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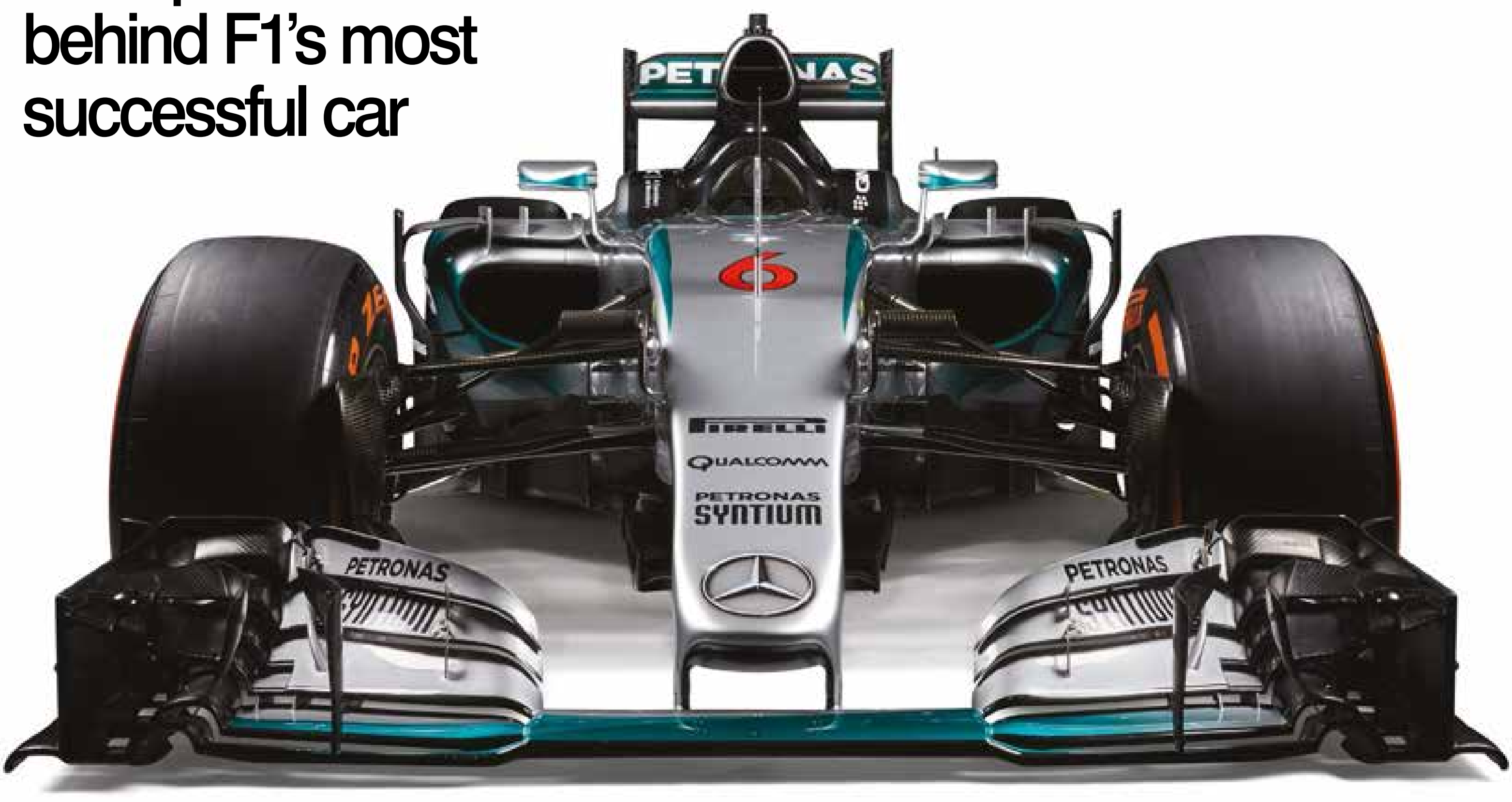
# Mercedes AMG W06

## Silver Arrows in the spotlight

The speed secrets behind F1's most successful car

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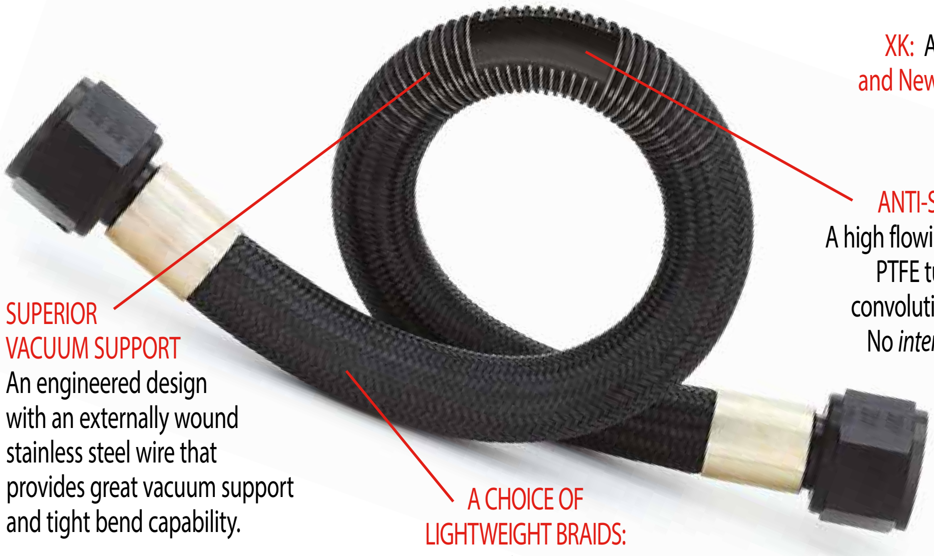

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# Facing the music

Ever wondered what's wrong with F1? Then you might want to listen to a little Mozart

Tom Wolfe explored and extolled the character and make-up of test pilots and astronauts in *The Right Stuff*, where testicular fortitude and a cool approach to crisis and challenge was built into the breed. Motor racing had much of the same requisites; talent and courage, plus a competitive spirit to bring out the best in the protagonists.

But during the course of the book the worm in the fruit began to appear. After the initial exploratory reaches of aviation, where flying skills were paramount, the progression into space flight led to the derring-do of pilots giving way to the work of engineers, relegating the pilots' role to being simply 'Spam in a can' in the subsequent capsule launches – not giving input into what was happening and just going along for the ride.

The revolt of the prospective astronauts, all stick and rudder pilots, led to the fitting of attitude rockets so they could manoeuvre the attitude of the capsule and have the illusion of control, so giving them back their self-esteem – much to the horror of the engineers, as for them it was not necessary.

## Musical notes

However, engineering was still the queen, with approximately 18,000 people associated with each mission. The astronaut was just the front man for the activity. But was also the most interesting thing about the whole endeavour for the general public, who actually were paying for it through their taxes.

In Formula 1, cars are now often lined up on grids two by two, the sister team cars being a couple of hundreds of a second apart, so we can say it is also engineering driven; but also now quite predictable. And the falling interest in motor racing, most visible with the higher echelons such as F1, is a direct reflection of man's need for surprise.

Here's another way of looking at this. Spectral analysis of the best music throws out some interesting findings, such as the fact that the most appreciated music in all cultures is that which combines the sequences of sounds to produce the optimum balance of surprise and predictability. Too much surprise and we have unengaging random noise, the extreme being white noise. Too much predictability and we are soon bored. We know what white noise is; it's the static we hear in between radio stations. No sound is correlated with the next one, so we get undifferentiated noise.

The other extreme is what is known as Brownian, or brown, music. It's based on Brownian motion, random motion of small particles, where every position is only a small distance from the previous position. Brown music is simply a random walk up and down the musical scale.

In between, though, is what is known as 1/f noise. Sometimes also called pink noise, this music has some correlation, but less than brown music and more than white noise. It is defined as a power law decay in the correlations between pitch over time.

Most music that we actually listen to is 1/f noise. It has the right combination of pattern and unexpectedness, and is pleasing to the human ear. Looking at the shape of the curve described by 1/f music, it can be seen that it has a fractal shape.

**Spectral analysis of music throws out some interesting findings**

XPB

**The usual suspects at the head of a grand prix field – our columnist argues that like music F1 racing needs variation if it's to entertain us**

But more important than the fractal nature of the rhythms are the variations in the predictability of this exponent for different types of music and different composers. For example, composers with a more varied style of music, such as Mozart or Scott Joplin, composed music with more varied spectral exponents, as compared to Beethoven or Vivaldi. Musical styles also varied, with ragtime or madrigals being far less predictable than symphonies or scherzos.

You might say, dear reader: 'Yes, yes, we know this, this is what we are complaining about. What is the solution?' Well, we have had other times when one team dominated, but all these were but short periods, with teams ascending and descending the staircase of success, being regularly substituted, in the usual cycles. Some of these periods were interesting because even if only one marque predictably won, the no-holds barred fight between the team drivers made for suspenseful racing. But this implies having a spectator pool knowledgeable about the sport, and which has its favourite drivers.

The question now is; in what direction do we want to go? Do we accept that to have technology at the level engineers find interesting there is a need to have major manufacturers involved, with the level of finance being carried by marketing? Or do we listen to the public that will want the emphasis on driver capabilities and derring-do?

To be a mass sporting event depends on the power to attract the masses, the prime target for manufacturers and event organisers, or else it will turn into a minority sport, in which case costs will tumble down to the size of the pocket that pays for it. But the major manufacturers do have an understanding of business, so they can also see that despite having marketing results for their products, they are also the providers of content, and by sharing the benefits some of their costs could be reduced by also sharing the income.

## The band plays on

The actual cost of racing when compared to the investments in R&D is quite small. If we look at the annual R&D budgets of the manufacturers, VW is number one in the world: $13.5bn, 5.2 per cent of its revenue, a value which is bigger than Samsung, Intel, Microsoft and Novartis, with Toyota following with $9.1bn.

When it comes to marketing VW spent $3.23bn in 2013. So, roughly, for each $100m spent in motor racing they are using respectively 1.056 per cent of R&D and 3.1 per cent marketing budgets. But, on the other hand, $100m for a small team is a major expense.

The numbers make it quite clear. Marketing will weight its spend for return on investment as three times more important than R&D would, plus R&D needs to be about product relevant technologies employed in racing. This is, of course, a simplified analysis and rationalisation, but it also stands the course of inspection.

Engineering will then be justified and validated by the manufacturers advertising and marketing their products, but this is only valid when there are spectators (who are also consumers), who need to be entertained. The downside is that manufacturers will only come into the sport if they can win, hence fuelling the escalating costs that are now a part of our sport, and have been for some time.

The conclusion? Show business will rule, and there must be limitations on the investment allowed. Or we might well be see the behemoth lying on his back, its feet in the air, and its tongue hanging out of the side of its mouth.

# The art of the matter

## Why are the liveries on many current Formula 1 cars so utterly uninspiring?

Formula 1 has not been short of criticism lately, and perhaps I can gently stir the pot a bit more, but from a simple perspective.

Regardless of all the politicking and endless discussions, there are ways to improve the show. Considering the vast sums sloshing about (for some), fundamental and relatively inexpensive opportunities to appeal to fans are being missed.

Some months ago I touched upon the spectacular Formula 1 concept proposed by Ferrari, and how that would create greater interest – among younger potential fans in particular – because of its futuristic looks. This is especially relevant, as to casual followers F1 cars probably don't seem to have changed very much in appearance for a long time. Maybe the 2017 regulations will help in this direction, but regardless of this, much could be done.

## Rainbow warriors

I've always thought that good engineering design should also be reflected in appearance. The current crop of superbly-constructed F1 cars are being let down by mainly dull and uninteresting liveries, inexplicable really considering the amazing graphic tools and materials available today. It seems that since the tobacco companies stopped sponsoring motor racing the imagination has disappeared from the grid. Older followers of F1 can surely remember the once-familiar red and white Marlboro scheme, employed most notably during its long-term association with McLaren (even with the Marlboro name removed as tobacco advertising became illegal, many didn't realise it at first and it remained the symbol of the American brand for a considerable time). There are no dramatic Gitanes-Ligiers now, either, in their white-outlined French blue with evocative 'Gypsy-Lady' logos, nor the eye-catching yellow and black Benson & Hedges 'Buzzin' Hornets' Jordan-Hondas. Gone, too, is the sophisticated blue, white and gold of Rothmans on the Williams cars. While outside of the tobacco corporations, the bright green and blue 7up Jordan livery enhanced what was already a notably pretty Formula 1 machine. I could go on, but I hope the point is already made.

At least Ferrari, thank goodness, is still bright red with its traditional white wings and therefore stands out most; but it is part carbon-black now (presumably to save weight). Lotus, pending future Renault plans, retains the iconic black-and-gold livery of yesteryear, albeit somewhat spoilt by the red bits demanded by the PDVSA sponsorship.

As for the rest, a yawning gulf exists, which amazingly has not been exploited by the multifarious agencies that exist for just such a purpose; you would think they would be champing at the bit to grab some of F1's many dollars.

This year's Sauber primary colours are admittedly better than the previous grey, but applied with absolutely no imagination. Just kid's colouring-book blocks of blue and yellow; no fading or blending, no artistic attempt whatsoever.

Meanwhile, Ron Dennis' fetish for shades of grey, albeit with black and a welcome bit of red, decorates the 2015 McLarens. Without a major sponsor outside of Honda, what an opportunity missed for something spectacular that would really grab attention (although on current form, maybe best to wait until next year for this). Marussia's

XPB

**Jordan's 191 was a stunning looking Formula 1 car and the green and blue livery added to the aesthetic effect. But why are modern F1 colour schemes so boring?**

red and white, unlike the clever Marlboro version, is awful; a four-year-old could do better. Maybe a major sponsor acquisition for 2016 will bring style with it. And the colourful but dark Red Bull branding of the eponymous team and Toro Rosso could do with greater distinction between them, or at least a little lightening-up for the Italian outfit?

Silver Arrows they may be, but the Mercedes W06s come across on-screen as grey, not helped really by the rather insipid aquamarine flashes of Petronas. Quickly think of Force India's most distinctive colour identity and you'll struggle; they've abandoned the previously standout green and orange and it's closer to the McLaren now. The Martini livery of Williams has presence and history to help it, but the bulk of the car is an inevitably bland white – no doubt to accommodate sought-after additional sponsorship, but it's missing out on F1's equivalent of power-dressing.

F1 would do well to look to Indycar and especially Japanese Super Formula, which surely tops the lot in single-seater colour schemes. Bold and artistic, their graphic designers seem to be capable of taking the sponsor's brand identity and turning it into a moving work of art; why can't GP teams exercise the same attention to visual identity? The 'wow factor' so beloved of agents flogging expensive properties also applies to racing cars and their teams, keen to get enthusiastic followers onboard. Such allegiance is much easier to achieve when the car looks the part, grabs attention, and allows the marketing and merchandising people to do their job.

## Formula fun

Which leads me on to some more innovative suggestions, especially following what was, unfortunately, a rather uninspiring Brazilian Grand Prix. With one race still to go at the time of writing, and the top drivers' and constructors' championship positions all sewn up, why not have a bit of fun to lighten matters? Here are just a few (tongue in cheeks) ideas …

- **Pastor Maldonado's onboard radio transmissions to continuously play *The Laughing Policeman* 'Ha-Ha-Ha-Ha-Ha' song for providing so much fun for us.**
- **Lewis Hamilton's Mercedes should be mandated to carry at least 25kg of gold chain and bling (Hamilton can certainly afford it and it will give drivers other than Nico Rosberg a more equal chance to take the fight to him).**
- **Rosberg's crash helmet should sport Viking horns, to reinforce his new aggressive self.**
- **Kimi Raikkonen's headphones should be wired to an alarm clock to keep him awake during the more boring races.**
- **On Jenson Button's McLaren-Honda a royal coat of arms should be displayed; for him being, well, just so very British about everything.**
- ***Lessons in Overtaking Given* advertising stickers should be pasted all over Max Verstappen's Torro Rosso.**

A bit silly? Of course. But, after all, it's meant to be show business, isn't it?

**Silver Arrows they may be, but the Mercedes W06 cars look grey on screen**

# History repeating

**Mercedes has dominated grand prix racing in the past, but with the W06 it's taken winning to a whole new level. We peeled back the silver to learn the secrets of its success**

**By SAM COLLINS**

The Silver Arrows of Mercedes-Benz have been in grand prix racing in full works team in three distinct eras – and the cars became the dominant force on all three occasions. In the 1930s its cars clinched the European Championship, in the 1950s they raced to a pair of world championships, and now in the second decade of the 21st century it has once again become the dominant team. But a second consecutive world championship victory for the team is just a headline, it's the detailed statistics that reveal the level of that dominance.

In 2015 the Mercedes AMG F1 W06 Hybrid was almost in a different class to the rest of the Formula 1 field. Indeed, no car has ever scored more 1-2 finishes in a single season – and the only car with more podium finishes in a single year is the Mercedes AMG F1 W05 Hybrid of 2014. As *Racecar* closed for press there was one race still to go in the season, and the likelihood is that the W06 will eclipse that record, and equal the record for the most pole positions in a single season for a car design, too, sharing it with the Red Bull RB7 (2011) and the W05. So when Paddy Lowe, executive director (technical) of the Mercedes AMG F1 team, describes the W06 Hybrid as a 'fantastic car', it almost sounds like a massive understatement.

## Unexpected dominance

The reality is that the Mercedes team did not expect to achieve the same level of dominance in 2015 that it achieved in 2014. 'We didn't know how the opposition would deal with it after a second go at this set of regulations,' Lowe says. 'Clearly there was a lot of scope for improvement relative to the first year, especially for the teams where they had not done such a good job. It's easy to find gains when you can see the benchmark; as a result of that we expected a much higher level of competition in 2015 and we did not expect to show the dominance of 2014 again, but the statistics show that it's been a very similar year. The main difference is that last year there was a range of competitors challenging us, mostly Red Bull and Williams. This year it has mainly been Ferrari and specifically Vettel.' It's actually interesting to note that the red cars of Ferrari have always been the nemesis of the Silver Arrows in grand prix racing; it was true in the 1930s (with Alfa Romeo), true in the 1950s, and it is once again the case right now.

The above is not to say that Lowe and the whole organisation at Mercedes AMG F1 in Brackley, England, did not expect to have a strong car, though. Using the W05 as a basis there could be few other outcomes. So when the W06 was rolled out at Silverstone in the early months of 2015 few were surprised to see a design that carried over many features of the 2014 title winner.

'We set our normal objectives over the winter in terms of target lap times, but in terms of championship objectives the aim was simple; to win,' Lowe says. 'Overall the car is a real evolution of the '14 car, so we just set out to go round the loop and do another iteration on everything. With such a new

**The reality is that the Mercedes team did not expect to achieve the level of dominance in 2015 that it achieved in 2014, let alone exceed it**

and different package in 2014 we obviously learnt a lot about how to do it better. We managed to find quite a few gains, in packaging particularly, and we pushed the engine a bit harder.'

Despite its very strong performances in 2014 the Merecedes AMG F1 team was actually dissatisfied with some elements of its car, and for the W06 Lowe tasked his team to resolve one major issue in particular. 'In 2014 our Achilles heel was really reliability, and actually that was one of the big weaknesses in the company in general. When I arrived I found that the expectation to finish a race was not at the level it should have been, so we have done a huge amount of work on that at a structural level. In 2015 we have started to see the benefit of that coming through. But it's a long game and you are dealing with something that is not hideously unreliable to start with,' Lowe says.

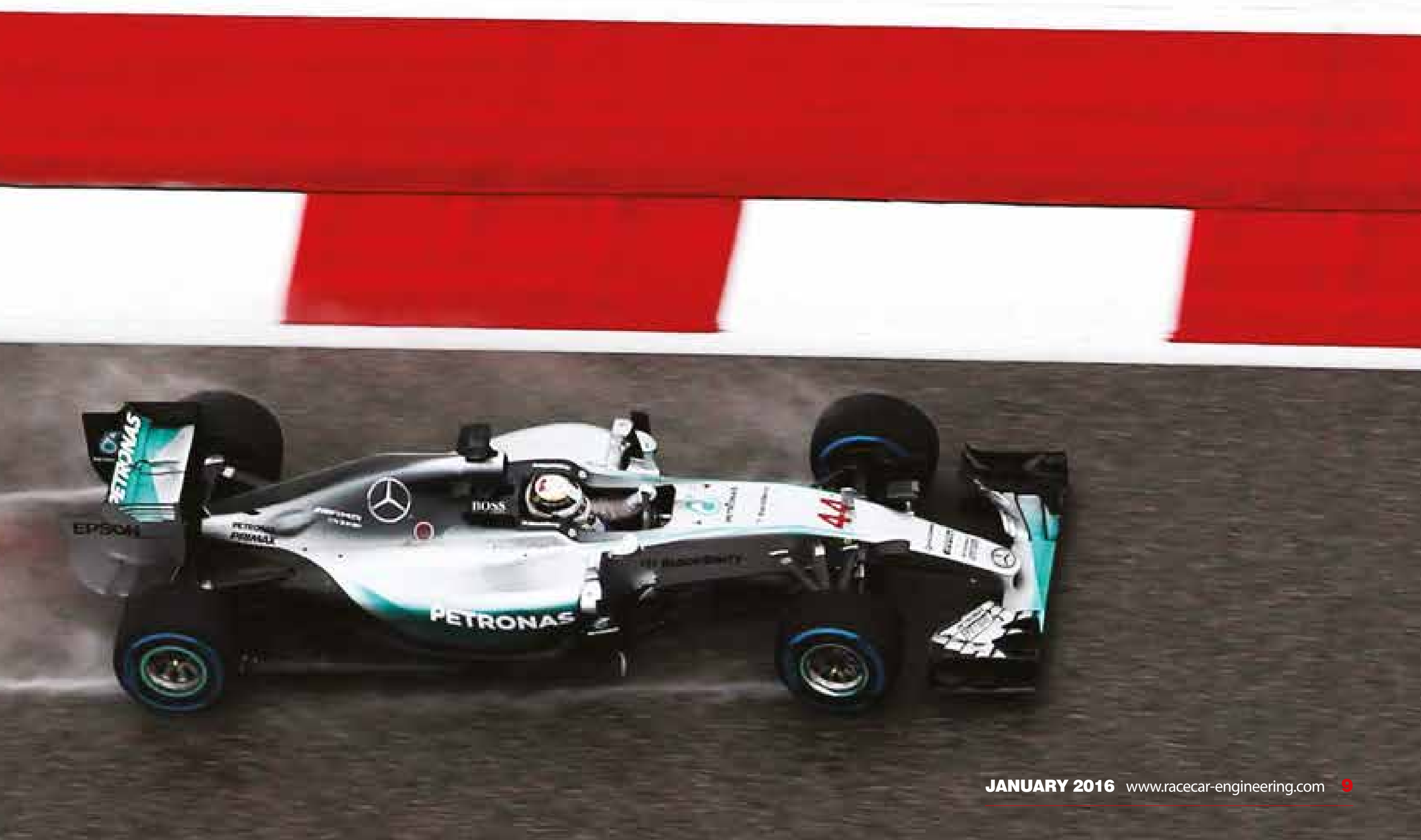
The W05 has to date proven notably more reliable that its predecessor, which failed to finish races five times. 'We had three DNFs this year which is three too many,' Lowe says. 'If you go back 15 years that would be an amazing level of reliability, but these days that is only just about acceptable. It's particularly important when you are Mercedes, a brand which stands for quality and reliability, and we have to set ourselves the objective to be the best in Formula 1 on that side, as well as in terms of lap time.'

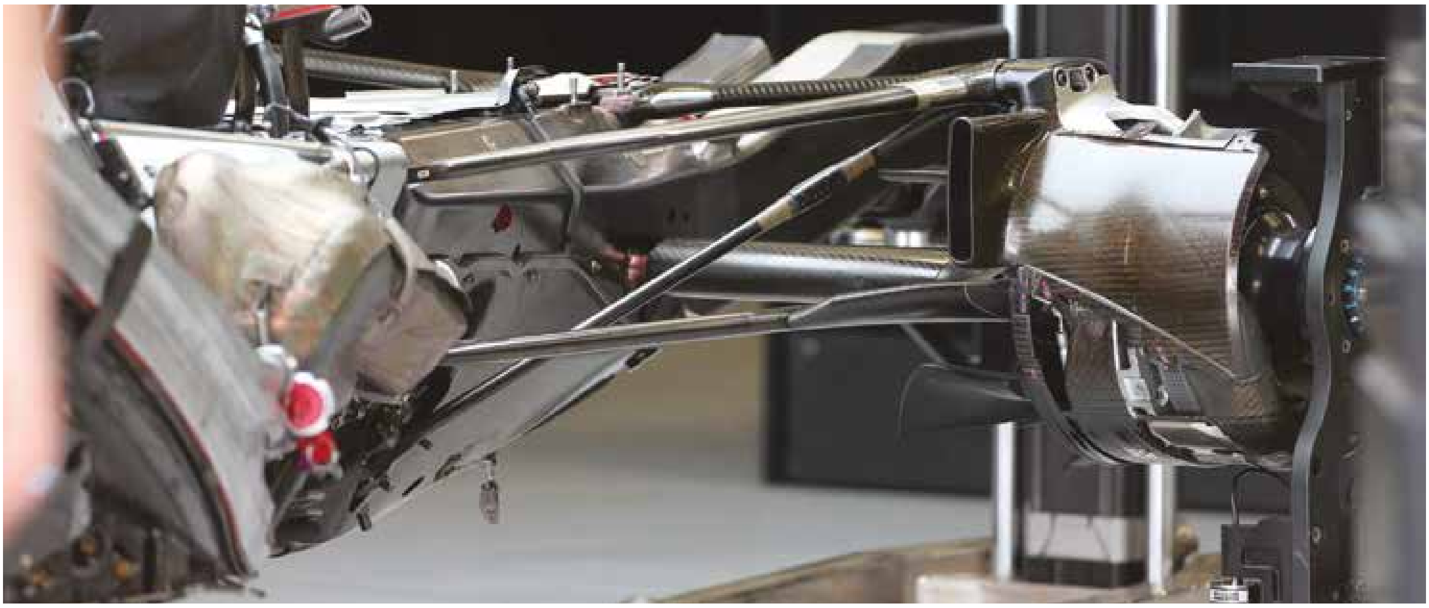
## Second year gains

Perhaps one of the reasons for the reliability gains is that the W06 has, as a result of rule changes in some areas and stability in others, been developed with a somewhat shallower learning curve than that of the 2014 design, which Lowe describes as the 'most complex car I have ever worked on'. Indeed, Lowe says: 'I don't think the car design and development process has made the step change between '14 and '15 that it made between '13 and '14 in terms of complexity. We actually lost a bit of complexity in some areas.'

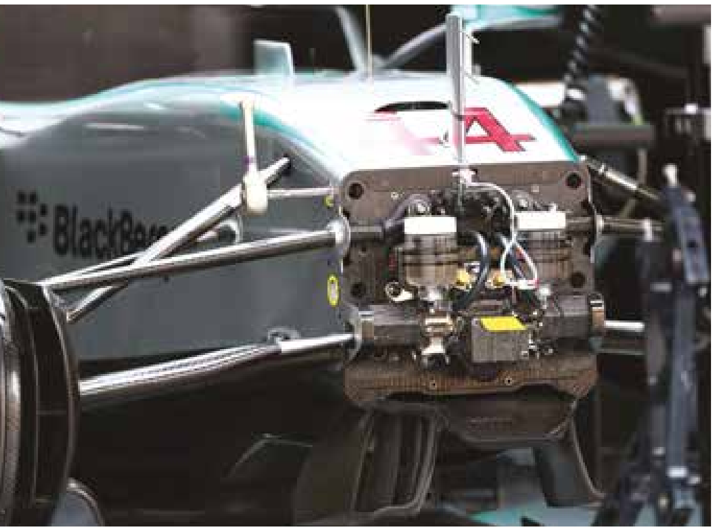
Not all of the design concepts from the W05 could carry over, sometimes because better solutions had been found, while other solutions had been outlawed. This is notable in the internal layout of the suspension. For a number of seasons the Mercedes team had utilised a hydraulically interconnected suspension, but part way through the 2014 season the legality of such systems, which by then were used on every car on the grid, was questioned by the FIA so every team opted to remove them from their cars. For 2015 the systems were banned formally and as a result, the W06 was designed from the outset not to feature 'FRIC', as it had become known.

'The W05 was built around the presence of the FRIC system,' Lowe explains. 'The W06 suspension system was designed without FRIC from the outset, which has presented opportunities to re-optimise in this area and others. With the W06, the packaging was a factor and not designing around FRIC has given us some different options in the sidepods.'

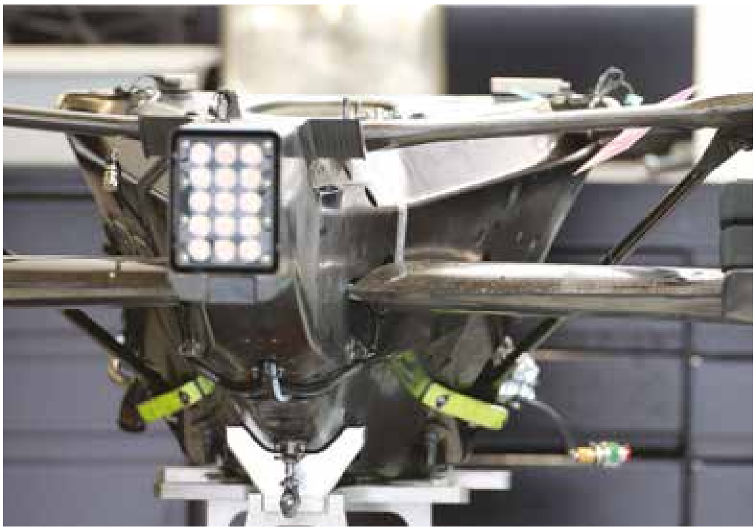




Mercedes uses a twin skinned transmission casing with a structural composite outer section and a titanium inner – the latter is just visible here at the front of the carbon case



The steering rack has been relocated on the front bulkhead and is now in line with the lower wishbone pickups, to improve the car's aerodynamic performance



A closer look at the composite/titanium hybrid gearbox casing. The driveshaft passes through the rear leg of the lower wishbones which pick up on the composite casing of the transmission

The main advantage of using interconnected suspension was to provide a better and more stable car in aerodynamic terms, allowing the teams to set up the car in ways that would be impossible with a conventional system. But with that now gone, the Mercedes engineers have had to make some different choices. 'Losing it impacts the ride height ranges we have to use, but I don't see it as a big architectural change on the car and how we operate it. In order to work around its loss we have changed around the geometries and the set-ups to go with that,' Lowe says.

Overall the suspension appears to be a straight carry over from the W05 in terms of concept, though not in terms of exact design, with unequal length double wishbones all round, pushrod actuated front torsion bars at the front of the car and pull rod actuated units at the rear. A third element incorporating a 'Cambridge' inerter is used both front and rear. None of this is all that different to the W05 but actually it is a good example of the optimisation of all areas of the car. The steering rack has been relocated on the front bulkhead from being in line with the inboard upper front wishbone pickups to being in line with the lower wishbone pickups, a change, according to Lowe, made in order to improve the aerodynamic performance of the car: 'It is all aerodynamically driven these days. If in doubt, it's always aero.'

## Aero driven

In order to improve the airflow around the suspension members at the front of the car, the W06 retains the blended lower wishbone concept seen on the W05, but now with the relocated rack the steering arm is also blended into this arrangement. 'The structural aspect of Formula 1 suspensions have become less and less structurally optimal, and moving more and more in an aerodynamic direction,' Lowe explains. 'Our lower front wishbone is a good example of that. The rear lower wishbones that we and others have are in that direction too, it's all for aero.'

With suspension members being designed around aerodynamic performance rather than for pure structural or dynamic reasons it could be expected that chassis engineers would become frustrated during a car's development. But according to Lowe they rather enjoy it. 'It's not a frustration, it's just interesting, you do things to make the car quicker and nobody

**'We managed to find quite a few gains, in packaging particularly and we pushed the engine a bit harder'**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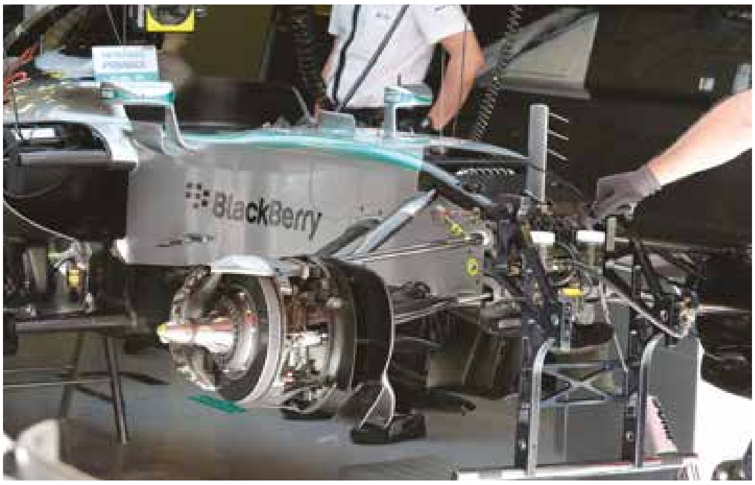
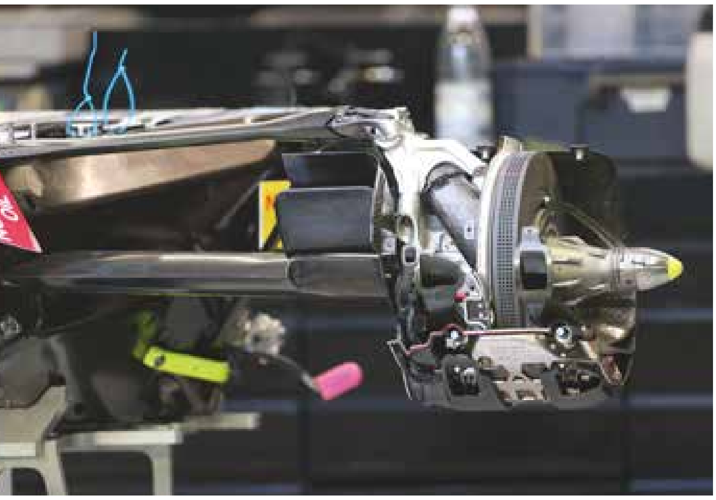
Front lower wishbone was a massive structural challenge as the team had to make it take the loads while delivering what the aerodynamicists demanded




With the Mercedes W06's vanity panel removed, the third element 'Cambridge' inerter is visible. The pushrod actuated torsion bars and the car's front brake set-up also shown here



The rear brake assembly and upright: the uprights actually receive a great deal of attention in modern Formula 1 and are machined from a solid aluminium billet


The biggest F1 rule change from 2014 to 2015 was to the nose of the cars but Mercedes did not have to change much in this area and the nose is similar to that seen on last year's W05

ever argues with that. The suspension guys are not cursing these terrible aerodynamicists for making them do horrible things. Instead the suspension designers embrace the opportunity to make the car faster, it gives them a challenge. Our front lower wishbone is a massive structural challenge. To make it take the loads and deliver what the aero demand is is not easy. To get the aero demands and be able to take the loads with the kinematics and stiffness that we demand is the kind of challenge engineers love.'

The development of the suspension systems on modern F1 cars has moved significantly in recent years and as Lowe says this is largely for aerodynamic reasons, but it has also changed the mechanical design approach fundamentally. 'If you stand back and look at cars over the last 10 years and look at how aerodynamics have pushed suspension members into these less and less efficient structural arrangements; it is one of the things you see when you go and look at the old cars. The wishbones used to be made out of a drawn aero section metal tube pretty much, and the rules were written with that mind, especially in terms of the dimensional things where you have the thicknesses and things like that. But it is nothing like that now and it has really become a challenge to make sure that components are all compliant. I imagine the FIA find it a bit of a nightmare analysing all of the drawings each February,' Lowe says, with a smile.

## Twin skinned

At the rear of the car, the driveshafts pass through the rear leg of the lower wishbones which pick up on the composite outer casing of the in-house Mercedes transmission. Unlike most other cars in Formula 1 the Mercedes uses a twin skinned transmission casing with a structural composite outer section and a titanium inner section. 'The carbon part is essentially a chassis so we have to crash test that with the titanium inner together as one piece. Like many things there are pros and cons to taking this route but obviously because we are using it the advantages outweigh the disadvantages, but it is fair to say that it is more complex and it is more expensive than a conventional solution,' Lowe says.

This was a concept used on the W05 as well but also refined significantly for the W06, some of the concepts it utilises, such as the exhaust exiting via a hole in the top of the casing (there is no separate bellhousing) and the inboard suspension components and hydraulics being mounted under the input shaft, have been copied by most teams on the grid.

On the outer limits of the wishbones sit the uprights, which are rarely seen due to the fact that they are usually clothed in many composite aerodynamic components, broadly termed as air ducts but in reality mostly serving pure aerodynamic purposes, rather than cooling brake components.

'The upright is a fairly trick bit of kit these days,' Lowe says. 'We are limited to an aluminium

**'The structural aspect of F1 suspensions have become less structurally optimal and are moving more in an aerodynamic direction'**

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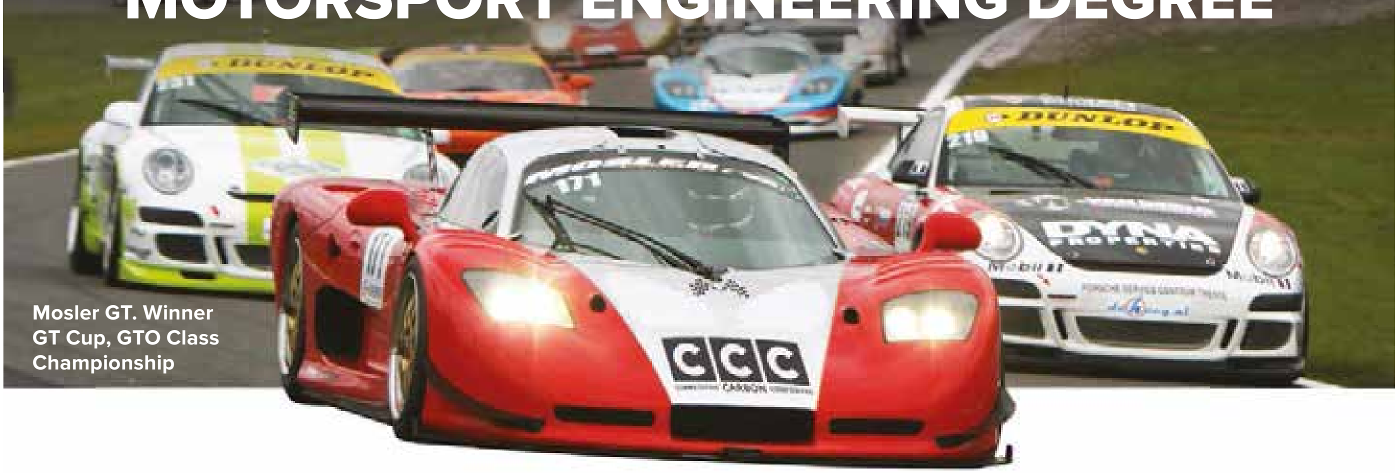

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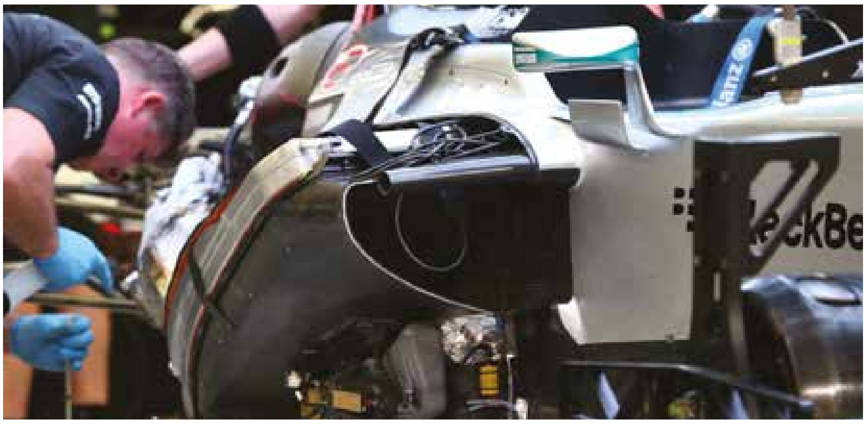


A view of one of the sidepod areas on the car. The cooling ducts are very similar in size to the W05 but the coolers and the ducting are more efficient. Cooling has been a challenge with the new power units since 2014

**'Singapore was not great. It was a very interesting event for us and, unfortunately, for our competition. It's taught us a lot and we understand it now.'**


Sidepod area with bodywork removed. Side impact structures are visible; it's not as neat as it was in the W05 in this area but loss of FRIC freed up some space

The twin forward roll hoop supports of last year's car have been replaced with an extremely thin single support under the centre of the roll hoop while the cooling duct is no longer there

construction but there is a lot of optimisation that goes on. The days of fabricating them from bits of sheet are gone; these are machined from solid billets. It's a very three-dimensional component and we go through a really complex process to optimise the most structurally efficient component. The design process is all about the trades: trading off the best aero solution against the kinematics we want for the tyres and the stiffnesses we want. Putting that together gives us the solution. We study the design for internal air flow, too, it's not just for brake cooling either as we are using it to cool or heat the wheels according to the conditions.'

## Fully integrated

Mercedes is one of only two teams on the grid which has a fully integrated approach to the car design, with the power unit and chassis being developed in unison (Ferrari being the other). This allows the Mercedes engineers to trade off not only chassis design considerations, but also to trade off the demands of the power unit against the chassis requirements.

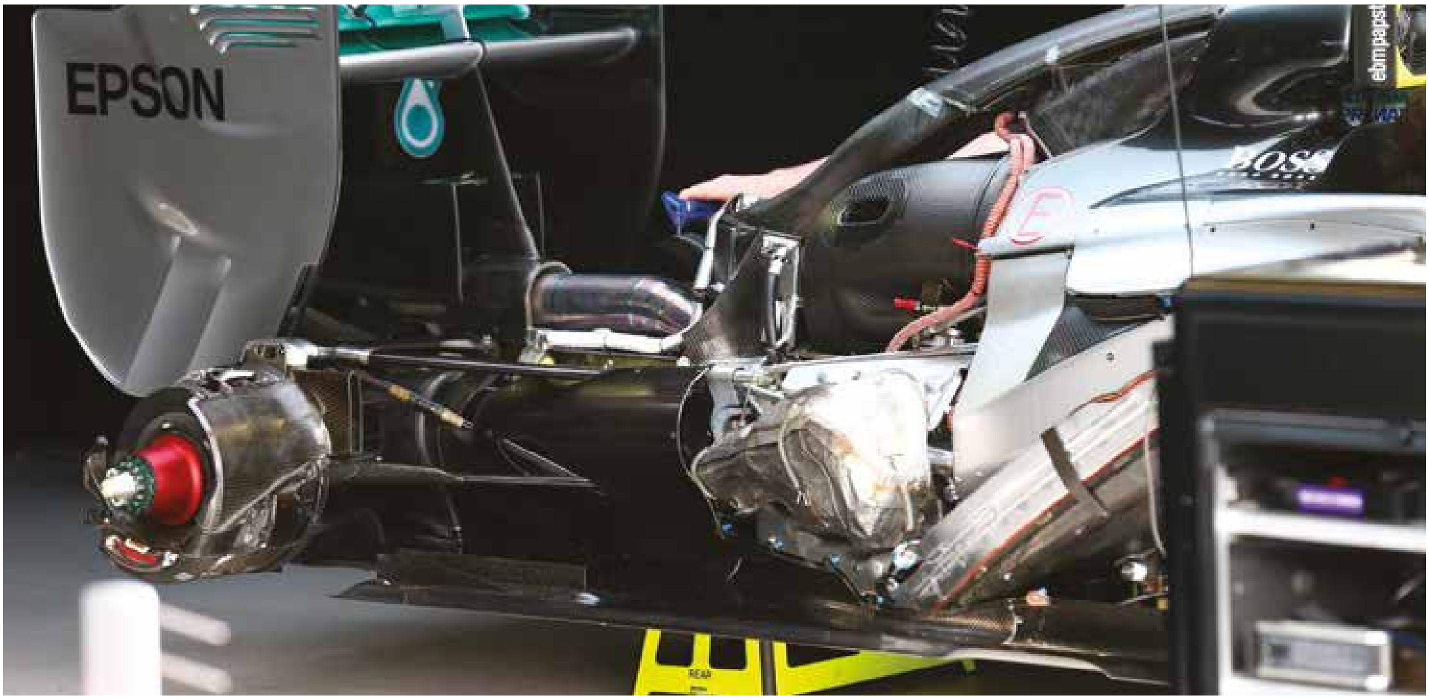
The power unit (detailed on P18) is one of the most significant differences between the W05 and W06, and that has influenced the design of the rear of the car substantially. In 2014 the neatness of the W05 was highlighted in these pages, but the W06 has lost some of that neatness, though clearly with no detriment to its performance.

'One of the things with the packaging on the car is that the exhausts take up more volume,' Lowe admits. 'Last year's car had the very neat log exhausts which allowed a lot of other things to be neat, so that is a stand out thing. It's a case of looking at the whole car, what makes sense one year compared to the next. A lot of the choices are made numerically. We can simulate and predict the benefit or loss of most things we think of doing before we do them. The car is then built up from that series of trades: trading weight, trading stiffness, trading aerodynamic forces, trading engine power and trying to find the best answer overall. It used to be done by gut feeling, and the designer with a lot of flair would make those choices intuitively, but now it's a far more objective process. That means that sometimes you can change a concept because of something that may not seem obvious externally, something that is only evident numerically year to year depending on the state of the car.'

Experience was another major factor in the development of the W06, according to Lowe. With a year under the new regulations completed, the engineers had a much larger data set to work with. 'One of the big challenges of 2014 with the new power units was cooling, particularly the charge air cooling, which was a significant new element. Now in its second year of evolution, we have been able to go through the analysis loop to find performance through a better optimised solution – the objective being to find the best net performance at the full range of temperatures experienced through a season. It's about the trades again; engine power versus cooling and drag, for example. On this car we have made the cooling at lot more efficient, but at the hot circuits we have a bit more of a price to pay.'

## Cool solutions

Some of that cooling optimisation work allowed the team to revise a number of areas of the chassis including a new roll hoop concept. Where the W05 featured twin external forward supports under the roll hoop and a cooling duct between them, on W06 the twin supports are replaced with a very thin single support under the centre of the hoop, while the cooling duct has gone altogether. 'We're constantly pushing to reduce weight in every area of the car and also to make the cooling package more efficient at the same time,' Lowe explains.




**The rear end of the W06, with the bodywork removed showing the larger plenum and new exhaust design – for more on Mercedes' all-conquering power unit turn to page 18 of this issue. This picture is also a great illustration of the sort of complex packaging that's a major part of a successful F1 racecar**

In 2015 the minimum weight of the car was raised by 11kg with the power unit remaining largely the same, meaning that most of the increase was applied in different areas of the chassis itself. 'When the rules were put together for the new generation of power units, it was quite tricky to estimate what weight would be required to incorporate the new systems into a car,' Lowe says. 'The number that was picked was quite aggressive – something which became apparent as the season drew closer. Some teams were content with the previous limit, while others were finding it very challenging. A 10kg increase was agreed only by majority vote, which is why there has been a notice period for the rule to be introduced for 2015. In addition, the 2015 tyres are around a kilo heavier than last year due to improvements to the rear construction, so the final weight limit is 702kg.'

With a lighter roll hoop, something which saves weight at the highest point of the car, Mercedes was able to deal with heavier components elsewhere, including the mandatory use of larger anti intrusion panels bonded to the side of the cockpit. 'The panels don't give any particular structural benefit or compromise. It's simply a question of meeting the safety requirement and, yes, they do put the weight up,' Lowe says. 'As always, it's a matter of choosing how best to use the extra weight for the most performance, not necessarily a chance for the drivers to start eating cakes! Saving weight has always been central to the sport – creating efficient structures that are lighter but also stronger and more aerodynamically beneficial. We have put a lot of work into finding those few percentage points on every single component. It is also about weight distribution, getting it just right front to rear, and the weight increase has made things a little easier in that respect. But you know weight just creeps up, it's one of those things. Just because the limit went up, weight is not off the radar.'

## Singapore hiccup

In general the W06 has met the objectives set out for it by Lowe in terms of performance. That much is clear from the opening paragraph of this piece, and the raw statistics. But things did not all go Mercedes' way in 2015. During the opening phase of the second half of the season things were not going exactly as intended and at Singapore the team underperformed badly. To this day there is still external speculation as to why that was. Even now the team will not give full details of what the causes were, but Lowe is willing to speak in general terms. 'Singapore was not great. It was a very interesting event for us and, unfortunately, for our competition. It's taught us a lot and we understand it now. It was down to all sorts of things; some of it was down to optimisation for a circuit, it is a very different circuit and not one we aerodynamically optimise around at all. You class it as a high downforce track like Hungary or Monaco, but it is something different to that.'

Many people have speculated that the lack of pace was due to a change in the advice from Pirelli in tyre usage in the wake of two major failures at the Belgian Grand Prix but Lowe dismisses that suggestion. 'There have been some special challenges this year in terms of the tyres. Pirelli changed the rear construction a bit and they changed the super soft too. That gave us a bit to get around in terms of set-up. Since Spa we have had some management from Pirelli [with] new minimum tyre pressures. What has complicated that is that those pressures are above what we would want to run for the optimum lap time. That has created some pressure, excuse the pun, on us to always run in the minimum and get the best from it. When it was first introduced we were quite concerned that the pressures would be problematic but it's been okay, though there has been some lap time lost from that. From our analysis it does not look like we have lost out more than anyone else though.'

The advantage that Mercedes has over the opposition at the moment may seem difficult to overcome, but the law of diminishing returns applies. With stable regulations in 2016, it looks almost certain that the next Mercedes Formula 1 car will have to fight harder for every point. But Lowe and his team are already looking forward to the challenge: 'Design sophistication creeps up on you,' Lowe enthuses. 'When you compare the W05 to the 2016 car it looks agricultural. I know I sound like a broken record, but it takes two years to see the difference.' That's a sentiment that is sure to worry Mercedes' rivals.

**Mercedes is one of only two teams on the grid which has a fully integrated approach to the car design**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# Motive **force**

**Improving on its dominant 2014 power unit was a big challenge for Mercedes but with its PU106B it did just this. The question is; how do you make a great engine even greater?**

**By SAM COLLINS**

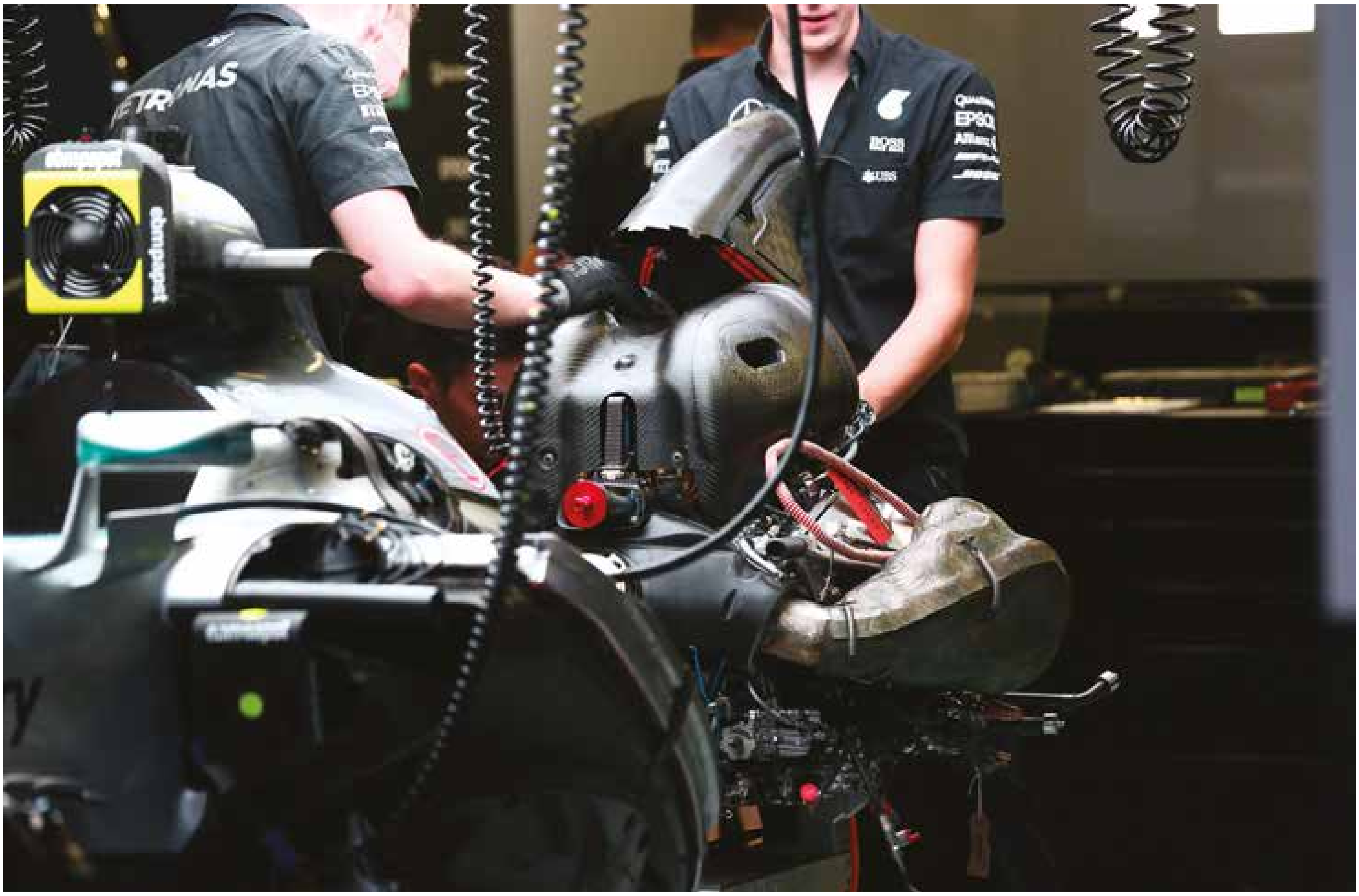

Mercedes AMG HPP could quite easily have been satisfied with what it had achieved by the end of the 2014 F1 season. In qualifying its product had been on pole position for every single race, and it had powered cars to 16 race victories and both world titles. But while the results were good, the staff at the factory in Brixworth were not entirely happy; and they wanted to build something better for 2015.

'As a company we have two missions on our intranet homepage which we see every time we login to our computers,' says Andy Cowell, managing director, Mercedes AMG High Performance Powertrains. They are to win the Formula 1 world championship, and have zero category one failures at the circuit. We did not have a perfect 2014 season and only achieved one of the two aims.

'There were some issues that were causing us pain at race weekends; in Canada, in Hungary and even the last race in Abu Dhabi, a coolant pump problem caused issues for Nico [Rosberg]. These issues were not things which could be resolved by little bits of chamfer change or radius change, it was much more. While any failure is an opportunity to learn, that is the very thin silver lining on a big dark cloud. We had to stop and think; how would we look at the concept to make it more robust?'

Improving reliability became a main aim for 2015, then. But Cowell says there were two other areas of focus for the engineers at HPP. 'We had three main aims, reliability I have mentioned, but another was to do with a change in the regulations. The rules dropped us to four power units from five per driver, with an extra race added to the schedule, potentially, so our internal durability target had to go up by a big chunk as we don't like grid penalties.'

The final focus for 2015 was perhaps the most obvious; to make the works Mercedes F1 car faster. But this is of course not a pure power unit development task and it relies on a very close working relationship with the Mercedes AMG F1 team based in Brackley near Silverstone. In fact, it is fair to say that the PU106B was designed around the Mercedes AMG F1 W06 Hybrid which, itself, was designed around the PU106B. 'The third objective is the most important, and it is in the title of the business; Performance. We have been working hard on all areas of the power unit to increase the conversion efficiency of every single system – trying to make our package more thermally efficient and produce greater absolute power. The focus in this respect has been on combustion efficiency and frictional losses – be they in core parts of the ICE or the ancillary aspects of both ICE and ERS.



The Mercedes PU106B. Note the exhaust routing (the engine is actually the wrong way round in this picture) and the large plenum which is a result of using a variable inlet system

On top of that there is energy flow efficiency and utilisation so we're not distracting the guys setting up the cars and the drivers driving them.'

Ahead of the 2014 season, the engineers at Brixworth were working in unfamiliar territory with the new technical regulations and the company's first ever turbocharged engine. For 2015 they had a starting point, and unsurprisingly the PU106B is mechanically very similar to the PU106A. Both are 1.6-litre V6 engines using direct injection and a single turbocharger. This internal combustion engine is mated to a pair of motor generator units, one used for kinetic energy recovery and the other for exhaust energy recovery – this is all defined by the technical regulations. The 2015 power unit has many features and concepts from the 2014 version including the distinctive split turbocharger layout: 'It's very much a case of evolution rather than revolution in 2015. Where last year was a case of "can we do it?" We are now faced with a different challenge – "How do we improve it?' Cowell said at the roll out of the W06 in Jerez, Spain. Yet he then went on to claim that the PU106B was an all new power unit, distinct from the PU106A.

**It is fair to say that the PU106B was designed around the W06, which itself was designed around the PU106B**

## New or upgraded?

Initially this was thought to be a bit of bravado as, under the F1 regulations, no more than 32 'development tokens' could be used to update the power units year on year. This equates to around 48 per cent of the total power unit so it seemed that an 'all new' power unit would be impossible. But Cowell went on to point out that you can also change parts for reliability reasons without using up any tokens, and with fewer units available per driver and maybe more races almost anything could be changed for reliability!

'I think we probably carried over the odd stud and a few washers but that was about it,' Cowell says. 'It was a big programme, not just a project. Because of the number of tokens that we thought we had, it provided a very broad opportunity. We did not do any filtering based on return per token spent. It was a case of everything can be in. Because '14 was not silky smooth in terms of reliability, and because of that step up in terms of usage, many parts that met durability targets in '14 had to be reworked. We decided that we wanted to be chasing it all. It was very tough because of that, there was perhaps less than five per cent carry over.'

At the heart of the power unit is the cylinder block which is a fully stressed component in modern F1 cars. On the PU106B, essentially every detail of it has been studied and re-optimised compared to that of the PU106A. Both share common design features which are defined in the regulations, such as the mounting points for the chassis and transmission, and a general concept in terms of layout.

'It carries a tremendous amount of load,' Cowell says. 'There is a real challenge just keeping the cylinder head on top of the crankcase as you increase the performance and the pressure during the combustion process. The head wants to come off. That is reacted by studs down into the crankcase, so you have the challenge of sealing those gasses in across the joint face, the challenge of making sure the load goes down into the heart of the crankcase and ensuring that the crankshaft does not come out of the bottom of it all. On top of that, the crankcase is the part that ensures the stiffness of the rear of the car, so it also has these big structural loads going through it. As if that was not enough, you have to then consider that it is a huge mounting bracket. There are probably close to 100 bosses holding ancillaries on to the side of it; gear hubs, hydraulic systems, and for all of those bits you would rather use a smaller fastener than a larger one, which increases the risk of a fatigue failure, or that a thread will pull out'. All of which highlights just how many areas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Another shot of the 2015 power unit. Again this is the wrong way round, but it's clear from this that the exhaust is much larger than the 2014 Birmann log design. Rod Nelson at Williams (a Mercedes HPP customer) says this increased volume is aerodynamically neutral

of the design needed to be reworked to cope with what may seem like a relatively innocuous increase in engine life. 'This year there are crankcases that have done lots of mileage. Sergio Perez has used one for seven race events and that went on and did several Fridays. That highly loaded bracket has a tough life,' Cowell adds.

To a generalist, the idea of increasing component life in this way would simply mean adding material to critical areas and generally beefing up the component. This would, one can safely assume, add weight, but in Formula 1 the power unit is built to a minimum weight and with restrictions on whole car weight distribution, an overweight power unit can be a major weakness.

'The weight limit is 145kg minimum, we all strive to be just a few grams above that. But to deal with more load you would typically put more material in to deal with local stress, or use a better material or some crafty design and shapes. You are constantly looking at areas which are okay and whittling them down, then looking at areas which are not okay and increasing them,' Cowell explains.

'Of course, after a year's worth of racing we had lots of examples, and a year of experience. We also had another year's worth of engineering analysis and that led to a more refined model. We have put a huge amount of effort into the optimisation of the stresses and the distortion from the loads without compromising performance, and all of that in harmony. We are fortunate that we are all on the same site and eat in the same canteen, it just helps with all the iterations and the development. I guess that the real focus is that it is one business with one ambition,' Cowell says.

> **'I think the MGU, compressor and turbine are not a big challenge but what lies between them is a monster challenge'**

## Regulatory limits

The technical regulations for Formula 1 power units could be seen as very restrictive as they define many areas of the power unit in great detail; including the cubic capacity, number of cylinders, cylinder bank angle, minimum centre of gravity height, crankshaft centre line height and even the cylinder bore. But Cowell does not believe that he is restricted too much by the current rules. 'I don't think the regulatory limits drive us to make sub-optimal decisions in general design terms. The deck height is free, for example, the bore size is fixed at 80mm, so we have not done any work on anything else, so I don't know if we are restricted there or not. I think 80mm was a number everyone was happy with,' he says.

One major design element to carry over, as mentioned earlier, is the split turbocharger concept seen on the PU106A. It features the compressor at the front of the engine and the turbine at the rear. The two are linked by a common shaft shared with the MGU-H. It is a concept rumoured to have been inspired by the Rolls Royce Pegasus jet engine but Cowell denies that this is the origin of the idea.'I have heard that story doing the rounds but it's not true. There is a bit of paper we have with the full list of turbocharger options which we could think of to use. Each one has the pros and cons for each solution, and where else the concept has been used. With this solution there was nothing against it for where it was used'.

But the split turbocharger itself seems not to have been the biggest challenge in creating this layout. Nor, according to Cowell, is the MGU-H. Instead, as has been suggested in these pages in the past, the real secret is actually to do with how they are all connected.

'I think the MGU, compressor and turbine are not a big challenge, but what lies between them is a monster challenge,' Cowell admits. 'The

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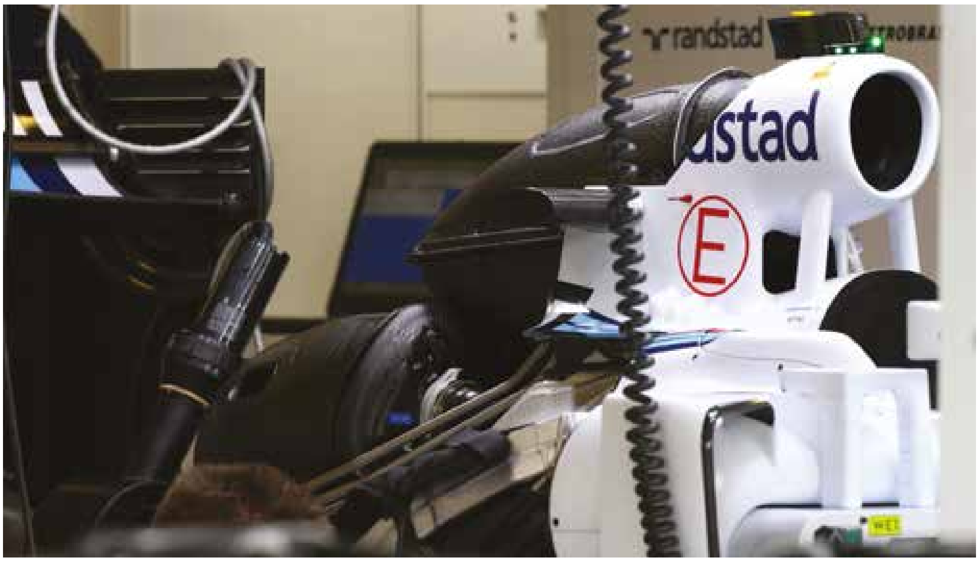
PU106A in the W05. While there are many carry over features on the 2015 unit, there are also some new concepts in use



The Williams FW37 has used the PU106B to great effect this year combining its slippery aero package with the Merc grunt

Installation of PU106B in Lotus E23. Next year it's likely that the Enstone team will revert to Renault power as works team

MGU is just an electric motor in essence. The power level is not prescribed in the rules, so the first problem is to understand what the desired power characteristic of the machine is in terms of torque and RPM. There you are balancing the two jobs it does, harvesting the energy from the turbine, and the second one is speed control of the overall shaft, and that is where you need to think about the drivability of the power unit, as it is controlling the compressor load into the engine, so there is that, too. Once you have that target and the 125,000rpm limit then you have some T-junctions to consider over which design route to take.'

Cowell, quite understandably, refused to elaborate further, indeed the design and installation of MGU-Hs remains something that all power unit engineers in the Formula 1 paddock are reluctant to speak about.

But not all of the designs on the PU106B are optimised versions of the concepts used on the PU106A, in some key and very obvious areas there are new concepts in use in 2015.

## New concepts

The 2015 design features a variable inlet system on the combustion engine, something which had not been permitted under the 2014 rules. 'We all decided not to do it in 2014 because we wanted the introduction of these new power units to be simpler, but some manufacturers were very keen to have the variable inlet from 2015 onwards. It allows us to keep the optimum tuned length of inlet while the RPM varies. We do have a variable inlet, and we do get an efficiency improvement because of it, we spent tokens on it, and it is fair to say that the car goes quicker because of it,' Cowell says.

Using the variable inlet system not only increases the complexity of the power unit but it also raises its centre of gravity and leads to a substantially larger plenum. 'Its got to earn its keep because of the implications of using it. Any system adds complexity and that increases the risk of not finishing a race. Any system adds mass and volume, and introducing such a system requires you to spend some resource, that's cash out of your budget and people out of your pool. It means you have to balance benefit and risk. For us, we put some good thinking into its design and it is a relatively simple layout which yields decent results. In terms of design it is a work of art, the engineering elegance is exceptional,' Cowell enthuses.

Another change immediately apparent from the first day that a car using the PU106B ran in public was that the innovative Birmann exhaust layout used on the PU106A had been dropped in favour of the larger and more conventional Sulzer style of exhaust header. The 2014 concept was all about getting the best gas flow to the turbine face which allows the MGU-H to recover more energy, but it's been suggested that this approach also saps power from the ICE. Cowell won't be drawn on the specifics but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The variable inlet system (or at least the best picture of it that's available). According to Andy Cowell it is simple and elegant

PU106B exhaust system features longer primaries, increasing the size and mass of the design but also the power output

points out that: 'you don't make a change like that unless you make the racecar quicker, so we obviously feel that this layout makes the car quicker. On this engine the pipes are longer, so the mass is probably greater, the volume is larger and therefore the power needs to be greater to overcome those things. With all three of those things there is also another full year of development in terms of the power aspect, the aerodynamic impact of having a blockage in the sidepod; you can do work to minimise the impact of that blockage and you can do work to minimise the mass of longer primaries.'

## Aiming for the stars

Perhaps the reason for this change can be explained by Cowell's ultimate target, total combustion efficiency. 'We would love to convert all of the chemical energy from the fuel into pressure on the piston, which would give us 1240kW in to the crankshaft, then you would have no energy going down the exhaust pipe. If you aim for the stars you might just clear the trees. But the combustion chamber is the best place to do the conversion.' The PU106B is perhaps the most efficient motorsport power unit ever. The exact number will probably not be known for many years but Cowell says; 'We are achieving over 40 per cent efficiency, but under 50 per cent. We are lot better than last year and the figure is phenomenal.'

## Lift and coast

But this constant quest for greater efficiency has been largely misunderstood and criticised by the mass media, especially those on television who can no longer simply say: 'More power is better'. It has obviously been noted, as Cowell is keen to stress the importance of building a more efficient power unit. 'I think overall everyone does a bit of lift and coast, which is what they did in the V8 era because everyone wants a lighter car at the start. Everyone knows that the lap time penalty of a little bit of lift and coast through the race is a small penalty to pay for being lighter at the start and being able to make up places. It's worked out remarkably well. I think there are a third of the races where we can run flat out and not worry about the fuel allowance, there is the other third, where we have to think about it a little bit but not too much, and then there is the final third where it's a bit more challenging and it adds to things; but those races tend to have it negated by a safety car. But there are perhaps two or three races a year where lift and coast is a pain, but for others it is an opportunity', Cowell explains.

'For the power unit manufacturers we are all chasing a good conversion efficiency and that is what is going on in the transport sector across the board. It's even happening in our homes, we want our house to be a certain temperature and we are not willing to compromise on that, but we want less energy going in so it is all the same game really.'

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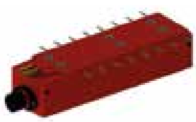

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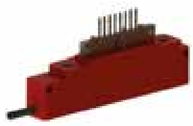

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The 2014 power unit in the Mercedes W05 – the much smaller plenum is clear in this pic, as is the smaller exhaust header

With the efficiency increase confirmed by the engineers and their test equipment at Brixworth, thoughts turned to production schedules and early ideas for 2016. Once the work on the 2015 unit had been signed off and homologated, the power units would be frozen in specification for the entire season. But then, as the festive season approached in 2014, it was announced that manufacturers would be allowed to develop the power units during the 2015 race season after all.

## Christmas present

'That was my Christmas present from Charlie [Whiting] last year,' Cowell says. 'I was actually right in the middle of my Christmas shopping when I received the news. It did not have any impact on us to start off with. We already had a very clear target for how we wanted to get to Melbourne, and we were heading toward 25 tokens usage, and driving for increased reliability and performance as planned. After about a 30 minute study of what the change meant and a bit of a think, we quickly decided that we would not do anything differently, we just stuck to our plan.'

But as the season developed it was clear that the engineers at Brixworth would have to do something with their remaining seven tokens, they were just not too sure what; and indeed not too sure how. 'After the first couple of races we stepped back and had a think about what to do. We simply were not set up for doing in season development like that,' Cowell admits. 'Our business was set up to innovate 365 days a year but only introduce one new product annually, for the first race of each season. We asked around "what are we going to do guys? Is there anything performance related left on the table?" But the answer was no, it was all on the power unit already. So we then had to look at what we are working on for 2016 that could be accelerated into this year. It was a major headache for the programme management people. How do you introduce these updates? Indeed, how do you track test it when you have no track testing? We just didn't know.'

Eventually an update package was decided on and it was calculated that Monza would be the best place to introduce it. Apparently it consisted of a new combustion chamber (including piston crown) and some associated components. Additionally, Petronas introduced a new fuel in conjunction with the update (and later introduced new lubricants at the US GP).

But the introduction of the updated power unit did not go as smoothly as the team had hoped. Water contaminated the lubrication system on Rosberg's car, and that left the team with a difficult set of options. 'We were pushing like hell for an in-season update, but we feel it was quite brave to bring in some 2016 development on the third and fourth power units for the works cars. But on Saturday morning at Monza we had some contamination and we didn't know what to roll back to. Eventually we opted to roll back to an old unit, we knew it was a risk. But we decided to race like hell because we like finishing right at the top,' Cowell says. The power unit, which had been fitted to the Rosberg car, had already reached the end of its planned life and was being used on one of the toughest tracks for engines of the year. Fighting to get second position when third was already secure, the team adopted a more aggressive strategy, and eventually a piston failed and the car retired shortly before the end of the race.

While the Mercedes team supported the move to run the power unit as hard as possible – 'We are racers, you have to try,' explained Mercedes technical director Paddy Lowe of the choice to push – seeing a Silver Arrow fail on track still grates with Cowell. But, overall, it seems that the Mercedes AMG HPP team feels more satisfied with its performance in 2015 than it did in 2014, although it should be noted that 'more satisfied' is certainly not the same thing as 'satisfied'.

'We have done considerably better than last year in terms of reliability, but there have been some issues. There was a broken crankshaft on one of the Force Indias, for example. There have been a few other smaller issues too,' Cowell highlights candidly. 'The amount of effort to deliver a good race weekend is still too high, so we are looking at that.'

## Future classics

But work now at Brixworth is all about the 2016 and even the 2017 power units, which are reported to once again be an improvement on their predecessors. With stable rules, and a reduced token allowance, the 2016 unit is expected to be closer to the PU106B than that was to the PU106A, but it of course will not be exactly the same. The turbocharger, for example, will look different as a rule change aimed at giving the cars a better exhaust note will see installation differences. 'The new rule on wastegates is really a routing issue. It does not help crank power at all, but it does improve the quality of the sound', Cowell explains. Looking forward to the 2016 power unit in general terms the aims have already been set, and as well as winning the championship and not failing in a single race, Cowell reveals that 'the durability requirement is the same in 2016 that it was in 2015, so that is not a big aim, but we are working on improving the serviceability of the power unit; then it's a programme to increase the efficiency of everything.'

In increasing efficiency and edging closer to 50 per cent perhaps Cowell and his team are doing more than just clearing the trees, but with rules stability, rivals such as Ferrari are rapidly closing the gap to the three pointed star. So perhaps the dominance of the PU106B may not be repeated for some years – but then, that is what was said about the PU106A.

## 'Our business was set up to innovate 365 days a year but to only introduce one new product annually, for the first race of each season'

# Indian **summer**

**Since the introduction of its B-spec VJM08 in July Force India has turned its season around – *Racecar* shines a light on 2015's most effective makeover**

**By LEIGH O'GORMAN**

Force India's delayed start to the 2015 Formula 1 season raised a number of eyebrows, and restarted stories that all was not well within the Silverstone-based team, especially with regards to its finances. The team looked to be in disarray, missing the first test in Jerez altogether and debuting a 2014-spec car at the second test, held in Barcelona. It introduced the first iteration of its 2015-spec VJM08 at the second Spanish test, and finally a 'B-spec' 2015 car at the British Grand Prix in July.

Yet, despite this start, the team has stepped up to grab fifth place in the constructors' championship – a record for the squad in its current guise – with 89 of its 120 points (as of the Brazilian Grand Prix) secured since the introduction of the 'B-spec' chassis at the British Grand Prix. Force India's championship position is particularly notable considering the size of both its engineering squad and budget compared to the world championship's big hitters, such as Mercedes, Ferrari and Red Bull.

There's an air of satisfaction within the organisation: 'Everyone here is very pleased,' says technical director Andrew Green. 'It has been a lot of hard work. To where we are from where we started the season, it was a fantastic effort.'

While there was much written and plenty of chatter about Force India's difficulties at the start of the season, Green's explanation for the delays is rather more prosaic: 'The single biggest reason for the interrupted development was the change of wind tunnel, from Brackley to TMG [Toyota Motorsport] in Cologne in January. That had a profound effect on our development and our strategy going forward. It took a big chunk out of what would have been development time, given that we were relocating everything to Cologne and having to re-baseline everything and find our feet again.'

## Winter winds

Whereas the wind tunnel used at Brackley limited Green and his team to a 50 per cent scale model, the move to the Toyota tunnel in Cologne, used by many other F1 outfits, enabled the team to use a 60 per cent scale model and Green felt that this would help the team in the longer term. 'We had an approach [to the design] that we wanted to take, but we were unable to take that with the Brackley wind tunnel,' he says. 'By moving to Cologne with a bigger tunnel, it would allow us to develop a car in a different way. It wasn't a case of changing tunnels and seeing what we can learn; we wanted to do this, we knew which way we wanted to go, but we just couldn't do it in our existing tunnel. It was an important direction for us that we wanted to take – we explained that to our shareholders and they agreed, and it was the main reason why we moved.'

Green's belief in the need for a new wind tunnel may have caused a hiccup during the build-up to the 2015 season, but he was keen to underline Force India's ambition at that time. 'With a new tunnel it did set us back, but we had our eyes on the longer term gain and we knew we needed the bigger tunnel,' he says. 'That was important to us for the development that we were doing, so it was an acceptable loss at the time.'

The enforced delay ensured that when the VJM08 did finally make an appearance at the final test, it was noted how much it owed to its predecessor, the VJM07. While the inherent reliability was very much still in place, changes to regulations regarding the front of the car, drawn up to banish the ugly nose designs of the previous year, meant that not everything was as dialled in as desired by the first race in Melbourne, with Green admitting that; 'the new regulations, especially around the front of the car and the new nose box, had quite a profound effect on the 2014 car. We did struggle a bit trying to recoup the losses we had with that change.'

However, despite the problems, both of Force India's drivers, Nico Hulkenberg and Sergio Perez, scored points on the VJM08's debut, helped by a final classification that featured only 11 cars, but thereafter points proved difficult to come by, although there were some changes introduced that were portent to what was to come later in the season.

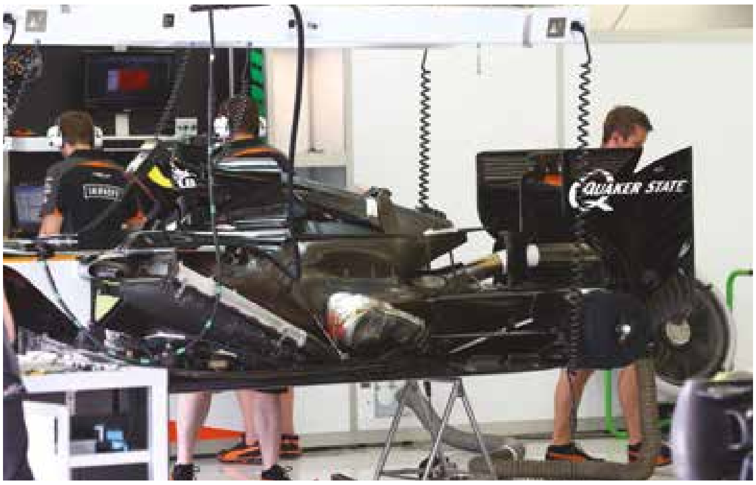
**'The biggest reason for the interrupted development was the change of wind tunnel, which was changed from Brackley to TMG in Cologne in January 2015'**

## Spring brake

Come the Spanish Grand Prix in May, Force India introduced a minor change by moving the brake calipers from ahead of the front axle to the rear of the axle. While the alteration did not deliver significant gains in itself, it did open the door for the team to investigate further developments in that area. 'It was the first step of changing the architecture of the caliper,' says Green. 'In itself, it was a very small change, but subsequently there are more changes that go on top of it which would become significant.' He also noted that placing the caliper to the rear of the axle served as an alternative way of ducting air through the brake duct and past the caliper, adding: 'It is the same philosophy that we set ourselves at the beginning of the year. It gave us performance in that area and allowed us to develop the front brake ducts further during the season, and it allows us to do more changes to them next year.'

Whereas midfield teams have often drifted backwards from mid-season onwards, as budgets flounder against more moneyed opposition, Force India's campaign stepped up a gear from the British

Front bulkhead showing steering rack and inboard suspension pickups. Unusually the torsion bars are mounted vertically on top of the chassis behind third element




The back end of the car stripped down to its bones with heat shields and some underbody parts remaining in place. Also visible is the exhaust manifold and the left side main heat exchanger

One of the changes on the B spec car was a new cooling system – as is the case with all modern Formula 1 cars the radiator is sculpted to fit tight sidepod space


Force India produced a light weight and heavy weight chassis for its drivers in 2015; the lighter to compensate for Hulkenberg's greater weight. Next year both drivers will use lighter chassis

Grand Prix onward. Although the VJM08B retained the same chassis and front suspension, much of the car had been completely altered, and the new design changed the fortunes of the team for the rest of the year. The 'B' car was launched with new cooling systems, rear suspension, front wing, rear wing, nose, bodywork and floor. 'It was significantly different to the car that we launched with,' Green says. 'The main drive for it was to make a better balanced car, to have a more uniform balance from corner-to-corner, circuit-to-circuit and different conditions, giving the drivers greater consistency, which helps them drive the car on the limit and it also helps preserve the tyres.'

Green acknowledges that much of the strength of the VJM08B began with the team's new-found sense of direction, as realised during the off-season. 'It was a general step forward,' he says. 'It was a 'global' philosophy change in lots of areas of the car – front wing, rear wing, rear suspension and rear brake ducts – it was all new concepts in those areas. We determined that we have made a step in the right direction when we went to the B-spec. By no means is it perfect – it is a long way from it, but it is a step in the right direction.'

## A nose for it

One of the more intriguing elements of the VJM08B is its nose cone, easily identified by two vents ahead of the front wheels but shy of the tip of the nose. Importantly, inside the opening are a pair of spoon-shaped underbody panels that brings the air slightly more inboard and improves the channeling of air under the chassis. These panels are crucial to the legality of the vents. Beginning as an attempt to reduce the length of the nose and increase aerodynamic performance, Green discovered that the basic architecture of the chassis, around the front suspension, actually prevented plans for a very short nose. 'We had to do it a different way and we came up with this vented solution,' says Green. 'It appeared to have similar gains to what we would have received if we had used the shorter nose, but it meant we could run, relatively speaking, a longer nose. It was really a packaging exercise and trying to work with what we had around the existing chassis.'

The solution, as Green admits, certainly saved the team much effort in trying to develop a very short nose, which would then need to be subjected to crash tests. 'We know some teams have done 50 to 60 crash tests to try and get the short nose to pass – that is something we just can't afford to do,' Green reveals. 'It is completely inefficient for us to do that, so we had to think about another way of doing it, and that's what we came up with.'

Vented noses are not permissible in the Formula 1 technical regulations if they are deemed to be 'see through'. However, while the vents captured the attention of many observers in the paddock, Green says there was never any question as to their legality. 'The legality was never in question – we didn't have to change the design from its initial launch. In order to be within the regulations, you can't have a [see] through hole. If you stood in front of the car and looked at the nose, you can't see straight through – there has to be a curve, so the vent

**The basic architecture of the chassis prevented plans for a shorter nose** ↳

**Mercedes twin-skin hybrid transmission and the rear suspension driveshaft passes through the lower wishbone. The use of the Mercedes 'box does bring some design constraints**

**For its roll hoop the Force India VJM08B uses a twin forward support philosophy in common with many cars on the F1 grid**

has to curve round, and that's the reason for the panels underneath. 'When you do look at the car from the front and you look into the hole, you cannot see daylight through it,' Green adds. 'The FIA were fully aware of what we were doing from a very early stage, and we explained to them why we thought it sat within the regulations and they agreed very early on, so we never made any changes to it after that.'

Following the introduction of the B-spec car, there were further developments later in the season when Force India brought upgrades to the rear suspension, diffuser and front and rear brake ducts to Singapore. Unusually for the team, there were even updates arriving as late as the Mexican and Brazilian grands prix, with additional rear wing and floor developments, with many of these elements set to feature on the 2016 car in pre-season testing at least.

One notable feature of the VJM08B has been the uprights – or at least the upright's surrounding elements. Although Green notes that the uprights themselves did not change from the part utilised on last year's car, the associated bodywork changed completely. 'That part of it hasn't changed ever since some very small modifications to the wishbones themselves. There was no reason to change the architecture in that area; it allowed us to do what we wanted to do without changing it, so we elected not to change it.'

## Design constraints

Designing the VJM08B was not all plain sailing, however. As a privateer team, Force India uses an internal combustion engine, energy recovery unit, hydraulics package and gearbox, as supplied by Mercedes. There is little doubt that Mercedes' expertise in these areas – as proved by another double championship this year – has done much to help Force India's cause, but from a design point of view, the use of bought-in units bring its own particular problems.

'It's always difficult when you don't have control of an area; not having control of the gearbox, and especially the suspension mounting points, rear impact structure and differential heights – those sorts of things we are not in control of at all, and it does make it tricky.'

Green notes that the biggest limitation to using a bought-in gearbox rests around the rear axle centre-line, which is defined by the gearbox design. With the gearbox parameters already in place, the basic architecture of the rear of the car from the rear bulkhead of the chassis, through the engine and gearbox to the rear axle centre-line is fixed to a pre-determined outlay. 'There is no latitude to move that at all and we have no opportunity to change that. That does create a bit of work when trying to optimise the front to the rear, knowing that we can't change the rear.

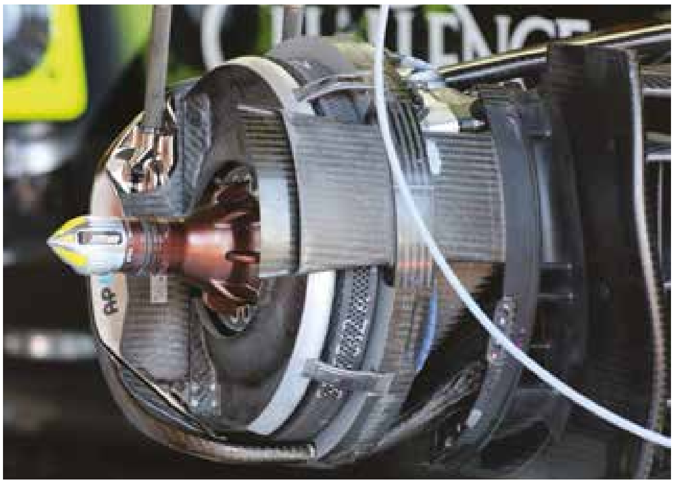
'It is a challenge because we have a concept that we are looking to develop around the rear of the car, and Mercedes GP have their own concept, and they are not necessarily aligned. There are compromises that we have to make with our car, because we are using their geometry.'

Despite these difficulties, Green contends that producing an in-house gearbox and hydraulics may be beyond Force India's reach – and that it might not necessarily be the worst compromise. 'Overall we are better placed from a development perspective to not be designing and manufacturing our own gearbox and hydraulics, which is a huge resource and requires a huge resource drain. It allows us to concentrate on aerodynamics a bit more, so it's swings and roundabouts. The geometry is not ideal, but we don't have to worry about it, so it gives us extra capacity.'

However, this is not an unknown area for Force India, which has been purchasing customer gearboxes for several years, having previously bought its transmission from McLaren. 'It was exactly the same issues that we had to overcome and we are quite well versed in it now. We have a good handle on how to get around the problems, so we don't even see it as an issue anymore,' Green says.

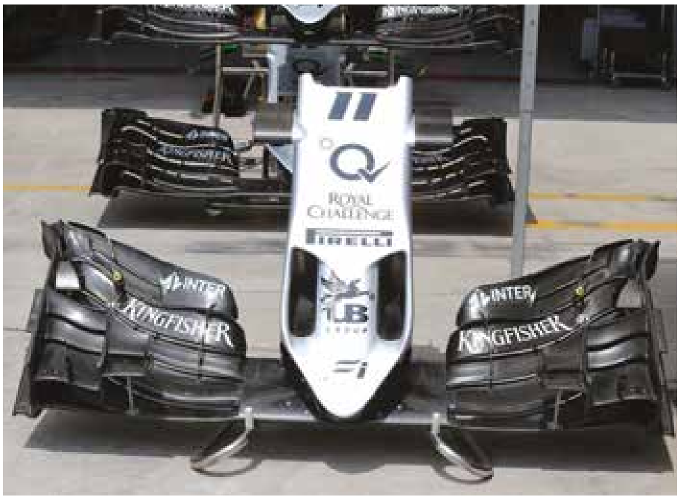
**Producing an in-house gearbox may be beyond Force India's reach**

The brakes on the VJM08 prior to modification. At the Spanish GP Force India introduced a minor change by moving brake calipers from ahead of the front axle to behind it (see right)



The newer VJM08 brake set-up with the new brake ducting. Moving the caliper served as an alternative way of ducting the air through the brake duct


The more conventional nose with which Force India started the season. It had hoped to change to a short nose but the chassis architecture at the front prohibited this modification




The VJM08B's striking nose: the vents are deemed legal as they are not see-through because of the fitting of a pair of spoon-shaped underbody panels inside the holes

While much of the season since the introduction of the B-spec has gone well, Green and his team did receive what he called 'a big wake-up call' during the Hungarian Grand Prix weekend. During practice Perez crashed heavily following a spin exiting Turn 11, causing his right-front wheel to tear off, which then tripped his VJM08B into a flip. Discovering an issue with the car's suspension, both the cars were withdrawn from the second Friday practice, returning for Free Practice 3 on Saturday morning. 'The Hungary failures took us by surprise; it was a unique set of circumstances that occurred when the drivers were running on the kerbs,' admits Green. 'That was the main reason for the suspension failure. It was kerb riding and accelerating at the same time and that put massive shock loads through the suspension, which we subsequently reinforced, and beyond that we redesigned the suspension to give greater strength in that area.'

Things took another turn during the race itself when Hulkenberg's front wing destroyed itself on lap 43, pitching the German into the barriers. Again Green pointed to the kerbs being the main issue. 'The bottom line was we underestimated the loads that the wing would see, again during kerbing events. That caught us out. The two things were very specific to that track. Now that we have the data, we can design for it and I don't anticipate the issue going forward.' The redesign has produced a very slight mass penalty, but Green dismissed this as an insignificant loss, as the VJM08B is slightly underweight. 'It was just a case of swapping some ballast for some mass and paying a very small penalty, but no aerodynamic penalty.'

## Cautious optimism

If nothing else, the B-spec Force India has certainly delivered on its initial promise. A podium in Russia for Perez was a well-earned reward and did much to take the team ahead of Lotus in the constructors' table. Perez even led on the opening lap in Belgium, albeit for approximately 100 metres.

Green remains cautiously optimistic ahead of the 2016 season, but the team is looking to consolidate its efforts from this year. While the VJM08B will carry over into pre-season testing, it is likely that it will appear with updates at the front, although Green says that, 'we are looking at another significant step in architecture once we get racing – the introduction of that is still to be defined.'

Green also notes that while Force India produced a light weight and heavy weight chassis to suit the needs of their individual drivers – the lighter to compensate for Le Mans winner Hulkenberg's greater weight – both of the drivers will next year be using a lighter weight chassis.

For now, though, the 2016 Green-designed Force India is still in the wind tunnel stage and, according to the man himself, requires further refining: 'We haven't got an end date for it yet. We don't know when it is going to be introduced, but it will be a significant package again, similar to what we did this year with the B-spec.' If that turns out to be true, don't be too surprised if Force India chalks up another raft of impressive results in 2016.

**The B-spec Force India has certainly delivered on its initial promise**

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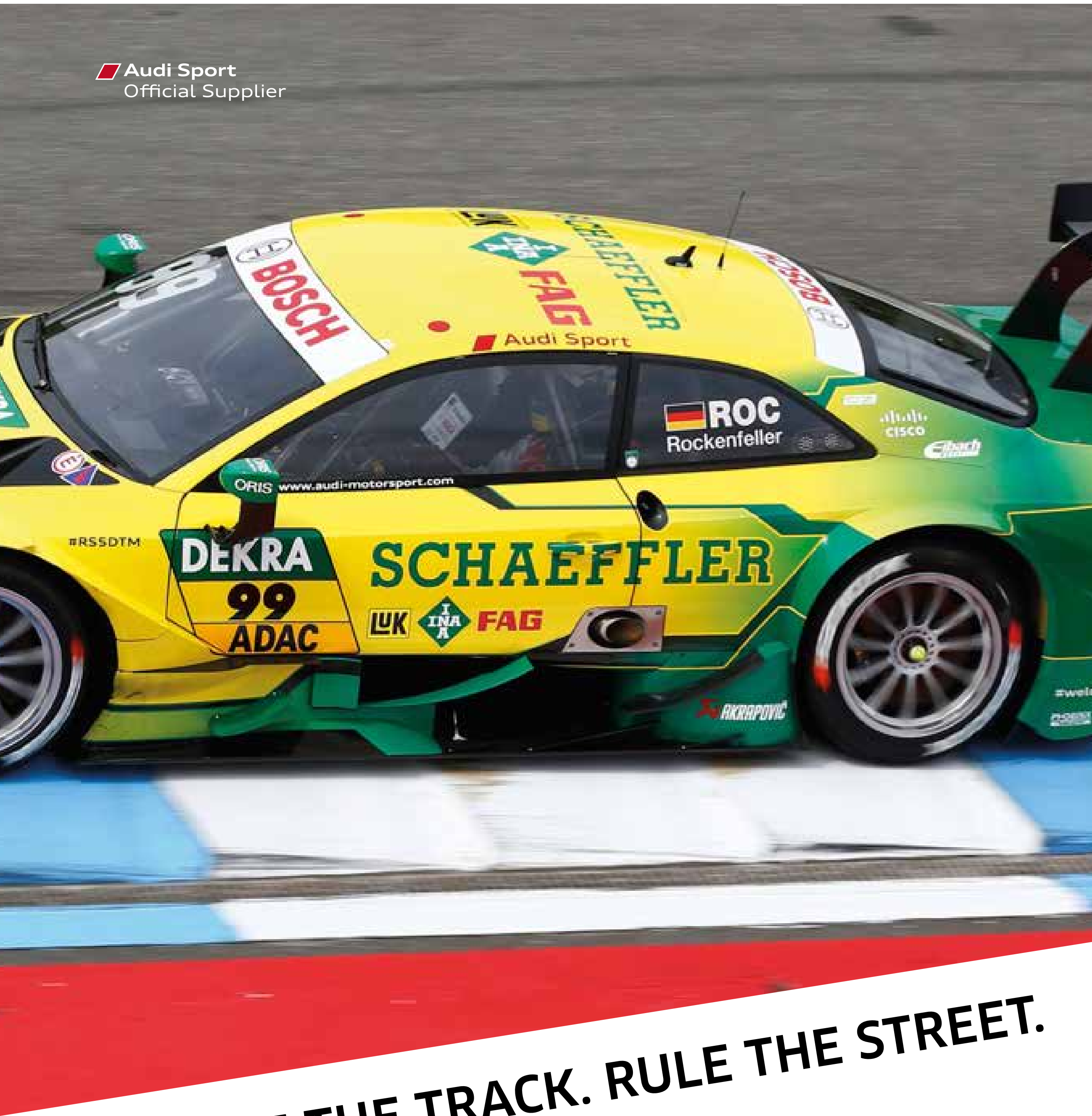



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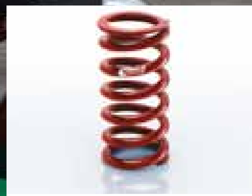
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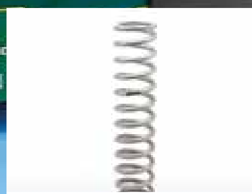
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# Skin **deep**

**Peugeot's 2016 Dakar challenger is wider, longer, lighter and faster than its 2015 version – and yet, as *Racecar* discovered, underneath it's essentially the same car**

By ANDREW COTTON

Peugeot returned to rallying in 2015 with its 2008 DKR that first featured in *Racecar Engineering* V24N12. It marked the brand's return to top level international motorsport for the first time since the cancellation of its Le Mans programme in 2012, and also offered a better return on investment with rallies in all of its key markets, including South America and China.

The team opted for a two-wheel-drive concept which allowed it to use bigger wheels, a lower weight car, and run with more suspension travel, but on tough terrain the vehicle would struggle for traction compared to its 4wd competitors. Yet for the 2016 version, the team considered the 2wd option to have yielded the desired results and it stayed with the concept.

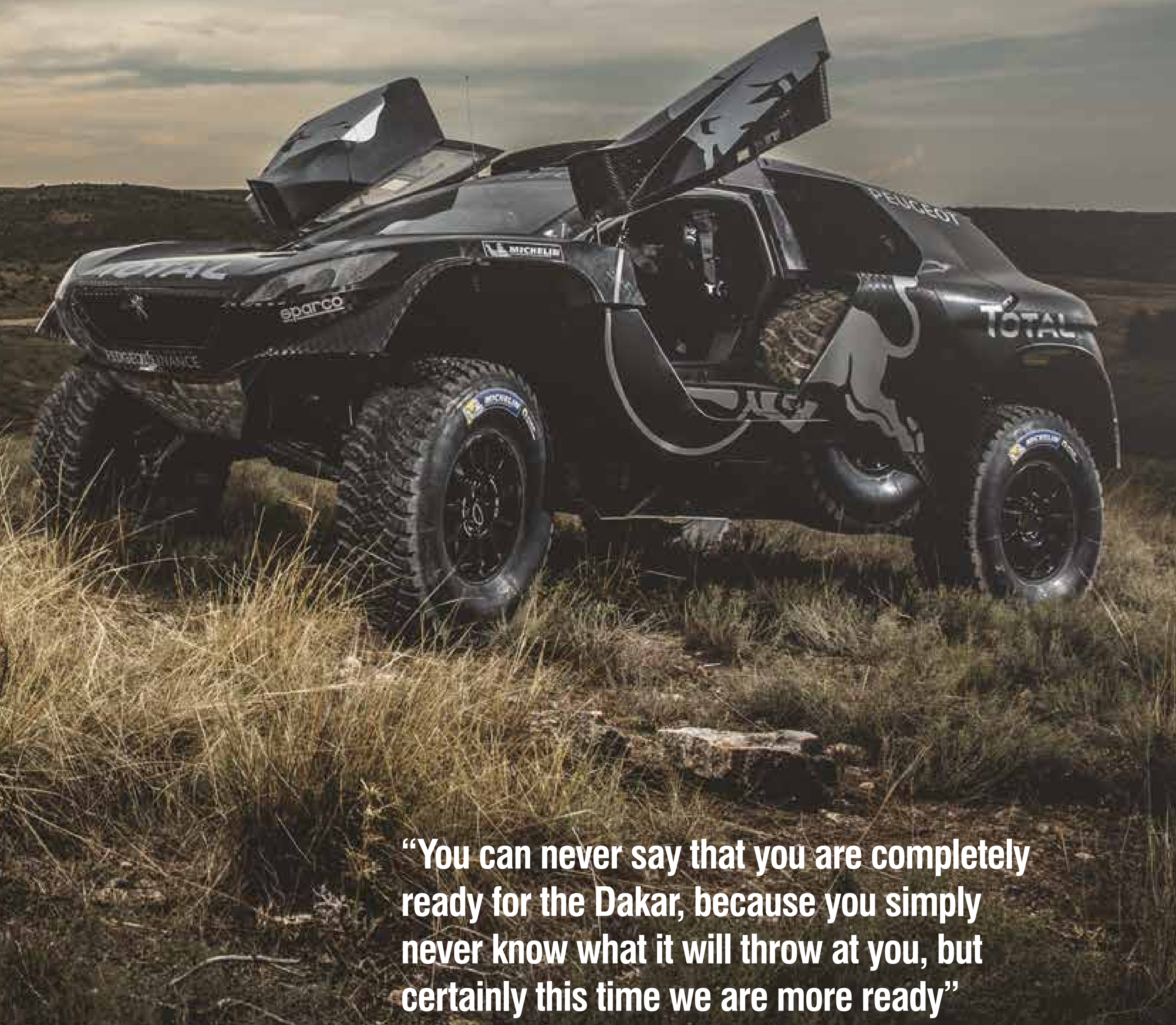
In fact, even though the car looks significantly different – wider and longer by 20cm to improve lateral stability, maintaining the two-door coupe concept, under the skin the team actually stayed with its original concept throughout the car.

'The concept of the 2015 car was very good, it was one of the conclusions that we made after the 2015 Dakar race,' says Peugeot's technical director, Bruno Famin. 'It is the same engine, same gearbox, same rear-wheel-drive concept, big wheels, on modern suspension. After that, we just wanted to improve the car in all the possible ways.

'One of the main weak points of the previous car was the lack of lateral stability,' Famin continues. 'One of the conclusions was to increase the width of the car by 20cm to the maximum allowed by the regulations, but you cannot do it just like that; you have to increase the wheelbase by more or less the same value. Already, when you decide that, even if you are still with the same concept, when you increase the wheelbase and width by 20cm, you have to more or less redesign the car! That is not very difficult because it is a tubular chassis, but it is very useful because, with the first experience, we used the opportunity to redesign the parts and make them lighter, make the car easier to maintain. Then, the car is also significantly lighter, even though it is bigger on the ground.'

The team also took the opportunity to further reduce the front and rear overhangs, and worked on the aero for the car too. The 2008 DKR16 benefits from improved aerodynamics: the bonnet and roof-mounted air-intake have been heavily revised in order to provide more balanced downforce between front and rear. The new air scoop also ensures better airflow.

Other evolutions lie under its carbon skin. The suspension has been redesigned to deal more effectively with the different and rough terrains. It also benefits from better weight




**"You can never say that you are completely ready for the Dakar, because you simply never know what it will throw at you, but certainly this time we are more ready"**

**Modifying tubular chassis was a relatively simple affair as it is easier than working on carbon, but a redesign was required nonetheless. The car is also lighter than 2015 version as the team made uses of lessons learnt to redesign some parts**


**Front and rear overhangs were reduced even further but the main difference between the DKR16 and its predecessor is that it is wider and longer with a lower centre of gravity. The roof-mounted air-intake has been the subject of aero development**

**While 2015 (left) and 2016 cars are visually different the new DKR sticks with the underlying 2wd turbo-diesel philosophy**

distribution, as well as magnesium one-piece wheels for the first time, matched to lighter tyres from Michelin. These replace the aluminium two-piece wheels from 2015, with the combination resulting in a significant weight saving.

The new car has been steadily developed since the first version finished the Dakar Rally in Buenos Aires in January. Peugeot's engineers went over their 'Lion' piece by piece, analysing what could be done better, with the help of its Dakar experts Stephane Peterhansel, Carlos Sainz and Cyril Despres.

These improvements were gradually applied and assessed through a series of tests, culminating in a one-two finish for Peterhansel and Despres on the recent China Silk Road Rally, using an interim-specification car. This was essentially the 2015 model with a number of development parts for 2016 added.

'We tested and raced in China where we finished first and second without a single problem,' says Famin. 'The competition level was not as high as Dakar or Morocco, but it was very good to make special stages without any problems. What we validated there was the lightweight wheels with the magnesium rims, monobloc [one-piece], and the new commercial tyres from Michelin. We also had a better engine in terms of driveability, even if it was not the final version. They were the key points.'

## Low grunt

The team worked hard on the development of the 3-litre V6 turbo-diesel, finding that it lacked torque at low revs, partly a result of running first gear ratios that were just too long. That meant poor driveability at low speeds, and so the team made a series of improvements to the new car.

'The gearbox is exactly the same, except the ratio,' says Famin. 'The engine has very little torque at low revs, and the first gear ratio was too long. The low revs performance of the car was very bad, especially when you go higher and higher with altitude. We are better now; the engine improved a lot, especially at low revs. We worked a lot on driveability, not so much on power, and on the gears with the same aim.'

With budget in mind, the Peugeot team had to be careful with its engine development. From its days in the International Le Mans Cup (ILMC) and at Le Mans, it knew that the air restrictor has only a limited effect on outright diesel engine performance compared to gasoline. However, Peugeot's engine is almost entirely production-based, and so has a natural cut-off point in terms of development.

'The base of the engine, the cylinder heads, blocks pistons, con rods is all standard,' says Famin. 'It is a standard engine. Then you have to limit yourself in terms of turbo pressure if you want the pistons to survive. Then the turbo pressure is limited not by rule, but by engine basis, and in our case it is strictly standard.'

Famin also says that the development has been throughout the car: 'There isn't one big

The DKR15+ raced to first and second in China but with limited opposition – yet this at least proved new parts for the 2016 DKR were reliable

In a bid to get down to the minimum weight limit Peugeot opted for one-piece magnesium wheels and lighter Michelin tyres; but 2008 DKR16 is still above the limit despite these and other measures

change that we have made on our car: instead it has been a series of small evolutions in different areas, which together we hope will amount to an overall improvement. The areas we have concentrated on include bodywork and aerodynamics – as a result of which the car looks slightly different compared to last year – as well as engine and suspension, which is all under the skin. The tests we have carried out up to now, as well as our one-two finish in China recently, indicate that we are heading in the right direction. You really cannot compare our state of preparation now to how it was for our first Dakar this time last year, when everything was new to us. Of course, you can never say that you are completely ready for the Dakar either, because you simply never know what it will throw at you, but certainly this time we are more ready.'

Peterhansel and Sainz have driven the new car through the different phases of its development and have found it to be a useful step forward from its predecessor, providing greater driveability, power and traction.

Peterhansel, who gave the 2008 DKR its first-ever overall win in China, said: 'You can really feel the difference now that the car is longer and wider, with a lower centre of gravity, because it's a lot more stable so cornering speeds are faster. You can feel the difference in the engine as well: not only is it more powerful, but you can also use all the power even at low revs. We've almost got a 'problem' now of how to manage all that power most effectively, but this is a very nice problem to have. We're still not at the maximum of our capabilities, but testing has been very productive so far.'

Sainz stayed behind post-rally to concentrate on development work rather than competing in China. As a result, he has accumulated plenty of experience of the brand new challenger. The Spaniard added: 'It's been good testing and the car has been running really well. The potential of the car is much, much bigger than it was at this time last year and reliability has been solid too. We've changed quite a lot in the car in many key areas, so really we can call this one a completely new car compared to last year. I feel optimistic.'

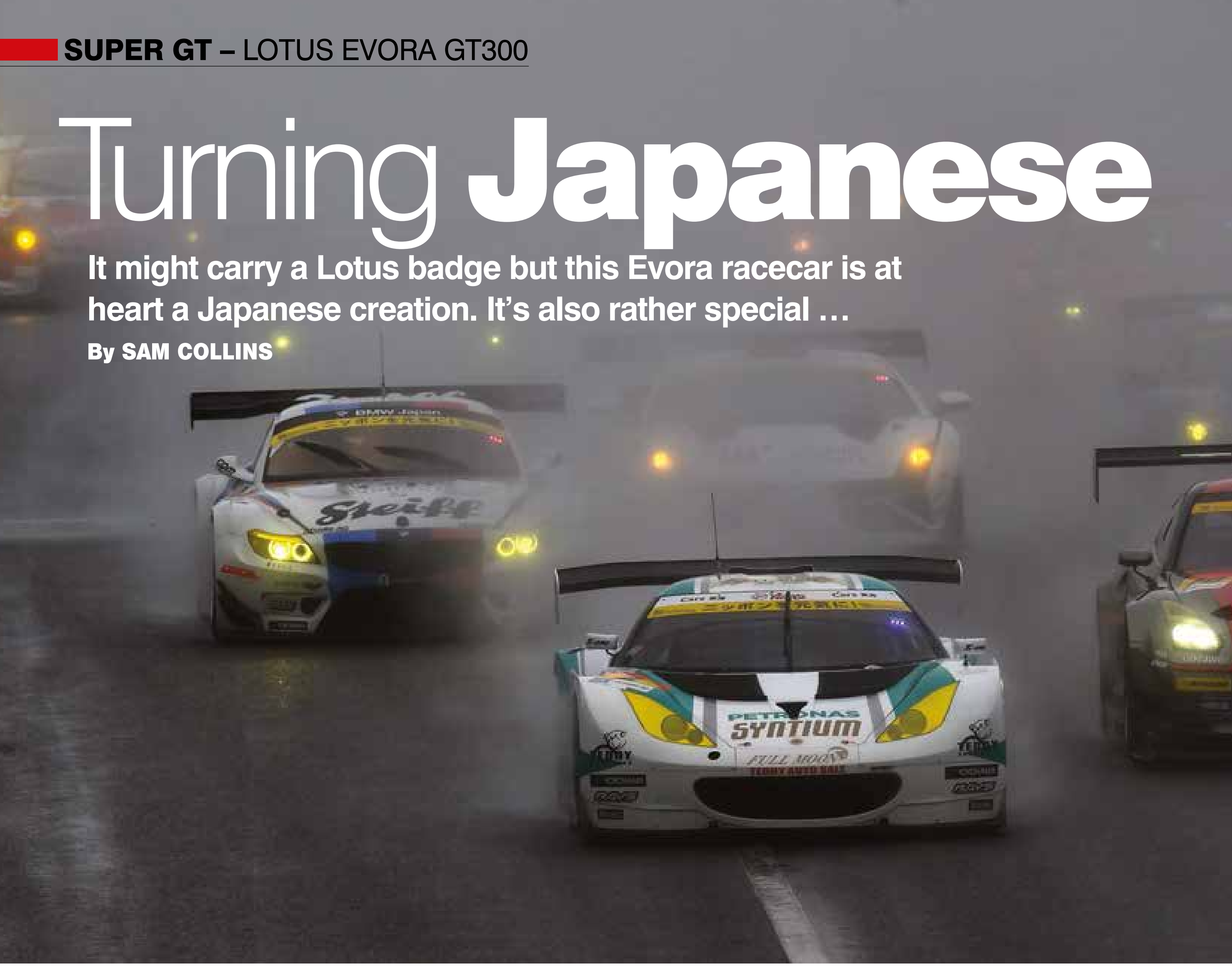
The off-road programme continues to offer better value for money for the brand than the Le Mans programme, but the desire to return to endurance racing still burns at Peugeot Sport, which is keen to address what it sees as unfinished business. Cost control measures must come into force before it can contemplate a return to Le Mans, possibly when there is a major chassis change in 2018. In the meantime the 2017 Dakar car is already on the drawing board and that is where the company's priorities lie in the medium term. Famin hopes that the new car will not have to be that different from 2016, further validating the team's concept.

**The off-road programme continues to offer better value for money for the brand than Le Mans**

# Turning **Japanese**

**It might carry a Lotus badge but this Evora racecar is at heart a Japanese creation. It's also rather special …**

**By SAM COLLINS**




Somewhere in Japan there is a Lotus Evora missing the badge from its nose, windscreen wiper, door handles and tail lamps. This is not the result of a strange car crime spree, but rather of a set of technical regulations introduced to the Super GT championship in late 2014.

There had been a growing concern in the Japanese motorsport industry that the GT300 class, which has always been designed for Japan's best tuning companies and privateers, was becoming essentially an FIA GT3 championship. Gradual rule changes over the years forced out some of the most extreme GT300 cars including the unlikely Mooncraft Shiden, a converted Riley Daytona Prototype powered by a heavily restricted Toyota engine. Many teams had then opted simply to buy an off the shelf GT3 car, which then reduced the opportunities for Japanese suppliers and engineers to compete in the series. Indeed, in 2014 only four non-GT3 cars entered the series at the start of the season, and it was felt that something had to give.

So GTA, the promoter of Super GT, turned to Dome for help and they jointly developed a new kind of GT300 car, known as the Mother Chassis (MC). Under this new rulebook, tuners could buy an off the shelf chassis from Dome and develop a car around it, and the optional Nissan based GTA branded V8 engine. The first car to be built to this rule book was the Toyota GT86, also developed by Dome, and a number of examples of this design have been raced in 2015 – not only in GT300 but also in the Thai Super Series where the MC cars are also allowed to compete.

## Mother superior

In late 2014, one of the teams which had switched from the 'others' rules (a make it up as you go along catch-all rules subset in GT300) to a GT3 car (a McLaren), announced that they would switch again. The Cars Tokai team revealed on the *Racecar Engineering* website that it was developing an MC version of the Lotus Evora. As the Evora in production car form is mid-engined then the new GT300 car would have to be mid-engined, too. Yet while Dome had designed the tub to accept a mid-engine layout, nobody had yet attempted it.

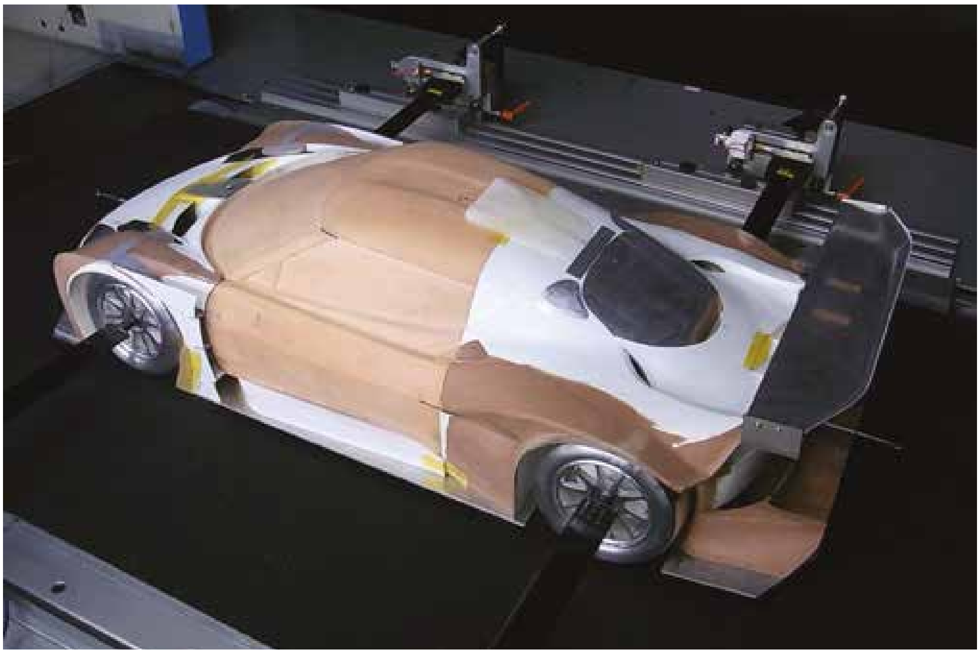
Takuya Yura's Mooncraft company, responsible for the Shiden run by Cars Tokai, was tasked with creating the most extreme Lotus competition car seen since the Bitter GT1. 'We looked around at some alternative models to base the car on which were not a midship layout, but we felt that for both commercial and engineering reasons the Evora was the best solution,' explains Shintaro Watanabe, the project's chief engineer. 'It has the best dimensions in terms of the base model and what we have to do within the technical regulations. The basic dimensions of our car are very similar to the production car, apart from the width, which is 100mm more.'

Like the GT500 'DTM' chassis, the Mother Chassis itself is produced jointly by partners, in this case Dome in Maibara, and Toray Carbon Magic, which took over and expanded Dome's composites business some years ago. Unlike the GT500 version, the GT300 tub does not feature any honeycomb core at all, and is made using a male mould on to which pre preg sheets are laid up. This approach cuts production costs significantly. But, as it was designed primarily for front-engined, rear-wheel-drive cars such as the '86, the team at Mooncraft had a bit of a challenge making it work for a mid-engined car.

'We did not just want to work with a European car like a GT3, we did that and did not enjoy it,' Watanabe says. 'We are a Japanese racing car constructor so the Mother Chassis was a natural choice for us. Making it all work

The 'Mother Chassis' GT300 Evora has shown promise but has yet to chalk up that first win. But with the level of engineering in this particular racecar it can only be just around the corner

## 'The biggest thing is that we have very good weight distribution and aero balance'



Design and aerodynamic work on the Evora started in April of 2014 after the mechanical layout of the car had been completed. A quarter scale model was prepared and tested in Mooncraft's own moving ground plane wind tunnel

Promoter GTA and Japanese racecer maker Dome jointly developed the Mother Chassis in a bid to counter the influx of GT3 machines into the GT300 class of Super GT. The Lotus Evora is the first mid-engined MC racecar

was a very difficult challenge. It's because the Mother Chassis was designed for a FR-car. It had some allowances for a midship layout so we did not have to do a totally new chassis like Honda in GT500, but we still had to work hard. Now we have an excellent chassis balance overall'.

## Racing heart

While with the production Evora the rear end houses a transversely mounted 3.5-litre Toyota V8 engine, the Mooncraft version is fitted with a semi-stressed longitudinally mounted GTA branded 4.5-litre Nissan VK45DE V8, the same basic engine found in most LMP2 cars. This is mated with a Hewland LLS 6-speed sequential transmission. 'The Mother Chassis rules do not give us the freedom to choose a transmission so we have to use that one, but our one has a magnesium casing to give us a bit better weight distribution, while the standard units have an aluminium casing,' Watanabe says. 'We have also used an AP Racing multi plate carbon fibre clutch rather than the Tilton unit used on the MC86, which is a metal design. This is again to save weight and give us better distribution.'

The rear suspension is carried partly on the transmission casing and partly on the bellhousing, and features a conventional layout with two spring damper units linked to the pushrods via bellcranks, a third element is also used. 'The suspension layout is not that special,' Watanabe says. 'It's a conventional double wishbone system, it's simple and is a basic layout, but it works. We selected Ohlins TTR dampers with Hyper coil springs based on our previous results using those products. Apart from those and the uprights, which are part of the Mother Chassis package, all the other parts are bespoke.'

At the front of the Evora GT300, the layout is similar to the rear with the dampers mounted vertically and the suspension members picking up on a front subframe.

The Mother Chassis components have initially been tightly controlled by GTA, though there is a plan to allow more freedom in future, something that many running this new breed of GT300 would welcome. 'At the moment we have to use a standard front floor, engine, basic transmission, ECU and other parts,' Watanabe says. 'But there are things like the ECU that have been decided, that we don't understand why.'

Somewhere in there is a Nissan VK45DE V8 – the engine also found in most LMP2 racecars. The rear suspension is carried partly on the transmission casing and partly on the bellhousing


One of the most distinctive features of the Lotus is its rear end and its exhaust exits – these suggest that the exhaust plume has some kind of aero influence

## LOTUS EVORA GT300

**Chassis**
GT300 'Mother Chassis' designed by Dome and GTA
Carbon tub is made using male mould on to which pre-preg sheets are laid up

**Dimensions**
4638 x 1946 x 1152mm
Weight: over 1100kg
Wheelbase 2750mm

**Engine**
GTA-branded 4.5-litre Nissan VK45DE V8 which gives around 430bhp
Normally aspirated

**Front suspension**
Conventional double wishbone system

**Rear suspension**
Conventional double wishbone system; mounted partly on bellhousing and partly on the transmission casing

**Transmission**
Hewland LLS 6-speed sequential gearbox with magnesium casing

**Clutch**
AP Racing multi-plate carbon fibre clutch

**Dampers**
Ohlins TTR with Hyper coils

**Wheels**
RAYS
Front: 18in/13J
Rear: 18in/13J

**Tyres**
Yokohama

**Brake system**
R Alcon 6-pod monoblock

**Lubricants**
Petronas

One of the areas of the car that Mooncraft is most proud of is its aerodynamic package, Takuya Yura has always developed distinctive looking cars which seem to work well aerodynamically. Design and aerodynamic work on the Evora started in April 2014 once the major mechanical layout had been completed. A quarter scale model was prepared and tested in the company's own moving ground plane wind tunnel. The results were encouraging and this was later evident on track.

'I think the old GT300 car, the Shiden, had a better L/D level but the Evora is evolving now. But like that car is very low drag for a good level of downforce. I suspect that it is the most efficient in the class now,' Watanabe claims.

One of the most distinctive features of the Evora is its rear end, and specifically its exhaust exits. These are placed in such a way that the exhaust plume clearly has some kind of aerodynamic influence, but on this topic Watanabe is cagey. 'It makes the air flow under the floor in a good way,' he says, without elaborating. There have been suggestions that Mooncraft is using the rear bodywork to create a low pressure area behind the exhaust exits and reduce back pressure in the pipes, though this is likely to be mere paddock patter.

## Long stints

On track, the Evora has had fairly mixed results and has yet to score a class win, though the Mother Chassis GT86 has only scored a single GT300 victory from more races, and that victory itself came as the result of benefitting from a chaotic set of pit stops under caution at Sugo (one well worth looking up on youtube to file under; 'Race strategy – how not to do it'). The Evora was seemingly on the way to a victory at another race when struck by an unexpected failure. The car has one stand-out characteristic in races, however, its ability to run extremely long stints, sometimes as much as 40 per cent longer than other cars in the class. This has the benefit of allowing the team to run its best driver in the car for longer (the second driver is a gentleman driver and not as fast).

'The biggest thing is that we have got very good weight distribution and aero balance and the set-ups we have can get the most life out of the tyres we run, but we also have other things that let us do it and those we keep a secret,' Watanabe says.

**The car has one stand out characteristic in races and that's its ability to run extremely long stints**

## Changing scene

Despite not winning a race in its debut season Watanabe is happy with what has been achieved with the Evora so far. But, like many who run the Mother Chassis, he has expressed concern over torsional stiffness of the chassis and in particular lack of power from the engine. 'Maybe the GT3 cars have over 500PS and the GTA V8 only has around 430PS, so we could do with a little more power perhaps,' he says. 'But this year we have had two pole positions and three fastest laps in the races, so in terms of pace I am satisfied. However, we have had lots of minor problems and some bad luck. I hope we will fix both over the winter.'

An upgraded MC Evora will race in GT300 this coming season but it will face very different looking opposition. Honda has confirmed that its CR-Z GT300 (built to the different JAF-GT300 rulebook) has been permanently retired. What will replace it is not clear though rumours of a GT3 specification NSX refuse to go away. Meanwhile, it seems likely that the popular Toyota APR Prius will also be retired, possibly to be replaced by a new Mother Chassis car. Also, many new GT3 cars are expected to raise the level of competition substantially, meaning the team at Mooncraft will have to work even harder for their results – and you can bet they are relishing the challenge.

The 2016 Super GT season starts at Okayama in early April.

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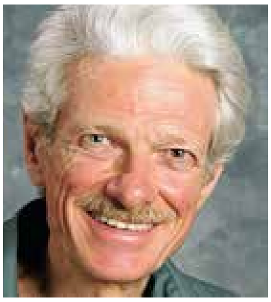

# Puzzling Polo's poor poise in quick turns

This month Mark Ortiz enjoys a Q&A with a baffled hillclimber

## Question

My car is a VW Polo GTI that I run in a lightly modified road registered hillclimb class. I use OEM GTI springs that are 15mm lower than normal Polo springs on the front. On the rear I have either the OEM 142lb springs or 130lb springs. The car has front (22mm) and rear (20mm) adjustable anti-roll bars both set to hardest setting. My non-adjustable front camber is - 3/4-degree and rear is - 1-degree.

I have seen pictures of my car coming out of tight corners and the inside rear has lifted. The car feels good in those corners and gets the power down well considering it has an open diff. The pictures also show that the front outside wheel is vertical. But in faster second and third gear corners when I'm trying to get power down the car is washing wide. I had thought that the lower 130lb rears were too soft and switching to the taller 142lb rears would get my elastic and geometric roll resistance up at the back and be the answer.

This was until I took a closer look at the pictures of my car when it was single wheeling. The inside rear which was well clear of the road surface appeared to have had to droop a long way before it could have detached. I'm thinking that on these more open corners maybe the inside rear on steady state cornering, or when getting the power down, is unable to leave the ground as the roll angle is less than when the car is in an uphill hairpin. The extra rear grip and more equal rear load sharing is exacerbating power-on understeer.

Looking at images of IRS FWD hatches showed that their inside rear only had small amounts of droop. To my mind they would be able to single-wheel much earlier than my car. So what is it with twist beam rear axles that governs how much the inside rear will droop? Is it twist beam torsional rigidity alone, rear spring rate/height alone, or a combination?

Lift is happening in tighter corners only because the car is pitching, which it wouldn't do so much in faster corners? I've fitted the stiffest aftermarket rear anti-roll bar that I can (which piggy backs the torsion beam) so I've reached the practical limit of adding more torsional rigidity into the twist beam. Stiffer rear springs will increase my rear roll resistance. If that forces me to soften off the anti-roll bar then isn't that just going to let the inside rear droop even more? I remember you said that twist beam and IRS rear ends behave very differently in terms of building forces on the outside wheel when single wheeling starts, and you also wrote about droop limiting cables. Does any of that apply here?

I'm only allowed mods located in factory positions. So I can uprate springs, dampers and anti-roll bars and make geometry changes. They allow my rear anti-roll bar when no OEM rear bar was fitted because it fits with the class. They baulked more at my rear shock tower cross brace, but allowed it.

I run road legal tyres and the hillclimbs I do last between 45-90 seconds. Since it's a grassroots class and I'm not exactly flushed with cash my front dampers are still OEM gas Sachs struts (MacPherson strut front end). I have (but have not fitted yet) some eccentric bolts that will allow me to shift each of the front wishbone subframes/cradles and eke out a little more than the factory camber and caster. Apart from the rear bar I have fitted Koni 'yellow' sport dampers w/ rebound adjustment, so I assume I have more compression damping in the rear which I would have thought would assist turn in and mid-corner, but not be enough to hurt exit. I have tried going back to stock dampers but it was worse. The rear Konis are oil damped.

To try to combat my understeer I even tried running Yokohama AD08Rs on the front only and street tyres on the rear. It worked very well on tight circuits but you could really feel the extra slip in the rear when speeds got up.

## The consultant

The rear Konis are non-pressurised? (Almost all shocks are oil damped). What setting are you using on the rebound adjustment? Can you get a larger diameter rear bar, or make one?

## Questioner

Regarding dampers, when compressed, they do not push back out. I'd assumed from that that they are oil damped. I guess they are non-pressurised then. The rebound damping is set to minimum which was Koni's recommendation (assuming their fronts were set to one turn out from minimum). The adjustments do work and have a marked impact on the rate at which you can pull the shaft out, so that side of things is working.

The rear bar is the stiffest I could find. It's 20mm and has three settings. It's on hard now. The twist beam is a U-channel. Could welding bridging strips across the open side of the beam torsionally stiffen the bar? Or could it be clamped in a few places across the beam?

While I have tried both the OEM and Koni dampers with the lowered softer rear springs, what I haven't done is try it with taller and stiffer OEM springs with standard dampers.

At the time that I upgraded the suspension with front and rear anti-roll bars I was already using the rear Konis. I only briefly swapped back to the OEM Sachs dampers at a test and didn't find an improvement.

**'In the faster corners when I'm trying to get the power down the car is washing wide'**

## Consultant

'Gas shocks' don't damp using gas. They use oil for that. The difference is that they use a trapped volume of pressurised gas to allow for the volume change inside the unit as the shaft moves in and out. This permits the full diameter of the unit to be used for the piston, and allows the unit to damp in both directions without needing a foot valve to prevent cavitation. The Konis and all non-pressurised shocks have an inner tube that has the piston in it, and a space between that and the tube. The outer compartment has some oil and some non-pressurised air in it, and oil flows into it through a valve at the bottom of the inner cylinder called the foot valve.

The reason I asked about dampers is that if you had stiffer damping in the rear, that could account for the car three-wheeling only in tight (hence short-duration) turns. But it doesn't sound like that's the case. So I'm not sure exactly why the car doesn't tricycle in faster turns. I've certainly seen Golfs/Polos


The hillclimb Polo looked at this month (not the racecar pictured) is good in the slow corners but not so hot in the quick

that do. You could just reduce front anti-roll bar stiffness and/or spring stiffness, but if the car rides bumps well enough now it would be better to increase rear roll resistance instead. You could do that by boxing the twist beam.

Making anti-roll bars isn't hard. A little diameter change does a lot. Stiffness varies with the fourth power of diameter. Going to 22mm would give you about half again stiffness as your 20mm bar. The most common material for solid ones is 4140 steel. You buy it in the normalised or annealed condition, heat it and bend it, and if you want flattened ends, beat those to shape on an anvil after heating cherry red. Drill holes as needed, then heat treat by hardening to full hard by heating and quenching, then tempering to similar hardness to your existing bar. In some cases you can get away with not heat treating. If the material is not sufficiently hard, it generally won't break but it will take a set when you corner hard or hit big one-wheel bumps. The car will handle differently in a right turn immediately following a left one or vice versa, and the readings on your wheel scales will be subject to mysterious large variations. If you see that, you should heat treat the bar. Rear ride height has very little effect on geometric roll resistance, although front ride height has a big effect on front geometric roll resistance. Rear ride height does have significant effect on anti-lift in braking, but this is not a concern.

Generally, when these cars are tricycling, the inside rear suspension is not at full droop. It is being held in partial compression by the twist beam and anti-roll bar. What I've said before is that droop limiting devices work somewhat differently on beam axles than on independent suspension. I was referring to ordinary beam axles, not twist beams as in the Polo. The VW twist beam is almost a pure trailing arm system with a built-in anti-roll bar, because the twist beam is almost at the front bushings. The twist beam provides about 25 per cent camber recovery in roll and a roll centre at about 25 per cent the height of the bushings. So changing the rear ride height an inch only changes the roll centre height about a quarter of an inch. If the beam were in line with the bushings, you'd have a trailing arm suspension. That system would have no camber recovery in roll and the roll centre would be at the ground regardless of bushing height. If the beam were on the axle line, you'd have a beam axle suspension. That would give 100 per cent camber recovery in roll, and the roll centre would be at bushing height. Changing rear ride height with that system would change roll centre height by an amount identical to the ride height change.

**If you had stiffer damping in the rear then that would account for the car tricycling only in tight turns**

## Questioner

Well if there is not a gross damping mismatch by having the Konis in the rear, perhaps I'll retain them and get front Konis as soon as I can afford them. I do have provision on my front anti-roll bar to go to a softer setting. I had moved away from this to the stiffer setting because in steady state cornering, the car had more understeer this way and was killing the sidewalls of the tyres, I assume because it was losing front camber. Going to the stiff front anti-roll bar setting gave the car a more planted front end but possibly at the expense of power-on understeer? I will explore a stiffer rear anti-roll bar like you advised.

If I've read rightly, the roll centre with my rear end will roughly be a quarter of the way up from the ground to the twist beam bush height? So I probably need to drop the idea that slight variations in rear spring/beam height is going to meaningfully affect geometric roll resistance – I should think of geometric roll resistance more or less as a constant considering what I use my car for, and then just think in terms of the effects that changes to elastic roll resistance might have. If I do add more rear elastic roll resistance with springs rather than more bar, that would have the side benefit of minimising squat when trying to power up a hill and help front end traction, wouldn't it?

The front is at OEM ride height that has the lower control arms and steering arms virtually horizontal to the ground. If I do lower the rear, does it inadvertently add small amounts of front caster relative to ground plane as the car is in a slight rear down attitude whereas OEM had it at a rear up? If so, is that a problem?

## Consultant

Reducing squat under power does not reduce rearward load transfer. If anything, we want the rear to squat, and prevent the front from rising, so that the c.g. will be as low as possible. However, the effect is very small, and simply lowering the car statically is just as good.

Lowering just the rear will increase caster. This may actually help. Lowering both ends a similar amount will have little effect on caster. Lowering the front does affect geometry adversely on a MacPherson strut suspension. In addition to the geometric roll resistance being reduced, camber recovery in roll gets poorer. However, the front will generally pick up a little static negative camber from lowering, which may help when the rules prohibit adding an adjustment or moving any points. The reduction in camber recovery and geometric roll resistance can be addressed with stiff springs and bars. Thus lowered and stiffened a car will generally be faster on smooth surfaces, but not ride bumps well.

It's worth considering using coil spring clamp/spreader adjusters. These can be used to either clamp adjacent coils closer together or spread them apart. This takes a coil out of action, which stiffens the spring. You also get a ride height adjustment that can be used to adjust diagonal percentage.

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

# Very best practice for viewing data

Our guide to viewing data and getting the best from analysis – sure to save you time in the pits and gain you time on the track

Data analysis software can be misleading if close attention isn't paid to how the data is being displayed within a plot. With this in mind, here's a few handy suggestions and tips you may wish to adopt that could save you from wasting valuable time deciphering data.

## Alarms

When looking at a screen that is full of data channels, checking that all of the channel values are within a safe range is a constant game of catch-up if you're just looking at traces or a list of numbers. Most software packages provide the ability to set alarm conditions for channels which help you monitor them easily, so that you can focus your analysis on performance without compromising safety. You will have to enable the alarms for your trace and set the minimum/maximum values you want to trigger the alarms. This can usually be found in the channel settings. What this will also do is provide you with an indicator on your trace as to where the alarm will be triggered. This has the auxiliary function of setting a datum for your channel should you need it (**Figure 1**). Certain channels, such as steering wheel angle, can take a positive or a negative value. It can sometimes be difficult to spot exactly where the angle passes through zero, from one polarity to another. This can be made distinguishable by utilising an alarm to set a reference point, in this case zero, so that it is clearly seen when the steering wheel reverses direction.

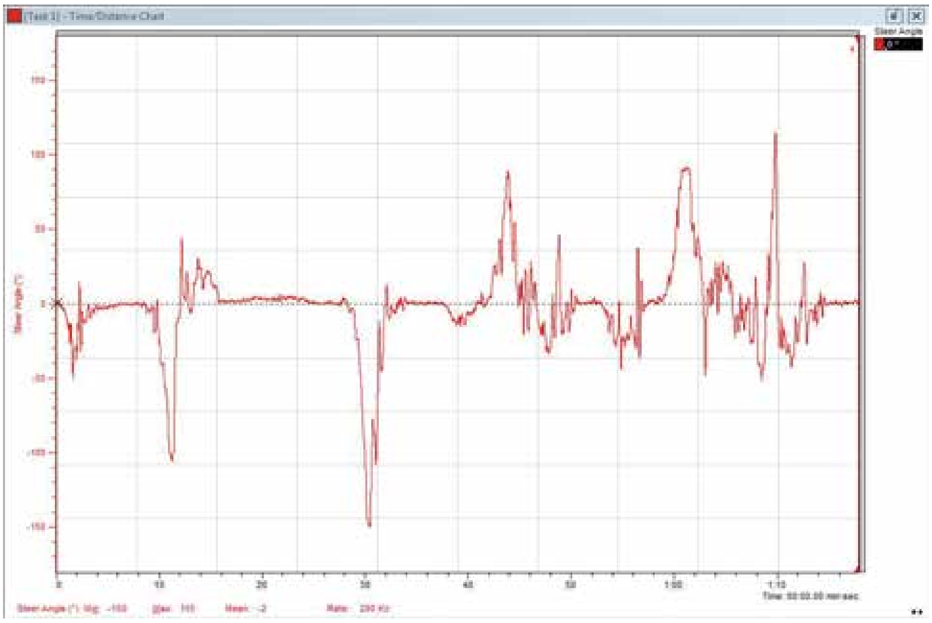

**Figure 1: Setting an alarm will also provide you with an indicator on your trace as to where the alarm will be triggered. This also has the auxiliary function of setting a datum for your channel in case you should need it**

## Lap Segments

A good indication of driver or car performance can be found from a lap-by-lap comparison of values at specific positions on the track. For example, adding a lap segment on a corner will allow you to identify oversteer and understeer throughout a corner and also enable you to determine the best lines through a corner for different track conditions. Setting your plot to only display the channel data from this segment will give you a close-up which will really help to speed up this process. By adding the throttle position and steering angle to the same

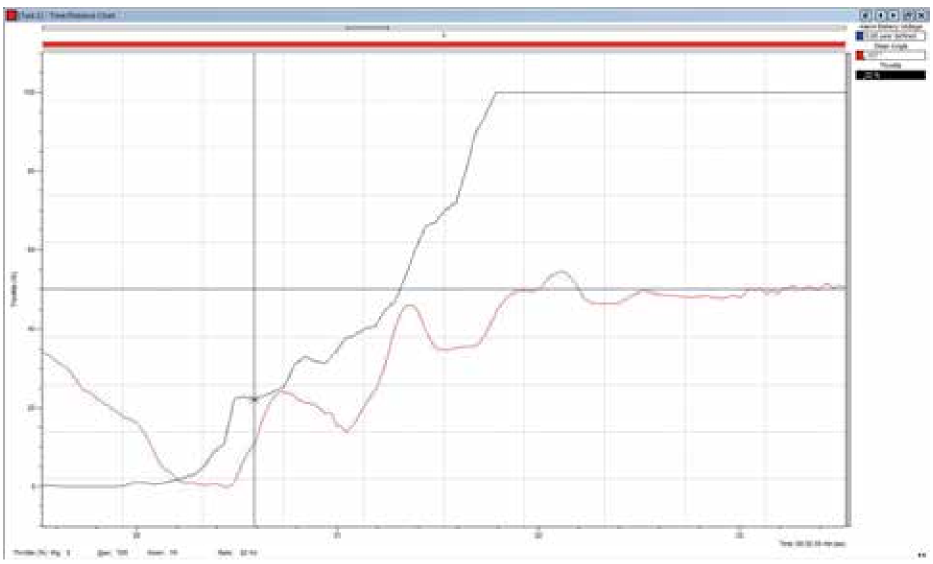

**Figure 2: Here it can be seen that during the exit part of the corner the driver is making steering corrections and also releasing the throttle momentarily and this suggests that the racecar is oversteering slightly**

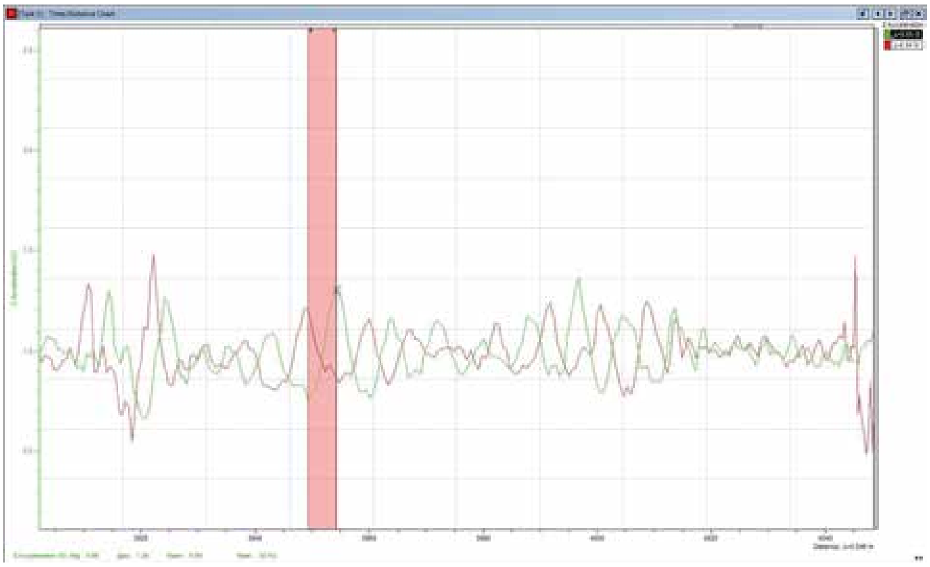

**Figure 3: At the end of the lap the distance channel has become offset from the other dataset due to lock-ups and wheelspin. This has resulted in the data being skewed by approximately five metres**

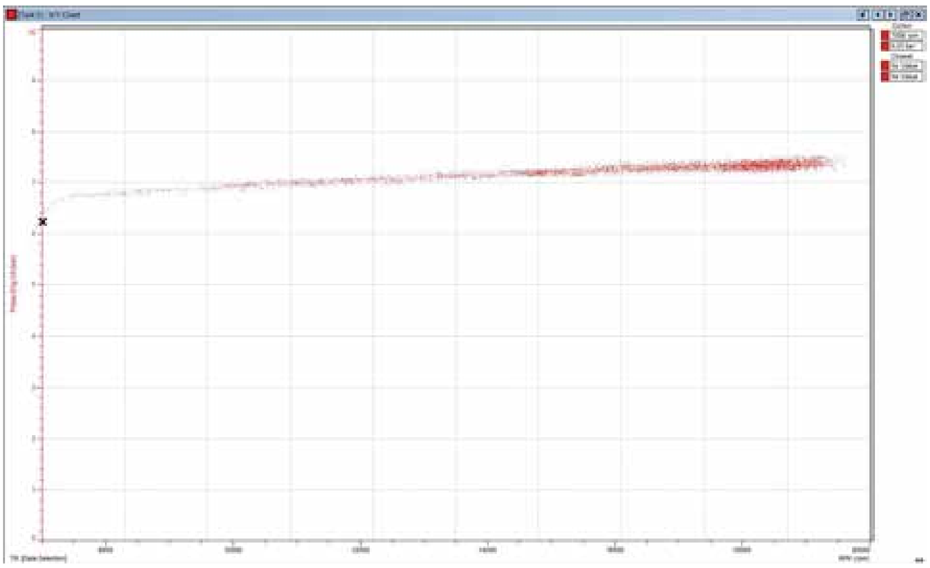

**Figure 4: An X-Y plot of oil pressure against rpm. Here you can clearly see a very strong correlation due to the narrow grouping of data points. This is a good indication that you're working with a healthy car**

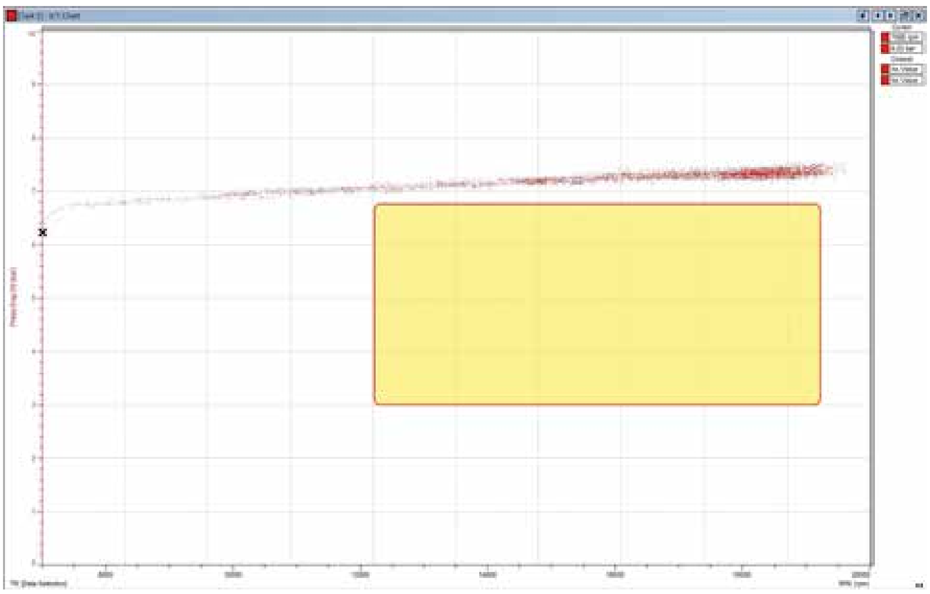

**Figure 5: the same plot as above but where a drop in oil pressure at higher rpm values indicates an engine problem. This would show a dispersion of data points underneath the trend line in the area highlighted**

trace you can spot whether the driver is applying the throttle too early or late into the corner. Similarly, he may be straightening the car out of the corner too late or early. Both of these possibilities will be easy to spot on the trace by identifying where the change of direction of the steer angle and the re-application of the throttle occur in comparison to each other. In **Figure 2** you can see that during the exit of the corner the driver makes steering corrections and releases the throttle momentarily, suggests the car's oversteering.

## Data alignment

When comparing data from different drivers and outings, care must be taken to ensure that the datasets are properly aligned. At a first glance the traces may appear to match up, but one way to be certain of this is to use the vertical acceleration of the car. When the car experiences wheelspin or a lock-up, the distance channel will become slightly skewed as the angular velocity of the wheel that is used to produce the distance value does not match the true distance travelled during these periods. The vertical acceleration, on the other hand, cannot be affected by anomalies such as these. By carefully examining the vertical acceleration across different laps it is possible to identify a noticeable bump or hole in the track that produces a small spike in the trace. Manually aligning the two traces at this spike by applying an offset to one dataset will ensure that the data you are looking at is at the exact same track position for both datasets. In **Figure 3**, you can see a perfect example of this. Towards the end of the lap the distance channel has become offset from the other dataset due to lock-ups and wheel spin. This has resulted in the data being skewed by approximately five metres, which could make a significant difference to how the data is interpreted for instances such as braking points.

## Data Correlation

X-Y plots can be a useful tool in determining correlations between car parameters and whether or not there is substantial deviation. As a data engineer, one of your fundamental duties is to check for any issues in reliability and X-Y plots can be particularly helpful in doing just that. **Figure 4** below is an X-Y plot of oil pressure against rpm. Here you can see a very strong correlation due to the narrow grouping of data points. This is a good indication of a healthy car. A performance issue could be spotted here if the data points had a greater spread. Typically with this example, a drop in oil pressure at higher rpm values indicates an engine problem. This would therefore show a dispersion of data points underneath the trend line in the area highlighted (**Figure 5**).

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# LMP3 ride height and yaw angle

The final instalment in our Ginetta P3 aerodynamic study

A new category in 2015, with new technical challenges, not least on the aerodynamics front, LMP3 has tempted some well-known and respected constructors into involvement, and we have been privileged to closely study one of them. The Ginetta-Nissan LMP3 car came into the MIRA full-scale wind tunnel with us last summer and we saw in our November 2015 issue that there was a good correlation on aerodynamic balance between the set-up found in prior track testing and in the wind tunnel.

The regulations for this new category mandate less powerful rear diffusers and wings than can be used in LMP2, and as a result the Ginetta initially needed more rear end downforce, which was achieved with large Gurneys on the wing and rear deck, in order to obtain an acceptable aerodynamic balance. Combinations of single and twin front dive planes were investigated in the December issue and we saw once more that dive planes can be very potent balance adjusters, although the actual responses to dive plane changes were different to similar cars we have investigated. This month we'll examine the responses to ride height and yaw angle changes.

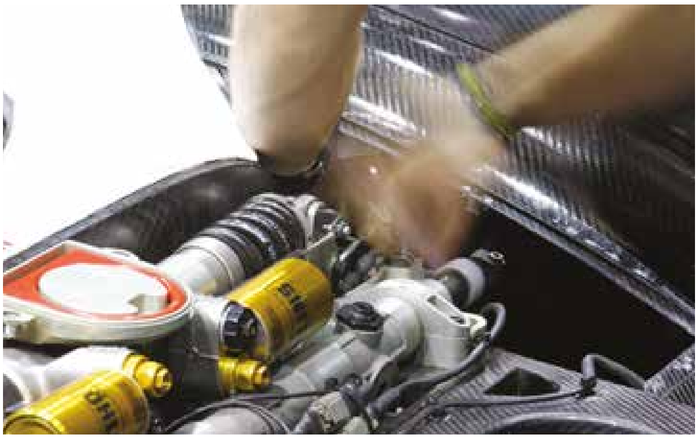
## Perfect pitch

Time constraints meant only a small matrix of changes was evaluated, but by concentrating on increments either side of baseline static settings the team was able to get a good idea of responses across a representative ride height range. Results are shown in **Table 1** as changes (Δ or 'delta' values) in 'counts' (where one count = a coefficient change of 0.001) relative to the baseline set-up, which had the front 10mm lower than the rear. The change in %front is absolute rather than relative.

Dropping the front by 10mm produced the expected increase in total downforce, most of which accrued at the front, and with the small reduction in drag this gave a significant increase in efficiency (-L/D). Raising the rear by 10mm had a similar but smaller effect on overall downforce and balance but, with a small increase in drag, the efficiency gain was not as great.

Lowering the rear by 10mm made the flat bottom horizontal and caused a loss of downforce, the majority of which was at the front. Despite the reduction in drag, efficiency was worse. And finally, dropping front and rear by 10mm caused a very small net gain in total downforce, with front end gains almost equalled by rear end losses. This therefore produced another significant shift in balance to the front. The reduction in drag also meant this was quite an efficient change. However, it


Last month we experimented with different dive plane combinations on the Ginetta LMP3 to help adjust its balance. Now we're looking at ride height and yaw angle



Dropping front ride height on suspension pushrods resulted in an increase in downforce

**Table 1 – coefficient and balance changes with ride height changes, relative to baseline**

| FRH | RRH | ΔCD | Δ-CLfront | Δ-CLrear | Δ%front | Δ-L/D |
|---|---|---|---|---|---|---|
| -10mm | - | -6 | +164 | +7 | +7.34% | +373 |
| - | +10mm | +12 | +68 | +21 | +2.70% | +120 |
| - | -10mm | -16 | -70 | -40 | -2.70% | -150 |
| -10mm | -10mm | -23 | +73 | -57 | +5.62% | +146 |

**Lowering the rear by 10mm made the flat bottom horizontal and caused a loss of downforce**

Raising the rear ride height had a similar but smaller result to dropping the front


The car's dive planes affected its response to changes in yaw angle in some very interesting ways – the Ginetta was tested with and without the dive planes in place

The Greaves Motorsport Zytek LMP2 had a broadly similar front end to the Ginetta (twin dive panes and similar front splitter) and responded like the LMP3 in yaw

The Ginetta has proven itself do be a neat racecar which responds well to aero tweaks

**Table 2 – the effects of yaw angle with dive planes fitted**

| Yaw angle | ΔCD | Δ-CLfront | Δ-CLrear | Δ%front | Δ-L/D |
|---|---|---|---|---|---|
| 30 | +1 | +10 | +21 | -0.23% | +57 |
| 60 | +2 | +34 | +33 | +0.50% | +124 |

**Table 3 – the effects of yaw angle with no dive planes**

| Yaw angle | ΔCD | Δ-CLfront | Δ-CLrear | Δ%front | Δ-L/D |
|---|---|---|---|---|---|
| 30 | +2 | -7 | +9 | -0.70% | -2 |
| 60 | +4 | +55 | +7 | +2.90% | +110 |

must be stated that the wind tunnel's fixed floor (and stationary wheels) will undoubtedly have influenced all these data, and perhaps this last point especially.

These ride height changes were tested in 'steady state' conditions. On track the car will be dynamically moving throughout the range covered here and quite possibly beyond, so the type of aerodynamic changes we saw here will happen dynamically, although the responses in transient situations will not necessarily be the same as in our steady state runs.

## Yaw move

A number of different configurations were run across small yaw angles to gauge whether any significant coefficient or, especially, balance changes occurred. For expediency just two yaw angles were run, three degrees and six degrees, in addition to straight ahead.

Let's look at the car's responses to changes of yaw angle with and without dive planes. **Tables 2** and **Table 3** respectively show the changes with and without the dive planes, relative to the straight ahead configuration, and there were some rather interesting similarities and contrasts.

First, we can say that drag changed very little in either case as yaw angle increased, although there was a very slight increase with each yaw increment. Second, in both cases there was a small shift in balance off the front with the first three degrees of yaw which reversed in both cases at six degrees to a shift on to the front. But that's pretty much where the similarities end because the details of those responses were rather different.

Looking at the three-degree yaw case, with dive planes present we saw an increase in downforce at both ends of the car, although more so at the rear to produce the small shift in balance to the rear.

However, with no dive planes present on the car, three-degrees of yaw produced a slight loss of front end downforce and a small gain at the rear, with therefore barely any change in total downforce but a slightly bigger balance shift to the rear.

At six-degree yaw, with dive planes present, there was an almost equal increase in front and rear downforce that produced a small increase in %front, whereas without dive planes there was a fairly significant increase in front downforce and only a very small increase in rear downforce, leading to a bigger increase in %front. Perhaps the most important conclusion from this is that, with dive planes present, there was less change in aerodynamic balance as yaw angle was introduced, and this would hopefully translate once on to the track as a more benign car that did not alter significantly its balance on corner turn-in.

As to the exact mechanisms by which these similarities and differences arose, we can only speculate; the wind tunnel simply reports the changes in forces at the tyre contacts, and there are numerous interactions that could be responsible for the changes we saw here. But back in 2012 when we studied the Greaves Motorsport Zytek LMP2, we saw a very similar pattern of that initial drop in %front at small yaw angles (two-degree and four-degree) which then reversed as yaw was increased slightly more to six degrees. Given that the Zytek and the Ginetta featured broadly similar front ends (twin dive planes, generically similar front splitter/diffuser), perhaps the similar responses should be expected.

**Next month** we will move onto another new project in the MIRA full-scale wind tunnel.
*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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# **Dark side** of the force

## Having developed a successful low downforce aero package to spice up the racing for 2016, NASCAR has now turned its attention to sideforce

**By ERIC JACUZZI**

In the wake of two great races at Darlington and Kentucky, which both used a lower downforce aerodynamics package, the verdict has been unanimous in favour of reduced downforce for the future of the NASCAR Sprint Cup Series. With increased chassis response to changes, softer tyres, and reduced corner speeds, it seems that this is the recipe for improved stock car racing. Drivers appreciate the difficulty of driving the cars while the fans get to watch their struggles in attempting to control racecars while racing around a walled oval with 42 of their rivals.

However, as any research and development team knows [Jacuzzi is an aerodynamicist at NASCAR], the opportunity to rest and take in the scenery is fleeting. By the time the cars take to the track in 2016, NASCAR R&D will be over a year into developing the next aerodynamics package, aiming to build on the success of the low downforce package and hopefully take it to the next level. The target improvement area is a unique aero parameter to stock cars that primarily turn left: side force, or lateral aerodynamic force. Sideforce has been an integral part of stock car aerodynamics for at least the last decade, but up until now it has not been seriously questioned.

Yet while the Sprint Cup Series is the king of R&D expenditure and effort, the NASCAR K&N Pro Series laid out the beginnings of the sideforce investigation. Late in 2014 the aerodynamics team was asked to assist in suggesting the aerodynamic performance level necessary for a new composite-bodied car to be competitive with both older cars as well as a rival series, the ARCA Series. This involved wind tunnel testing separate variants of current K&N Series racecars along with a current

The 2015 Darlington Sprint Cup counter featured retro liveries on many cars, but also gave us a glimpse into the future as the downforce package used is to play a big part in the 2016 season

## The driver is in some state of balancing the car for almost half a lap

ARCA car to establish performance baselines. Modifications were then made to the front valence, underbody pans and rear spoiler of the new composite body racecar to achieve the appropriate drag/downforce balance to make the car competitive.

In speaking with the teams who ran the cars, an interesting titbit of information was revealed about skew. For those outside of the stock car world, skew is the ability to pre-yaw the body of the car relative to the path of the vehicle, thus generating substantial lateral force on the front and rear of the car. The front and rear split of sideforce creates a yaw moment on the vehicle, with a stabilising (and faster) yaw moment being positive, or clockwise when looking down from the top of the vehicle.

Axle skew is what leads to the appearance of the car to 'crabwalk' when it goes down the straight. One K&N crew chief confided that he could pre-yaw the car in this manner to a high degree, thus generating substantial sideforce and a fast single car lap time. However, this set-up was so poor in traffic that the team found they had to intentionally limit how far they went with skew to avoid being pinned down in traffic, unable to pass. The amazing revelation to us was that this occurred at the relatively low speeds of the K&N Series cars relative to NASCAR Sprint Cup cars.

## Days of yaw

There were also indications from the NASCAR Camping World Truck Series that all was not right with sideforce. With their long truck beds and high amounts of body asymmetry achievable within the regulations, the trucks are capable of massive amounts of sideforce and very high yaw moments. However, there have been strange interactions between trucks during passing manoeuvres, some of which are severe enough to cause a spin. Avoiding these areas has become necessary learning for drivers in the series. Again, it is another piece of evidence that led us down the path of investigating sideforce more deeply.

While all cars in yaw make sideforce, the unique phenomenon of long banked corners leads to sideforce and yaw moment playing a huge role in the driver's feel of the car. At a 1.5-mile intermediate track in a low downforce configuration, the start of braking to the end of throttle modulation on corner exit can last up to 700 metres, repeated twice per lap. Thus, cornering is nearly 50 per cent of the lap distance, meaning the driver is in some state of balancing the car for almost half of the lap.

My favourite mental image of the driver and car balancing the tyre and aero forces was taught to me by Dr Eric Warren of Richard Childress Racing. If we froze the car at any point in the centre of the corner, imagine the car on a sheet of ice. If we walked on to the track and pushed our hand into the left rear quarter panel, the tail of the car would rotate toward the wall and the car would spin in a counter-clockwise

Figure 1. Total sideforce magnitude variation of trailing car versus lead car. Sideforce variations in traffic appear to be quite substantial

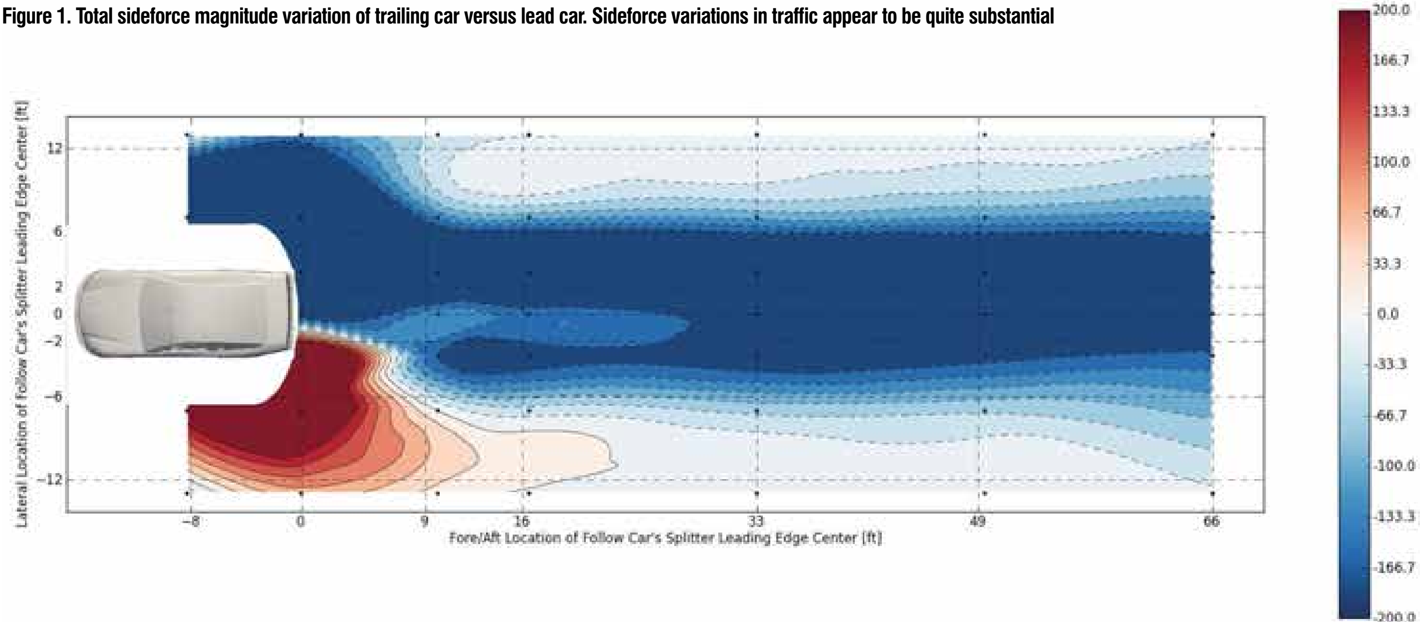
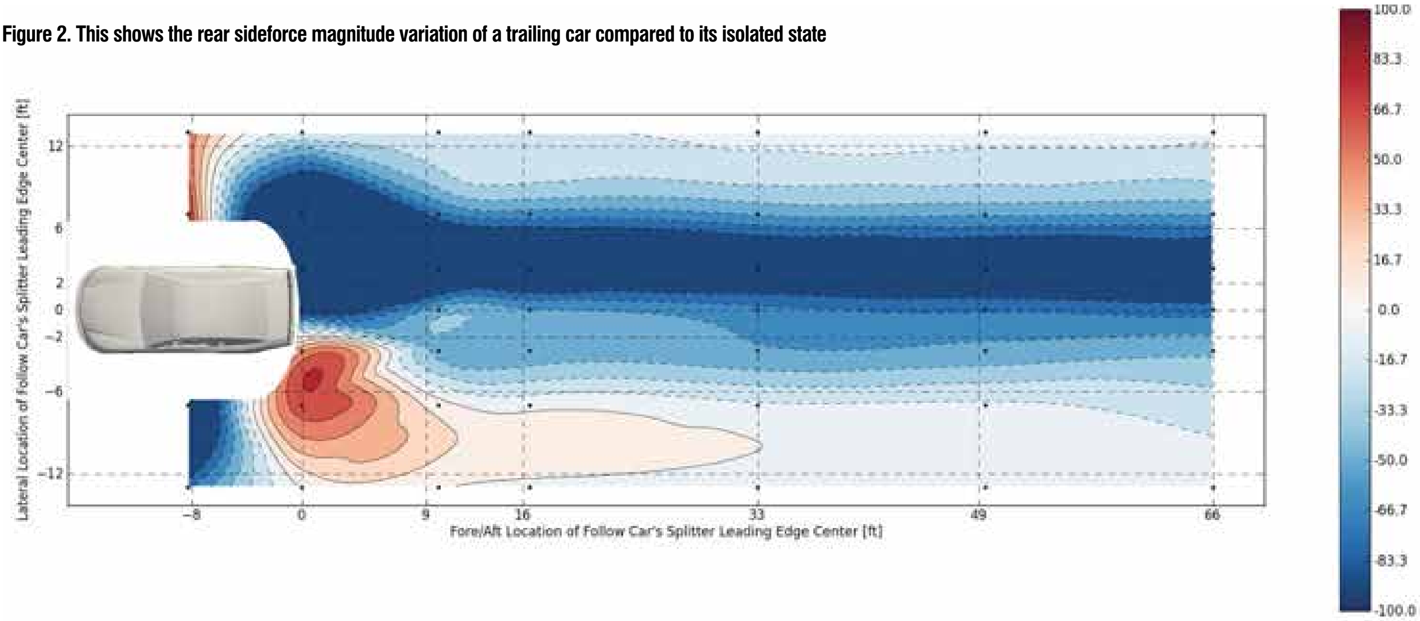



Figure 2. This shows the rear sideforce magnitude variation of a trailing car compared to its isolated state




fashion. Likewise for pushing our hand on the left front fender – the nose of the car would head for the wall. The key to our mental scenario is that the driver has balanced the car so that there is nothing left to accommodate any changes in performance – all aero and mechanical cornering ability is being used up. In reality, there is always some margin, although the best drivers are as close as possible to 100 per cent for lap after lap.

A further thought exercise is to think of the driver during this state. The driver is balancing the car in cornering at the limit for several seconds, transitioning from corner entry braking, to off-throttle apex cornering, and then blending lateral and longitudinal acceleration with the throttle and steering on corner exit. All of the inputs into the car performance — tyre forces via mechanical and aerodynamic downforce, sideforce on the front and rear of the car — are summarised into the seat of the pants feeling of the car's tendency to rotate either clockwise or counter-clockwise. This means that if the car is neutral throughout the corner, it has no tendency to rotate in either direction, and exceeding grip would result in a purely lateral slide.

## Lateral force

The reality is that this condition is unlikely given the demands of the three main cornering phases. A car could be neutral at the centre of the corner, but tending toward oversteer on exit (rotating counter-clockwise or loose), while on entry it may tend toward understeer or tight conditions. Since Sprint Cup cars have in excess of 750bhp, corner exit and early throttle input tend to dominate lap time performance. But how does this play into aerodynamic forces in traffic situations?

Sideforce acts directly laterally on the body of the car. It is not transmitted through the tyres like downforce. Downforce acts on both the body and underbody of the car. Typical spring rates are between 2000 to 5000lbf on the front corners, while the rear axle can be as low as 100 pounds or as high as 2000 pounds. The actual spring rate of the rear axle is complicated by bump stops, coil binding etc. Typically, in traffic situations, CFD and track testing has shown that body lift on the greenhouse is reduced by the decreased airspeed from being in traffic. However, the greenhouse is constructed of lightweight sheet metal that can deform noticeably under aero loading. So how much of this is downforce, and how rapidly it is transmitted to the contact patch of the tyre is

**Sideforce has been an integral part of stock car aerodynamics for at least the last decade, but up until now it has not been questioned**

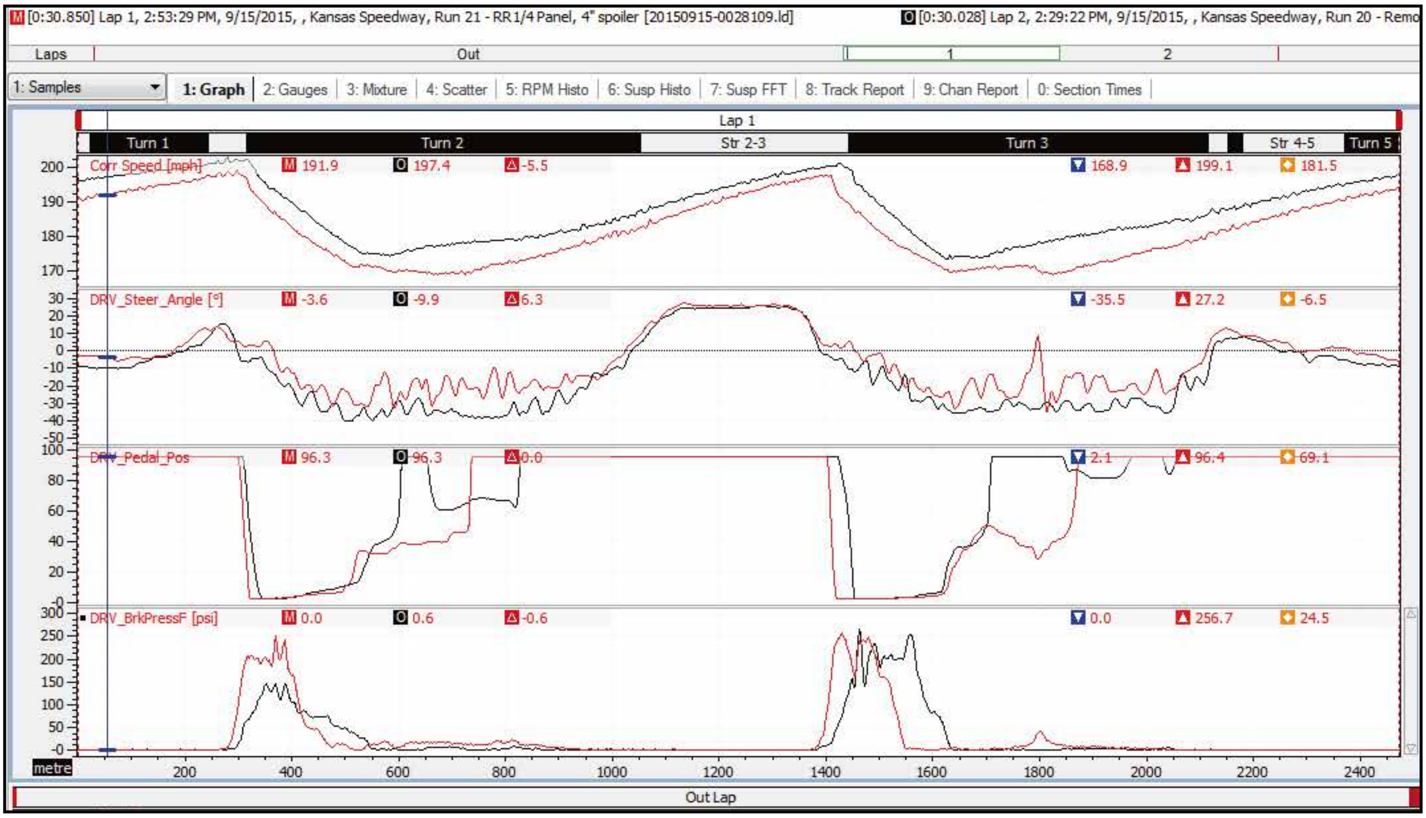



Figure 3. Fastest lap data from NASCAR X-3 test car in Kansas. The black trace represents the baseline run while the red trace is the car with reduced sideforce

**Table 1: Wind tunnel comparison of Kentucky low downforce and high drag aero parameters**

| Car | Package | Total DF (lbf) | Front SF (lbf) | Rear SF (lbf) | Total SF (lbf) | Yaw Moment (lbf-ft) |
|---|---|---|---|---|---|---|
| Average data | Low Downforce | 1731 | -236 | -304 | -540 | 311 |
| | High drag | 2264 | -208 | -411 | -619 | 934 |
| | %Change | 30.77% | -12.13% | 35.20% | 14.50% | 200.64% |

debatable. One thing for certain is that there seems to be a latency that is difficult to quantify, except on the splitter. Because of its position forward of the centre of gravity of the car, and its high downforce production, drivers are very sensitive to splitter variation in terms of ride height or traffic conditions.

Sideforce variation in traffic appears to be quite substantial, as shown in **Figure 1** and **Figure 2**, with swings of over 200lbs possible even at multiple car-length trailing distances. This has a corresponding impact on the instantaneous aerodynamic yaw moment of the car. The main question is, how do losses in downforce and sideforce translate into time on the track? Let's review some single car data from our September tests at Kansas Speedway to assess real-world sensitivity to both.

Increases in downforce are observed to decrease lap time on track in a predictable manner. At almost any overall starting downforce magnitude for a Sprint Cup car, a good rule of thumb is that 100lbf of downforce yields a 0.1 second lap time decrease on a 1.5 mile track. Downforce is the biggest number, whether in the low downforce configuration (1700lbf) or current 2015 specification (2700lbf). But how sensitive is sideforce?

Recently, we tested a low downforce, low-sideforce car at Kansas Speedway. The car was deliberately designed to be able to remove the tail offset from the car, lowering rear sideforce by approximately 105lbf, with downforce decreasing by approximately 110lbf. On track, this should have resulted in approximately one tenth of second lap time lost based on our rule of thumb, excluding the sideforce change. So it is a fair test of the effect of sideforce on lap time. The results, however, repeated over two separate runs, show that the lap time loss was closer to 0.7 seconds a lap. A 105lbf rear sideforce decrease resulted in six-tenths of a second loss on track when separated from the downforce loss! This is a massive loss in lap time that was not expected. Data for the fastest lap of each of the configurations is shown in **Figure 3**.

## Wild fluctuations

Of course the argument can be made that, were we to adjust the car to this new condition, we could certainly improve it and cut the time loss. That is for certain. But in traffic conditions the aerodynamic sideforce is fluctuating wildly – there is no mechanism to adjust the car to respond instantaneously. The rapid transient changes in sideforce lead to an unpredictable car, reducing the driver's ability to confidently corner at the limit and get back on throttle. This leads to a growing gap to the car in front until predictability returns. Quite simply, there is no way to instantaneously accommodate for these fluctuations and for the driver to know what the car is capable of at that instant. The only option is to proceed with caution.

In the October issue of *Racecar Engineering,* I discussed the failings of the high drag package that we raced at Indianapolis and Michigan. The intention was to create more slipstream opportunities to pass down the straights, while holding downforce to a similar level to the current 2015-spec car. Unfortunately, handling issues superseded the improvement in drafting. At Kentucky and Darlington, a low downforce package was utilised and both races were a success. The biggest thing we learnt from these divergent paths was just how poorly the High Drag package handled when in traffic. Drivers were complaining of nearly spinning on the straights when they got behind another car. How could the car be so bad, when we had only added 1in more spoiler and a Gurney flap as opposed to the 8in spoiler we raced throughout 2014? More tellingly, drivers were very specific that the car was constantly loose in traffic (oversteer). Generally, there is a mix of comments on traffic behaviour – understeer,

## Sideforce acts directly laterally on the body of the racecar. It is not transmitted through the racecar's tyres like downforce

X-3 test car at the Windshear wind tunnel. The car was developed by NASCAR in conjunction with Richard Childress Racing

The X-3 features a raised splitter centre section to reduce ride height sensitivity, while it's also fitted with shorter side skirts

The symmetric spoiler and quarter panel. Lack of tail offset substantially decreases yaw moment and overall sideforce

oversteer, both etc … But in this case, it was unanimous that the racecar was loose.

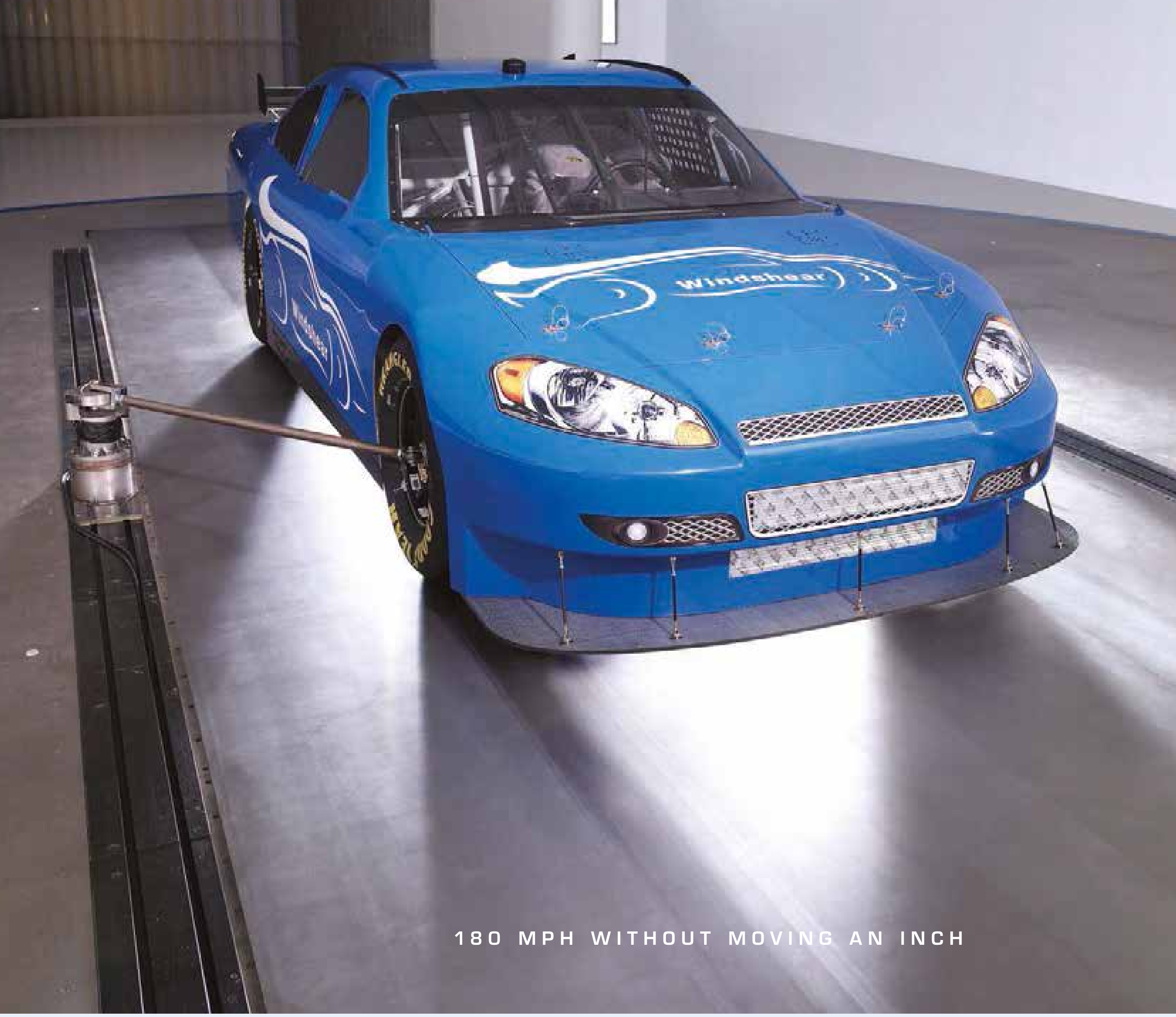
We then directly compared the two packages. **Table 1** is actual wind tunnel data from the development work on the High Drag package. The cars were impounded after the Kentucky race, baseline tested as they were raced, then modified to the High Drag specification (9in spoiler, 1in wicker, 43in radiator pan, and tail extension). While downforce is 30 per cent greater with the High Drag package, it is still lower than what we currently race in 2015 at present. So we can safely eliminate downforce as being the culprit.

## Yaw and disorder

There are two culprits left that reared their ugly head. The effect of adding so much drag to the spoiler at the rear of the car, working in conjunction with the deck-lid fin (used to prevent lift-off), caused the rear sideforce to increase on average 35 per cent, while reducing front sideforce by 12 per cent. Additionally, inherent to the car design is a 4in tail offset to the right, meaning the spoiler is not actually centred on the car. It is instead shifted to the right. Thus, the centre of pressure of the spoiler is to the right of car centreline. This led to an increase in yaw moment of 200 per cent when compared with the same cars in the low downforce configuration, shown in **Table 1**. Now we're on to something.

The obvious question is; why did we still proceed with the package if this was the case? The honest answer is that the effect of sideforce and yaw moment had never been studied in such a stark comparison. When the Generation 6 Cup car was being developed, the Car of Tomorrow (COT) racecars were used as an aero benchmark to match. By the end of the COT era, teams had learned to work with NASCAR's inspection templates to such a degree that they were able to successfully pass body inspection with the tail a full 2in further to the right than when the car first appeared! Teams discovered the key to speed on track was sideforce rather than downforce. The first teams to discover this had a distinct advantage, and it led to cars that noticeably looked different than a car that was designed strictly around downforce.

With NASCAR set to embark on the low-downforce route, cutting downforce to approximately 1700lbf at 200mph for 2016, work has begun on improving the cars for 2017. Work started in late 2014 on a reduced downforce/sideforce car, to assess what was possible and whether any benefit could be found. After several months of CFD and design, NASCAR partnered with Richard Childress Racing to build and test a prototype car dubbed


180 MPH WITHOUT MOVING AN INCH
Windshear

# Changes involved in reducing sideforce included a raised splitter centre section, shorter side skirts, and a symmetrical tail with central spoiler

the X-3. The car is capable of running in both the standard tail offset configuration and a symmetrical rear section. Along with reduced downforce, the car also features a substantial reduction in sideforce, shown by comparison to other recent rules packages in **Figure 4**. The changes involved in reducing sideforce include a raised splitter centre section, shorter side skirts, and a symmetric tail with centred spoiler. The lack of tail offset and corresponding spoiler offset substantially decreases both the yaw moment and overall sideforce magnitude.

Another interesting thing learnt from the Kansas test was the effect of yaw moment and what is referred to as the crossover point. In simple terms, this is the point at which the aerodynamic yaw moment goes to zero – when it crosses the horizontal axis. A positive yaw moment (clockwise in the Z-axis if you're looking down from above the car) is a stable condition, correcting the tail of the car from spinning out when entering a left hand turn.

Typical slip angles at maximum lateral acceleration are between three and four degrees. Most cars with the 2015 intermediate track package have a crossover point in excess of six degrees, while the 2015 low downforce package has a crossover point around five degrees. This is important because it means the driver is within the margin of the crossover point and not exceeding it. This allows an arcing corner entry and thus higher speeds than would be possible without sideforce. It also means sideforce is a critical component of the corner process, and makes the car easier to drive.

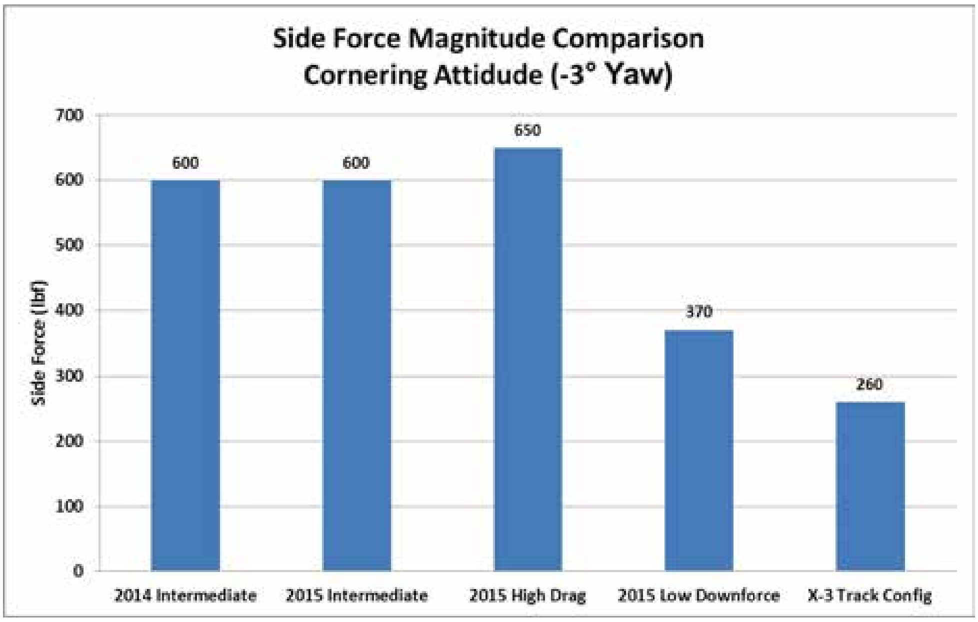



**Figure 4. Sideforce magnitude comparison between the X-3 and some of the more recent NASCAR aerodynamic packages**

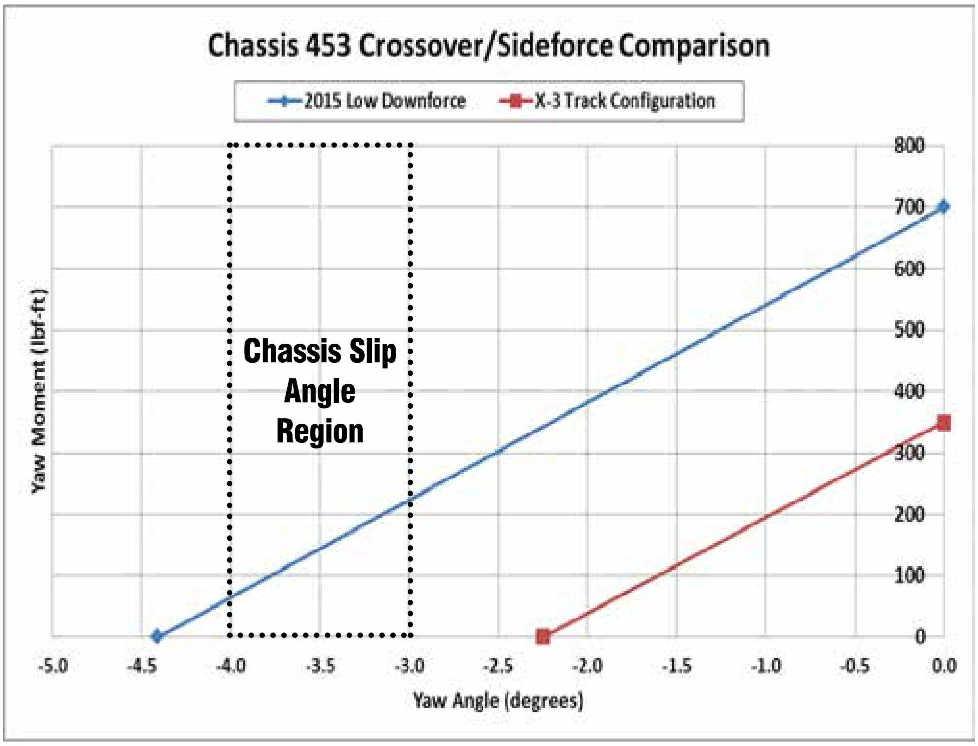



**Figure 5. Yaw moment and crossover point comparison showing the difference between 2015 car and the X-3 test vehicle**

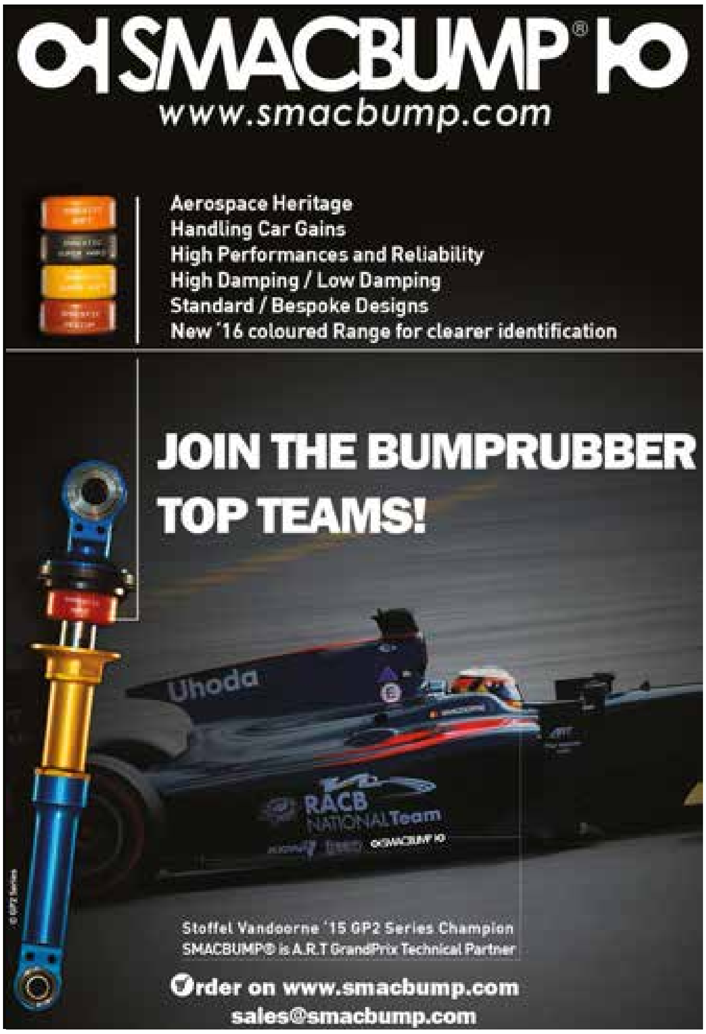
## Pushing the limit

Since we know a high crossover point allows the car to yaw more and generate more sideforce, a knock on effect is that it promotes teams to push the limit on axle skew to gain speed. While this practice had been reined in with tighter suspension regulations, there are well-known (if illegal) methods to gain skew on track. A car with a low crossover point eliminates the effectiveness of this tactic completely, since there is no point in pushing the body yaw angle any higher than it would naturally attain at peak tyre cornering slip.

The yaw moment of the test car is plotted in **Figure 5,** showing the difference between the car with the current tail configuration and with the body made symmetrical. An interesting thing to note is that the preferred on-track configuration by drivers Austin Dillon and Bobby Labonte featured the car with a crossover point in this region. The original design target was a 3.5-degree crossover point, but both drivers noted that they felt like the car was more predictable if the sideforce was not a factor in the corner at all. This is precisely what we get with a low crossover point.

With a successful first track test at Kansas, further revisions to the car are underway. These include further body and underbody changes meant to reduce the sideforce level and tune the downforce upper limit to around 1500lbf. The team will visit Homestead-Miami during the Goodyear tyre test scheduled for mid-December to evaluate these changes in isolation, and then run the car in traffic with other cars at the test to evaluate traffic performance. While the other cars at the event will not be of the same specification as the X-3, it will still provide a suitable aerodynamic evaluation of whether the reduced sideforce level and lack of driver dependence on it will lead to more consistent cornering performance.

So while the NASCAR industry enjoys its well deserved holidays after the 2015 campaign, the Research and Development team will be hard at work preparing for the sport's future – and hopefully the best Sprint Cup racecar we have ever put on a race track.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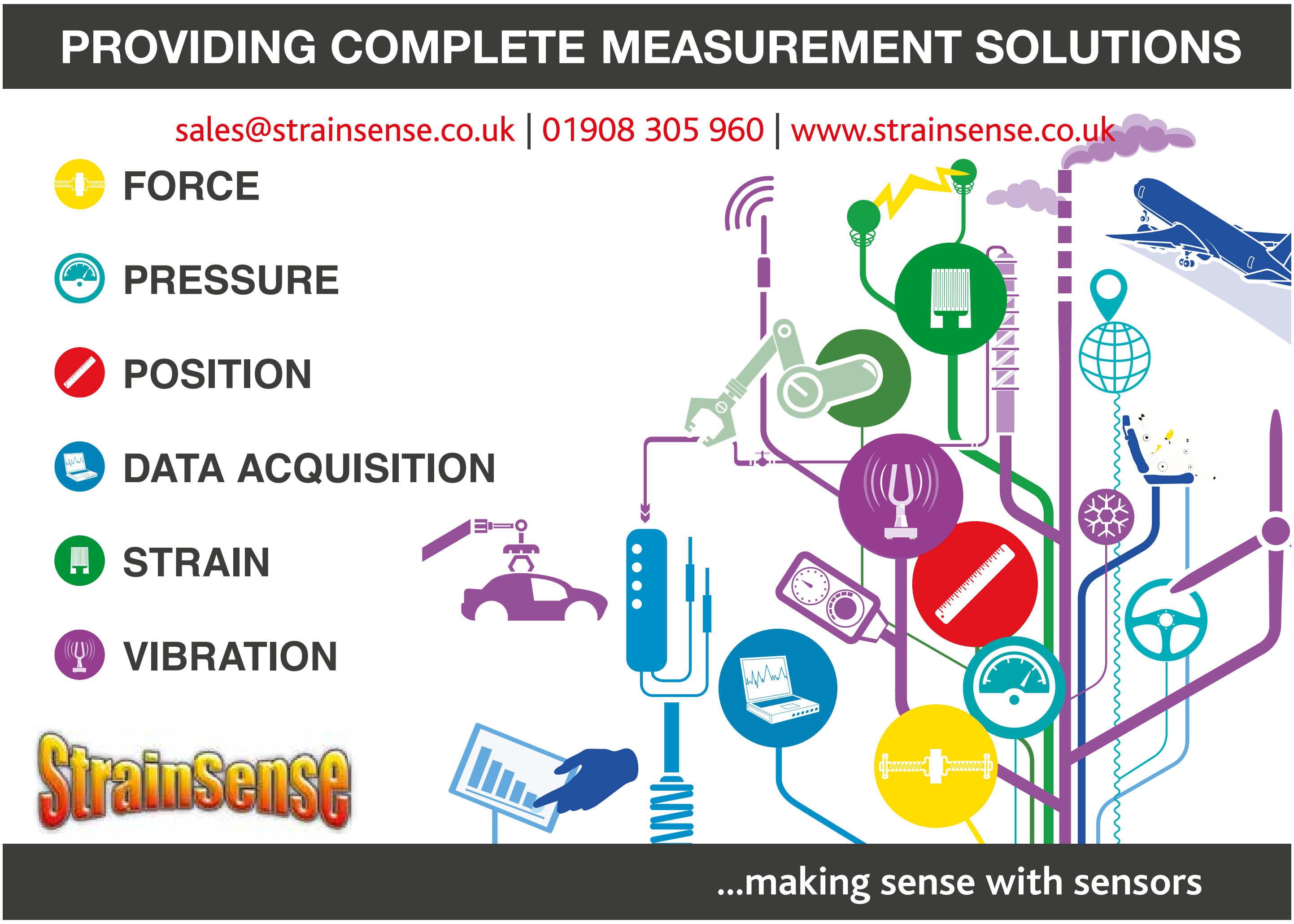
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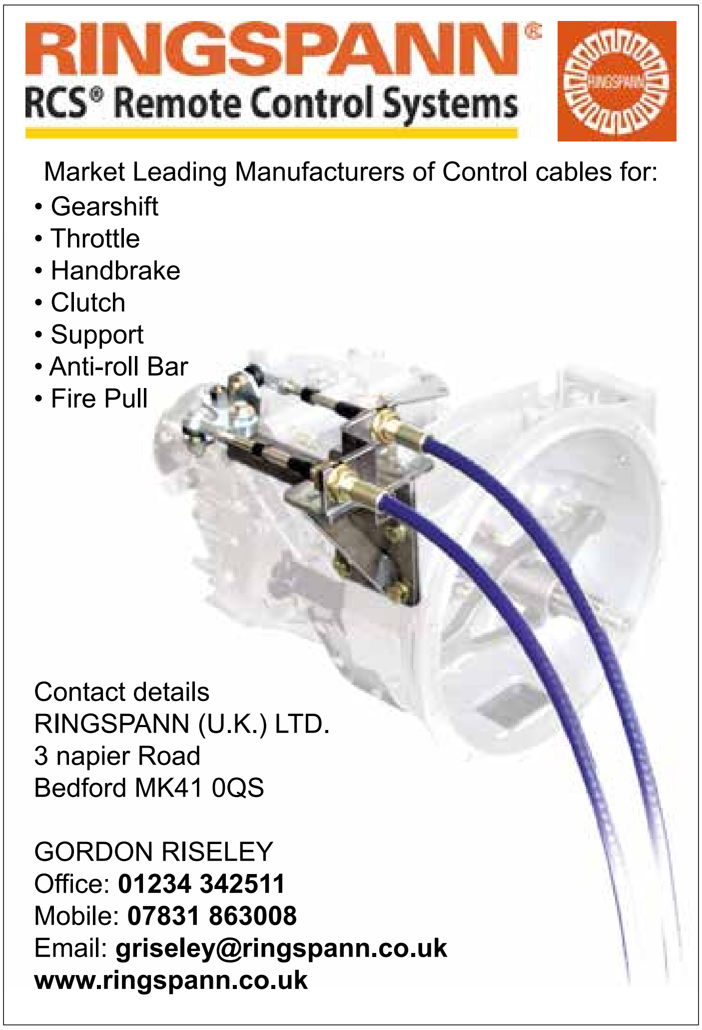
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# Simulate to create

## Simulation packages can be as useful in the design process as they are in performance tuning, says the man behind ChassisSim

**By DANNY NOWLAN**

One of the untold stories about ChassisSim is how it has been used as a racecar design tool, as opposed to a race engineering tool. The bulk of the literature about racecar simulation, and ChassisSim in particular, is how it has been used to model and tune racecar performance. Given the abundance of spec formula and limited budgets this isn't surprising. However, the focus of this article is how to go about using racecar simulation (ChassisSim in particular) as part of the racecar design process.

I realise I wrote a similar piece about a year ago, but that was more of an introductory article to open your mind to what you can do with simulation. The focus of this article will be to cover the process if you're using simulation to design a racecar. Even though we'll be covering some of the same ground, think of the first article as the introduction. This is the cook book.

To kick this discussion off, what we'll be discussing here is not theory. The techniques we are about to discuss have been used in anger. For example, the Pilbeam Racing Designs MP84 (it was the first project I ever worked with Mike Pilbeam on), its MP98 and the MP100 LMP2 car had ChassisSim fingerprints all over them. In particular, it played a big role in defining the aero targets of these vehicles. More recently ORECA has used ChassisSim in both its LMP1 and LMP2 programmes. Also, there have been a range of suspension geometry design projects that I have used ChassisSim on. Valuable lessons have been learned and we'll be discussing this in detail.

However, to kick things off the first point I must make is don't be mindlessly guided by what the simulation tells you. I realise, as a simulation principal, commercially this is suicide for me to say. However, as an engineer, and as a mentor, I am terrified at what I am seeing out there, as simulation results are being regarded as sacrosanct. Don't get me wrong, racecar simulation is a powerful tool, but it must always be cross referenced by actual experience, hand calculations, and ultimately the stop watch. Anything else is just total rubbish.

The first role that simulation plays in the design process is that it actually forces you to understand what you have. To illustrate this consider the comparison to actual and simulated data that is shown in **Figure 1**.

As we can see there is precious little difference between actual and simulated data. We can see this for the throttle, damper and steer traces. Believe it or not this is the foundation of good design because if you have done your vehicle modelling properly you are going to know your car inside out. This is the key reason I have always stated that you need to do the modelling yourself, because you learn so much about your car in the process.

A mentor of mine once taught me a key principle in motor racing: if it is rubbish at least understand why it is rubbish. Simulation will give you this bedrock of knowledge, so don't leave home without it. This principle is illustrated in the correlation we see in **Figure1**.

Before we discuss the magic sauce, we need to cover a few basic prelims first.

ORECA uses ChassisSim as part of the design process for its Le Mans Prototypes XPB

# If it is rubbish, at least understand why it is rubbish. Simulation will give you this bedrock of knowledge, so don't leave home without it

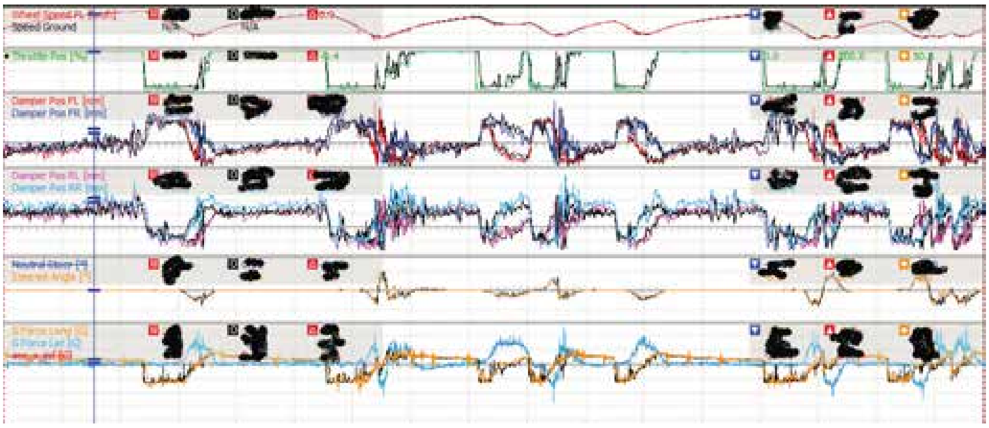


Figure 1: This shows a comparison between the actual data and the simulated data for an Australian V8 Supercar

## EQUATIONS

### EQUATION 1

$$I_x = \iiint (y^2 + z^2) \cdot \partial m$$

$$I_y = \iiint (x^2 + z^2) \cdot \partial m$$

$$I_z = \iiint (y^2 + x^2) \cdot \partial m$$

What we have here is the following:

$I_x$ = Moment of inertia of the x axis ($kgm^2$)
$I_y$ = Moment of inertia of the y axis ($kgm^2$)
$I_x$ = Moment of inertia of the z axis ($kgm^2$)
x = Distance of car component from the x axis (m)
y = Distance of car component from the y axis (m)
z = Distance of car component from the z axis (m)
dm = Mass of the car component (kg)

### EQUATION 2

$$I = I_{CM} + m \cdot r^2$$

Here we have

I = Moment of inertia of the component to be applied to the car ($kgm^2$)
$I_{cm}$ = Moment of inertia of that component ($kgm^2$)
m = Mass of that component (kg)
r = Distance of the c.g.

### EQUATION 3

$$I_{x\_new} = I_{x\_base} \left( \frac{tm\_new}{tm\_base} \right)^2$$

$$I_{y\_new} = I_{y\_base} \left( \frac{wb\_new}{wb\_base} \right)^2$$

$$I_{z\_new} = I_{z\_base} \left( \frac{tm\_new^2 + wb\_new^2}{tm\_base^2 + wb\_base^2} \right)$$

Here we have,

$I_{x\_new}$ = New moment of inertia about the x-axis ($kgm^2$)
$I_{y\_new}$ = New moment of inertia about the y-axis ($kgm^2$)
$I_{z\_new}$ = New moment of inertia about the z-axis ($kgm^2$)
$I_{x\_base}$ = Current moment of inertia about the x-axis ($kgm^2$)
$I_{y\_base}$ = Current moment of inertia about the y-axis ($kgm^2$)
$I_{z\_base}$ = Current moment of inertia about the z-axis ($kgm^2$)
$t_{m\_base}$ = Current mean track (m)
wb_base = Current wheel base (m)
tm_new = Current mean track (m)
wb_new = Current wheel base (m)

Firstly, we need to get a good handle on the moments of inertia of the car. This will ensure that as you start increasing tracks and wheelbases the simulation results won't just magically keep getting better and better. To quantify this we have **Equation 1.**

A really handy party trick is to have known inertias for bits like engines, gearboxes and tyres in a spreadsheet. Then all you need to do to calculate the relevant moments of inertia is to use the parallel axis theorem. This is presented in **Equation 2**. The great thing about **Equation 2** is that you can add all this up in a spreadsheet and update your simulation package accordingly.

You can also use this knowledge to change moments of inertia if you want to do a quick sweep of tracks and wheelbases. This is presented in **Equation 3**. I realise that this isn't going to win any prizes for elegance or subtlety, but it will ensure you don't go down any blind traps as you start changing wheelbases and tracks. This will allow you to adjust your inertias to suit, which will add sanity to the sim results you'll get back.

Finally, let's discuss some ballpark moments of inertia so you don't get lost. These are presented in **Table 1**. Don't consider these set in stone, but they are definitely in the ballpark.

## Springs and dampers

The next thing to bear in mind is to not get carried away with specifying springs and dampers that are far removed from a current set-up. A spring and damper set-up on a car that is currently working is usually there for a number of good reasons. Firstly, it provides the car with a stable platform. However, more importantly the combination of springs, dampers and roll bars give the appropriate heating for the tyre. Consequently, you go off these at your peril. Now that we have covered all that, we can get down to talking about how to apply racecar simulation in the design process.

The first thing to discuss is using racecar simulation to specify suspension geometry. Firstly, use an interface like the ChassisSim suspension geometry dialogue to get a quick handle on where your points need to be. This interface is illustrated in **Figure 2**. The last thing you want to be doing is spending hours in a CAD package. That can come later. When simulating here is your order of business:

- **Focus on roll centre migration and camber loss and gain.**
- **Do not focus on lap times – at this point they are irrelevant.**
- **Look at the returned suspension data.**

While I can't speak for other simulation packages ChassisSim will return cambers and force-based pitch and roll centres. The aim of the game is to minimise the migration of cambers and roll centres. If you've done your job right you should have something like **Figure 3.**

The plot in **Figure 3** showed the comparison between the standard geometry for a Mitsubishi Evo 9 and a double wishbone design I did some years ago for an Evo 9 Time Attack car. As can be seen, the standard is coloured and the design is in black. We can see in both camber and suspension geometry there is significant improvements. This is what you are aiming for.

In terms of aerodynamics, simulation makes its presence felt in specifying targets for downforce, drag and aero balance. First things first, when doing your simulation work you pick a template that most closely resembles your target car. This will ensure you arrive at something as close as possible. You then establish your targets by varying the global CLA (downforce) and CDA (drag). For this evaluation, keep the aero balance the same as the weight distribution. Again, don't go silly with this. Keep this to within validated CFD and actual targets. Also, to make your life easier use a CVT transmission.

Once you have established your downforce targets then move on to aero balance. However, a word of warning here. Monitor actual versus neutral steer very closely. One of the biggest traps for young players is that you keep moving the aero balance forward and the car goes faster. Strictly speaking, in terms of ultimate grip, the simulator hasn't misled you. However, fast set-ups are very difficult to drive, which is why you must be monitoring neutral versus actual steer carefully.

## Hybrid targets

The other area that simulation proves its worth is in specifying the KERS Hybrid targets. We discussed this at length in my piece on the Nissan LMP1 GTR (*RE* V25N10) and here the simulated channels on rear tyre grip made the case for this a total no brainer. Also, while I won't discuss other simulation packages, ChassisSim will return charge power and you can also specify how you want the KERS power delivered, and this is all data logged. The key thing here is you move on to this once the aero targets have been established. It also goes without saying that you should take into account the mass and inertia of the KERS components.

In terms of tying this all together, the following principles have served myself and other members of the ChassisSim community very well indeed:

- **Establish a solid baseline.**
- **If needed, establish aero targets using the current engine spec.**
- **Fix roll centres and establish front and rear tracks.**
- **If needed investigate engine and KERS.**
- **Suspension geometry.**
- **Tune in spring and dampers and ride heights**

The above integrates all the elements quite seamlessly. Firstly, by establishing a solid baseline from previous modelling or a current template and fixing the roll centres you have established a stable start point. Then you can establish aero and KERS targets. Then refine with suspension geometry and refine your spring/damper/bump rubber and roll bar package.

However, there are some perspectives you need to keep in mind here. Firstly, simulation is a start point. You forget that at your peril. Also, treat every simulation run critically and look at the data. Always ask yourself; does this make sense? And, if possible, cross reference with actual data. Also, bear in mind a simulator is a calculator. It is not a magic wand. One of the things that is frightening me about computer aided engineering tools right now is the going from CAD, and then pressing the start button and it's designed the structure for you. This is very dangerous, because results should always be looked at critically.

In closing, simulation is a very powerful tool to use for racecar design. If you start with a solid baseline and make sure you have modelled the car components correctly you have an excellent start point. Also, remember your basics, such as quantifying inertias and keeping the spring and damper changes in check. Then your game plan is to proceed down the road of aero, engine and or KERS then suspension geometry. Once you have done that, critically reviewed your results and cross referenced them to actual experience, then you will have a very firm basis for a successful racecar design.

**Table 1: Ballpark moments of inertia for various racecars**

| Car | Ix ($kgm^2$) | Iy ($kgm^2$) | Iz ($kgm^2$) |
|---|---|---|---|
| Formula Ford | 100 | 300 | 500 |
| F3 | 150 | 400 | 600 |
| GP2/IRL | 200 | 800 | 1200 |
| V8 Supercar/NASCAR | 400 | 1300 | 2500 |

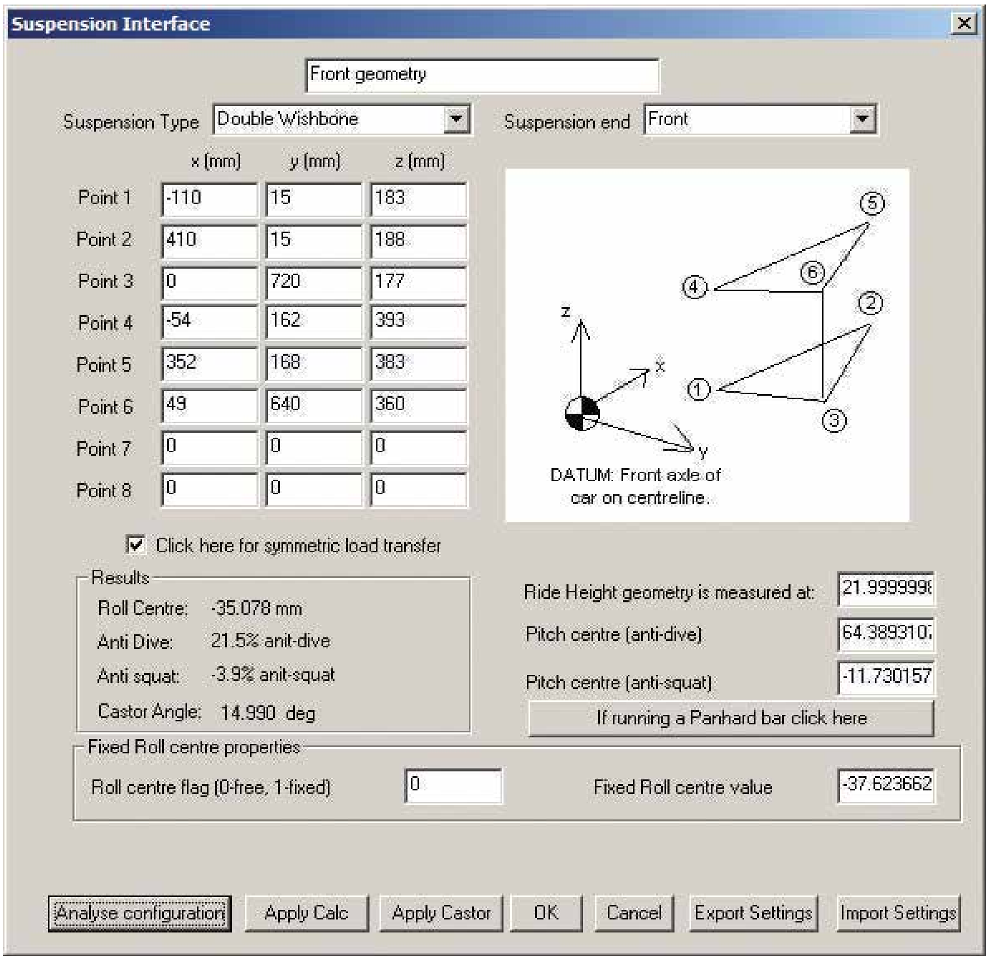



**Figure 2: Something like ChassisSim's suspension geometry interface should be your first port of call when designing a car**

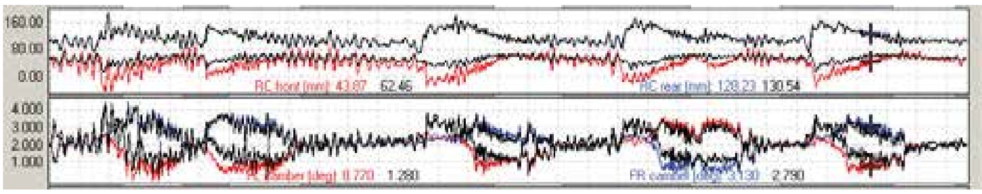
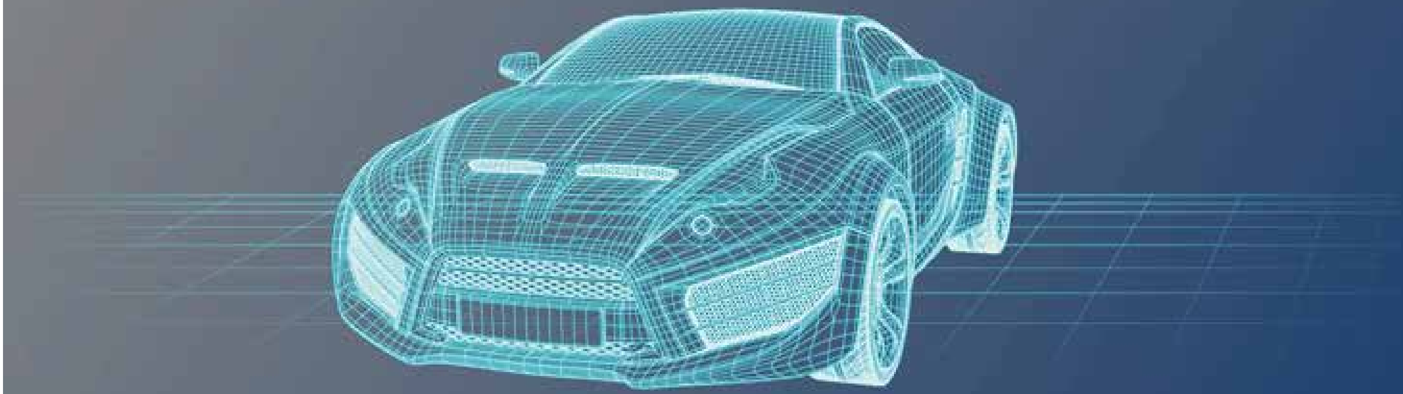



**Figure 3: A comparison between baseline geometry and twin wishbone geometry for a Mitsubishi Evo 9 Time Attack racecar**







# Evolution of the species

## Gaining performance within the tight constraints of the DTM rules is always a challenge but Mercedes hopes that with its new C63 it might have found an edge

**By LEIGH O'GORMAN**


**Mercedes has upgraded its C63 for the 2016 season but because of the tight regulations governing DTM, it's been restricted in the modifications it can make – particularly when it comes to the portion of the car's silhouette above the wheel arches**

Pascal Wehrlein and Mercedes works Team HWA AG may have claimed the 2015 DTM drivers' and teams' crowns at the Hockenheim finale, but Mercedes still managed to miss out on the manufacturers' title. It would have hurt the Stuttgart manufacturer to have lost its three-way fight with fierce market rivals BMW and Audi – and in fact it came last of the three, which would have hurt even more. But Mercedes believes its upgraded C63 could go some way to righting this wrong in 2016.

Yet Mercedes' push to introduce an updated version of the C63 for next season has once again revealed the heavy restrictions placed upon the technical regulations in the DTM, and it has had to carry over much of the original C-Coupe car into the new C63 machine – although that is not to say the German marque's design office has been idle.

Ulrich Fritz, head of Mercedes-AMG DTM, explained the extent of the limitations his design team faced: 'From the regulations standpoint, we cannot change too much on the car – more or less, it is a change of the silhouette. We need to maintain all the interior of the car and also the aero [design] over the top point of the design line.'

The design line – a sector split by an imaginary line that runs along the top of the wheel arches and approximately halfway up the door's height – regulates the areas that can receive 'additional development'. Above the line, the silhouette must remain as homologated, apart from the wing mirrors and the bonnet surface – the former of which has sprouted a longer winglet than seen on the 2015 iteration.

As far as carrying over aero from the existing C-Coupe is concerned, Fritz says: 'We have [brought over] most of the aerodynamics [that lie] underneath the so-called design line. We also have to go with the same engine and all the suspension parts – that's all homologated.'

Fritz admits that finding gains within the tight confines of these regulations has always been one of DTM's great challenges – especially since the introduction of the 2012 rule book. He also accepts that the manufacturers are severely limited by the aerodynamic designs of the road car from which the DTM model is adapted, but that does not mean evolution of the machine is stopped dead in its tracks.

'You need to find a solution how you can combine the already existing part of [the

**Mercedes has had to carry over much of the original C-Coupe car in to the new C63 – but that's not to say its design office has been idle**


**The new C63 has had a number of aero nips and tucks including a modified front and rear diffuser, while the DRS-fitted rear wing is basically a DTM controlled item which is also used by rivals Audi and BMW**

aerodynamics] with the new roof, so that is basically what we try to achieve,' Fritz tells us. 'We are on to it and we will develop this car [to be] as good as possible.'

For 2016, the new C63 will include modifications to the front splitter and side panels, front and rear diffusers and the flat bottom. Like Audi and BMW, Mercedes races with a controlled rear wing, which is formed of a single-plane with a Gurney flap. The inclination of the wing – which includes a Formula 1-style DRS – can only be adjusted from 10-degrees to 25-degrees, although the minimum inclination can be adjusted to just five degrees at the Norisring race only.

## Secret suspension

Fritz remained tight-lipped when pressed for details on the C63's suspension, claiming it to be 'a Mercedes secret'. However, it is understood that the C63 operates independent suspension at the front and rear, as supplied by H&R Springs. The suspension consists of a double-wishbone, pushrod system with a spring-damper unit and adjustable gas pressure dampers.

One small but notable difference between the C63 road car and its DTM counterpart is its height, with the road going version measured at 1210mm and the DTM C63 some 60mm smaller. This is because DTM regulations specify a maximum vehicle height of 1150mm. There is an interesting DTM regulation relating to this (see sidebar).

Much of what has been seen thus far of the new C63 has amounted to little more than publicity shots and Fritz admits that there is still plenty of work to be done on the car. But with the first 2016 test sessions not set to begin until the spring, the car is still being evaluated for wind tunnel measurements, while CFD work continues apace.

Once that stage has been completed, the next phase can begin – in one of the few areas where the constraints are not quite as tight as in other formulae. 'In DTM, wind tunnel development is completely free and that is [also the same] for CFD,' says Fritz. 'It is for wind tunnel 1:1 and also for modelling tunnels, so that is free in DTM. No restrictions, no issues.'

While there are some minor avenues for development of a car's aerodynamic features in DTM, the technical regulations as a whole remain unchanged for 2016. Like its predecessor, the C63 chassis is formed of a carbon fibre (CFRP) monocoque, which is connected to a high-strength steel roll cage forming six crash structures at the front, rear and sides. The monocoque also contains an integrated fuel tank.

## Under the bonnet

The engine – a four-stroke Otto unit – is a 4.0-litre 90-degree V8 naturally aspirated unit with a maximum torque of 500Nm. The unit produces 360kW at 7500RPM, culminating in a power output of approximately 470bhp and a top speed of approximately 170mph – although there are not many circuits on the DTM calendar that will allow the machine to hit its absolute top end. The air inlet system contains two air restrictors limited to a maximum diameter of 28mm.

DTM cars are rear-wheel-drive and the C36's transmission is a standard 6-speed transverse-mounted semi-automatic gearbox built by famed race transmission expert Hewland, with pneumatically operated sequential gearshift controlled via steering wheel, with a foot-operated 4-plate carbon fibre clutch.

AP Racing supplies brakes for the C63, with monoblock light metal brake calipers, the UK-based brake and clutch specialists utilising a hydraulic dual-circuit system, with front and rear ventilated carbon fibre brake discs, the front-to-rear bias adjustable by the driver.

**'Wind tunnel development is completely free, and that is also the same for CFD'**

One of the sporting challenges faced by teams in the DTM is that of managing success ballast. Indeed, it became a significant talking point in 2015, when new rules defining manufacturer ballast appeared to skew race weekends in favour of one manufacturer or another – best represented when BMW used the advantage to secure the top seven positions at the second race in Zandvoort. Asked whether it was possible to design the potential for success ballast into a machine such as the C63, Fritz said: 'You try to have as little possible weight; [to have] as much as possible chances to play with the weight. But this is also somewhat limited because it is a big car.'

Fritz revealed that the new C63 will be the silhouette that will compete under the upcoming Class One regulations, alongside current DTM opponents BMW and Audi, as well as Super GT giants Honda, Lexus and Nissan. Extensive delays to the finalisation of Class One regulations have meant that a start date for the category has yet to be agreed.

Meanwhile, Fritz was careful not to overstate Mercedes' prospects for next season, knowing full well that both Audi and BMW will also be working hard to make a step forward. Yet despite this, he is looking forward to 2016, and speaks with a positive tone in his voice as he says: 'I think this is a great step in the right direction. The car looks really quick. I think the new C63 AMG Coupe is a good base for that and we are just looking forward to having this great machine in DTM.'

## Scale models

Using the software programme Catia Version V5, DTM series chiefs have been able to scale the machinery down in order to fit the tight confines as stipulated by the technical regulations. DTM technical chief Michael Bernard said the reasoning behind the scaling regulation is quite simple: 'As standard road cars have different shapes, different front and rear overhangs, different drag and different frontal areas, the idea of scaling is to harmonise those areas in order to give all manufacturers equivalent opportunities in terms of aerodynamic performance – whatever the road car looks like,' he says.

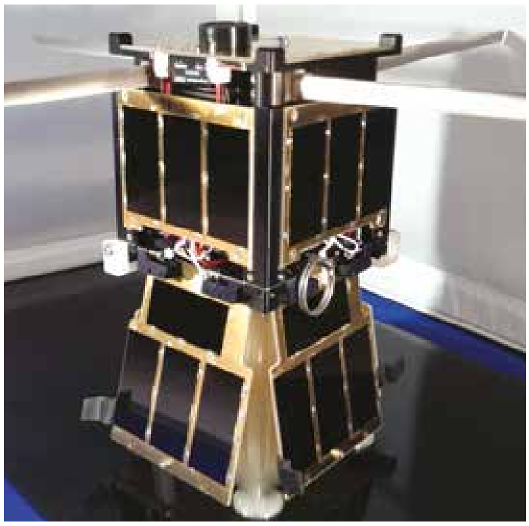
These scaling regulations do not merely refer to shrinking the height of each of the manufacturers' entries, but apply to the rear section as well. Bernard says: 'If you have a look to the rear bonnet [boot lid], you will find a standardised spoiler as well. Together with the rear diffuser, what is seen as a kind of common part, and the rear wing, we achieved a comparable air flow in that area as well, whatever the standard shape of the rear bonnet is.'

However, the 'shrinking regulation', as Mercedes boss Fritz calls it, does not open the door for simply any car to be submitted for competition scaling, as Bernard explains: 'A road car must be within given dimensions in order to be allowed to use it for DTM and to scale it.'

# From race track to the space race

## While motorsport is still a challenge for any business one company is finding that space truly is the final frontier


CRP Windform 3D printed parts have met some of the toughest requirements on Earth to get into space



KySat-2 has gone into orbit with Windform 3D printed components

CRP Windform parts are also found in many race applications

The policy shift in recent years to develop and open space flight and travel to private companies has helped to jump-start the space industry, and CRP Windform materials are now moving from the race track into the new 'Space Race'. Windform LX 2.0, Windform XT 2.0, Windform GT and Windform SP have all passed outgassing tests that have been carried out at NASA. The result states: 'Materials were tested in accordance to the ASTM E-595-07 standard and are considered passing.'

This test covers a screening technique to determine volatile content of materials when exposed to a vacuum environment. This analysis is fundamental, especially in space applications, as the outgassing of the material can change its mechanical and structural properties. The result has allowed Windform to be proposed and incorporated into the burgeoning CubeSat industry.

Recently Windform XT 2.0 has passed the ESA outgassing test, too, in accordance with ESA TEC-QTE 7171 (based on ECSS-Q-ST-70-02C). Metallised coated and uncoated samples of Windform XT 2.0 have been tested in the VCM facility of the TEC-QTE laboratory at ESA/ESTEC, Noordwijk, Netherlands.

Windform 3D Printing materials were launched into orbit on KySat-2 in November 2013. The collaborative team of students from the University of Kentucky and Morehead State University, along with Kentucky Space, launched the KySat-2 into orbit as part of the NASA ElaNa IV mission out of Wallops Flight Facility in Virginia. Thirty-five minutes after deployment from the launch vehicle, KySat-2 began beaconing its telemetry data and was almost immediately heard by amateur radio operators. Since then the KySat-2 team began performing system checks for each of the various subsystems that make up the satellite.

## Space and pace

'There were several 3D printed components on the KySat-2 made by CRP USA,' explains Twyman Clements, KySat-2 project manager, Kentucky Space. 'One of the subsystems is the camera systems that acts as an attitude determination system called Stellar Gyro. The 3D printed parts were produced using the additive manufacturing technology Selective Laser Sintering and Windform XT 2.0 material. The additive manufactured process 3D printed the mounting hardware for the system, extensions for the separation switches, clips for holding the antennas in their stowed position, and the mounting bracket for the on-board batteries. The process and the material were critical to achieve the right components for KySat-2.'

Windform 3D printing in aerospace and motorsport applications has presented both opportunities and challenges to engineers in the field. The ability to produce parts and components with Windform gives the possibility to avoid the restriction of tooling through the additive process, representing fundamental opportunities. Several race teams have decided to adopt this technology on-track as functional parts, small volume production runs that can be obtained in a few days, instead of weeks. Driver compartment accessories, custom ducting, packaging optimisation, are just a few areas where engineers are designing custom solutions using Windform materials for on-track production parts. CRP USA has also built different parts for stock car racing teams, for example, alternator shrouds and electrical enclosures, to name just two. More and more often the racing world is looking for interesting technologies, as much as those in the space industry. Racing teams have found in Windform a reliable material that is now able to move from Race Track to Space Race.

# FIA calls for interest from engine makers for low cost Formula 1 powerplant

**The FIA has put out to tender the contract for a new independent cost-controlled engine to be introduced into Formula 1 in 2017.**

It's believed the 1.6 turbo engine is to be sold for around £10m and it will be a non-hybrid unit, though with equalised performance with current PUs. It is also be designed with a more crowd-pleasing engine sound in mind.

In a statement the governing body said: 'The FIA has decided to launch a consultation among the engine manufacturers in order to potentially identify for the 2017, 2018 and 2019 seasons an exclusive alternative engine manufacturer which will be solely entitled to supply this alternative engine to the competitors entered for said seasons of the championship.

'The FIA is now calling for expressions of interest to identify candidates interested in becoming the exclusive supplier of the alternative engine to the competitors.'

Engine builders interested should have contacted the FIA for the technical specification of the proposed power unit before the end of November. They will also have needed to have included details of their fitness to supply the unit in terms of their financial situation and their technical know-how.

Reaction from the teams was mixed, but Toro Rosso boss Franz Tost was upbeat: 'I think it's a good idea. We from Toro Rosso will support it because we want to have this new engine – at least to have the possibility to choose something, to bring up a new engine for lower costs because the current power unit costs a lot of money.'

But Sauber team principal Monisha Kaltenborn was less enthusiastic: 'Looking at this alternative, we are a bit sceptical about this because, looking at other series, you see how difficult it is if you have two kinds of different engines in one series. It's not worked in the past. We're seeing it now, currently, that there are a lot of issues attached to it. That's one point,' she said.

'The second one is it's meant to have parity with the current engine and that's a complex area. It's not easy to achieve that. And moreover, there's a world out there and we have to move with that world. Hybrid technology – you might like it personally or not – but that is the demand on the market today.'

Kaltenborn added that she believed that Formula 1 would be better served trying to reduce the cost of the current units: 'We should try to get the prices down, which in our view is absolutely doable,' she said.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Toro Rosso team principal Franz Tost says he is in favour of the introduction of new budget F1 engine

# Future of Austin F1 race in doubt after funding is slashed

**A significant cut in the amount of financial support the Circuit of Americas (COTA) receives from its state government has thrown the future of the US Grand Prix into doubt.**

The Texas government had agreed to subsidise COTA to the tune of $250m over a 10 year period – an amount which was thought to be in keeping with the economic impact of hosting the event – and around $25m was awarded each year for the first three races (in 2012, '13 and '14).

However, it's now been widely reported – and confirmed by Bobby Epstein, the chairman of COTA – that the payment is to drop by over $5m a year, to somewhere between $18m and $19.5m. This is because Texas has changed the way it calculates economic impact, and hence the size of subsidies, following an audit into the process.

The findings of its new economic impact process suggests the F1 race is worth considerably less to the Texan economy than previously believed – 20 per cent less in fact.

To make matters worse, the bad weather that hit the United States Grand Prix this year also hit the attendance figures. The event found itself on the receiving end of torrential rain and electrical storms which resulted in the smallest race day crowd in the grand prix's history. Epstein told local press: 'It was a tough weekend … A financially devastating weekend for the company.'

Compounding the event's troubles is a hike in the race hosting fee, which it has to pay F1. This is widely believed to have been increased year on year from the first race in 2012 (when it was around $25m) to $33.3m in 2015.

COTA's state payment comes from the Texas Event Trust Fund, a programme that pays event organisers a portion of sales generated by spectators travelling from outside of the state. The US Grand Prix received $25m from the fund in 2014, which compares well with the $1m given to the Texas Motor Speedway for its NASCAR Sprint Cup race in the same year.

COTA has generally pulled in good crowds and provided good racing – but is its time in Formula 1 about to come to an end?


XPB

# Tatuus snaps up junior single seater deal in the USA

**Italian racecar constructor Tatuus has been chosen to design and manufacture the next generation of chassis for the first two levels of the Mazda Road to Indy single seater ladder in the US – the USF2000 Championship and the Pro Mazda Championship.**

The new Tatuus USF-17 (for USF2000) and Tatuus PM-18 (Pro Mazda) chassis will make their competition debut in 2017 and 2018 respectively.

Based in Concorezzo, Italy, Tatuus has been designing and manufacturing racecars since 1980. The company, managed by Gianfranco De Bellis and Artico Sandona, is a leader in the production of the FIA F4 racecar and also produces the Formula Renault 2.0 chassis, amongst others.

Dan Andersen, owner and CEO of Andersen Promotions, the company behind the two championships and also Indy Lights, said of the deal: 'To enter into this new venture with [Tatuus] as partners is exciting and I know they will deliver a very high quality, safe and fast racecar – a car that career-minded drivers from around the world will see as a real step up from other open-wheel series cars.'

The Tatuus USF-17 is said to be a significant step up in technology over the current Van Diemen USF2000 chassis. It is a full carbon monocoque built to the latest FIA F3 test specifications and packing the current Mazda MZR 2.0-litre naturally aspirated engine.

There are also additional safety features to meet the specific needs of oval racing, including full Zylon side intrusion panels and reinforced bulkheads. The USF-17 will also feature a six-speed paddle-shift gearbox, four-way adjustable dampers, Cosworth data system, LCD steering wheel and ECU.

The PM-18 will use the USF-17 as its base car to help control the operational costs for teams who wish to move up. It will have more power over the USF-17, from a Mazda Skyactiv engine, plus more sophisticated aerodynamics with a revised underbody and diffuser, a three-element rear wing and a front wing with adjustable composite wing flaps.

The new USF2000 chassis will be unveiled at the Indianapolis 500 in May. Prototype testing is expected to begin in June with car deliveries taking place in the autumn.

Tatuus makes the new BRDC Formula 4 car (pictured) and has now also picked up two new single seater contracts in the United States

# NASCAR signs long term deal with leading North American race tracks

**NASCAR has come to an agreement with 23 circuits to field NASCAR Sprint Cup Series races for the next five years, while it has also agreed a deal with tracks to host its second-tier NASCAR Xfinity Series races, and its Camping World Truck Series, until the end of 2020.**

The US stock car governing body has also unveiled its 2016 calendar for all three of its major racing series.

Steve O'Donnell, NASCAR's executive vice president and chief racing development officer said: 'NASCAR and the tracks take seriously our collective responsibility to the fans and each stakeholder to ensure the sport is healthy, strong and growing, so we can deliver great racing to the fans for many decades to come. The live event experience always will be important to creating a lifetime fan in NASCAR.

'Among the goals that we set out to accomplish with our track partners was to provide consistency for race fans and the industry stakeholders. We feel like we have a nice balance of that for 2016. The stability of five-year agreements positions us well to deliver fans with schedules as early as possible over the next several years. This is a new approach for our industry, and one that benefits everyone: fans, tracks, teams, drivers, OEMs, media and partners.'

NASCAR will kick off the 2016 season at the re-imagined Daytona International Speedway, with Daytona Rising – the venue's $400m redevelopment project – due to be finished by the time both the Xfinity and Sprint Cup Series launch at Daytona Speedweeks. The 2016 Daytona 500 will be held on February 21.

After the Daytona 500 NASCAR events will be held the following week at Atlanta Motor Speedway. Both the Sprint and Xfinity series will then travel to Las Vegas Motor Speedway, Phoenix International Raceway and Auto Club Speedway for the return of 'NASCAR Goes West'.

O'Donnell said: 'We learned that NASCAR Goes West worked very well in keeping momentum and interest for NASCAR in these markets. The tracks put a lot of effort behind making it successful and we think it can continue to have a positive impact as it gains traction from being an annual effort. The efficiency of conducting three consecutive events also is helpful to the teams and industry.'

NASCAR will be visiting the Las Vegas Motor Speedway early in the 2016 season as it repeats its 'NASCAR Goes West' marketing initiative

# Motorsport insurance giant formed with Ellis Clowes buyout

**Integro, an international insurance broker and risk management firm, claims to have become the world's largest motorsport insurance broker following its purchase of Lloyd's broker Ellis Clowes.**

The deal was finalised in November, but no financial details were disclosed. London and New York-based Ellis Clowes has been a leader in the field in global motorsports insurance for more than 30 years, while the firm also provides tailored insurance solutions to clients operating in the conflict and security sector, marine and aviation.

Neil Clayton, leader of Integro's global Entertainment and Sports practice, said of the deal: 'For over 30 years, Ellis Clowes has built an unrivalled reputation for providing services in the motorsports sector internationally, and we are delighted that Karen Ellis and her incredibly accomplished team of specialists in the UK and US have agreed to join us. Ellis Clowes is a great brand and strong addition as we build Integro's sports specialty practice.'

Karen Ellis, CEO at Ellis Clowes, said: 'The scale and reach we will achieve by joining Integro will benefit our clients enormously. When Integro approached us, we recognised that their culture and plans would accelerate our growth, particularly in the United States. The fact that Integro has a complementary hostile territories and security team strengthens our joint position as a market leader in this sector.'

The Ellis Clowes brand and team will remain in place, and continue to be led by Ellis, who also assumes the role of global head of motorsport within Integro's Entertainment and Sports practice.

**INTERVIEW** – Paul Hembery

# Pumped up

## Pirelli has landed the contract to continue supplying F1 tyres until 2019 but as its motorsport boss explains it's no easy task working in such a demanding arena

By MIKE BRESLIN

XPB

**'Formula 1 pushes you. It pushes you as a business as well. It pushes you always to be better'**

It's the penultimate lap of the 2015 Belgian Grand Prix. Sebastian Vettel has nursed his tyres through a 29 lap stint and looks set to reap the reward of a podium finish. Then the rubber lets go dramatically. In the paddock there are recriminations, Pirelli is once again at the centre of a media storm. As it turns out this issue was far from the Italian firm's fault, but it was not the first time the tyres have been the story of a race weekend, and with a new deal signed to supply F1 until 2019 it will almost certainly not be the last time Pirelli will have to deal with PR fallout. Which sometimes makes you wonder, why does it bother?

Paul Hembery, Pirelli's motorsport director, laughs when asked the above question, and then he says: 'The tyre maker's lot is not always an easy one. I mean, you get other problems on cars, but with a tyre it's so visible it creates a focus that is probably disproportionate to the problem. But that comes with the territory.'

## Pressure gauge

That's a fair point, perhaps the only other failures as visible would be a dramatic engine blow up or brake failure, but the PR implications are still obvious. Yet Hembery gives the customer credit for seeing behind the headlines. 'People are actually well informed. No matter what item you go to buy today, be it a tyre or other goods, people do research and they try and understand what they are going to buy,' he says. 'People do understand that we supply the vast majority of prestige and premium car manufacturers in the world; they're able to understand that if those manufacturers chose Pirelli after two or three years testing, there's good reason. The consumer, from what we've seen, is able to separate what is sport and entertainment from the road car business. But yes, it does put the brand in the spotlight. If you're in the spotlight, in any form of sport, the majority of times it's good, but a few times it can be bad, but then it gets disproportionately amplified.'

There is, of course, no doubt that Pirelli wants to be in Formula 1, even with the occasional PR headaches this entails. It has recently fought off Michelin to keep the supply deal until 2019, and while this not been signed off by the FIA, Hembery tells us this is just a formality.

Pirelli also spends a great deal of money for the privilege of being in F1, as much as a Formula 1 team per season, in fact, and probably more than most F1 teams. Hembrey says: 'That's excluding the actuation [such as the huge trackside advertising presence]; that's the cost of us being present at the circuit, and of course we don't get payments like the teams from Bernie [Ecclestone]. The 10th team [in the championship]; rumours suggest they get $50m, but unfortunately we don't get that.'

But then there's always the money from selling the tyres to the teams to recoup some of this, isn't there? 'Well the teams don't actually pay, because the reality is they get a share of what the promoter is given from us, and that far exceeds the cost of the tyres.'

## True grip

All that said, Formula 1 obviously works for Pirelli; why else would it pay the money and take the grief it sometimes gets? But it's about more than just being associated with 'the global motorsport brand', as Hembery calls F1. 'It pushes you; it pushes you as a business as well; it pushes you always to be better. I don't think anybody involved in Formula 1, no matter what role they have, is there just to think what you do today is good enough for tomorrow. It's a great laboratory for pushing your know-how, your skills, the whole system of a company; from design, manufacturing, through to communications, logistics; every aspect of the business.

'That's something that Formula 1 gives you,' Hembery adds. 'Because it's an uncompromising environment, very demanding, and it's not for the faint hearted. You know, there's probably a few hundred tyre companies in the world, and there were only two that felt they wanted to come into Formula 1. There's probably only three, possibly four, in the world that could actually supply Formula 1, because of the demands of the sport.'

Come 2017, there will also be new challenges for Pirelli to face, in the shape of


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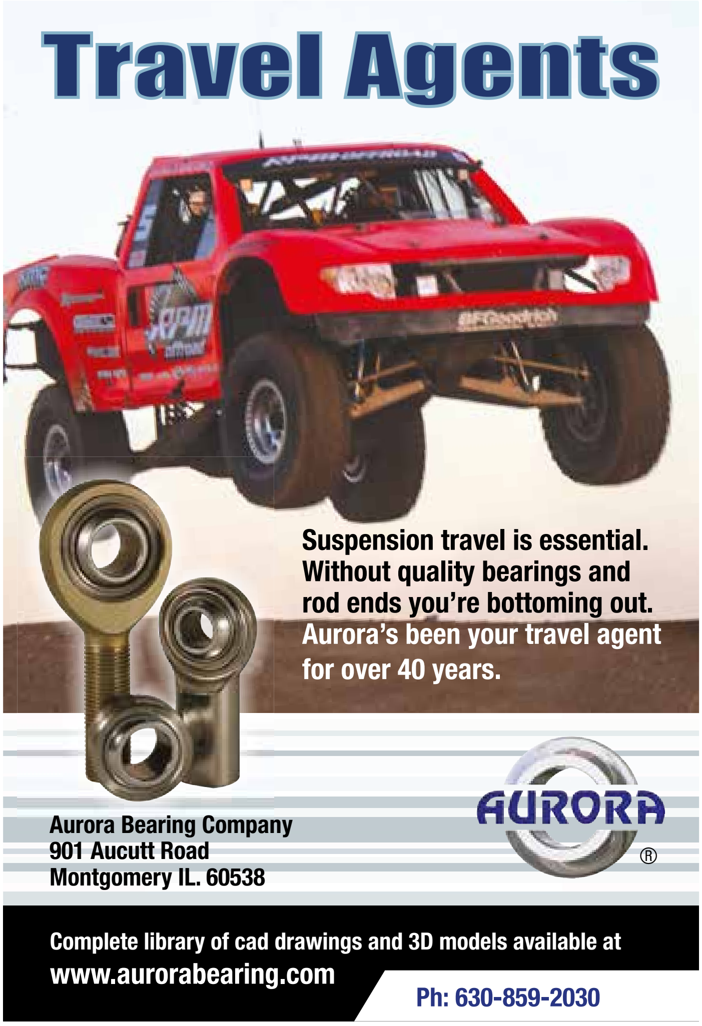
**Sebastian Vettel's high profile tyre failure at this year's Belgian Grand Prix put Pirelli in the spotlight for all the wrong reasons**



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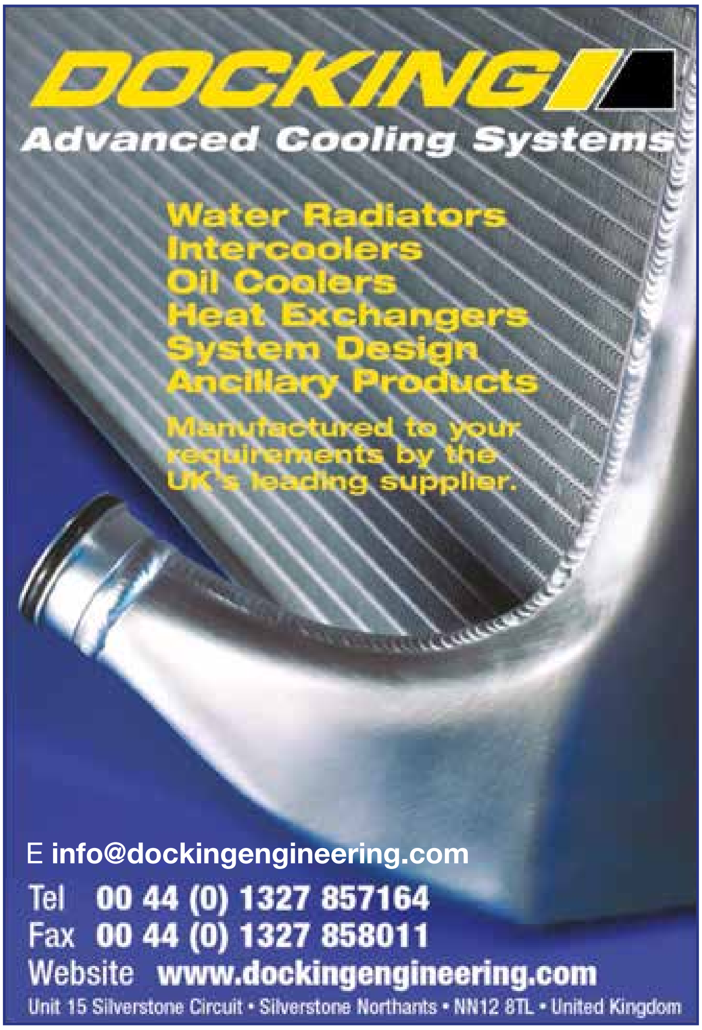

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the new formula. For Hembery this new era has already started well, as Pirelli's finally managed to get Formula 1 to agree to allow it some in-season tyre testing from 2016 onwards, something that he says has been by far his biggest frustration with the sport up until now. 'I think that's something that seems to get lost, in terms of the reporting in the media. That the biggest single scandal was that Pirelli can't go testing, and that was something that we actually had to change to go forward, so there's now a recognition that we need for the 2017 tyres the ability to test them.

'The actual details we still have to discuss because we don't actually have the technical regulations, but the concept is there and understood. We need to be able to test in a correct and detailed manner. Because currently we have zero kilometres testing on not just the current cars, we can't even take an old car, we can't even take a 20-year-old Formula 1 car and put a tyre on to test. So it's a system that has not been helpful to us in achieving our aims.'

But, as Hembery says, to test a tyre first you need a car. 'There's probably three levels of questioning: can you test the new tyres on a current car; can you test it on a current car modified; or do you need a bespoke car made. So that's the phase that we're at at the moment; understanding what are the practicalities and what platforms can we test on.'

## Judge tread

While Pirelli's deal is for control tyres, there are often calls from within the sport for a return to a two-tyre F1, or a tyre war as it's invariably called. But Hembery believes there are inherent problems with this. 'We're involved in open competition in 90 championships this year and we win many more than we lose; in motorcycling 80 to 90 per cent and in cars I think it's 65 to 70 per cent this year, so we do know the feeling of winning. But what happens with a tyre war is eventually somebody gets the upper hand and then somebody else leaves. It happened in Formula 1 before, one manufacturer left when the other one was winning, so you ended up with one supplier. So it's a very short term battle if it happens, because at the end of the day big companies don't like losing.'

Tyre war or not, Hembery says the firm is pumped up about its future in F1. 'Well you've got to be excited; if you're not excited you might as well get out. Formula 1 is still the pinnacle. And we've got some nice ideas to come for 2017, where we will be working on some new technologies.' But new technologies or not, don't be surprised if the only time the wider world takes notice of Pirelli is when something goes wrong. But then, as the man says, that comes with the territory.


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**Pirelli's investment in Formula 1 is huge – it spends more than many of the teams**

## RACE MOVES

**Adrian Moore has been appointed managing director at transmission specialist Xtrac. Moore, who was previously the company's technical director, succeeds Peter Digby in the role, the latter now moving in to a new position as executive chairman. Moore will take over the day-to-day running of the business while Digby will continue to manage the main board of directors, concentrate on corporate strategy, and focus on sales and support of key international motorsport customers.**

**Jay Frye** is the new president of competition and operations at IndyCar, filling the position left vacant with the departure of **Derrick Walker** in September. Frye has race team management experience from running the MB2 and Red Bull squads in NASCAR prior to joining IndyCar's parent company Hulman Motorsports, where he was chief revenue officer before taking up his new role.

**Dirk Rockendorf** is the new marketing director for Kumho Tyre in the European market, a role which includes responsibility for the company's motorsport activities, as well as price and product management, communications, PR and sponsorship. Rockendorf previously worked as head of marketing for the Middle East and North Africa at Continental.

**Jonathan Day** has joined the Motor Sport Association (MSA) as its director of development. Day was previously at British Cycling, where he had worked since 2006, and since 2009 had been Cycle Sport Manager, with responsibility for developing the sport in the UK. Day's role at UK motorsport's governing body will include overall responsibility for the growth of club motorsport, the recruitment and training of volunteers, talent development and coaching.

It's been reported that **Bob Bell** is to return to Enstone when Renault completes its expected takeover of the Lotus team. Bell, who has now stepped down from his role as a technical consultant at Manor, previously worked for Renault at Enstone from 2001 until 2010, as technical director and then briefly as acting team principal, before joining Mercedes for four seasons from early 2011.

Former IndyCar team owner **Robbie Buhl** has set up a Global Rallycross team with his bother **Tom Buhl**. The outfit is called Buhl Sport Detroit, in deference to its Michigan base. Buhl raced in CART and the Indy Racing League before turning to team ownership after retiring from driving in 2004. He co-owned the Dreyer & Reinbold Racing IndyCar team up until 2013.

The National Hot Rod Association (NHRA), the body which oversees drag racing in the US, has taken on **Tyler Schulze** as vice president and chief financial officer. In his new role Schulze will oversee several administrative departments, assist with developing NHRA's strategic vision, and will implement new business initiatives. He will report directly to NHRA president **Peter Cliff**.

Australian touring car team bosses **Roland Dane, Todd Kelly** and **Tim Edwards** were re-elected to the V8 Supercars Board and Commission at the annual meeting of the championship's team owners. All three were unopposed and elected unanimously.

**Thomas Sedran** has been appointed head of Group Strategy at the Volkswagen Group. Sedran was previously a member of the management board at Opel. As interim CEO he was instrumental in developing the Drive Opel 2022 strategy, designed to return the company to sustainable profitability. From July 2013 he was president and managing director of Chevrolet and Cadillac Europe.

**Fred Gallagher** has confirmed his retirement from the role of clerk of the course on Wales Rally GB. The former World Rally co-driver has held the position since 1996.

## RACE MOVES – continued

NASCAR's senior vice president and chief communications officer, **Brett Jewkes,** is to leave the organisation, having accepted a senior management position with Atlanta-based AMB Group. Jewkes joined NASCAR in 2011, after serving as an outside agency counsel to the sanctioning body from late 2000.

US Marine Corp veteran **Kirk Dooley** has been recruited by IndyCar to work under series CEO **Mark Miles** in an internal administration capacity. Dooley has no previous motorsport experience – in the military he's worked in special operations and intelligence.

The MIA has postponed the Motorsport Technical School for racecar and race bike mechanics, due to start at the end of this November and run through the winter, because of a lack of time. It has rescheduled it to take place from November 2016 until February 2017. For more on this go to www.the-mia.com

Former top rally co-driver **Anne Riley** (nee Wisdom) has died at the age of 81. Riley sat alongside driver **Pat Moss** and the pairing were hugely successful between 1956 and 1962, not only in the Ladies' class, but also in terms of overall results.

McLaren Automotive has appointed **Duncan Forrester** and **Freddie Gilbey** to its Global Communications team. They will report to Global Communications director **Wayne Bruce**. For Forrester it's a return to McLaren, as he enjoyed a spell of work experience with its F1 team back in 1987 and 1988.

**Terry Ozment** has joined the Sportscar Vintage Racing Association (SVRA) in the US as national director of event management. She was formerly vice president of club racing at the SCCA, where she spent 10 years of her career. In her new role Ozment will define and oversee the process and procedures of organising events throughout the SVRA's season-long schedule.

Also joining the SVRA (see above) in an executive role is **Dan Pinsonneault,** whose racing experience comes through owning, preparing and driving racecars – he drove a 1969 Camaro Trans-Am racer to the SVRA Group 6 championship in 2006. Pinsonneault will serve as national race competition director.

WC Vision (WCV), the organisation that promotes the US-based sportscar championship the Pirelli World Challenge, has confirmed that **Greg Gill** is its new CEO, removing the 'interim' that's been attached to his job title since he stepped into the role vacated by a departing **Scott Bove** in September. Gill joined the series in October 2012.

**Brian Allen,** who drives the motorhome for NASCAR Xfinity driver **Brian Scott,** has been reinstated by NASCAR after being banned from all its competition in September for his part in an altercation between Scott and **Darrell Wallace Jnr** at the Kentucky Speedway round of the second tier NASCAR series.

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# Former McLaren man Ryan back in Formula 1 with Manor

**Dave Ryan, once a stalwart at McLaren, has been signed up by the Manor F1 team as its new sporting director.**

Ryan will replace Graeme Lowdon in the position, who along with team principal John Booth is to leave the squad at the end of this season. Lowdon and Booth's resignation is reportedly due to a difference of opinion with team owner Stephen Fitzpatrick over Manor's future strategy.

Fitzpatrick, who is the founder of independent energy company Ovo, saved the Manor team with his timely financial intervention in February, after it fell into administration towards the end of the 2014 season.

Ryan worked at McLaren for 30 years before leaving under a cloud for his part in the controversy over whether Lewis Hamilton lied to stewards at the 2009 Australian Grand Prix. Since then he has run the Von Ryan Racing squad in the Blancpain and British GT series.

'I'm very excited to be joining the Manor Marussia F1 team at a pivotal time in its development,' Ryan said. 'Having spent time with Stephen [Fitzpatrick], and understood his vision for the future, it is clear he has ensured there is a strong platform from which the team can make big steps forward in the seasons ahead.

'Manor has all the hallmarks of a fiercely competitive racing team, but having grown up in a much more contemporary Formula 1 era, it is a very lean operation with a collaborative culture, which leaves it well placed to contend with the sport's future direction,' Ryan added.

Fitzpatrick has now confirmed the departure of Lowdon and Booth: 'I am able to confirm that John Booth and Graeme Lowdon will be leaving the team at the end of the current season. I have the utmost respect for them as individuals and for all they have achieved, both with this team and in their long careers in motorsport,' he said.

Hopes are high for Manor for next year as it has secured an engine deal with Mercedes. On top if this, by dint of it finishing in the top 10 in the past two seasons, the team is also in line for substantial FOM payments.

Meanwhile, recently retired race driver Alex Wurz has been linked with the now vacant Manor team principal position.

# Darren Cox steps down from Nissan motorsport role

**Darren Cox, the man who spearheaded Nissan's ill-fated return to top-line sportscar racing in 2015, has now left the Japanese company.**

Cox, who in his role as the marketing and motorsport boss of Nissan's sporting arm, NISMO, brought Nissan back to Le Mans with the radical front-wheel-drive GT-R LM project, leaves Nissan after 13 years with the firm.

Darren Cox and Nissan have now parted company

While the LMP1 car was generally seen as a failure, in its first year at least, Cox was also responsible for launching the hugely successful GT Academy, which turned gamers into professional racing drivers, while he also oversaw the radical DeltaWing and ZEOD RC Garage 56 Le Mans assaults.

Cox said of his departure: 'The decision to leave Nissan was not an easy one. I have enjoyed a great many years working on some amazing projects with great people and have thrived on the challenges, successes and even failures in equal measure.

'I have seen GT Academy grow from a small European initiative to now embracing countries representing half the world's population,' he added.

It's believed that it was Cox's own decision to leave Nissan and although he did not say the LMP1 project was the reason for his departure, there has been talk that he was unhappy to lose control of the operation when Mike Carcamo came in as team principal in the summer.

Cox joined Nissan UK in 2005 from sister company Renault, before moving on to Nissan Europe in 2007. He is now planning to set up on his own as a marketing consultant.

While Nissan's GT-R LMP1 project has not been abandoned the team withdrew from the WEC to concentrate on car development ahead of a return to competition in 2016.


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# It's show time!

**If you're in the motorsport industry there's only one place to be in January – here's our guide to all things ASI**

Running from the 14th to the 17th of January at the NEC in Birmingham, Autosport International is Europe's largest pre-season motorsport event. Suppliers and buyers of cutting edge technology choose the Autosport show to accelerate business in the New Year by showcasing their latest products and establishing long-lasting professional relationships.

Autosport International provides a platform for industry professionals to meet in a business-to-business environment, generating an estimated £1bn of global motorsport business. The UK remains the home of the global motorsport industry, with the sector driving £9bn to the economy. As such, Autosport International is ideally located and the event continues to be the premier show for exhibitors from across Europe, Asia an America .

## Autosport Engineering

The 2016 show represents a significant milestone for Autosport Engineering, which celebrates its 20th anniversary of bringing the world's leading technology and advanced engineering companies together.

Run over two dedicated trade-only days on the 14th and 15th January in Hall 9 Autosport Engineering, held in association with *Racecar Engineering*, caters specifically to technology suppliers and buyers and will feature the world's biggest names from the world of motorsport, advanced engineering and the high-performance automotive sector.

## Williams at ASI

A major highlight of Autosport International in 2016 is a tie-up with Williams that brings all of the glamour of a F1 race weekend to the Autosport stage. For the first time ever, the eight metre tall Williams Martini motorhome will be constructed away from a race circuit to form part of an all-new Autosport stage, which will host insightful interviews with well-known motorsport personalties.

Williams will bring a selection of its Formula 1 cars to the NEC, from the very first Williams Ford FW06 to this season's Williams Mercedes FW37. Among them will be what some consider to be the team's greatest car, the Williams-Renault FW18, which won 12 of 16 races in the 1996 season. The car will be reunited with driver, Damon Hill, who has recently confirmed his attendance at Autosport International.

As well as interactive features focusing on Williams' F1 exploits, visitors will also get 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.

Autosport Show director Ian France said: 'Our partnership with Williams encapsulates what Autosport International is about. It showcases the cars, the stars and the advanced and cutting edge technical expertise of the motorsport industry and it is unlike any other show as it can all be found under one roof.'

Those wishing to secure their place at one or both of the dedicated trade days at Autosport International can register now at www.autosportinternational.com/trade.

## Key attendees in 2016

Global engineering, strategic and environmental consultancy, Ricardo will be returning to the show. The company, currently celebrating its centenary, employs over 2700 engineers, scientists and consultants globally. Ricardo's expertise extends to virtually all types of transportation – from rail to high-performance automotive, and from commercial vehicles to clean energy power generation. The consultancy is one the largest users of specialist production engineering equipment.


**Williams is to have a major presence at this year's show with its motorhome and racecars on display. It will be the first time the motorhome will be set up outside the F1 paddock**

# Engineers and managers stand to benefit from many business and networking opportunities

Banbury-based Laser Lines is also at the show and is one of the UK's foremost suppliers of lasers and accessories. It will be demonstrating the Ulyxe laser marking system – which is said to be a compact economical unit for direct part marking of metals, plastics and composites. Laser marking provides an indelible mark, which permits full traceability. Laser Lines also offers lasers for marking, welding, drilling and cladding.

## Getting Technical

In addition to Autosport Engineering, production engineers and managers stand to benefit from many business and networking opportunities at the Trade and Technical area of Autosport International. This area will run for the entire duration of the show and features an array of the world's leading technical suppliers.

## In good company

Aero Tec Laboratories (ATL) Racing Fuel Cells will be at the event for the 26th time, having exhibited at every show to date. The company manufactures composite bladder devices and fluid transfer systems for not only racing cars but also aircraft, marine and defence vehicles. This year, ATL supplied every winning team at the 24 Hours of Le Mans race including the race-winning Porsche 919 LMP1 Hybrid, which employed the firm's state of the art flex fuel bladder. This year, ATL is set to showcase a wide variety of its highly advanced products from its motorsport catalogue.

For over a decade Omex Technology Systems Limited has been designing, manufacturing and supplying quality electronic units mainly to the fast road and motorsport markets. It will have numerous examples of its offerings on display from simple rev limiters and shift lights to full engine management ECUs for V12 racecars.

Based in Illinois, USA, the Aurora Bearing Company is another company which has been present at every Autosport International since it began in 1991. It offers a complete line of standard rod end and spherical bearings, in addition to designing and manufacturing bespoke products to meet a variety of applications.

The Motorsport Industry Association (MIA) will once again provide its ever-popular International Business and members Lounge, which offers further networking opportunities to visitors on the first two trade days.

Other companies to look out for at this show include the following:

## Old Hall Performance

Old Hall Performance returns to Autosport International again next year to launch its recently homologated and FIA-approved seat insert. The EC 50 is the first seat insert of its kind to meet both driver impact and fire resistance tests. It exceeds stringent FIA specifications for driver safety and such is the groundbreaking nature of the product, it can also be used for additional head protection in racecar seats.

Old Hall Performance's new seat insert has already proven itself at the highest level of motorsport having been used by LMP1 teams at this year's 24 Hours of Le Mans.

EC 50 can be moulded by Old Hall Performance and is manufactured using a highly advanced, fire-resistant and self-extinguishing EA urethane foam (4.7lb/cubic foot) that can operate at temperatures of up to 205degC. To meet FIA regulations the EC 50 was shown to not melt or drip when exposed to extreme temperatures making it one of the safest seat inserts currently available.

Autosport Engineering will mark the first time that Old Hall Performance will showcase the innovative EC 50 to the public and affords race teams and racing drivers the opportunity to discuss their bespoke requirements with the expert team from the company.

## Bosch

Bosch will unveil its brand-new MW 7.4 premium engine control unit designed for high-end touring, monoposto, rally, and long-distance racing applications.

MS 7.4 ECU has the ability to integrate engine control, injection power stage units, and data recording in a single device. It manages fuel injection for engines up to eight cylinders with triple high-pressure injection. In addition it works on engines with up to 12 cylinders with low-pressure injection. With an integrated data logger with dual 4GB capacity, the device eliminates the need for an additional data logger. Within a customer code area (CCA),

## AP Racing

AP Racing has expanded its Pro 5000 R range, with three brand new entry level brake calipers (CP9444 and CP9445). Featuring innovative Radi-CAL technology, the calipers represent the next generation of the popular Pro 5000 range and set the benchmark for value and efficiency.

The CP9444 is a four-piston caliper that features AP Racing's Radi-CAL technology and is suitable for 13in wheel applications. The caliper has a forged two-piece aluminium alloy body and benefits from a radical asymmetric design concept, offering superior dynamic performance.


**Popular motorsport brake producer AP Racing will be showing off three new Pro 5000 brake calipers**

The CP9444 features an integral pad retainer, designed to enhance caliper stiffness and suits discs up to 280 x 18/21/22/25mm thickness. The smaller bore version, CP9445, is of the same design but is suited for rear applications. Both calipers are internally ported.

Of similar design, including a forged, two-piece aluminium alloy body, the CP9668 is a six-piston caliper that again incorporates the Radi-CAL design philosophy and features a radial mount with 180 x 42mm ctrs. The caliper is suitable for 390.0mm x 36mm or 378.0mm x 32.0mm thick cast iron discs.

The internally ported CP9668 also benefits from a radical asymmetric design concept which offers superior dynamic performance and increased stiffness. The pistons and wear plates are made stainless steel, while a bolted pad retainer with a quick-release spring clip is also supplied.

AP Racing has also announced new calipers for sportscar racing, the CP6277 and CP6278, which are designed specifically for GT/endurance race applications. This six-piston Radi-CAL caliper is machined from solid Monobloc aluminium alloy and features a radial mount, 210 x 42mm ctrs.

Built around a radical asymmetric design concept, the caliper offers superior dynamic performance and is designed to operate with iron or carbon brake discs. Thanks to its ducted air cooling feature, the caliper temperatures are reduced during operation, improving braking performance. The new caliper features stiffer titanium pistons, a carbon duct and comes with dry-bleeds fitted as standard, whilst optional ceramic piston insulation caps are available.

The CP6278 is a rear caliper four-piston Radi-CAL design suitable for all GT and endurance racing, and features the same cutting edge technology as the CP6277. This includes a radical asymmetric design concept as well as ducted air cooling and a monobloc aluminium body. The calipers are supplied with pistons to suit a 25mm thick brake pad. Optional extras include dry-bleed fittings and a body Thermo-Sensor, as well as ceramic piston insulation caps when used with a 32mm brake disc.


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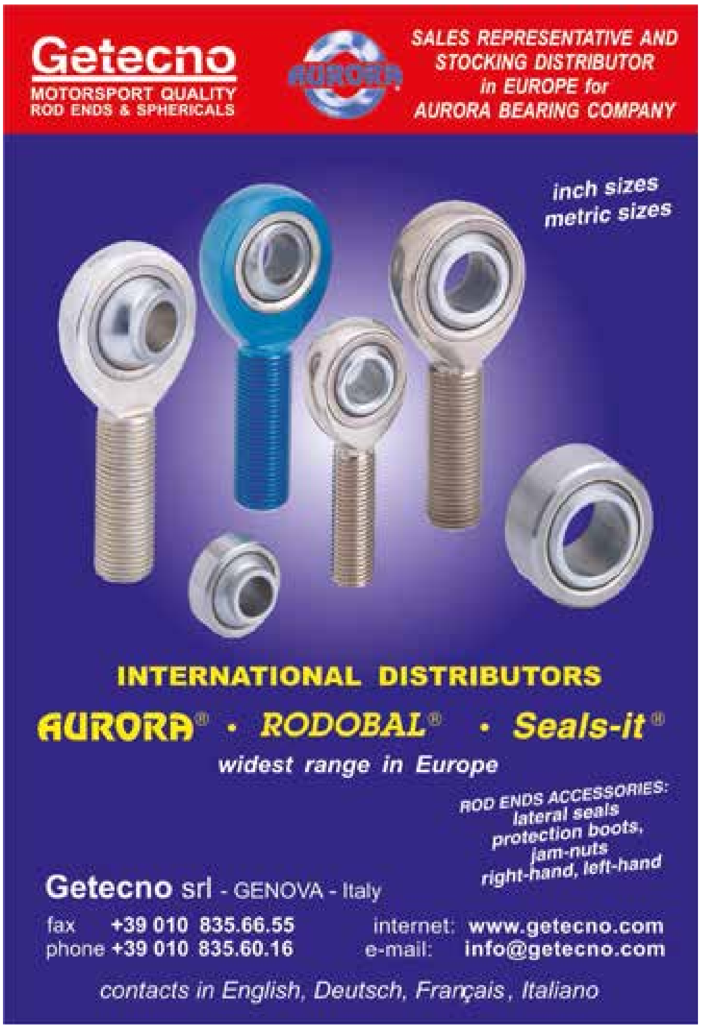
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## Turatillo Trailers

Aberdeen-based Turatillo Trailers will have one of the most imposing exhibits at Autosport International as the company showcases its F35 Motorsport Living Trailer.

Built and designed in-house by Turatillo Trailers, the F35 Motorsport Living trailer is one of the biggest and longest on the market and is one of the only trailers currently available that can accommodate a GT-sized racecar and sleeping quarters for three people.

The entire trailer can be raised or lowered to the ground thanks to two hydraulic cylinders fitted between the front and rear axle beams. Bearings, integrated into the axles' mounting brackets, allow the beam to rotate when the hydraulic cylinders are deployed.

This has the advantage over hydraulic tilt trailers in that all four corners can be lowered by up to 210cm making it the best solution for loading racecars and sportscars with extremely low ground clearance. Furthermore, the trailer can be lowered for long-distance transit to reduce drag and ultimately the fuel consumption of the tow vehicle.

The outer body is made of insulated sandwich panels and clad on an anodized aluminium frame, while for the sleeping quarters, Turatillo has used filmed plywood panels and treated non-slip floors and can be customised further according to a customer's precise requirements.

The living quarters include lockers, a single fold-out single bed with a further foldaway double bed above it, storage shelves, chemical toilet, shower tray, fridge, 220/12V transformer, water tanks and a boiler for hot water.

Autosport International will be the first time that the F35 will be shown to the public and is ideal for customers who need light and practical transportation to and from race circuits. It can be towed on a B and E driving licence, too.

## SPA extinguishers

The FIA has homologated SPA Design's new fire suppression systems with APS technology. The SPA Systems are now available for teams to run trials in preparation for the World Rally Championship in 2016. The SPA System's utilise new APS technology which features a unique single auto-flo nozzle that allows for optimum spray coverage. This means that only one nozzle is required in each area – one for the engine and one for the cockpit.

The New Systems with the APS technology have undergone an extensive testing, development and validation programme in order that they fully comply with the new stringent FIA regulations. The regulations state that the system is deployed in both the engine bay and the cockpit, and this means that teams will use two bottles.

SPA Design engineers have produced a technology to rapidly deploy fire suppressant into the target area that will effectively snuff-out the fire rendering the area safe and virtually removing the threat of reignition. This is largely achieved through the use of a slave compressed gas cylinder in conjunction with a cunning new internal chamber system that forces whichever suppressant has been selected at high-speed through the auto-flo nozzle to reach the target area and fully suppress the fire. All SPA Extreme Cockpit systems use Novec 1230 gas, which in the designated concentration levels offers a completely safe option for the occupants. SPA says that Novec 1230 gas has proven to be an extremely effective extinguishant especially in combination with its APS technology.

SPA also offers a duel-system for the engine that uses a combination of Novec 1230 and F-500 within the same cylinder. The Novec1230 works quickly to knock down the fire then the F-500 suppresses the fire preventing it from reigniting and neutralising any remaining fuel it comes into contact with.

## DMS Technologies

DMS Technologies is using Autosport International to showcase its range of lead-acid and lithium-ion batteries for racecars and motorcycle-engined cars. For decades DMS has supplied the reliable Varley Red Top lead-acid batteries to club and professional racers and this year it will be showing off its newly developed range of Lithium batteries.

The Varley Lithium range was designed originally for motorsport applications with particular attention paid to minimising the effect of shock and vibration as well as making sure the optimal power transfers to the terminals.

Lithium batteries have become increasingly popular during the past three years as they weigh significantly less than their lead-acid equivalents (Red Top 30 weighing 10.6kg while the Li16 weighs in at 3.2kg).

The new lithium battery range, all nominal 12V, are available in three capacities 2.4Ah (Li-3), 5.5Ah (Li-5) and 16.1Ah (Li-16). The Li-5 is DMS' most popular model capable of starting engines up to 180hp and optimal for D-Motor and Rotax 912 engines. DMS has also found an increasing demand for the lithium batteries in light aircraft applications.

## 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

**Stand rates**
**AUTOSPORT INTERNATIONAL & PERFORMANCE CAR SHOW**

- **Shell scheme – £345 per m$^2$ plus VAT**
- **Space only – £320 per m$^2$ plus VAT**

**AUTOSPORT ENGINEERING**

Turnkey shell scheme package: fully equipped 6m$^2$ 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 m$^2$ 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.

**SPA Systems will be using the show to promote its new fire suppression kit**

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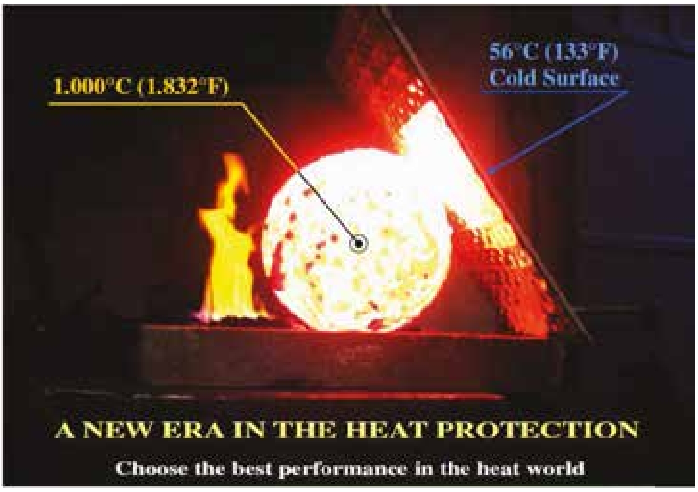


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# MSV acquires land for new French track development

Motor Sport Vision chief executive Jonathan Palmer says his new French facility will serve customers throughout northern Europe

**UK circuit operating giant Motor Sport Vision (MSV) has expanded its business outside its home country with the acquisition of a French airbase which it intends to develop into a huge motorsport complex.**

MSV, which is headed by former F1 driver Jonathan Palmer, has completed the freehold purchase of the Laon-Couvron aerodrome, which is located five miles north-west of the city of Laon and is a former French air force and army base – and was also used by the Luftwaffe in WW2.

The site extends to 1263 acres and includes two former runways, the largest being 3000m long, together with extensive perimeter roads and apron areas. There are over 60 buildings, including many vehicle workshops, personnel accommodation buildings, a sports centre, restaurant, cinema, rifle range and an equestrian centre, with a total building area of 1.5 million square foot.

MSV France (MSVF) intends to redevelop the base into a giant motorsport village, which is to be called Laon Autodrome. The centrepiece of this will be the five mile circuit, featuring a uniquely long 1.5 mile main straight where top speeds of over 200mph will be possible, MSV says.

The driving facilities will include a number of circuits as well as a 1000m asphalt oval track, drag strip, rally stages, 4x4 courses, and an extensive urban road driving centre for driver training. Vehicle workshops and garages will be available for permanent and temporary use, together with hospitality facilities, restaurants and guest accommodation both as hotels and apartments, which will be for lease or sale.

MSV already owns and operates five UK motorsport circuits – Brands Hatch, Oulton Park, Snetterton, Cadwell Park and Bedford Autodrome. Palmer, its chief executive, said: 'We have been eager to expand into Europe and had targeted this area, midway between Paris and Brussels, so that our new Laon Autodrome circuit will serve not just the French market but equally importantly the whole of northern Europe.'

Palmer added that activity at Laon will mainly be centred on high performance road car driving, with track days and manufacturer events, but MSV also plans on holding four race days a year.

Phase one is planned to open in April 2018, with construction starting in spring, 2017.

## SEEN: Ginetta G57

**Ginetta has released details of its new G57, a development of its LMP3 car which is designed to find a broader market for the chassis. The G57 has been heavily redesigned to increase performance and will sport a new engine and gearbox plus a revised aerodynamic package. A 6.2-litre 580bhp Chevrolet LS3 engine will sit in place of the spec Nissan LMP3 unit and cogs are to be engaged via an upgraded Xtrac sequential gearbox. Ginetta tells us that the G57's aero kit will give it 30 per cent more downforce on the base LMP3 model.**

**The new car is aimed at open sportscar championships around the world, and particularly in the US, while Ginetta also has an eye on the burgeoning track day market. The G57 has already been approved for use in the VdeV championship.**

**Ginetta's chairman Lawrence Tomlinson said of the G57: 'The European Le Mans Series provided the perfect platform to further introduce the Ginetta brand to the European marketplace [with the LMP3], and we worked closely with the ACO to ensure both the car and the series was a success. As a business, we must now continue towards our goal of increasing export, which inevitably means creating a new, and significantly faster, car which is eligible for competition on a number of different global platforms.'**

# Williams scoops top tech award for its FE battery

**Williams Advanced Engineering (WAE) has been awarded the prestigious Simms Medal by the Royal Automobile Club for its Formula E battery.**

The Simms Medal is only awarded in years when the Royal Automobile Club's Technical Committee deems there to have been contenders of sufficient merit.

The Formula E battery had to be designed from scratch within a 12-month time-frame, fit into a strictly pre-determined safety cell, cool sufficiently, be 100 per cent consistent from one team to the next (40 racecars plus spares), and last an entire season with no loss of power or performance. The batteries showed remarkable reliability in the inaugural Formula E season, with only one failure in 440 race starts.


Craig Wilson (right) accepts the Simms Medal from John Wood

WAE is only the eighth recipient of the Simms Medal, with previous winners including Ben Bowlby in 2012 for his DeltaWing racecar and Lord Drayson in 2013 for world record breaking achievements with the Drayson B12/69 LMP-type EV.

Meanwhile, the recipient of the RAC's prestigious Dewar Trophy was GKN Hybrid Power for its flywheel energy storage technology. The company was actually previously owned by Williams and operated from 2008 as Williams Hybrid Power, until its sale to GKN in 2014.

John Wood, chairman of the RAC's Technical Committee, said: 'The Formula E battery is a design, technological and packaging marvel, and its creator, Williams Advanced Engineering, a very worthy recipient of the Simms Medal in recognition of its contribution to motoring innovation. Each of these batteries has enough energy to charge a smartphone every day for 13 years and holds the equivalent energy of 10,000 AA alkaline batteries.'


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## Fluid transfer
# Flexible flow solution

**Specialty Fasteners, in conjunction with its technical partner Samco, have released AeroFlo, a brand new integral silicone hose and fluid coupling assembly which is said to eliminate the need for complex tube bending.**

This new product features the unique Hydraflow 14J21 coupling with a Samco Xtreme Aramid fibre reinforced silicone hose. This allows for smooth and safe water and air transfer for quick release radiators and intercoolers. The hose removes the need for complex tube bending and allows for greater packaging options. An additional benefit in the cut and thrust of close racing is the greater resistance of hoses or tubes to becoming dislodged in the case of an impact.


The system comes in a range of configurations and sizes (from 32mm up to 63mm, larger or smaller upon request) with specials also available. It is offered in both coupling to coupling and coupling to push-fit variants.

Extensive prototype testing was undertaken with BTCC team Motorbase Performance, which was impressed with the benefits the new system brings.

Oly Collins, team manager at Motorbase said: 'We were delighted to work with Specialty Fasteners and Samco on this project. The flexibility it offers is great, and it allows for faster component changing. Add to this the fact that it is a cost effective solution, and it ticks all the boxes.'

Sales manager for Specialty Fasteners, Graham Leo, said of the product: 'Ever since we started the prototype project we knew this would give great benefits to the teams and our testing has shown this. It is now production ready and when Samco took it to the SEMA show recently it picked up a Global Media Award straight away, so that is very encouraging.'

AeroFlo, in a variety of configurations – some suitable for stock car racing which include a 2in water hose for high pressure systems – will be on display at the PRI show on both the US Distributor Coast Fabrication Inc booth (3706) and the Samco Sport booth (4524).
**www.AeroFlo.co.uk**

## Sensors
# Pressure and heat

**Kistler has a new member in its 4080A family of piezoresistive absolute pressure sensors for motor racing applications. The Type 4080AT is a combined pressure and temperature sensor in a compact package – with a body length of 24.4mm, weighing less than 12g.**

Suitable for universal use, this sensor features a temperature probe and integrated signal conditioning. Specifically designed to cope with harsh ambient conditions in motor racing, as well as demanding requirements on the test bench, the new sensor can be installed directly in to a vehicle. The Type 4080AT supports reliable monitoring of low pressure cooling water, fuel and oil circuits, to enable the early detection of problems, optimisation of system design and real-time monitoring of critical operating conditions.

The additional integrated PT1000 probe allows dynamic temperature measurements in liquids at up to 200degC. Maximum flexibility for connection to a data acquisition system is ensured by the unique concept that includes integrated signal conditioning and an analogue voltage output from 0.2 to 4.4 VDC (pressure) and 0.5 to 4.5 VDC (temperature).

With its 5, 10 and 20bar pressure ranges, the Type 4080AT is suitable for universal use in low pressure applications in cooling water, fuel and oil circuits. It is FIA-homologated and can be supplied with either a LEMO plug connector or a flylead cable.
**www.kistler.com**

## Lubricants
# Slick shifting gear oil


**A new transmission fluid from Driven, which was used exclusively in the 2015 NASCAR Sprint Cup Series, with wins in six races, is now also available to all racers running on both short tracks and road courses.**

Driven's 75W-140 Racing Gear Oil is a synthetic blend used by top race teams. The company says it reduces operating temperatures more than some other brands. The oil is also said to reduce friction and provides shear-stable viscosity for 'outstanding gear durability'. It eliminates the pitting and scratching of gear sets, as seen with lower viscosity oils, and it does not increase drag or reduce horsepower. Even after six hours of driving it maintains its viscosity, and extended change intervals allow it to be used race after race. It is available in quart bottles or cases of 12.
**www.drivenracingoil.com**

## Transmissions
# Clearance to fly low

**Quarter Master's new LGC (Low Ground Clearance) Bellhousing Kit is designed to help maximise downforce and lower the centre of gravity by allowing the nose of a car to be as low to the track as possible.**

The additional ground clearance is achieved through a smaller ring gear and a flat-bottom bellhousing that makes it flush with the bottom of the tightest-fitting dry-sump oil pans.

The bellhousing also features both internal and external strengthening ribs to maximise strength and stiffness while reducing parasitic drag. The kit is designed for oval track or road racers using 5.5in clutches and a rear-mount starter. It can be used as a retro-fit option or an entirely new package. Quarter Master LGC Bellhousing Kits, featuring either magnesium or aluminium bellhousings, are also coming soon, for all popular applications.
**www.quartermasterusa.com**

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# Riding the cycle

The withdrawal of Citroen from the World Touring Car Championship did not come as a shock to anyone in the Macau paddock as teams, drivers and manufacturers prepared for the final round of the newly-formed TCR series. The French manufacturer announced on Thursday, November 19, that it would scale back its WTCC assault to two cars in 2016, and instead concentrate on the World Rally Championship in 2017. The only surprise was that the driver dropped from its roster of three was Sebastien Loeb.

The Frenchman runs a customer team in the series and as a driver has won multiple World Rally titles for the Peugeot Citroen group. However, according to insiders, despite his press release post announcement that he was surprised, he was already well aware of the decision having committed to the Dakar Rally with Peugeot. No doubt he, too, will be part of the WRC programme in 2017, having lost the chance to win the WRC, the WTCC and go on to win the World Rallycross title to finish his career.

What affect will Citroen's decision make on the series? For many, it was both expected and welcome. There has been ill-feeling in the paddock for a long time as the rivals waited for the regulations to be finalised and then, when they were, Citroen presented a ready-to-roll car. Having achieved a head-start, it then dominated the races, winning all the titles in 2014 and then in 2015 too. That ill-feeling was further extended as factory driver Sebastien Loeb's team cars were eligible for the lucrative privateer prize fund.

> **TCR needs a strong WTCC in order to grow under the radar**

In the TCR paddock, the mood was upbeat, but no one was jubilant at Citroen's news and for many reasons. The TCR needs a strong WTCC in order to grow under the radar, and there was a real fear that a weakened WTCC may seek for a new set of regulations, ones that produce cheaper cars and better value for money for competing manufacturers. There are a number of options; British Touring Car Championship regulations, and those of the TCR among them.

There is a precedent for such things. Racing alongside the TCR in Macau was the inaugural FIA GT World Cup, the first manufacturer-based race for GT3 cars. The series are at different stages of their development. As I have written before, GT3 was introduced for customers, as low-cost feeder series to GT2 and ultimately to GT1. The racing was not of the highest calibre, and it wasn't supposed to be. This was customer racing in supercars, and the rules were carefully structured.

As GT1 became too expensive, and GT2 morphed into GTE, GT3 found a natural home in Stephane Ratel's Blancpain series. However, there were carrots that were too attractive for manufacturers. Overall wins at the Nurburgring 24 hours, Spa 24 hours, and now at Macau have proven to be too good value for money and so full manufacturer entries were created. Apply that same theory to TCR, where the Macau race and support races of the Formula 1 World Championship are on the schedule, and it doesn't take a genius to work out that this presents fantastic value for money should a manufacturer take the notion.

Those involved in setting up the touring car series, including Marcello Lotti who was responsible for the S2000 touring car regulations that saw the WTCC grow into a globally recognised entity, Alessandro Mariani, managing director at JAS Motorsport which runs the Honda WTCC programme and builds cars for the TCR, and Jaime Puig, who ran the SEAT WTCC programme, understand that this is customer racing. Each was clear; there is no point in building the TCR up into something that it is not, repeating the mistake of the GT3 model and allowing manufacturer entries.

Yet that is not the natural cycle of the sport. TCR was originally built as a feeder series for the WTCC, educating younger drivers in the art of touring car racing and providing strong competition. The plan is not only to feed the drivers into the WTCC, but also to feed the TCR cars into national series, but this is nothing new, either. The S2000 cars were supposed to do exactly that. However, the cost of running them proved to be too high, hence the Swedes introduced the TTA and the British Touring Car Championship went its own way too.

The GT3 plan is in the final stages of its evolution from original form to factory programmes, and Ratel is in the process of turning his attention to GT4 and providing another genuine feeder series to his showpiece events.

For his part, Lotti was completely unconcerned; as far as he is concerned it is up to the competing manufacturers and the FIA to decide what to do with his regulations. He thinks that he has put into place all the necessary foundations to keep his series as originally intended. The engine cost is less than a third of that for an S2000 car, and it lasts three seasons, rather than three engines a season.

The cars are low-cost, the racing's good, manufacturers are committing to it attracted by the format, the reach and the reasonable purchase and running costs. As Puig stated: 'There is no need for more manufacturers in the series. They just need a stable grid, and to understand that this is no place for manufacturer racing.' Unfortunately, this idea has also been tried before; by King Canute. The WTCC must stay strong, or the vacuum created by its implosion could get complicated!

**ANDREW COTTON** Editor


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