$40m from Ferrari's own in-house marketing spend.

Strong on-track performance pays dividends for Williams

Williams Grand Prix Holdings has released its interim results for the six months up to the end of June of this year, which show a marked increase in revenues for the F1 operation on the back of its impressive 2014 season.

In comparison to the same six-month period last year Williams Grand Prix Holdings PLC, the holding company of the Williams group of companies which includes Williams Grand Prix Engineering Ltd, has reported that turnover has improved by just over £19m, from £44.1m to £63.2m.

However, due to ongoing investments in the team and the Williams Advanced Engineering business, the earnings before tax, interest, depreciation and amortisation (EBITDA) is actually down from £19.6m to £1.4m. For the F1 operation revenues are impressive, though, up from £34.6m last year to £51.8m, with an EBITDA of £2.5m.

Group CEO Mike O'Driscoll said of the results: 'Our first half results represent a significant improvement over the same period in 2014, with strong revenue growth and positive cash flow. We made a small EBITDA loss through the first half of the year, which was in line with our expectations.

'Mid-way through 2013 we set out on an ambitious turnaround strategy to reinvigorate the Formula 1 team, create a strong and profitable Advanced Engineering business, and divest non-core activities,' O'Driscoll added. 'In 2014 we made excellent progress against those objectives, with a third place finish in the Formula 1 constructors' championship, and an expansion of our Advanced Engineering division. This progress has been sustained into 2015.'

O'Driscoll said that the team's extra income has come from two main sources: 'The improved performance of our Formula 1 team on the track is now reflected in both higher commercial rights income and increased sponsorship revenue, bolstering our financial results,' he said.

Despite the upturn in form O'Driscoll has warned against complacency and said it could be difficult to keep pace with better funded teams. 'Overall, these

interim results are encouraging, and represent very good progress,' he said. 'However, we face continued cost pressures due to the spending levels of our major Formula 1 competitors, and this challenging environment will undoubtedly continue in the near term. We remain determined to build the necessary foundations for future sporting and commercial success, both on and off the track.'

XPB



Williams bagged a well-deserved podium at Monza's Italian Grand Prix while its financial results for the first half of 2015 have also been rather impressive

RML and Swindon scoop British Touring Car contracts

The British Touring Car Championship has awarded RML with the contract to supply spec parts to the championship, while Swindon has retained its TOCO engine supply deal.

RML Group's deal begins next season and will see it take over from GPRM, which has supplied parts since the Next Generation Touring Car (NGTC) regulations were introduced back in 2011.

The deal will run for six years and the company – which is a well-known race team in its own right both in touring cars and sportscars – was awarded the contract after what the BTCC tells us was a lengthy tender process which began earlier this year and involved the BTCC Design Group, comprising many of the championship's leading designers and engineers.

RML will provide NGTC chassis design, engineering and component supply services

and will undertake comprehensive evaluation and design-work. Initially this will involve concentrating on some technical updates which will be available to all teams for the 2016 season onwards – the vast majority of which will be compatible and interchangeable with current components. It will work alongside both the BTCC Design Group and the Technical Working Group (BTCC TWG) – made up of existing teams and TOCA technical staff – to oversee and approve any revised designs.

A number of re-designs of mandatory components have been requested by the BTCC TWG and are already underway. Further updates that primarily improve durability and ease of use by the teams, but importantly without directly changing the current concept or performance and price, will also be assessed.

RML has previously run teams in the BTCC with Vauxhall, Nissan, SEAT and Chevrolet cars, while it also competed in the World Touring Car Championship with its Chevrolet Cruze.

Alan Gow, BTCC series director, said: 'We welcome RML back into the BTCC family. In fact we actually go back a long way together, as the 1993 BTCC was their first touring car project.'

Meanwhile, current TOCA engine supplier Swindon Engines has retained its deal until the end of the 2021 season. Teams have had the option to use the championship-commissioned engine since the NGTC regulations were introduced and 19 cars in the current field are powered by it. Nine manufacturers expressed an interest in the engine deal, with four going forward on a short-list for consideration by the BTCC's review panel.



BTCC is to have a new standard component supplier from next season but will retain current TOCA engine builder

SEEN: Mercedes AMG C63 DTM



The 2016 Mercedes DTM racer has broken cover. Because the regulations are frozen for next year the only major changes are to the bodywork which has been reshaped above the 'design line', level with the wheel arches.

The new C-Coupe will be raced for just a single season, as the DTM's Class One technical platform is to be introduced in 2017. BMW has said it will stick with its existing M4 next year while Audi says its focus is on the 2015 season for now.

Mercedes' DTM chief Ulrich Fritz said of the new car: 'The DTM car again takes its design and technological cues from the AMG line of the new C-Class Coupe. We took the first steps in adapting designs for the new DTM car last year. The regulations severely limit areas for development, so a large number of components have been taken from its tried and tested predecessor.'

Fritz added: 'Obviously, in the DTM, we seek to continuously optimise the overall package and, consequently, the vehicle passes through various development processes and stages during the course of its entire life cycle as deemed necessary.'

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SEEN: BMW M6 GT3



BMW has shown off its new GT3 in evocative works livery and has announced that the BMW M6 GT3, which replaces the Z4 GT3, is to retail at €379,000. BMW motorsport director Jens Marquardt said: 'The heart of the BMW M6 GT3, its engine, has been transferred from the production car with only minor modifications. Furthermore, the car sets

new benchmarks when it comes to safety – with a completely re-designed front, a large distance to the safety cage, and the driver's seat oriented well towards the centre of the car.'

The M6 weighs less than 1300kg and sports a sequential 6-speed racing gearbox. BMW says: 'The reliability, efficiency and ease of maintenance of the

BMW M6 GT3 will be tuned to master the demands of endurance racing, and its longer wheelbase promises to deliver significantly improved handling characteristics compared with the Z4 GT3. BMW M6 GT3 customers will also benefit from the service laid on by BMW Motorsport support engineers and a track-side supply of parts.'

Infinite prospects for lucky five Formula 1 Academy winners

Five university engineering students from across the globe have been given the career opportunity of a lifetime as the winners of the 2015 Infiniti Performance Engineering Academy.

Muhammad Zafar (20, from Saudi Arabia), Andre Plakhotnichenko (25, Russia), Daniel Sanham (24, UK), Zhang Zitong (22, China) and Alex Allmandinger (22, USA) were chosen after an intense international selection process.

Each of the students will now receive a 12-month work placement split between the Red Bull Racing F1 team and Infiniti,



Contestants attended regional finals events where they were put through their paces by a panel of judges from Infiniti and Red Bull

complete with full salary. The winners have moved to England to work across a variety of roles spanning vehicle dynamics, vehicle design, aerodynamics and electronics. They will spend eight months at the Red Bull Racing factory and four months at Infiniti's European Technical Centre.

Now in its second year, this year's Academy saw thousands of engineering students enter the programme and after a series of interviews with the best entrants 10 finalists in each region (Europe, USA, Saudi Arabia, Russia and China) were selected to attend a regional final event where they were put through their paces in a structured assessment day by a panel of judges from Infiniti and Red Bull Racing. One winner per region was selected for the main prize.

Tommaso Volpe, global director Infiniti Formula 1, said: 'The calibre of entrants this year was very high which made for a tough selection process, but if last year's winners are anything to go by, it will not be long before all of them are making a significant contribution both to us and to the race team. With F1 becoming more and more relevant to the automotive industry and an increased focus of the placements this year being on the road car development, we are training a new generation of engineers who will play a key role in the crossover between the two industries.'

Williams to supply F1 tech for new armoured vehicle

Williams Advanced Engineering has scooped a £17m contract to work with global defence company General Dynamics UK to bring its F1-bred technologies to the state of the art Scout Specialist Vehicle (SV).

The contract will see Williams Advanced Engineering, the arm of the Williams group that brings F1 tech to market, design and manufacture what it describes as the Scout SV's 'Core Infrastructure Distribution System'. This is the power and data backbone of the vehicle, which will enable the distribution of power and data around the armoured fighting vehicle, Williams tells us.

Formula 1 has long used sophisticated electronic data



Advanced Engineering MD Craig Wilson says experience in F1 will prove useful for Scout SV project

logging and with this project Williams will be tapping in to its expertise in data analytics and systems integration.

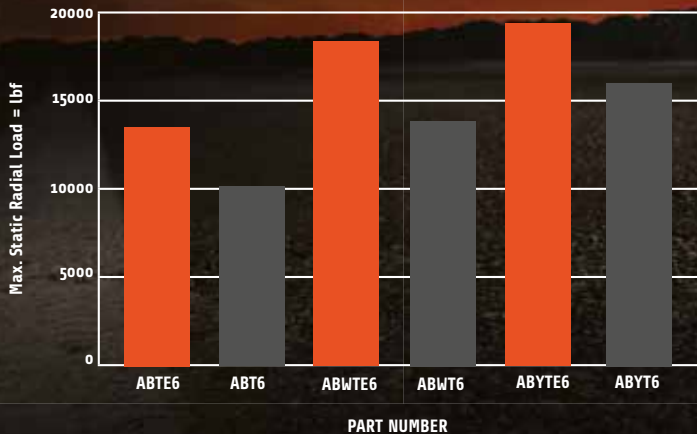
Scout SV is the replacement for the British Army's reconnaissance vehicle fleet, and its six variants – all tracked vehicles – will provide the medium-weight core of the British Army's deployable armoured capability up to 2045. There are to be 589 vehicles in all, due to be delivered to the British Army through 2017 to 2024.

Craig Wilson, managing director at Williams Advanced Engineering, said: 'Williams Advanced Engineering specialises in complex technological problem solving and bringing Formula 1 technology and processes to industry. We have started expanding outside our traditional strength of motorsport and automotive.'

'We are working closely with General Dynamics UK to make sure that Scout SV has an electronic architecture that is best-in-class technically and also packaged efficiently. These are core skills that the Advanced Engineering team can transfer directly from Williams' extensive experience in motorsport.'

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Future of Turkish Grand Prix venue in the balance

XPB



Could Istanbul Park really be turned into a used car lot? Pictured is 2010 Turkish GP

Istanbul Park, widely regarded as one of the best modern style Formula 1 venues, is awaiting news on its fate amidst reports that it will either host a returning Turkish Grand Prix or will suffer the ignominy of being turned into a used car lot.

The circuit, which hosted the Turkish Grand Prix from 2006 until 2011 and was famous for its Turn 8 – which although fringed with acres of runoff was regarded as a real challenge by many drivers – cost almost \$300m to build and has a capacity of 155,000.

But Istanbul Park failed to attract the crowds and it fell off the calendar in 2012. It has been reported in the Turkish press that car rental company Intercity has signed a 10-year lease and plans to sell 25,000 cars from the site, which could now be called Istanbul Park Auto Market.

However, it seems there is still a chance that the circuit could escape this fate as Intercity chairman Vural

Ak has now had talks with Formula 1 supremo Bernie Ecclestone and has stated that the track 'still has a grade 1 FIA licence' and could therefore return to the calendar 'in the future'.

Ak added that the talks had gone well and there was only the final hurdle of approval by the Turkish government to be cleared, which would have to wait until after the Turkish election at the beginning of November. 'The Turkish government should approve the race because it's an international activity,' said Ak. 'For this reason, we are waiting for the election.'

Istanbul Park was designed by F1's favoured track designer, Hermann Tilke, who included a number of 'error generator' corners, while there were also turns based on famous corners from other circuits, such as Spa's Eau Rouge and Monza's Parabolica.

The circuit has also hosted MotoGP and the DTM in the past.

IN BRIEF

Good view

IndyCar has seen its TV viewing figures increase for the second year in a row. This season viewing numbers shot up by 16 per cent, and since the 2013 season IndyCar has increased average viewership by 38 per cent. For the year, combining NBCSN and ABC telecasts, IndyCar races averaged 1.1m viewers. That follows a 19 per cent viewership surge in 2014 over the previous year. Meanwhile, the season finale at Sonoma showed a 123 per cent increase in viewership over the 2014 race.

R8 order book opens

The new Audi R8 LMS is now available to customers. Audi is to build 45 of its second-generation R8 GT3 racers for customer sport and deliveries are set to begin at the end of October, ready for the 2016 season. The new R8, which replaces the first-generation car introduced in 2009, retails at €359,000 plus taxes and €398,000 with a parts package. This year it's been run by the WRT and Phoenix teams in selected rounds of the Blancpain Endurance Series and VLN long-distance championship – plus the Nurburgring 24 Hours which was won by one of the new R8s – as part of an in-competition development season. As *Racecar* went to press Audi revealed that it had made its first sale to British GT operation Optimum Motorsport.

Barber expands

The Barber Vintage Motorsports Museum on the site of Barber Motorsports Park in Birmingham, Alabama, is being significantly enlarged. The museum, which opened in October 2003, is to add more than 84,000sq.ft to take its floor space up to close to a quarter of a million sq.ft over five floors. Earlier this year the venue opened a 440ft-long pedestrian bridge which linked the museum to the infield track. Other improvements made at the circuit recently include a new classroom and garages for the driving school. The museum boasts the largest motorcycle collection in the world.

Porsche extends

Porsche has confirmed it will race in LMP1 in the World Endurance Championship until the end of 2018, extending its original commitment by two extra seasons. Porsche embarked on a five-year programme, planning to race in the 2014-16 seasons, when its return to top-flight sportscar racing was signed off in the summer of 2011. The two extra years will now take it into the next LMP1 rules cycle, which is set to come into force for the 2017 season. The German manufacturer won Le Mans for the 17th time this year with its 919 Hybrid. Its re-entry into the WEC last year came after an absence from top-level sports prototype racing of 16 years.

SPONSORSHIP

Holden, the Australian arm of General Motors, has entered into a multi-year promotional license agreement in Australia and New Zealand to promote the **Star Wars** movie franchise through its V8 Supercars programme.

Shell has extended its technical partnership with **Ferrari** for the next five years in a deal that was announced at the Italian Grand Prix. Shell will carry on providing Ferrari with its performance fuels and lubricants package, while it has also committed to continue to dedicate 50 full time technical staff to the partnership every year.

Ferrari team principal Maurizio Arrivabene said: 'Historically the engine is at the very core of Ferrari, which means that everything we do with Shell is working around our heritage as an engine constructor. Already this season the work that Shell has done has contributed to our wins in Malaysia and Hungary, which is proof of not only a professional commitment, but is also the result of a great partnership as well.'

Todd Kelly's Nissan Altima V8 Supercar has a new primary sponsor in the shape of **carsales.com.au**, which is Australia's number one automotive online business. It is the first time the company has partnered with a top level V8 Supercars operation.

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Gibson seals LMP2 engine deal

Gibson Technology has been selected as the sole supplier of engines for LMP2 from the 2017 season.

Formerly known as Zytec, Gibson will supply a normally-aspirated 4.0-litre V8 to power new LMP2 cars built by selected manufacturers Dallara, ORECA, Onroak/Ligier and Riley/Multimatic – as announced in July. The deal will cover the World Endurance Championship (WEC) the Le Mans 24 Hours, the European Le Mans Series and the Asian Le Mans Series. The engine will produce 600bhp, with lower running costs than the current breed of LMP2 powerplant.

The FIA and Le Mans organiser the Automobile Club de l'Ouest (ACO), the two organisations behind the new-for-2017 LMP2 regulations, have also chosen a spec electronics

supplier for the new engine, Cosworth Electronics.

However, Cosworth's contract differs from that of Gibson in that it also covers the United SportsCar Championship in the US (to be known as the IMSA SportsCar Championship from next year). IMSA is otherwise to remain an open championship when it comes to engines when LMP2 switches to Gibson in Europe and the rest of the world.

In a joint statement the FIA and the ACO said: 'Gibson Technology and Cosworth Electronics have been chosen according to criteria of performance, quality, reliability, service, maintenance and price competitiveness.'

Gibson has a good pedigree in one make formulae, most recently with the Formula Renault 3.5 Series, while in the

world of endurance racing the Gibson-Nissan developed VK45 engines have achieved great success with many WEC and ELMS LMP2 teams. Gibson also builds chassis for current LMP2 competition.

John Manchester, Gibson's operations director, said: 'Gibson is extremely privileged to have been chosen as the engine manufacturer to the new LMP2 series and it is a testament to our workforce and the products they have produced over many years.'

'Gibson has over 20 years experience supplying engines for single make racing series and we are confident that we can make a valuable contribution in helping what is already a flourishing series become an even more successful sportscar racing category,' Manchester added.

Lydden Hill circuit plans major upgrade



UK venue Lydden is set for build programme if plans are approved

Lydden Hill, the UK circuit chiefly known as a venue for rallycross, has unveiled plans for a redevelopment project at the Kent track.

Lydden, which is Britain's World Rallycross Championship venue and also in many ways the spiritual home of the sport, having staged the first event in 1967, has submitted a planning application to Dover District Council. The submission includes plans to build a part two-storey, part three-storey spectator hospitality building, two grandstands, and a two-storey building which will house competitor hospitality, administration and scrutineering facilities.

The proposal also includes new two-storey engineering units and a site entrance building. It also suggests that an existing but unused

entrance should now be used to help to ease the traffic flow on race days.

Lydden, which is owned by multiple British rallycross champion Pat Doran, was first used for motorsport back in the 1950s.

The new application also proposes that the circuit and its new facilities should be used for additional non-motor racing activities, such as track days – including corporate and experience driving days – police driver training, cycle racing, and non-driving based events such as car shows, craft fairs and hot air ballooning.

The plans have been drawn up by London-based architect and designer Alexander Sedgley Ltd, which says construction work could begin as early as next year if the planning application is successful.

Gibson is already active in LMP2 as chassis (pictured) and engine supplier but from 2017 becomes P2's sole engine supplier



Miller Motorsports Park complex acquired for \$20m by company planning China track developments

A company that plans to build five new race tracks in China has snapped up the Miller Motorsports Park to use for training personnel and as a template for its ambitious Far Eastern enterprise.

Mitime Investment and Development Group bought the Utah race circuit and test facility from Tooele County for \$20m and now intends to upgrade the facility.

Tooele was keen that any new owner should keep the track as a going concern after previous lease holders the LHM Group of Companies decided to let go

of the venue earlier this year.

Tooele County commissioner Shawn Milne, who has driven efforts to find a new owner, said: 'The commission recognised early on that we cannot afford to have the facility close. There are over 90 workers employed by the motorsports park itself and hundreds of others that depend upon the regular operations throughout the year.'

Mitime initially expressed interest in purchasing Miller Motorsports Park as a training facility for the development of proposed race tracks in China, but will now also operate the track as

a going concern. The company has hired renowned track designer Alan Wilson to design and build five race circuits in China, all scheduled to begin operations in the next decade.

Wilson, also the designer of Miller Motorsports Park and its general manager during the first three years of operation, said: 'This opportunity couldn't come at a better time for the world of racing and the growth of motorsports in one the world's fastest growing economies. This deal allows the facility to remain fully operational and to export the American racing model to China.'

Mitime intends to invest heavily in the Miller facility with the aim of achieving FIA and FIM international standard, while there are also plans to build a drag strip and rallycross circuit, plus motorsport industry and educational projects at the site.

It's been suggested that the economic activity generated by the Miller project could generate \$1bn for the region over the next 25 years. 'Mitime's commitment to both this facility and the motorsports industry is unparalleled,' Wilson said. 'We are looking forward to many years of success at the facility and in Tooele County.'



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INTERVIEW – John Surtees

Driving engineering

The racing legend explains why he's helping youngsters into engineering and ponders on what might have been if his team had been able to continue in F1 ...

Interview by MIKE BRESLIN



'I think it's worth getting youngsters emotionally involved in something that will perhaps lead on to a career'

John Surtees has always been thought of as an engineering sort of driver, and indeed rider. From his earliest days he's been fascinated by things mechanical, which no doubt helped him as he went on to become world champion in both cars and bikes, and, he tells us: 'If I hadn't been a rider I would have developed a career in engineering! Now he's hoping that that love of engineering will rub off on some of today's youngsters. But he's not just talking about it; in typical Surtees style he's doing something about it, starting up a new scheme to encourage young people into engineering through the Henry Surtees Foundation.

The Foundation was set up by John Surtees (81) in the immediate aftermath of the death of his 18-year-old son, Henry – killed in a Formula 2 accident at Brands Hatch in 2009. 'Basically it was born on the day we had the service,' Surtees says. 'We had so much generosity from people who donated cash instead of flowers and that went to a project called Headway in Tunbridge Wells, a charity for head injuries. I hadn't thought about it before, but it grew, and the Foundation became an official charity the following year.'

Since then the Foundation has raised about £1.1m, which has been donated to a number of good causes, including air ambulance charities, while there is also an annual karting competition which offers useful prizes to help cash-strapped racers. The event, the Henry Surtees Challenge, is held at Buckmore Park, where Surtees has now also stepped in to help the venue in a time of need, taking control of the kart track when its future looked uncertain (his main business these days is property) to ensure that racers at a grassroots level are still able to compete.

Engineering careers

Meanwhile, as mentioned, the Foundation has also began to look at helping people at the start of engineering careers, and even putting them on the path to engineering, through a new scheme Surtees is hoping to set up in conjunction with a number of education providers. 'The plan is to a large extent in the hands of other people; that is the various education institutions, schools and suchlike we've approached and asked: "if we give you the tools what would you do?" So we're trying to put programmes together. I would like to have feeder programmes in to some of the major colleges and universities. Because I think it's worth trying to get youngsters away from a life that's a little unreal through just screens and playing games and suchlike; get them emotionally involved in something that will perhaps lead them on to a career.'

This is not so much about promising careers in motorsport, though, it's more about using motorsport as a bait, in a sense. 'That's the point,' Surtees says. 'If you can come along and use the lure, and get them enthusiastic, then that's a way.'

Surtees' own love of engineering began at the end of WWII when his father, a well-known motorcycle racer before the war, returned to London – and racing – after his Army service in the

north of England. 'I was there in the evenings trying to help him, learning how to use some tools, and also the cleaning rag! He came home one day and he said: "Lad, those boxes are for you." And there were some tea chests full of parts. He said: "Put it together and you can ride it". It was a very early single-speed speedway Blackburn. So that was it, that's where it started. I put that together, I rode it, and it went on from there.'

As did his engineering: 'I didn't carry my schooling forward, I went into an apprenticeship at Vincent HRD, which was one of the premier motorcycle companies in the country. I served my apprenticeship there, during which time my racing developed.'

Racing memories

His story from then on his well-known – seven world championships on bikes, one in cars (1964, for Ferrari), and six F1 grand prix wins – but what is sometimes brushed over is Surtees' time as a team owner (in F1 from 1970 to 1978), and even racecar designer. 'I did some of the outline work, I didn't get involved in sitting down and doing the details, we had a nice little team who came along and joined us to do that. We didn't have any established people there because we were a young team, but I had specific ideas about what I think worked and what didn't work, and that was it. And also, of course, you had to trim your ideas to fit your pocket. You couldn't just go along and say this is exactly what we want, we must do this.'

The Surtees F1 team often suffered through lack of funds, despite some creative sponsorship deals often brokered by



A Surtees TS16 F1 car running some laps at this year's Austrian Grand Prix meeting

Surtees himself – such as Brooke Bond Oxo, Matchbox (mainly in F2) and, of course, the at-the-time controversial tie up with condom manufacturer Durex. But it was another, unnamed, sponsor that ultimately led to the closure of the team. ‘We were at the point where we were getting podiums, we were right there, even though we didn’t have the benefit of lots of engines and things like this and we were working on relatively small budgets. Then we were severely restricted when there was a major problem, which was the sponsorship that didn’t pay. And that’s the thing that I fought for about three years in the courts, and it ran us dry. That’s why I had to call an end to the team.’

What might have been

The really sad thing is that Surtees was on the verge, he believes, of something rather good. ‘The ground effect car which we developed with Southampton University was so very, very promising. It was going to be the TS21. We built [an interim version based on an existing car], which we called a TS20-Plus, which we in fact ran in some Aurora [British F1 Championship] races. It won at Silverstone [in ’79], went like a rocket, and it would have been very high on the British Grand Prix grid that year with the times it did there. When I tested it I think I set the fastest lap which had ever been achieved around Goodwood. So it was very promising, but there’s no point if you don’t have the finance.’

With a good ground effect car in 1979 Surtees might well have done a Williams, which became a leading team on the back of its success with the FW07 that year, and it could still be a feature in grand prix racing today. Mind you, Surtees is not completely taken with present day F1, so perhaps it’s not too much of a regret: ‘At times there’s a difference between what is good relative to the advancement of technology, and what is good for motorsport. Also, I think we are bugged in Formula 1 these days with too many regulations, and perhaps a rather restrictive formula.’

What might have been if Surtees had stayed in F1 is just one of very many ‘what ifs’ in the sport, but you can’t help thinking that the engineer in Surtees would have loved a constructors’ crown to add to the riders’ and drivers’ titles he is so famous for. Then again, who knows, maybe one of the youngsters starting on the engineering path cleared by the Foundation will one day work for an F1 team that does just that.



RACE MOVES



Mark Miles, the CEO of IndyCar and Indianapolis Motor Speedway owning company Hulman & Co, has taken on the day to day running of IndyCar as the series searches for a replacement for **Derrick Walker**, who stepped down from the position of president of competition and operations at the end of the IndyCar season.

Blair Julian, chief mechanic on Scott Dixon’s Chip Ganassi Racing Dallara Chevrolet, has been awarded with IndyCar’s Chief Mechanic of the Year Award. **Scott Harner** and **Barry Wanser**, also of Ganassi, jointly accepted the Team Manager of the Year Award.

Lord Montagu, who established the UK’s National Motor Museum on his country estate in Beaulieu, Hampshire, in 1952, has died at the age of 88. As well as being the driving force behind the museum Lord Montagu was also a motoring journalist and a leading figure in the vintage car world.

Former Bowman F3 boss **Steve Hollman** has now taken on a management role at the Buckmore Park kart track, replacing **Chris Pullman** as joint managing director after the latter decided to pursue other opportunities. Hollman will manage the well-known venue alongside fellow joint managing director **Mike Griffiths**.

Dick Guldstrand, well-known for his exploits racing Corvettes in the US and also the founder of Guldstrand Engineering – the Corvette tuning specialist – has died at the age of 88. As a driver Guldstrand won Pacific Coast Championships in 1964 and 1965.

Former NASCAR Xfinity (then Nationwide) team owner **Todd Braun**, who competed in the second tier series between 2003 and 2010 with his Braun Racing organisation, has now set up a new team to race in the NASCAR K&N Pro Series. The new outfit is called Braun Motorsports.

Damien Lewis, the chief mechanic at the Rebellion Racing sportscar team, has died from injuries sustained in a road accident in Germany after the Nurburgring round of the World Endurance Championship. Lewis had been number one mechanic at Rebellion since the team’s inception.

Former racecar designer, team owner and inventor, **Chuck Jones**, has died at the age of 84. A self-taught engineer Jones worked in everything from Formula 1 to NHRA, where his Sidewinder twin-engine dragster achieved legendary status. He was also known for his work managing and raising sponsorship for Formula 1 minnow Ensign in the 1970s.

Lord Drayson has stepped down from his position as honorary president of the Motorsport Industry Association in order to focus on other business activities. The MIA said in a statement: ‘It is with sadness that the Executive Committee accepts this news, as Lord Drayson has been a most influential individual, providing maximum benefit to those MIA members who wish to exploit their capabilities within the world of defence and energy efficiency.’

Eric Thompson, a former grand prix and sportscar racer, has died at the age of 95. Thompson raced in one grand prix, the British in 1952, in which he finished fifth, but enjoyed more success in sportscars, including a third place at Le Mans in 1951 driving for Aston Martin.

The board of WC Vision, the body behind the Pirelli World Challenge, has voted unanimously to accept the resignation of **Scott Bove** as CEO. It has appointed **Greg Gill** as interim CEO until a suitable replacement for Bove can be found.

Bentley Motors has a new PR line-up. **Caren Jochner**, senior communications manager Europe, will continue to lead the team, which includes **Mona El-Mahdi** (communications manager Europe west); the newly appointed **Sebastian Michel**, (communications manager Europe central); and **Maddalena Manfredi**, communications coordinator.

OBITUARY - Don Burgoon

Performance Friction Brakes founder and CEO, Don Burgoon, lost his life in a car accident in Italy in mid-September. The 60-year-old was involved in a collision with another car in which a second person was also fatally injured.

The loss of Don was a considerable blow to the industry. But despite the suddenness of Don's passing, plans are already in place for his succession. PFC has been restructured in accordance, to continue onward and upward with Don's vision. Mary Ann Burgoon, Don's wife, continues her service on the board of directors and will serve as its chairman. Effective immediately, Don's chosen successor and daughter, Nina Burgoon, will assume his day-to-day responsibilities as president of PFC. Tom Davis has served PFC



as its CFO and Don's trusted financial advisor for over 25 years and will continue in that role. Tom will also serve as PFC's executive vice president. Darrick Dong will continue as Head of Motorsport.

Don worked tirelessly to build PFC into a dynamic force in the industry, and the management says it is unified in its commitment to fulfil and continue with Don's plans for the company.

Since the mid 1980s, thousands of race wins have been achieved with PFC brakes, while the commitment to bringing innovative solutions to the market was one of Don's many passions.

'The racing industry is one big family and this is a monumentally sad time for the global motorsport community,' says *Racecar's* head of business development, Tony Tobias. 'Don's passion and enthusiasm will be missed. The industry has lost a legend and a unique, highly talented individual.'

'I have known Don for over 25 years and we developed a deep respect and understanding and we regarded each other as true and loyal friends both on a personal and professional level. We both shared a competitive spark which was the common bond that drew us together. I would like to extend my condolences and deep affection to his wife Mary Ann and daughters Nina and Ariel at this truly sad time.'

OBITUARY - Guy Ligier

Grand prix winning team boss Guy Ligier has died at the age of 85. Ligier came to F1 at the relatively late age of 35 as a driver in 1966, but he had already found success in other sports – rugby and rowing – and business; his construction company played a large part in the building of the French autoroute network.

As a driver Ligier raced at the Le Mans 24 Hours in 1964 and achieved a best finish of sixth in Formula 1, at the 1967 German Grand Prix. With the death of his close friend Jo Schlesler in 1968 Ligier hung up his helmet to concentrate on building racecars – his cars always carried the type-number prefix 'JS' in honour of Schlesler.

Ligier bought Matra Sports in 1974, which acted as a springboard for his return to F1 as a constructor and team owner, and the Ligier name was then a mainstay of Formula 1 until the

end of 1996, when it was taken over by Alain Prost and its title was changed to Prost Grand Prix – though by this time Guy Ligier was long gone, having sold the team to Cyril de Rouvre in 1992.

The team enjoyed periods of competitiveness, and was a real force at the start of 1979, when it looked like its JS11 might dominate the championship, only for it to be overtaken by both Ferrari and Williams as the season progressed. After a period in the doldrums Ligier scored a surprise farewell win in 1996 when Olivier Panis won an eventful Monaco Grand Prix.

Beyond F1 Ligier made another fortune, this time in the fertiliser business, and then developed the Ligier Microcar. Since then the name has been seen in sportscar racing, with a title tie-up with LMP2 and LMP3 constructor Onroak.

Guy Ligier 1930 – 2015

RACE MOVES – continued

XPB



Ferrari technical director **James Allison** has signed a contract extension and will now remain with the Scuderia until the end of 2018. Allison joined Ferrari from Lotus midway through the 2013 F1 season and his contract was due to expire at the end of this year.

Former UK engine builder and club racer **Trevor Clapton** has died at the age of 80. Clapton was known for his work at Jennett's Engines.

Angus Fitton is the new head of PR at Porsche Cars Great Britain. He takes over from **Mike Orford**, who leaves the company to join Volkswagen UK as head of press and public relations.

Chip Ganassi, the owner of eponymous IndyCar and NASCAR outfits, has broken a clavicle in a cycling accident. Ganassi tweeted a picture of an x-ray which showed the rod that he had had implanted, thanking the doctor for 'putting me back together'.

Jaguar director of design **Ian Callum** has been named as the first inductee to the Scottish Motoring Hall of Fame at a ceremony in Edinburgh.

Comcast, the company that sponsors the second-tier NASCAR series through its Xfinity brand, has announced the creation of a new award to honour charity work undertaken by NASCAR team members. The Comcast Community Champion of the Year Award will present an individual from each national series with \$60,000, to donate to a charity of their choice.

FIA president **Jean Todt** chaired an extraordinary meeting in Geneva to discuss safety in rallying after six spectators were killed on Spanish event the Rally of La Coruna when a car rolled into them, while 39-year-old Frenchman **Frederic Comte** lost his life when he crashed his Citroen Xsara WRC on the Rally Mont Blanc. As a result of the meeting the FIA decided to develop a rally safety action plan.

Jim Hall, the man behind the ground breaking Chaparral sports racers of the 1960s and '70s, was the grand marshal for the Austin WEC and United SportsCar double header, waving the green flag to get both races underway.

Irish motor racing writer **Brian Foley** has died at the age of 73. Foley was well-known and greatly-respected throughout the motorsport community in Ireland.

Peter 'PK' Kaczmar, who for 10 years was lead technician at Risi Competizione, has died at the age of 60. While at Risi Kaczmar tended cars that won at Le Mans and in the American Le Mans Series.

Audi's motorsport boss **Wolfgang Ullrich** has been banned from the DTM pit lane and from using team radio for the remainder of the season for his part in the now infamous 'push him out' saga. The incident, in which Ullrich told **Timo Scheider** to push **Pascal Wehrlein** and **Robert Wickens** out of a race, took place at the Red Bull Ring round of the DTM.

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Show time 2016

With just a couple of months to Autosport Engineering the excitement is starting to build

The racing season is split in to two halves. From the eager anticipation of the start of the year, cars are launched in January, public testing begins in February and March, and then the season begins, and we're well into the heart of it by June.

In August, there's a break and after that, the stories change from how good the new cars are and who could win the championships, to who is leaving which team, and the title fight starts in earnest.

But there's another thing that starts to take centre stage at this time of year: show preparation. There are shows all around Europe, some take place at the end of the racing year, the PRI show before Christmas, for instance, and then there's the Autosport International Show in January, and of course the Autosport Engineering Show that is a part of it: as always, held in conjunction with *Racecar Engineering*.

Once again, show organisers are expecting a strong presence of global suppliers from the motorsport industry, which is to be held on January 14 to 15 2016.

Autosport Engineering is on track to yet again become the world's leading forum for companies from the world's motorsport supply industry. Established over 20 years ago it is recognised as the one stop shop for motorsport professionals to meet under one roof, at the NEC in Birmingham.

Already booked to exhibit are leading suppliers from all over the world, and in addition

to major UK suppliers there will be exhibitors from USA, Italy, France, Australia, Greece, Scandinavia, and Germany.

These include:

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Major UK suppliers will include:

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Ricardo
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Xtrac

Motorsport professionals, who attend from countries worldwide, can expect to see the latest in components, materials and technologies from companies exhibiting leading edge products, materials and innovative services.

Once again *Racecar Engineering* is proud to be the official media partner of this highly acclaimed Motorsport industry trade event.

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Useful information

Ticket prices:

- Trade tickets – £28
- MSA members – £23 (available later in the year)
- BRSCC members – free (available later in the year). Members will need to contact the BRSCC for tickets
- Live Action Arena – £11

How to book –

www.autosportinternational.com/trade
or call 0844 335 1109

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- Shell scheme – £345 per m² plus VAT
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Turnkey shell scheme package: fully equipped 6m² stand package including shell scheme walling, carpet, power socket, strip light, nameboard and a table and chairs.

- 6m (3x2) – £2425 plus VAT
- 9m (3x3) – £3638 plus VAT
- Space only – £320 per m² plus VAT

The shell scheme price includes a modern attractive shell scheme system with fascia board. All stands include carpet, cleaning, free stand listing in the official show guide and a hotlink on the Autosport International website.



The motorsport industry is gearing up for another Autosport Engineering extravaganza at Birmingham's NEC in January

Aero Tec Laboratories invest in new plastic moulding machinery

Aero Tec Laboratories Ltd (ATL), the Milton Keynes-based industry leader in safety fuel cells, have recently confirmed a substantial investment in new plastic moulding machinery.

The new machine will allow for greater freedom to create FIA certified plastic moulded tanks to custom shapes.

Well known for supplying the entire F1 grid with flexible fuel bladders for over 20 years, ATL considers the investment to be of particular interest to manufacturers or racing series that do not currently specify an FIA FT3 fuel cell, but would like to increase their level of safety.

ATL managing director Giles Dawson

said: 'The ATL moulded tanks have had great success as the only genuine low cost option for an FIA FT3 fuel cell. With our new manufacturing capabilities we believe we can offer this popular and safe FIA approved solution to small runs of cars at a far reduced cost. In fact, one manufacturer that we are in discussion with believes that the initial set-up costs will be repaid in a run of only 12 units. We strongly believe in making increased safety even more affordable, and we hope that our investment encourages more manufacturers and racers to adopt the proven safety standards of the FIA.'

ATL Stand 805



ATL's known for supplying high-end teams but new machinery will help with lower cost cells

Wheel deal for Skoda series

Wheel producer EVO Corse has announced that in 2016 it will be the official wheel supplier of the Czech Skoda Octavia RS Cup, a new race series dedicated to the Octavia, that will start next year replacing the old Ceska Pojistovna – Skoda Octavia Cup.

There is a strong history of cup style races in the Czech Republic, and in the past Ceska Pojistovna has been one of the most successful, not only in its home country but throughout Europe.

During its 12-year term (from 1998-2010) the Skoda Octavia Cup was contested by over 120 drivers, some of them now well-known, such as former ERC champion Jan Kopecky and two-time European Touring Car Cup winner Petr Fulin.

There are several similar branded cups, directly or

indirectly supported by vehicle manufacturers or importers. In the Volkswagen Group the most famous are the Seat Leon Cup, the VW Golf Cup and, new this year, the Audi TT Cup.

But the Skoda brand has been missing from the list. The Skoda Octavia RS Cup now aims to fill this blank space on the motorsport map with this exciting new series.

EVO Corse, which will supply the Octavias RS with Sanremo Corse 9in x 18in wheels, says it is very proud to support this new motorsport series and that it has the ambition to build on the success of its predecessor, in order to offer high value sports, attract new spectators, and help talented drivers to enter the motorsport world.

Stand E1065

New user-friendly software for professional tuners set for show

Rapid TPM Software is a new user-friendly interface designed for turbocharged petrol engine add-on modules

Rapid TPM is an advanced platform allowing professional tuners to manage and customize the setting parameters, to maximize the concept of 'custom-tailored calibrations'.

The software interface is conceived as an alternative to the tuning console and, indeed, it represents the evolution of the well-known tuning device.

It allows you to:

- Monitor and control the setting parameters that are displayed in both graphical and numerical mode
- Easily perform real-time tuning via USB, both on the road and on the dynamometer
- Download standard calibration pre-set by Rapid technicians (the 'configuration' number

then appearing in application lists)

- Download up-to-date firmware versions for applications already supported and for new applications.

Rapid TPM Software is available in two versions.

Light version: available for free download, the software is tied to one TPM module's serial number only. The software allows a range of operations on the pre-set configuration.

Advanced version: provided with a security HASP dongle, this allows you to save custom configurations and change the internal firmware of one TPM module to support any of the vehicles indicated in the application list. In short, it's one versatile software to set Rapid TPM for all the turbo-petrol vehicles supported.

Stand E748

Williams F1 motorhome to take centre stage at Autosport show

Visitors can look forward to a spectacular new attraction at Autosport International, a celebration of one of the UK's most famous, successful and revered racing teams, Williams; which will also include its vast Formula 1 motorhome.

The Grove-based racing team, originally established by Frank Williams and Patrick Head in 1977, and the winner of nine Formula 1 constructors' championships, will have a major presence at Autosport International 2016, with features celebrating its past, present and future.

Williams will exhibit some of its most celebrated racing cars, alongside appearances from current drivers and famous faces

Unprecedented fan engagement will be a theme of Williams' presence at the NEC and

as part of a major development of the Autosport stage area the Williams Martini Racing motorhome will be constructed immediately next to the main stage – the first time it has ever been erected away from a race circuit.

As well as interactive features focusing on Williams' F1 exploits, the event will also give visitors an insight into the world of Williams Advanced Engineering, the division that transfers technology from Formula 1 to market sectors as diverse as defence and renewable energy. In addition, visitors will be able to learn about Williams Heritage, the team's historic racing division.

Claire Williams, team principal, said: 'Autosport International is the world's biggest racing car show, covering every aspect of our sport and the industry that supports it. We are delighted to have a major presence at the show.'

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UK funding available through the Motorsport Industry Association (MIA)
Contact Clare at clare.kelly@the-mia.com



Drivetrain Rev for big power

QA1 has launched a range of carbon fibre driveshafts for vehicles with up to 2000bhp with a max torque rating of 1500lb.ft.

Available for many applications (particularly drag racing), these driveshafts are lighter, stiffer and stronger than aluminium, steel and, its maker claims, other composite driveshafts. The Rev series of driveshafts is currently available with

either 1310 or 1350 series U-joints, with popular conversion joint options also available.

While other carbon fibre driveshafts are often made by cutting a pre-made tube to length, QA1's driveshafts are designed and manufactured in-house, using filament-winding equipment. The part features an exclusive 3M matrix resin that uses spherical nano scale silica, which provides

improved abrasion resistance and longevity, higher compressive strength and minimal water absorption for increased torque capacity and longevity, we're told.

QA1's driveshafts are currently offered in a 3.2in and 3.7in diameter with several length, slip yoke and U-joint options.
www.qa1.net

Machinery Master of the port

Mastercam's Port Expert add-on creates accurate, efficient engine cylinder head porting toolpaths on port surface or solid data.

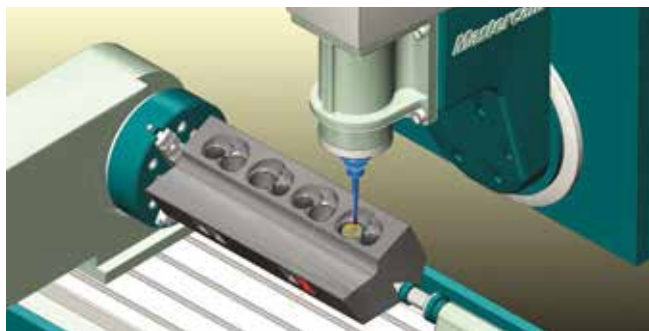
Port Expert minimises unnecessary motion during machining, aiming to give a highly efficient toolpath with superior finish quality. It can also be used for any tube type work that is similar in design to a port. The product uses a tapered lollipop tool, and has collision checks for the entire tool (shank, arbor, and holder).

There are multiple cutting

options available with Port Expert. For instance, you can cut only the top; cut only the bottom; or specify how much stock to leave on the entire port.

The Port Expert toolpaths use 3-axis machining as far into the port as possible, and then convert automatically to 5-axis motion with minimum tilt. This leaves no fishtails or inefficient reverse moves, and smoothly transitions where the toolpaths meet at the middle of the port.

www.mastercam.com

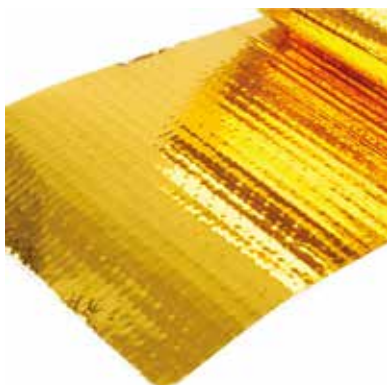


Heat management The gold standard

Reflect Gold Heat Barrier is a metalised polyamide polymer laminated glass cloth with a high temperature pressure sensitive adhesive, designed for use in extreme environments.

According to its maker it is extremely lightweight and capable of handling continual operating temperatures of 850degF. Suggested applications are firewalls, fuel cells, engine covers, bulkheads and seat bottoms.

www.firesleevetec.com



Lubricants Slick oil

Torco's SR-1R Catalytic racing oil is a selective cross blend of highly advanced 100 per cent synthetic base oils and proprietary additive systems, which is aimed at increasing power, efficiency and engine protection.

Its maker claims the oil is designed using components over and above standard additive technology. The oil uses Torco's Generation-2 MPZ and low friction base oils to reduce frictional losses and increase horsepower and torque by as much as three per cent, it is claimed.

www.torcousa.com



Heat management Sheath executive

Design Engineering's new lightweight Ultra Sheath MA reflects the direct and radiant heat that can damage under-hood components, burn ignition wires and wiring, or excessively heat up brake and fuel lines.

Designed as a replacement to aluminium or foil sleeving, and said to be the most advanced protection for cable lines, wire and hose, the product sustains direct heat up to 1100degF and is over 40 per cent lighter than foil covered sleeving. More flexible than standard foil or bonded aluminium products, Ultra Sheath is easy to trim to desired lengths for quick and easy installation. Ultra Sheath MA can be purchased in multiple sizes and lengths.

www.designengineering.com



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The roar of the crowd

In 2004 Maserati brought the MC12 to GT racing. It was a controversial car from the outset. In the US, the car was allowed to race in the American Le Mans Series, although in scrutineering the ACO pointedly turned their backs on the car as it passed through, making it clear what they thought of it, and it would never race at Le Mans.

Just 50 were built and Stephane Ratel, who was in charge of the FIA GT Championship, largely based in Europe, was terrified of it. He remembers a telephone call from FIA President Max Mosley telling him not to worry, that through a newly-conceived system of performance balancing, this would be the last time that anyone tried to introduce such a car to GT racing. Ratel was circumspect, but went along with the plan and the series entered what many consider to be a golden era, with Ferrari, Aston Martin, Maserati and Corvette competing against each other in fantastic GT1 cars.

Balancing power, weight and aero, the cars were broadly brought into line. The front and rear overhangs of the original Maserati were cut before the FIA would homologate it late in 2004, leading to much hand-wringing in Maserati headquarters as it had to mothball the panels already built, and start again. That can't have been cheap! I do wonder what happened to that bodywork – did they keep it and offer it to collectors after all was said and done?

Balancing the performance was no easy, or cheap, task and there were numerous interpretations of the original concept of balancing on both sides of the Atlantic. Circuits are different in the US, with different altitudes, race lengths, and so on, but in Europe where the concept was conceived, there was a slight problem. After winning 40 races out of the 94 entered, six teams' titles, two constructors titles and six drivers' titles, it was clear that the Maserati was an exceptionally versatile car.

While the Aston Martin and Corvette excelled on certain types of circuit, the MC12 was just good, or great, everywhere. One item that was not included in the balance of performance, for example, was driver change – the Corvette C5R had a cross brace by the driver that had to be negotiated, the Maserati had a clearer exit. Therefore, the driver changes were faster, the pit stop times were quicker, and races could be won. Balance of performance became a political battle on both sides of the Atlantic, and the arguments are still on-going today, particularly in GT3 where the entire series is based on BoP measurements.

In the US, however, things have taken a new and rather interesting turn – the fan base has started to weigh into the

arguments. Under IMSA rules at the start of the year, there were four balance of performance adjustments that could be made in the Tudor United SportsCar Championship during the season. According to one manufacturer, two of those were wasted with rather pointless adjustments but, come the end of the season, the Corvette was not winning races, and its strong fan base was getting restless.

An online petition was launched, addressing the organisers, demanding that the balance of performance be adjusted. Now, there is some debate over whether or not this was listened to, or even noticed by the IMSA rule-makers, or whether the IMSA organisers had in mind that it would modify its regulations and allow a further balance of performance change. But there was a fifth change of the season, on September 10, that gave Porsche and extra 20kg for the final races of the season.

I very much doubt that IMSA even noticed the petition, and it would have been highly unprofessional to have

changed its own regulations according to it, but it just goes to show how open the balance of performance is to scrutiny. The petition included an analysis of top speeds in every race of 2014, not hard to get hold of and certainly not a

reliable basis of an argument. But if the public feel that they can, and should, get involved in these arguments, organisers need to be careful.

The original balance of performance was based on science. It was an experiment, and it needed adjustments, but it achieved what it was supposed to achieve; cars of very different capabilities were brought into the same ballpark and allowed to compete. It then was taken to the next step, and became a performance differentiator, and therefore open to politicking. One organiser reckoned that if everyone left the discussion room unhappy, the BoP was probably about right. If one left smiling, he knew he had made a mistake.

What would happen if someone, somewhere, thought that crowd-based petitions was a good way of engaging with the public? This is an idea that has formulated slightly tongue in cheek, but Formula E already encourages fan participation through a fan boost, and that system reached a new level at the end of the last season. Usain Bolt offered to get tweet support for the winner of a sprint race (on foot) for the drivers before the final race in London. No one, least of all Max Mosley, could have conceived that idea back in 2004.

ANDREW COTTON Editor

The Corvette was not winning races, and its strong fan base was getting restless

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