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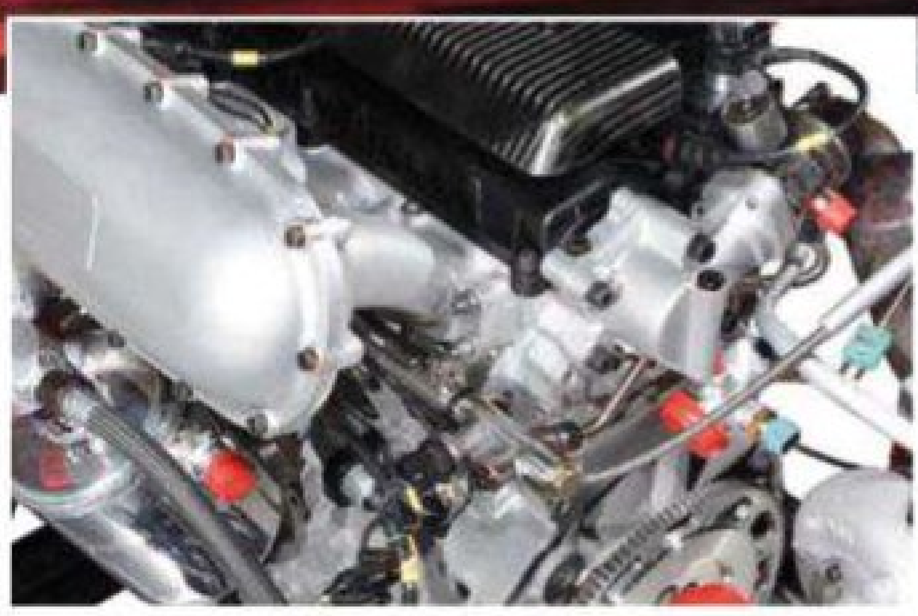
Formula 1 2012

- FIA closes loopholes
- Teams reveal their secrets



King of Hammers

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278bhp from a pre-war 1.5-litre V8 race winner

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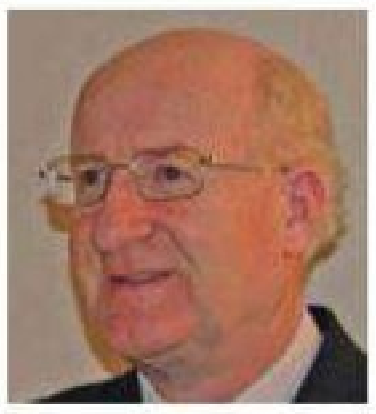

David 3, Goliath 0

It takes more than manufacturer muscle to win at Daytona

The tremendous combined effort, although admittedly short of downright collusion, to win the Grand-Am Daytona 24 race with GM-friendly Daytona Prototypes deliberately styled as customer-attracting Corvettes, came to naught as Ford-powered Riley cars took all the podium spots. To rub salt into the wounds, the first and third spots were taken by outside betting odds team entrant, Michael Shank Racing.

As reported in *Racecar Engineering* V22N2, a huge push had been made by Grand-Am organisers and GM to craft a new DP car standard based on bodies resembling cars that GM sell rather than purpose crafted racing 'shells. We are told that thousanes of supercomputer CPU hours went into CFDing the Corvette body shape alone, and no doubt commensurate money was spent on other aspects of the project, yet in the race engine problems seemed over-abundant. GM supported a four-team effort at Daytona, but its new creation could manage only a disappointing fifth place. It is true that the rest of the series lies ahead so the manufacturer can develop the new cars, but that is the same for the other teams, too. When racecars seem to be designed around marketing needs before performance, one has to wonder about the rationale behind them.

Many fans certainly did travel to Daytona to see the racing Corvettes and rather fewer perhaps to see the Rileys with their out-of-date Ford engines. (Here I must admit a very small commercial link with the winning team as I previously supplied one of Michael Shank's race engineers with mathematically-based optimisation software so I have a natural Ford bias!).

Racing, of course, relies hugely on manufacturers, so they must be coddled, but is it just too cynical when organisers and manufacturers get together to try and fool the buying public with plastic body shapes slapped onto a common chassis that cannot be found in a road car?

It is no secret that Grand-Am and GM got together to plan the Chevy-looking car to attract punters into GM showrooms, but I can add that it may also be Grand-Am's plan to get Ford and maybe other manufacturers to do their own bodyshells for the same commercial reasons. Jim France now controls / owns both NASCAR and Grand-Am series and this plan is of course exactly what his father, Bill France, did for NASCAR: evolve (some say stagnate) a standard chassis with almost interchangeable bodyshells vaguely reminiscent of manufacturers' road cars, hoping to persuade the public into buying on the following Monday whichever body shape happened to win on Sunday. One can argue that the strategy worked very well for NASCAR as a business empire, but now the vestigial bodyshells are reminiscent of little more than a series of abstract, NASCAR-designed curves. This is due to change in 2013 with recognisable body styles re-appearing, but still on a largely mandated chassis that has nothing to do with the street car.

If US Sports Prototypes are now to go the same way as NASCAR, but with sports-related bodyshells rather than saloon-related bodyshells, will that really improve Sports Prototype racing? One doubts it somehow.

"Racing relies hugely on manufacturers so they must be coddled, but..."

In welcome opposition to my usual cynical carping, the positive side of the Daytona 24 was the extraordinary performance of the third podium car. This was another Ford Riley from Michael Shank Racing, but driven by a bunch of inexperienced youngsters who, despite a load of things stacked against them, still managed to finish just 45 seconds behind the winner.

Michael McDowell, Gustavo Yacaman, Felipe Nasr and Jorge Goncalvez had a previous generation car with chassis design dated 2003 and bodywork design from 2008, presumably with somewhat less than GM's hours CFD time!

They suffered an unplanned, pre-race, overnight engine change, a narrow escape from a cut tyre and an extra pit stop to change brake pads. That they finished at all was good, that they came third in the face of the massive effort against them was nothing short of extraordinary.

The team's race engineer, Jeffrey Chrstos of JPC Engineering, sings their praises: 'Three of my four drivers are 19 or 20-years old, and the old guy is 27! We had the old car and the aero handicap meant we lost about seven tenths so we couldn't fight for the win but we were still on the lead lap at the end. The amazing thing about the young guys is that by the time the race started they really had listened to everything we told them and they just carried out the plan. Even when we got a few laps down, they didn't panic and just trusted us to get their laps back, which we did. We spent a lot of time going over with them what they could and could not do, how aggressive they could be and when they should back off. I got some of the experienced drivers to talk to them as well and somehow it worked... Getting a podium with three 20-year olds who had never raced one of these cars, never done an endurance race, never driven at night was a huge accomplishment.'

If there are lessons from the 2012 Ford benefit Daytona 24 then they have to be: don't rely on CFD, don't rely on collaboration with the series owner to bend rules for you and, most of all, don't think that new hardware is necessarily good or that inexperienced young drivers are necessarily bad!

GM hogged the limelight, Ford did the business, and both want to sell cars

The one in the middle wins races

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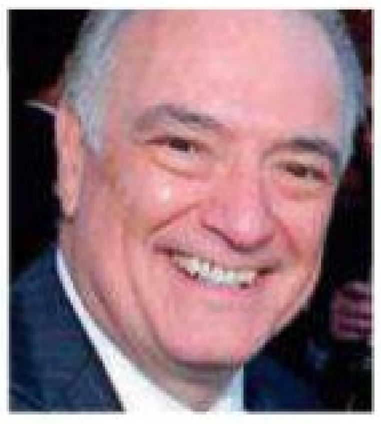


Full steam ahead

Now is the time to start making contacts in the emerging markets

Finding new markets is more important than ever. UK motorsport exports more than 65 per cent of its sales, making it a truly global business. Others now see the importance of international trade and are strong competition to Motorsport Valley.

Europe and the USA are well established 'traditional' export markets with strong sales in many disciplines, and must not be ignored. European suppliers should target the USA as it remains the largest consumer market in the world, and the most competitive, too.

But what of emerging markets? Brazil, Russia, India and China, say the economists, will become leading economic countries within the next 20 years, to be followed by Vietnam, Indonesia, Columbia, Mexico and the like. Some protect themselves with trade barriers to control import spending, but wherever cars or motorbikes are enjoyed, there will be motorsport business of some kind.

Some have little currently, so suppliers appoint a local sales agent to build business from a low start. In years ahead, some of those agencies can grow to be substantial businesses, so must be part of your export plans, but each 'new' market needs a different approach.

Brazil and Argentina have successful existing markets and offer the best immediate opportunities. Both have excellent local motorsport suppliers but are opening up to imports – high tariff barriers are reducing and the single trade community of MERCOSUR is growing. Brazil has just announced a major track development, while Argentina, with its huge crowds and great tracks, just contracted Radical UK to supply engines for their major Stock Car series, TC 2000, which already use Xtrac transmissions from the UK.

This is the perfect time, as local companies start to look overseas for suppliers, to check out these markets. The MIA is holding a free seminar on Argentina in March and hopes to take a business development group to Brazil and Argentina later this year or early next.

India's automotive industry has a long history and is growing in influence. Witness Tata's success with Jaguar Land Rover. They need more good quality tracks to really boost business, but many are under construction, and the Formula 1 race has raised awareness, nationally. It will be a year or two before the market is of value to exporters from Europe or the USA, but now is the time for initial business connections to be made.

Russia is in a similar situation to India. It has a good local automotive industry, but little motorsport infrastructure. One or two new tracks have opened recently, with more planned. They have enjoyed ice racing, rallying and off-road motorsport for years, relying on domestic manufacturers. Now their market is opening to new suppliers, and their successful companies will look to buy from established producers in the USA and Europe.

China is the big anomaly. The population has only relatively recently been allowed to buy cars, which they are doing in abundance. A fast growing, wealthy group are enjoying European 'sports car' brands, and circuits are being built for their enjoyment. The China Touring Car Championship sent a delegation to Europe in January to source product, and European companies are visiting China more often. The rate of growth in Chinese motorsport will be greater than anywhere, and will take off in the next two or three years.

"Wherever cars or motorbikes are enjoyed, there will be export business of some kind"

Formula 1 now has Russia and India as serious investors, and Brazil has long supplied drivers, fuel companies and banks. China has yet to take a position but it cannot be far away. Such involvement consolidates opportunities for business partnerships in wider motorsport.

There is no short cut to developing these markets so start the groundwork now to get the best results. Do detailed desk research, collecting information from the web, media, internet and any contacts in the markets. Governments help companies to research markets. In the UK, the UKTI EMRS scheme pays 50 per cent of market research, and their International Posts will carry out targeted local research for just £1000 or so.

You need local market knowledge to target your product offer accurately. While you are likely to modify your basic product to suit local conditions, the essence of delivering quickly a competitive, efficient product at the right price remains the same.

Once you have some knowledge, take a business visit to the market. The MIA organises some of these business visits, as do Chambers of Commerce. Meet and talk to as many people as possible there, keep your eyes and ears open and aim to learn all you can. Make no decisions, just research and build networks for later use.

On your return, keep in contact with all your new contacts, find out what business is open and arrange to meet at an international show. Following those meetings, your export strategy will take shape, and you will know which market will deliver the best return on investment for your company.

These valuable, new markets are set to become large buyers of motorsport products over the next three years. Start your desk research now to get your share. The MIA specialises in this kind of motorsport work, and can help you gain as much knowledge as possible – see www.the-mia.com. Come to one of our export events, or contact me, I am always happy to help any business grow their exports. Happy hunting.

Argentina has already shown the way, sourcing UK-built engines and transmissions for its flagship TC2000 Touring Car series

Open season

Aerodynamically-positive exhausts, nose jobs and tyre compounds are the talk of the first test at Jerez

BY SAM COLLINS

Formula 1 has undergone a major change over the winter, which could upset the established order on the starting grid. Unless you are looking at a McLaren, it is easy to spot a 2012-spec Formula 1 car from its 2011 cousin. A small change in the technical regulations made to improve safety in car-to-car impacts has altered the face of grand prix racing, and not for the better. The maximum nose height has been reduced by just 75mm, but the height of the front of the monocoque remains unchanged. The change was implemented to reduce the risk of the nose hitting the driver in a 'T-bone' situation. But inadvertently, it has led to almost all of the cars featuring an ugly step in the nose.

Whilst this inevitably catches the eye, the aerodynamic significance of it is small. 'It is an aerodynamic fact that the underside of the nose is what does all of the work,' explains James Allison, technical director at Lotus F1 Team. 'They are quite insensitive to top surface shape so you can have a fairly abrupt shape on the top surface of the car, as long as you are focussing on the underside. Indeed, there are lots of other abrupt shapes – just behind it you have the windscreen and cockpit.'

Allison, according to another team's technical director, actually suggested the rules should be changed as the cars look so ugly!

Other teams, however, may have found a gain in that area. When Red Bull released pictures of its RB8, immediate attention was drawn to a large duct on the nose 'hump'. Suggestions have been made that it serves some kind of aerodynamic function to do with the front wing, but the team deny this. 'The step on the nose is really just a product of the regulations where they restrict the height of the nose but not the height of the front of the chassis,' explains Adrian Newey. 'Most of the teams have gone one route to try to satisfy the regulation with a higher chassis and ended up with an awkward looking step. For styling, we have moved the driver cooling duct from where it is traditionally at the front of the nose. We did it purely for aesthetic reasons to break up the ramp on the nose.'

Perhaps, but the duct is far larger than the tiny driver cooling ducts found on the cars at hot races. It is also larger than the apertures used on the now outlawed f-ducts, so its real purpose is not clear, though driver, Mark Webber, did claim to be suffering numb feet as a result of the large duct.

Sauber does not offer any such explanation for the duct featured on the nose of its C31. It will not be drawn on the purpose of the duct and, with it facing away from the nose of the car, it is not likely to be for driver cooling...


TOTAL

1. Red Bull's 'driver cooling duct' has attracted much discussion 2. McLaren's exhaust exits sit a long way outboard of the chassis and on the limit of the regulatory box. Some have already questioned the legality of the design 3. Ferrari has experimented with many variations of its exhaust in an attempt to re-capture some of the lost downforce 4. Sauber's nose duct faces the opposite direction to the one on the Red Bull

McLaren has approached the nose height reduction problem from a different angle. It already had a relatively low nose and, as a result, has avoided the ugly step. Some in the paddock believe this approach could limit the scope for aerodynamic development on the lower part of the front of the car, especially on areas like barge boards, but the Woking-based team do not seem too worried about that, or what other teams think.

With the changes to the regulation on the nose having a fairly minimal impact on the actual performance of the car, it is likely to be a topic of discussion throughout the season on forums and in the mass media. Where there is a more substantial change in the design of the cars, however, is at the rear.

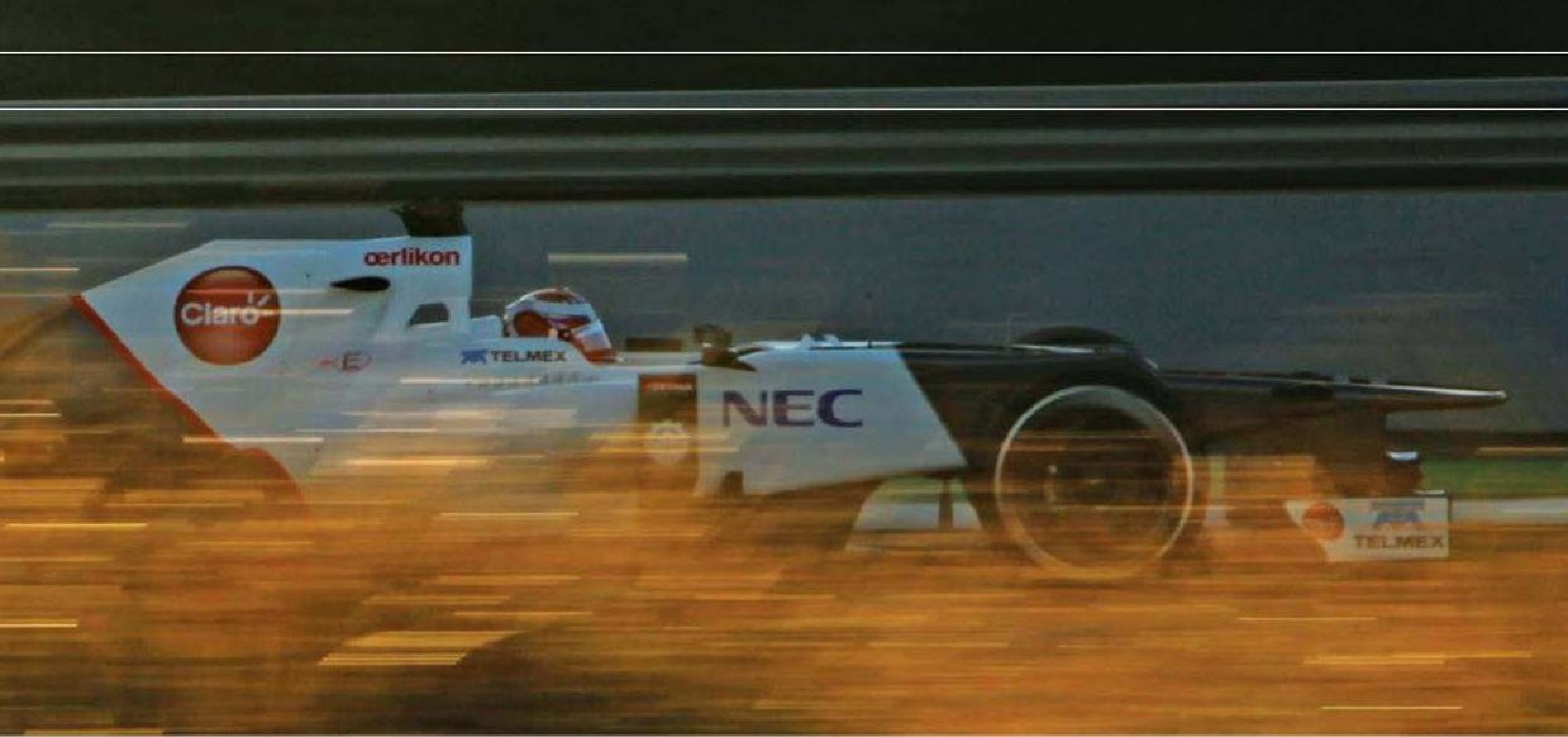
THE EXHAUST ISSUE

In 2010, and especially in 2011, many teams took advantage of a loophole in the regulations that allowed engine exhaust gasses to be used to drive the car's floor, essentially increasing downforce. Notably Red Bull and Renault built their cars around the concept. Special engine maps were created which, in very broad terms, turned the driver's accelerator pedal into a torque demand switch whilst the engine ran at 100 per cent throttle 100 per cent of the time. The downforce gain from the concept was significant, but it was clear that the situation could not continue. A mid-season ban was mooted, enforced and then dropped, but blown floors were definitely on the way out.

'The teams decided around Silverstone in 2011 that we were going to get rid of exhaust blown rear diffusers, and that point alone requires a very different design concept,' explains Allison. 'Recent car designs have been heavily influenced by their rear exhaust configurations, and the intent of the rule is to stop that happening. The rules on the exhaust geometries themselves have been reinforced by some engine operation rules which don't sit in the technical regulations, but which arrived by Technical Directive quite late last year. The exhaust issue, although agreed in principle at Silverstone, continued to unfold as late as mid-November, so the challenge has been to roll with the punches as the detail emerged over a fairly extended period – trying to make the best of each version of the rules as they've come out, whilst trying to anticipate where the end position is going to be.'

For 2012, the new regulations dictated that the exhaust must exit in a prescribed box that is in a similar location to the top exit exhausts of 2008 and 2009. The designs are also subjected to particular exit angles and diameters as a means of providing further restriction. Finally, a raft of technical regulation changes were introduced to limit software, especially on the engine and transmission maps.

'For us in the world of engines, 2012 involves dealing



with the backlash of the exhaust regulation changes,' explains Rob White, Renault Sport's F1 engine boss. 'The easy option would be to go back to what we did in 2010, but we can't. We can't because things move on and we cannot unlearn what we've learnt. More particularly, we are not permitted to do some of the things that we were doing then. Some of the engine set up things we found quite useful for reliability and performance reasons have subsequently been forbidden. So now our job is to work out new solutions to those problems and deal with specific installation challenges of the cars we have.'

"For us in the world of engines, 2012 involves dealing with the backlash of exhaust regulation changes"

RE-CAPTURING LOSSES

Despite the rule makers' best efforts, it seems the teams have already started to find ways to re-capture some of the losses, or at least are actively trying to do so. One team's chief designer claimed that gaining points of downforce from exhaust blowing was 'addictive'. The way the rules are written, too, could leave some areas open for interpretation, and this has already sparked debate.

'The overall intention of the rule change was to make the exhaust as aerodynamically neutral as possible. The written rules allow lots of solutions that are aerodynamically neutral, but they also allow lots of others which are very aerodynamically positive,' explains Allison. 'The FIA has indicated in technical directives that the intention of the rule had to be respected as well as what is written. So there are solutions that are legal by the regulations, but are not legal in the intention of the regulations. So the real challenge is to judge where to exit the exhaust and whether that is acceptable in the intention of the regulations, and what acceptable means!'

Force India's technical director, Andrew Green, openly admits that his teams of engineers at Silverstone and Brackley are actively trying to circumvent the ban and find ways of using the exhaust to generate downforce. 'We have quite a few developments in this area, but it is a very, very fine balancing act between trying to get the exhaust to deliver in the area where we had it last year without fundamentally bringing down the overall performance of the car.'

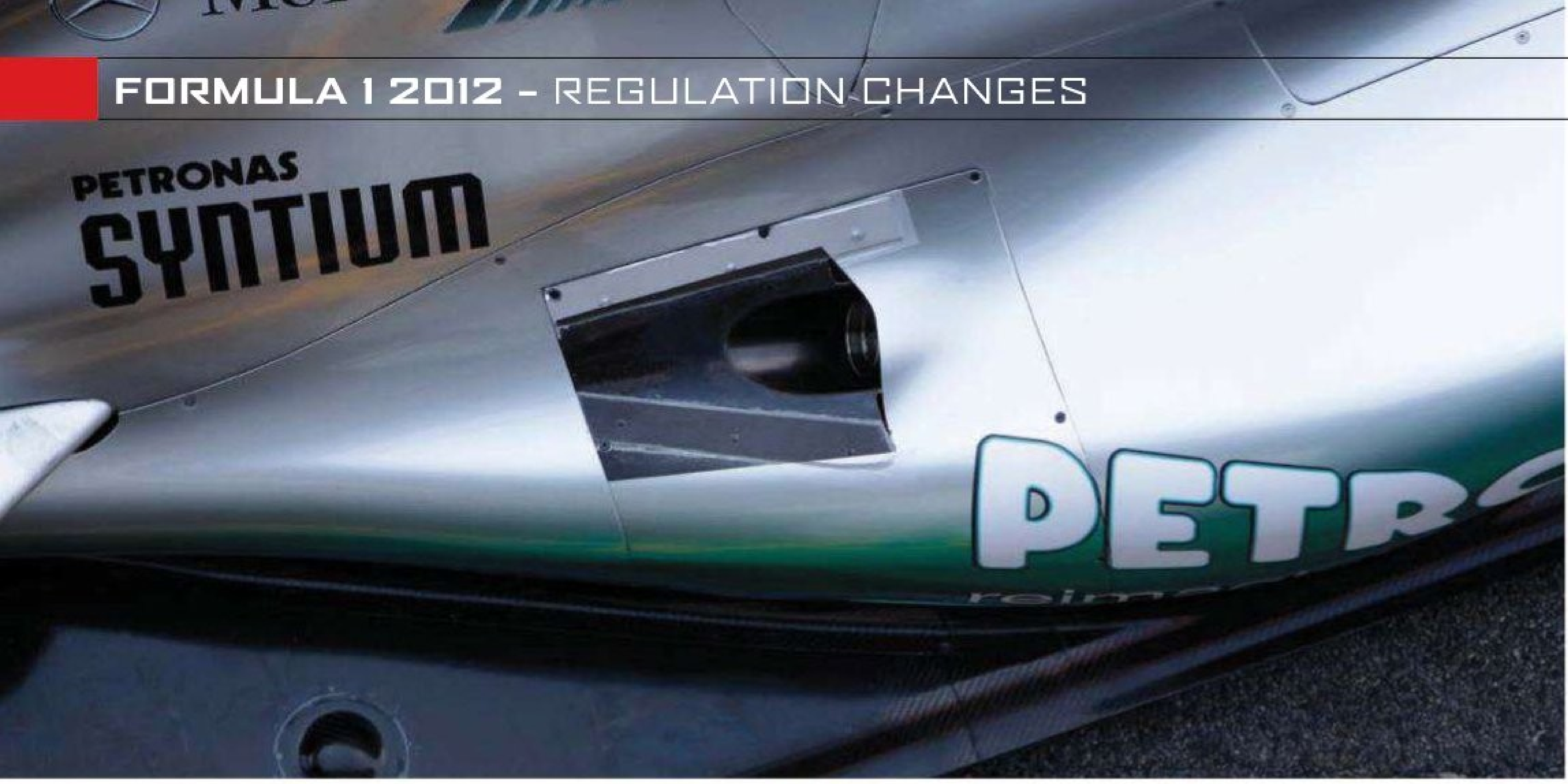
'The exhaust position and direction is pretty well tied up, but you can do a little bit with it and you'll see teams tweaking it in testing and early races, but I think the main source of development is going to be the way the bodywork reacts with the plume around the exit of the exhaust, and that is where the development will be trying to get the exhaust to attach to the bodywork and drag it down to the rear. It's about adding energy to the rear of the car. It's a huge source of energy you want to do something with and it's about trying to get it down to that suction point on the car. There are areas that have shown promise and it comes down to the amount of development resource you can apply to it. We are actively pursuing it and we see it as an important area to exploit.'

But with software restricted more heavily than in 2011, the teams are now faced with a new challenge – not only are the exhausts critical in terms of engine performance and downforce, they are also critical in the driveability of the car. In 2011, the complex maps used by the teams meant exhausts created downforce when the driver was off the pedal. In 2012, that is not possible, creating another complex problem: 'You really do have to get the balance right though, on and off the throttle,' Green continues. 'You can start to exploit the exhausts but it suddenly gets harder and harder to drive, and it's a balance between the car being driveable and aerodynamic performance. That's all being developed in the simulator.'

Even if the FIA suspect that a design is not complying with the intention of the rules, it seems hard to comprehend how the scrutineers will check the direction of the exhaust gasses in practice.

Developing a workable blown floor was not easy in 2011, and not all teams were able to reach fully working solutions, so it seems likely that in 2012 there will also be teams that are not able to develop optimum layouts. 'I do not mind displaying my ignorance in this area,' explains the candid technical director of the Toro Rosso team, Georgio Ascanelli. 'We cannot be the best because our simulation capacity is limited in this respect. We cannot simulate this in our wind tunnel, yet. It depends on the pulse, the speed of exhaust gasses compared to the speed of the airflow, the expansion rate, the temperature, ride height and cornering speed. We cannot simulate all of these things with sufficient certainty. Ferrari supply us data on what they expect the exhaust plume to be, so what we can do is try to apply theory.'

But not everyone places such importance on the exhaust position, including the technical boss of the team that gleaned the most benefit from blown floors in 2011. 'There is not a lot to come out of them,' contests Red Bull's Adrian Newey. 'As often happens when there is not a lot to be gained, you get a real variety of different positions.



Working within tight bodywork regulations, the teams are having to find a way to ensure exhaust gasses flow down toward the rear of the car

NEW TYRES = NEW PRODUCTS

Whilst the Pirelli tyre compounds for 2012 have been revised, they are still from the same family, and this could see a continuation of a phenomenon seen since the introduction of the Italian rubber at the start of 2011. English firm Zircotec, best known for its thermal barrier coatings, came up with a solution, dubbed ThermoSlik, in 2011 and has opened the product up to the wider market in 2012.

'Ensuring clean surfaces is essential,' explains the firm's managing director, Terry Graham. 'A development from our smooth thermal barrier coating – itself conceived to minimise disruption in and around the diffuser – adds a repellent property to the formulation.'

With tyre degradation, aerodynamicists have been troubled by the build up of debris, notably rubber 'marbles' on aerodynamic surfaces. 'The repellent element is an intrinsic part of our thermal barrier coating,' adds Graham. 'It offers a lightweight, subtle solution that not only prevents delamination, but also adds a little aero performance.' Developed over the past eight months and proven in the second half of 2011 on track, the ThermoSlik coating is applied at Zircotec's UK facility where all preparation, coating and finishing takes place. Due to the application process and materials used, ThermoSlik is only validated as a combined heat and repellent offering, but Graham leaves the door open for further derivatives. 'We are always keen to work with the teams on specific issues,' continues Graham. 'We have a number of other projects in the powertrain and aero where a coating is solving issues or unlocking performance.'

Understanding the tyres is also critical, and another English firm has re-worked its products to meet the demand of the teams. bf1systems has introduced a new ECU for its tyre monitoring systems. It is 50 per cent smaller than the company's previous motorsport digital ECU, whilst retaining all the same functionality. Later in the year, the firm will introduce a combined ECU / antenna unit, which will be introduced to teams using its systems, replacing the existing antennas and ECU on the car with a single box. 'We are able to offer a 140g (down from 250g to 110g) saving over the current on-car parts,' says bf1systems' electronics manager, James Shingleton. 'Together with a much simplified wiring loom, this is a notable weight and complexity saving. Testing of the combined system is expected during the season and direct pin-out compatibility means users will be able to make the smooth transition without concerns over loom connectivity when it is released.'

With testing so restricted and teams craving ever more data, bf1systems is offering an eight-channel version of its tyre pressure and temperature monitoring system. 'For the first time, we are enabling engineers to accurately and reliably measure the inner tyre carcass temperature at two different places on the tyre,' claims Shingleton. 'The opportunity to acquire temperature data from two parts of the same tyre concurrently, on all four tyres, is especially important with the new tyres and running time being so limited.'

I doubt there is really a lot to be had though and the FIA do not want to see flow-catching ducts. In other words, scooping the exhaust flow up and then using that flow somewhere on the car. When double diffusers were banned at the end of 2010 we were largely able to replace the fact they had gone with the exhaust pipe location. With this rule change it is very difficult to replace the exhaust effect and there is no big grand idea that will replace the diffusers of last year.'

INCREASED POWER

All of this has more than just an impact on aerodynamic performance and engine tuning. The change to the exhaust exit location and, more significantly, the changes to what is allowable in terms of engine maps, has effectively increased the amount of power produced by the 2.4-litre V8 engines, and also has had an impact on the cars' fuel tanks. To power a blown floor effectively and generate additional downforce, an engine must produce significant amounts of exhaust gas. Simply put, the more fuel burned, the more exhaust is produced, and potentially more downforce. According to Renault, the teams using its RS27 engine at the 2011 Australian GP were able to burn 10 per cent more fuel than normal without running out, giving more exhaust flow to its partners using the blown diffuser.

But whilst pretty much every


180 MPH WITHOUT MOVING AN INCH

FERRARI FRONT SUSPENSION by Nicholas Tombazis

'The reason we went for pull rod front suspension was primarily aerodynamic. We feel it handles in a better way the flow structures that come from the front wing, so that is the main driving force. We were obviously very concerned about the loadings to the suspension and so did quite a lot of work making sure we have done our homework correctly. In quite a few areas we found that the front suspension had to be made more robust, which we have done to overcome those loads. if you look at the front view of the car, you will notice the pull rod and the wishbone form fairly regular triangles in relation to each other. So, in the end, we found a solution that was probably a bit more loaded, but was quite acceptable from both a mechanical and an aerodynamic standpoint.'

Ferrari has taken a very different approach to its front suspension on the F2012, uniquely for the 2012 season going for a pull-rod layout

OTHER RULE CHANGES

Car floor
The floor under an F1 car (the so called step and reference planes) has to be designed flat. Because things cannot be made perfectly flat, a manufacturing tolerance of +/-5mm was permitted. It was felt latterly that this 5mm tolerance allowed opportunities to design [illegally] some mild contours into the floor. To clamp down on this possibility, the tolerance has been reduced to +/-3mm.

FOM cameras
Recent seasons have seen the FOM nose cameras located in a manner clearly aimed at promoting the performance of the front wing, rather than to deliver effective TV pictures. A new article (20.3.4) has been introduced to ensure a minimum standard for the field of view of any nose-mounted camera. A similar minor change is made to the roll hoop camera location to ensure that a clear picture is not sacrificed on the altar of downforce.

Suspension
Suspension members (wishbones / track rods etc) are bound by strict aerodynamic limitations on such as chord, symmetrical section, maximum incidence angle etc. This is not true of the uprights, which hold the wheel on to the suspension. Their design has always been free and there existed a possibility (albeit never yet exploited) that someone would make a giant, aerodynamic upright to make use of this hypothetical freedom. Pre-empting this, a change to article 10.5.3 has been introduced to ensure that the uprights cannot protrude beyond the volume currently allowed for brake ducts, effectively preventing the giant upright problem from ever occurring.

car on the grid features a smaller fuel cell, the effect on weight distribution is not that great, at least according to Newey. 'There is a small reduction in fuel consumption due to the exhaust regulation change but it is not 10 per cent. The fuel is carried centrally in the car so it has a small effect on start line weight, but its effect on weight distribution is negligible.'

Anyone watching the free practice sessions at the 2011 Abu Dhabi GP could not have failed to notice the front wing of the Ferrari fluttering badly. This wing could pass all of the load tests designed to stop wing flex at high speed, yet still clearly flexed a large amount. So a technical directive was issued by the FIA in November, increasing the amount of load the front wings have to take without flexing during the scrutineering tests. This small regulation change was aimed at stopping teams using clever composite design to circumnavigate the intention of the regulations, but it had unintended consequences. 'It was a bit of a shock to have the front wing change so late in November,' admits Newey. 'The main consequence is that the front wing becomes heavier, which is particularly difficult for drivers like Mark Webber, who is naturally heavy in the first place, and that puts a bit of the challenge on the weight distribution.'

Further increasing the technical directors' headaches at that late stage was that the fixed weight distribution window introduced in 2011 to help Pirelli join the series as a new tyre supplier was carried over for 2012 and 2013. This limits teams to a maximum front axle weight of 291kg and a rear of 342kg in qualifying (and subsequently the race) and only gives designers a 7kg window to operate in.

SOFTLY, SOFTLY

One of the factors all teams' engineers will have to deal with is the Pirelli tyres. The Italian firm has adjusted some key characteristics of its tyres in response to the 2012 aerodynamic regulations, specifically the loss of blown floors. The results of on-track tests with the teams and Pirelli's own Toyota TF109 test car have been integrated with the data from simulation, which is able to recreate and predict tyre behaviour and performance at the circuits and weather conditions of the 20 tracks that make up the Formula 1 calendar.

Pirelli found that without the blown floors there would be a reduction in downforce acting on each tyre, requiring a wider and more even contact patch. This objective has been met by having a less rounded shoulder on each tyre and using softer compounds, which the firm claims will produce better grip and more extreme performance.

Three of the four slick tyre compounds have also been changed. The soft, medium and hards will all be somewhat softer, as Pirelli attempts to reduce the performance gap between them. During the 2011 season, there was a difference of between 1.2 and 1.8 seconds per lap among the different compounds. For 2012, however, the firm's engineers have targeted a difference of between six and eight tenths of a second, though not all in the paddock expect to see that happen.

'We get basic Pajeka book data and the profile data from Pirelli, along with a compound working range stiffness chart, which lets us compare where the compounds sit compared to last year, and we have our own thoughts on that and they are different to where Pirelli think they sit,' reveals Green.

The season, it seems, is likely to be dictated not by which team has the best (or ugliest) nose, but rather who manages to best exploit the exhaust gasses and the regulations covering them, and also the one that succeeds in working the tyres in the best possible window.

One thing at least seems certain – Red Bull will not have such an easy ride as it did in 2011. The RB7 was entirely built around a now-outlawed concept, so the RB8 does not have that in its favour, and its rivals are certain to take full advantage of that fact.

Same, but different

The arguments surrounding exhausts, rear bodywork and engine mapping are set to continue in 2012, but new rules have created very different looking cars. We take a look at the runners and riders for this year

BY SAM COLLINS

Scuderia Toro Rosso was created to find two extra cockpits for the stars of the future coming through the ranks of the Red Bull Junior Driver Programme.

Seven years along, that is still very much the team's *raison d'être*, with a completely new driver line up for 2012, featuring Daniel Ricciardo and Jean-Eric Vergne.

The STR7 is the third car to be designed and built by the team at Faenza since it stopped using Red Bull Technologies chassis. Along with a policy to bring on new talent, the team appears to have given its designers free reign to create a technologically innovative car, and they may well have succeeded.

The roll hoop air intake on the Toro Rosso is very pronounced, with widely-spaced supports. This is due to an additional cooling duct being placed beneath it to provide additional flow to the heat exchangers. This, apparently, was a trade off to allow the main sidepod apertures to be smaller.

'One of the rule changes for this year that had a significant effect on the design of the car was the need to lower the nose,' says the team's technical director, Giorgio Ascanelli. 'The shape of the front end of the car is now less favourable than it was.

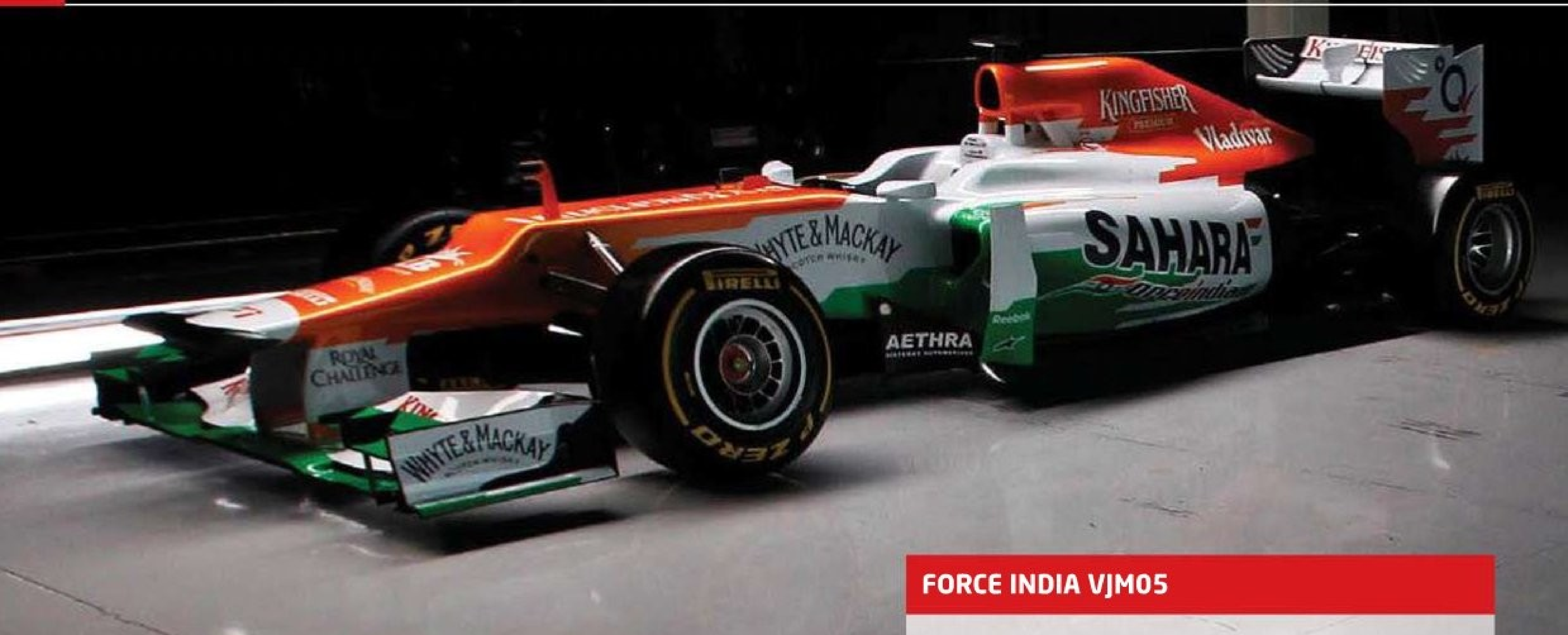
'We also had to contend with a rule change that extended the anti-penetration panels around the car, which are now larger, to provide greater protection. A good move for the drivers, but one with implications on the performance.

'Concerned by vibration and excessive deflection of the front wing, for 2012 the governing body has drastically reduced the flexibility, allowing it to move by only 10mm instead of 20mm when a 100kg load is applied.

'The need for added stiffness means an increase in weight, so we have a large amount of weight added to the nose of the car, which can be problematic in dealing with the regulation regarding the weight distribution.'

Last year's STR6 worked better with a high exhaust, so the team continued this trend with the STR7. 'Cooling as always, plays a major part in the design of the car and we have done something that should allow even more of an undercut on the sidepods, aimed at getting a better streamlining of the rear of the car. In simple terms, we have made a shorter chassis, with a larger distance between the engine and the gearbox, so that the car can be thinner and more streamlined.

'We have also tried to improve the behaviour of our DRS and have a new generation of wings aimed at this. We've also worked on the braking system, to improve its efficiency both front and rear.'



FORCE INDIA VJM05

Force India was the first team to run its 2012 challenger on track, immediately after a low-key launch at Silverstone. The VJM05 is the second car to be created under the watch of technical director, Andrew Green, and the first upon which he has had complete influence. The team seeks to build on its sixth-place finish in the 2011 Constructors' Championship. 'We have set our sights on challenging for fifth place,' explained team principal and managing director, Dr Vijay Mallya. 'To do so, we will need to begin the new campaign by delivering the kind of form we showed in the second half of 2011. I believe this is a realistic goal and that we have the talent and determination to realise these ambitions.'

Summing up the approach to 2012, Green added: 'The car looks more refined, a lot racier and a lot more purposeful. You can start to see the aerodynamic concepts coming through now. It looks quite a bit different to the previous years, and so far the performance in the [wind] tunnel has been encouraging.'

The VJM05 retains the McLaren / Mercedes rear end with the Mercedes-Benz HPE FO108Y 2.4-litre V8 and McLaren gearbox. This has given the team limited scope at the rear from a mechanical perspective, but it is a clear area for development in 2012. Green told *Racecar Engineering* that there is already a range of bodywork packages for the car, which can be used for varying temperature conditions.

WILLIAMS FW 34

The mechanical and aerodynamic design and development of the FW34 has been driven by a new technical leadership under Mike Coughlan, so takes on a fresh design philosophy.

The switch to Renault power has been a critical change for the team, as chief operations engineer, Mark Gillan, explains: 'The initial feedback on the engine from Pastor Maldonado was very positive, even on the installation lap. It is incredibly unusual for the driver to get out of the car and comment on the improvement he felt straight away.'

The installation of the engine has also opened up some design scope, according to Gillan: 'The Renault engine differs in a number of ways to the Cosworth. It has opened up more flexibility in terms of mapping and it allows us to run a lot hotter with the water and oil which, from an aerodynamic point of view, is much better. Now we can close up the bodywork a bit. The RS27 also has less degradation with mileage in terms of the engine life. At the end of the season, when they try to preserve engines, that makes a big difference.'

Behind the new engine sits the incredibly small Williams F1 gearbox, carried over at least in concept from the FW33. 'That whole area is an evolution, as it worked well on last year's car. We have tried to ensure that what we gave up mechanically for the aerodynamic benefits, we get back.' The car also retains the Williams' hybrid power KERS used on the FW33.

McLAREN MP4-27

RED BULL RB8

Adrian Newey's 23rd Formula 1 car is the fourth in a family of evolutionary designs dating back to the RB5 of 2009. Despite being a direct evolution of the 2011 World Championship-winning RB7, there are some fundamental changes, as Newey explains: 'With the restriction on exhaust outlet position we have lost the exhaust technology that we were able to develop and perhaps be ahead of the pack on in the last couple of years. That led to a big re-think over the winter. Whether that will affect us more than other people is difficult to know of course. We designed last year's car around that exhaust position and were probably the only people to do so, so it may be that we've lost more than other people through that. We've had to go back and look at how we developed the car through the last one and two years and try and, if you like, make sure that the routes we had taken weren't only suitable for that [side-exit] exhaust position. Probably one of the key things there is the rear ride height. The exhaust allowed us to run a high rear ride height, and it's much more difficult without that to sustain that, so we have to go back down and re-develop the car around that lower ride height.'

The exhaust location on the RB8 seems to be fairly conventional, but note how closely the tail pipe sits to the upper wishbone, blowing directly onto it. So much so that the wishbones have been clothed in a thick thermal barrier jacket.

The rear of the car retains the pull-rod suspension seen on all recent Newey Red Bulls. Indeed, a very tight rear end has been a trait of this high achieving family of cars. The RB8 also features other evolutionary elements, such as the roll hoop, which is a carry over from the RB7.

While the all-new MP4-27 closely resembles last year's multiple race-winning car, the 2012 chassis has been substantially revised from the ground up, with all major systems updated or re-designed for the new season.

Most obvious is the lack of a stepped nose on the MP4-27. This is because the chassis is lower at the front than any other car on the grid, so it still complies with the 550mm regulation, with the added bonus of retaining a more attractive look.

Other evident visual differences to the 2011 design include more tightly waisted rear bodywork, developed to improve flow to the rear of the car, and a revised cooling system, which re-directs the gearbox oil cooler. Last year's u-shaped sidepods have also been re-designed – a legacy of the FIA's new exhaust regulations that re-define the shape of the rear bodywork. The unusual outlet shape is likely to raise eyebrows along the pit lane and could be what some technical directors have suggested to be 'on the edge of acceptable', according to the intention of the regulations (rather than the exact wording).

Much attention has been paid to the exhaust exit, which sits a long way outboard of the car's sidepods and this is an area in which we expect to see major development. The total area of the cooling apertures on the car seems to be smaller than on the MP4-26 with the roll hoop-mounted gearbox cooler absent altogether.

FERRARI F2012

The F2012 is the 58th car built by Ferrari with the express purpose of taking part in the Formula 1 World Championship.

Practically every area of the car has been fundamentally revised, starting with the suspension layout: both the front and rear feature pull-rods, aimed at favouring aerodynamic performance and lowering the c of g. The front wing is derived from the one introduced on the 150° Italia in the final part of its racing life and has been evolved from there. Further evolutions are planned in this area for the opening races of the season. The nose has a step in it that is not aesthetically pleasing.

The lower part of the rear of the car is much narrower and more tapered, a feature achieved partly through a new gearbox casing and also by a relocation of some mechanical components. Naturally, a great deal of effort was expended in the area of the exhausts, based on changes to the regulations introduced this year.

The rear wing is conceptually similar to the one used in 2011, but every detail has been revised and it is now more efficient.There is likely to be much discussion about the car's nose design, where the monocoque meets the nose structure. The Ferrari has the space between the 'turrets' filled in, whilst others have it open. The deep nose supports with the twin camera mounts inside are a direct carry over from the 2011 car, in concept at least.

LOTUS E20

E20 is the first Lotus-branded car to roll out of the team's Enstone facility (the 20 signifying two decades of car construction there). It also marks a change in the tradition of Lotus-branded cars running with 'T' numbers.

The E20 incorporates ground-up re-designs and optimisation of previous Enstone design philosophies. Notably, the forward-facing exhausts of 2011's R31 have been abandoned, and a step has appeared on its nose, both the result of regulation changes. The car has been designed utilising the team's new 60 per cent scale wind tunnel, as well as its enhanced CFD facility.

The front and rear suspension layouts have been substantially revised in the quest for aerodynamic efficiency. Last year the track rod was aligned with the lower wishbone, for example, now it's separate

Whilst the front wing fitted to the car is a continuation of concepts used by the team during recent seasons, a lot of development is expect from the team in this area.

In the second pre-season test held at the Barcelona circuit, the E20 suffered a chassis failure, thought to be a front suspension pick-up point pulling out of the monocoque. This will have to be addressed before any further progression can take place, and will almost certainly have a detrimental effect on the car's early development.

MERCEDES W03

Because the overall technical regulations are largely unchanged from 2011 (with the exhaust rules really the only substantial alterations) the W03 is clearly an evolution of the W02, which itself is an evolution of the W01 and Brawn BGP001/Honda RA109. This can clearly be seen in the roll hoop design, but the overall shape of the car is also very similar, right through to the nose hump, which the W02 already had elements of.

This is the first full car produced by a new technical team that was strengthened last year with recruitments at every level. According to the team, the W03 has some 200 more parts than its predecessor, but has achieved a lower core weight due to better, more efficient packaging. Aerodynamic efficiency and detail was an area of focus for Mercedes as they try to address the relatively poor performances of 2010 and 2011.

'Last year, we produced a very bold car,' explains team boss, Ross Brawn, 'and, although its more radical elements didn't always deliver the results we had hoped for, the experience we gained has been invaluable to the design of the 2012 car. The F1 W03 is a more integrated package, which reflects the ever-strengthening ties between our technical teams in Brackley and Brixworth, and demonstrates that our Silver Arrows works team is taking the next step forward in terms of on-track performance.'

All of the mandatory FIA crash tests were successfully completed at the first attempt.

SAUBER C31

Summarising all the efforts put into developing the new Sauber C31-Ferrari, chief designer, Matt Morris, said: 'The C31 is revolutionary where we had fresh ideas, particularly at the rear of the car, and it is an evolution where we knew we could carry over certain approaches.'

The car's packaging was optimised under the sidepods in order to open up more aerodynamic development scope in that area, following the concept first seen on the Ferrari F92A. The cooling layout is based around a similar philosophy to the C30 and helps move the volume of the coolers forward, allowing for a very compact rear bodywork.

A familiar element of the car is the Ferrari engine, onto which an all-new carbon transmission is bolted, also supplied by Ferrari. The longitudinally-mounted transmission is a very tidy unit. The entire rear of the car is much more tightly packaged and, in addition, the engineers have gone in some new directions around the floor at the back of the car. So much so that at the roll out, this area was blocked from view.

By an overall tidier design, the front suspension has been optimised for integration with the chassis and the upright. Otherwise, it's a traditional layout with a push rod and a high-level wishbone. The dampers and springs are packaged quite differently to the C30 in order to support a new philosophy for the set up of the front suspension. The design of the new front wing has benefitted from directions engineers were pursuing towards the end of the 2011 season.

MISSING IN ACTION – HRT F112 and MARUSSIA MR01

HRT's F112 should have made its track debut at the second pre-season test but it failed its crash tests. In fact, the new car passed 14 of the mandatory impact tests, but failed two, and as a rule change for 2012 states that all cars running in official testing must first be fully homologated, this meant that for the opening test HRT could only run its aged Dallara F110-based 2011 car.

Williams has supplied the team with a transmission and it is thought to be a version of the tiny unit that featured in the FW33 and FW34.

The team opted to skip the second test all together but were delighted with the appointment of a new chef!

Another absentee as *Racecar Engineering* closed for press was the Marussia MR-01. The team formerly known as Virgin Racing was taken over by its title sponsor during the winter and, with Nick Wirth's organisation no longer involved, the new car is being developed under the guidance of Pat Symonds. As a result, aerodynamic development has been undertaken in wind tunnels, as well as CFD.

CATERHAM CT01

Tony Fernandes took control of the small English car company, Caterham, in the summer of 2011 and quickly brought the brand to Formula 1, trading in his controversial Team Lotus brand in favour of the one of his new concern. The car, however, is a direct evolution of the Team Lotus T128, retaining the Renault RS27 V8 engine and Red Bull transmission. As a result of the latter, pull-rod rear suspension is also retained.

Caterham has a clear target – to establish itself as a mid-field team, rather than one of the three back-of-the-grid new teams. To this end, it has also acquired Red Bull's KERS.

There has also been substantial investment made in other areas according to chief technical officer, Mike Gascoyne: 'Aerodynamics is always the main focus of performance and improvement. Last year it was all about the blown diffuser, which we struggled with because not having it in 2010 meant we were always playing catch up throughout the 2011 season in comparison to other teams. The fact it's banned this year certainly plays to our advantage. Other teams had so much more development time, they were able to get much more out of it than we were ever able to, so that eliminates a little of the competition in terms of technical development. But really, aerodynamics is always one of the main features of development and that's why we've put so much additional resource into it.'

Overall, the result seems to be fairly conventional, with a slightly different exhaust layout to other cars on the grid with a 2009 Toyota-style exit on the top of the sidepod.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Hammer time

There are few rules in building a vehicle to survive the world's most brutal one-day off-road race

BY MIKE MAGDA

It's rock racing's version of NASCAR's 'the big one'. A car gets stuck, or rolls, at a bottleneck in a rocky trail and the field gets stacked behind. Horns blast, tempers flare and impatient drivers try to manoeuvre over the stuck vehicle or attempt a different line, usually resulting in broken parts, blown tyres, or another stuck or rolled vehicle

Top right: Two years ago, a log jam in the Jackhammer trail resulted in chaos as thousands of spectators descended the steep canyon walls onto the course. Following an accident at another race, not associated with KOH but on the same land that left eight people dead, federal officials foced KOH organisers to implement strict spectator controls.

Hardly any motorsport discipline remains that, at its core, offers an unlimited opportunity to build any type of vehicle and compete in an event in which man and machine are truly unique. Some land speed record classes still have open rules, but even Top Fuel dragsters are limited in engine and tyre sizes and have severe restrictions on technologies such as traction control and fuel / spark management, so it's just as much a cookie-cutter class as a field of SCCA Spec Racers.

Ultra 4, on the other hand, or Unlimited 4-Wheel-Drive, is a throwback to the glorious '60s, when sports car, Formula 1 and drag racing experienced a dramatic escalation in technology and performance – all due to an encouraging atmosphere of innovation, experimentation and, most importantly, risk taking. No two Ultra 4 cars are alike, even if they come out of the same shop.

Sometimes affectionately referred to as 'rigs', Ultra 4 cars may appear at first to be quite primitive, but much of that perception is because they race over terrain that is, literally, prehistoric. Ultra 4 cars were born on a racecourse formed millions of years ago through volcanic and tectonic activity, leaving a rugged desert floor and treacherous rock valleys that claw into the sides of mountains. The essence of Ultra 4 is to conquer both types of

PHOTOGRAPHY BY MIKE MAGDA AND CHRIS COLLARD

terrains the fastest way possible. Too many rules would just get in the way of that task.

Any engine is allowed. Any vehicle weight. Any wheelbase or track width. Mid-engine, front engine, rear engine – your choice. Single seater is fine, but most racers prefer a co-pilot. Suspension and steering options are wide open, as well, but the wheels do have to be connected by axles, so no hydraulic motors at each wheel. About the only common denominators among the current crop of Ultra 4 vehicles are a tube frame, transfer case and four wheels, but even the latter can be wrapped with rubber of any size, compound and tread pattern.

'Racers have lots of choices,' says Dave Cole, who, along with former partner, Jeff Knoll, organised the Ultra 4 class while developing its premier event: the Griffin King of the Hammers (KOH). 'The strategy is to use those choices to take advantage of, or balance out, all the options.'

The KOH race is held every February in the Johnson Valley Off-Highway Vehicle area, a federally-managed tract of almost 200,000 acres dedicated to off-roaders. A few years ago, Cole and Knoll challenged a few friends to see who could run all the Hammers – a series of rock canyons popular with heavily modified Jeeps – in the fastest time. Word of that spontaneous adventure spread quickly through the internet, and suddenly scores of rock enthusiasts wanted in for the next challenge. As a result, Cole and Knoll formed Hammerking Productions and worked with federal officials and local 4x4 clubs to promote a 42-mile race in 2008.

Two years later, the race was 135 miles and only 43 of 100 vehicles finished in the allotted 14 hours. For the sixth annual race in 2012, the two-lap event covered a total of 165 miles, and of the 136 starters that came from seven different countries, only 49 finished.

GOING GLOBAL

Cole now promotes the Ultra 4 concept full time, scheduling an eight-race national and regional series in seven US states, but has plans for events in England and Australia, too. Ultra 4 has also added Stock and Modified classes in a separate race with the goal of enticing more auto manufacturers, vendors and newcomers to the sport. But it is the Ultra 4 Unlimited class that draws the most attention.

The first KOH races attracted

Left: a typical drivetrain layout on a vehicle with a reverse-mounted mid engine configuration. An intermediate driveshaft runs from the transfer case to a carrier bearing and the rear driveshaft. The Atlas transfer case is operated with two handles, so drivers can switch between high and low range and also between front, rear and four-wheel drive. Note the two spare driveshafts and spare alternator!

Shannon Campbell, the only two-time KOH winner, also races on the East Coast over tight, muddy forest trails. Together with his brother, Nick, they build their cars on a garage floor using chalk lines, a tape and a plumb line.

existing recreational trail rigs and a few cars built for competitive rock crawling. They worked well in the rock sections but struggled for speed in the open desert. As more cars were built specifically for KOH, desert racing technology developed for the big Trophy Trucks running the Baja 1000 was adapted to the rock crawlers. But priorities for the two disciplines are not the same.

'In the days of rock crawling, wheel travel wasn't critical,' says Brian Shirley, who builds cars for both endurance and short-course rock racing. 'Higher speeds totally changed the game.'

For crawlers, axle articulation, ground clearance and torque were more important than desert racing's goals of horsepower, vehicle balance and wheel travel. Ultra 4 racers and car builders therefore have to decide whether to go for the win in the rocks and try to keep pace in the desert, or pass everyone in the desert and hope to survive the rocks.

The rocks are definitely the equaliser in this sport. While desert racing technology has evolved considerably from the '60s following the first Baja 1000 races, rock crawling is much more dependent on driver experience and courage.

'The race has to stay true to the rocks,' says KOH veteran, Rick Mooneyham, who has three podium finishes in vehicles that he built from a more traditional trail-rig configuration. 'Otherwise we'll just go desert racing and there's no need to mess with four-wheel drive.'

The new generation of rock racers take development cues from the desert racers in building Ultra 4 vehicles. The challenge is knowing how and when to compromise the haulin' and crawlin' technologies.

"The challenge is knowing when to compromise the haulin' and crawlin' technologies"

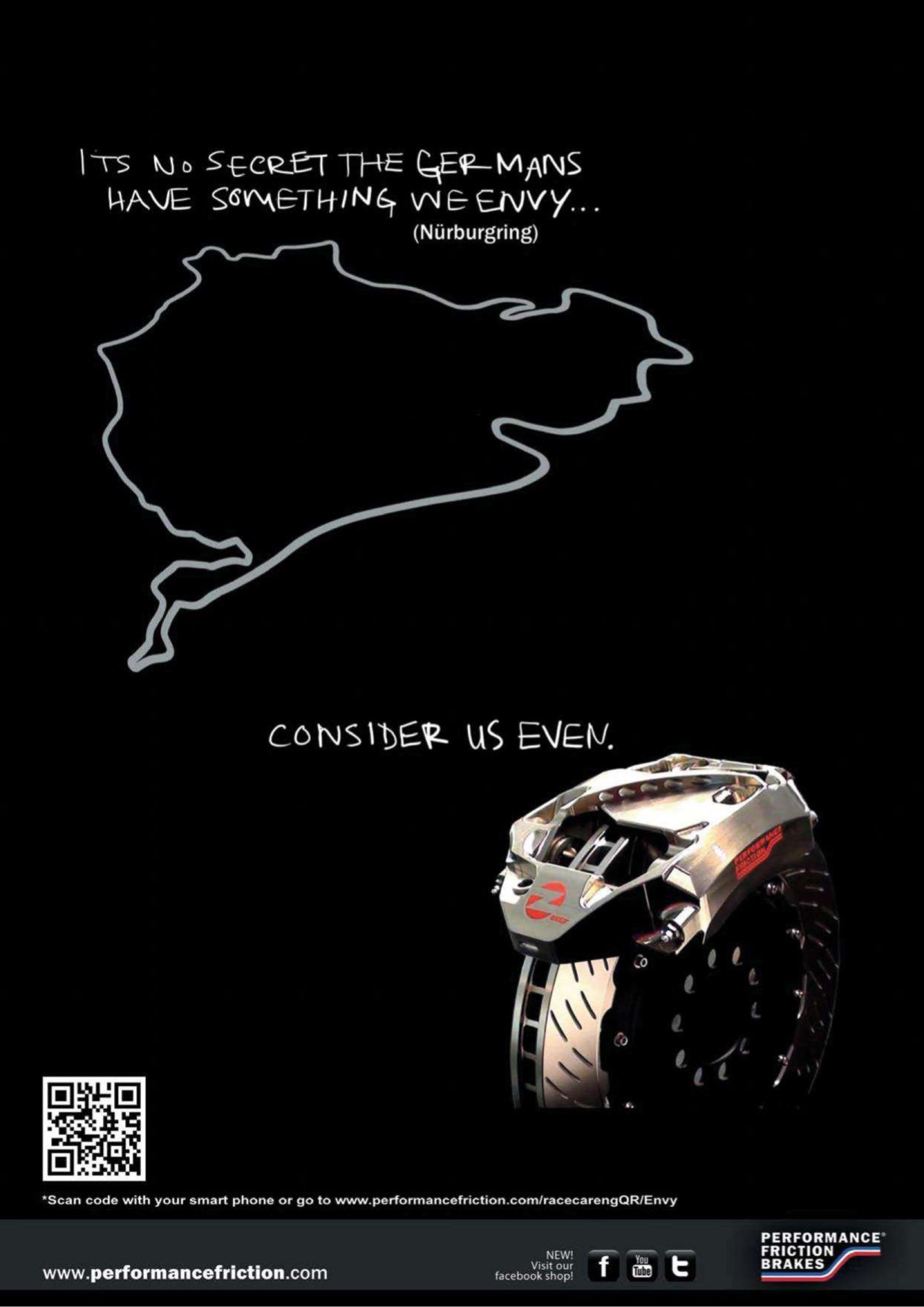
The wheelbase on Ultra 4 cars generally falls within 108-116in (2743-2946mm). That's longer than a typical trail Jeep of about 101in (2565mm) and shorter than Trophy Truck at 125in (3175mm). Outside-to-outside tyre width is around 80in (2032mm), much narrower than a Trophy Truck at 90in (2286mm) or more. All rigs are built around a tubular frame of either DOM mild steel or 4130 chromoly. Favourite size is 1.75in (44.5mm) diameter with a 0.120in (3mm) wall for the rollcage and areas around suspension pick-up points, but thinner 0.095in (2.4mm) tubing may be used in some sections. 'You want it as light as possible, but still able to take a tumble at 100mph,' says Jason Scheer, the 2009 KOH winner.

SUSPENSION TECHNOLOGY

Suspension choice generates the most heated debates among builders. A triangulated 4-link with a sway bar (anti-roll bar) is leading the way, but there are variants. Many builders now prefer trailing arms for the lower links in the rear though some racers still like a 3-link / Panhard for its simplicity, while others have experimented with radius arms. Every team has its own idea on link lengths, triangulation angles and mounting points. Some use traditional sports car and dirt track theory in computing variables such as roll centre, roll axis, anti-squat, c of g, instant centre and roll steer. Others simply start building from the axles inward and rely on personal experience.

'It always boils down to a packaging issue,' adds Scheer, noting that the extreme wheel travel can interfere with engine location, exhaust routing, driveshafts and vehicle plumbing.

Independent front suspension is the current rage at KOH. Last year just three cars sported IFS, but for 2012 nine IFS cars showed up. Again, everyone has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their own theory on control arm and steering designs.

'You can only get so much out of a solid axle car,' says Matt Messer, who debuted a new IFS car but crashed in the race trying to pass slower cars in a dust cloud. 'I think independent is the future, but I can see this design evolving into lighter weight.'

'IFS is a different animal in the rocks. You'll always see this car with at least one tyre in the air because you don't have the kind of front-end droop as you would with a solid axle,' adds Rob Lynch, who 'switched to IFS to reach the rocks before anyone else.'

Early racecars had air shocks – a carryover from competitive rock crawling – but those could not tolerate the intense heat build up in this combined discipline. The most common set up is now a coilover and bypass shock combination for each wheel. The coilover usually sports an external reservoir and dual or triple springs, while the bypass shock has either three or five external metering valves, with the majority of valves on the compression side. With no fewer than five major shock absorber manufacturers catering to Ultra 4 racers, there is no shortage of opinion on shock mounting locations or tuning theory. 'The biggest challenge is keeping the rear tyres happy,' says Messer.

Dual brake calipers used on the rear axle – one for the main system and another for the cutting brakes, with protective covers for the brake lines

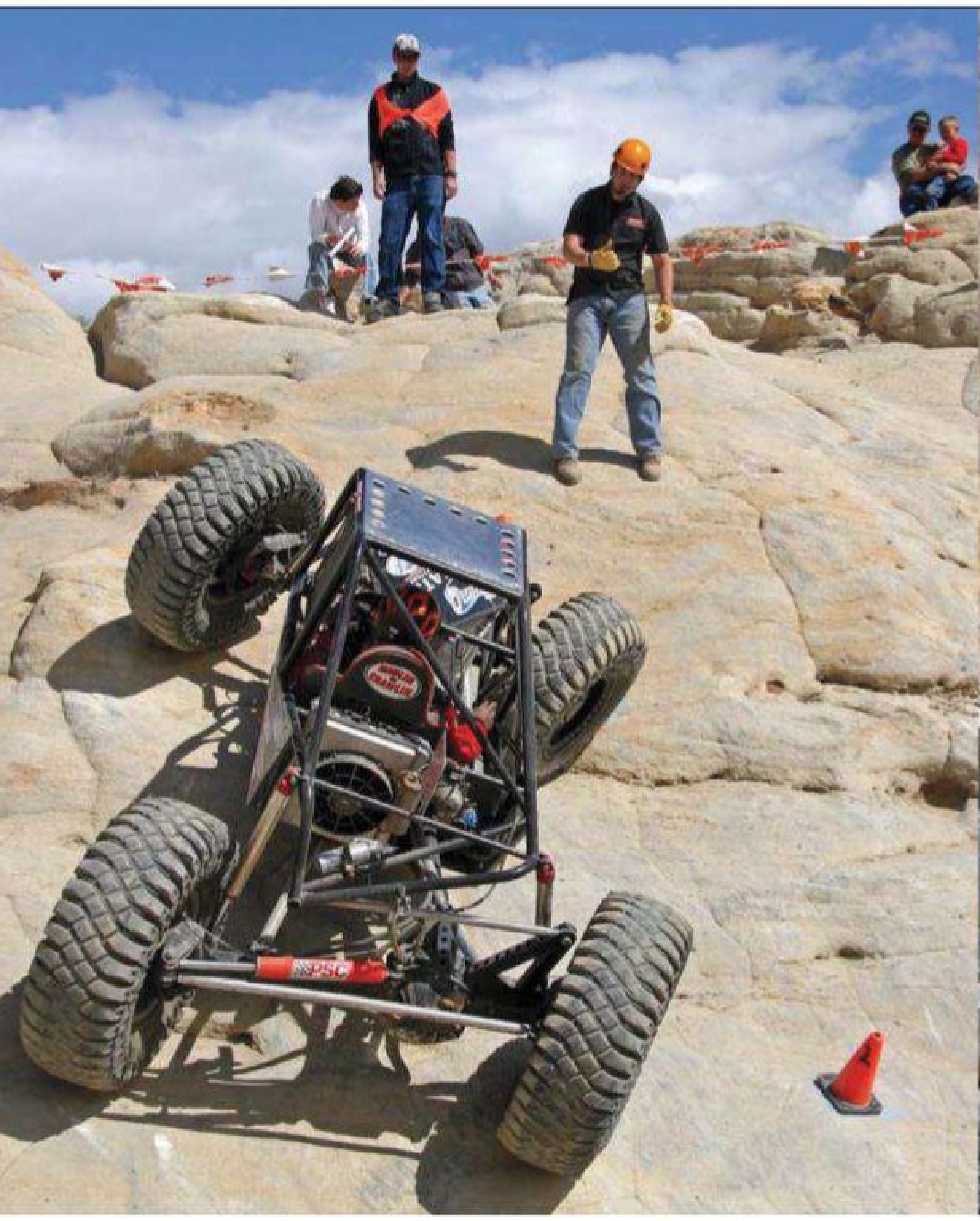
Above: Jesse Haines wanted a recreational 'trail rig' that could also compete in the new Stock Modified class so his car is based on stock replacement Jeep chassis rails. Since hydraulic steering is not permitted in that class, he designed a steering system based on a Saginaw box, two bell cranks, hydraulic assistance and a drag link that pivots in close relation to the lower suspension links

TURNING POWER

The majority of cars utilise full hydraulic steering – another carryover from rock crawling. Conventional power-assisted systems couldn't provide enough turning power when crawlers went to larger tyres. Also, as long-travel suspensions were introduced, the mechanical links were too restrictive and aggravated bump steer. A typical hydraulic system includes an orbital valve on the steering shaft, high-flow pump driven by the engine and a steering ram. Most racers use a double-ended ram with separate tie rods connected to each steering knuckle, though some choose a simpler, single ram system with a single tie rod linking the steering knuckles, accepting the steering action is not as balanced as the double-ended ram.

While hydraulic steering is very effective in the rocks, it provides little feedback to the driver at high speeds and doesn't hold centre. Since the front differential is secured to the chassis on an IFS car, a traditional rack-and-pinion steering can be designed with a mechanical link back to the driver, although there are challenges in setting up the links to the steering knuckles. More solid-axle cars are therefore switching to mechanical steering.

'Hydraulic is just too sketchy at high speeds,' says Jason Carner, who designed a complicated but unique arrangement of rods



It started with WWII veterans buying up surplus Jeeps and trying to see who could climb the highest hill or trek deepest into the forest. Rock crawling moved a from recreational club activity to competitive events in the early '90s when rules were introduced that required cars to manoeuvre cleanly between a series of 'gates' within a certain time limit. Points are deducted for infractions such as backing up, and extra points awarded for clearing bonus gates. Early racers used heavily modified Jeeps and pick-ups, but purpose-built 'moon buggies' took minimalist functionality to the extreme with small, flat-plane engines, lightweight 3-link suspensions, single air shocks at each wheel, 60-degree front steering and available rear steering. These innovative crawlers also used water-filled tyres and on-board winches to compress the suspension in precarious situations

Everyone rolls in the rocks at some point. Ultra 4 regulations cover basic safety rules, but the use of advancements such as fire suppression and HANS devices are left to the discretion of the racer

and bell cranks to connect the steering wheel to a front rack. 'You can feel what the car is doing. My car now has one turn, lock to lock. I'm not chasing it all over the place.'

Early KOH cars relied on modified stock axles like a Dana 70 from heavy duty trucks. But higher speeds lead racers to utilise custom fabricated axle housings that accept a race-prepped Ford 9-inch third-members for easy gear changes.

Experienced rock crawlers will include separate hand controls for cutting (turning) brakes in the rear. 'Even with the nose in the air I can still turn it,' says Mooneyham proudly.

Numerous tyre manufacturers provide DOT and / or race-only compounds in very aggressive tread patterns and with heavy sidewalls. A few racers run tyres as tall as 42in on a 20in wheel, but most prefer 39 or 40in tyres on a 17in wheel. Beadlock wheels are necessary as some drivers race with their tyre pressures as low as 12psi.

SNAPPY THROTTLE

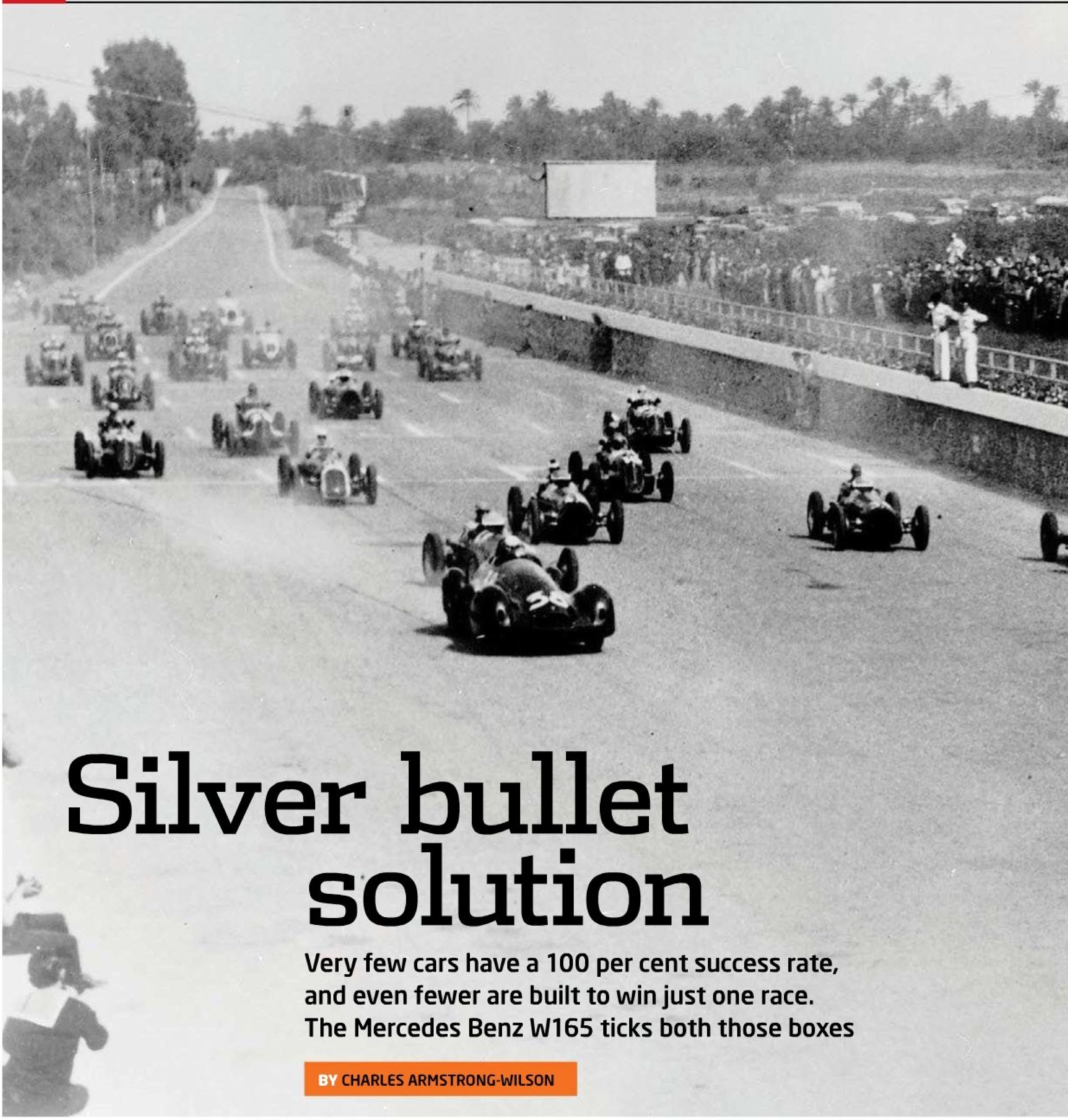
Unsurprisingly, the most popular engine is a GM LS-style V8 making around 450-600bhp, although some rigs with turbocharged four-cylinder engines have shown promise. Fuel injection is a necessity due to the extreme vehicle driving angles on the hills and canyons. Engines are tuned more for low-end torque, snappy throttle response and durability than high horsepower. Oiling remains the biggest challenge – again due to the extreme operating angles – and engine builders are pushing for more dry sump systems, but racers are reluctant because of packaging. Other major concerns include keeping the air filter clean and cooling.

Modified TH400 automatic transmissions are most popular, with some racers trying an overdrive transmission such as the 4L80E. Most teams also prefer an Atlas transfer case, which offers racers a wide variety of low range gear ratios and fully selectable modes.

The remainder of the vehicle build up lies in the details, such as comfortable seats, lights and wiring, fuel tank size and location, body panels and navigation. KOH racers can download the course into their GPS systems a few days prior to the race. For the first time in 2012, organisers required all racers to have tracking systems to ensure course compliance and improve safety. The system will alert officials if there is a sudden *g*-force recorded, or if the vehicle is upside down.

It may have started as a low tech sport, but new technologies are being introduced all the time. Now, after every race, the internet discussion boards light up with suggestions, criticisms and theories. Look for additional hi-tech data acquisition and simulation work in the future, with professional builders now seeking fabricators with SolidWorks and FEA experience. 'The trend will be more controlled wheel travel,' predicts Scheer. 'But it's such a young sport, even with the data we have now we don't know what to do with it.'

But as Ultra 4 racing expands to Europe and Australia, more daring and different ideas will be introduced, and this exciting branch of motorsport will go from strength to strength.



Silver bullet solution

Very few cars have a 100 per cent success rate, and even fewer are built to win just one race. The Mercedes Benz W165 ticks both those boxes

BY CHARLES ARMSTRONG-WILSON

At this year's Goodwood Revival meeting, Daimler Benz will be fielding a batch of four Silver Arrows of the 1930s from its treasured collection. Three are well-known examples of the era, the W25, W125 and W154 – all grand prix cars famed for their competitor-crushing performance. The fourth is less well known, mainly because it only ever competed in one race. Yet, despite being less powerful than its stable mates, it too executed a dominant one, two finish. The story goes something like this.

By 1939, the grand prix world was getting a bit sick of the dominance of the state-funded German teams. The richest prize of the season was the Tripoli Grand Prix in Libya, thanks to a lottery that raised a huge prize fund. Having cleaned up in the previous four events, it seemed inevitable that the German teams would be likely to scoop that prize in '39. But, being an Italian colony, they cooked up a plan to change all that and give the Italian cars a chance.

With just eight months until the next event, it was declared that the race would be run for 'voiturette' cars only. That meant 700kg cars with 1.5-litre engines. It was like declaring a round of the grand prix World Championship would be for F3 cars only. At the time, Alfa Romeo and Maserati, who made money out of selling racecars to customers, already had

The Italians changed the rules for the 1939 Tripoli Grand Prix specifically to exclude the Silver Arrows. The Germans simply built a new car to meet the challenge...

something suitable to race. The German teams, however, only had bigger, heavier grand prix spec cars, which at the time was for supercharged 3.0-litre engines.

It was reckoned that it would take 18 months to design and build a new racecar, so the organisers felt confident that neither of the German teams would even attempt the challenge. Auto Union did consider it, but eventually dismissed the idea as impractical. Mercedes Benz, meanwhile, held a crisis meeting at Stuttgart. Managing director, Max Sailor, was an ex-racing driver and not the type of person to back down in the face of such a challenge. After a fraught meeting, it was decided to go ahead. Double shifts would be agreed with the factory staff and everything would be conducted in secrecy.

The cars were designed, built and tested within that short, eight-month period and, as history relates, they took first and second places in the Tripoli Grand Prix. Then war broke out that September and the cars never raced again, keeping their 100 per cent success score intact. But what did they manage to create in that short time? Using a contemporary document, we have an insight into this most specialised of cars.

The company's W154 cars had addressed the new-for-1938 rules by replacing the old straight eight of the W125s with the M154 engine, an all-new, supercharged, 3.0-litre, 60-degree V12. Then, for the 1939 season, this acquired two-stage supercharging to raise the power to 476bhp at 7800rpm. It was decided that the car for the Tripoli race should be a lighter version of this car, powered by an all-new, 1.5-litre, 90-degree V8.

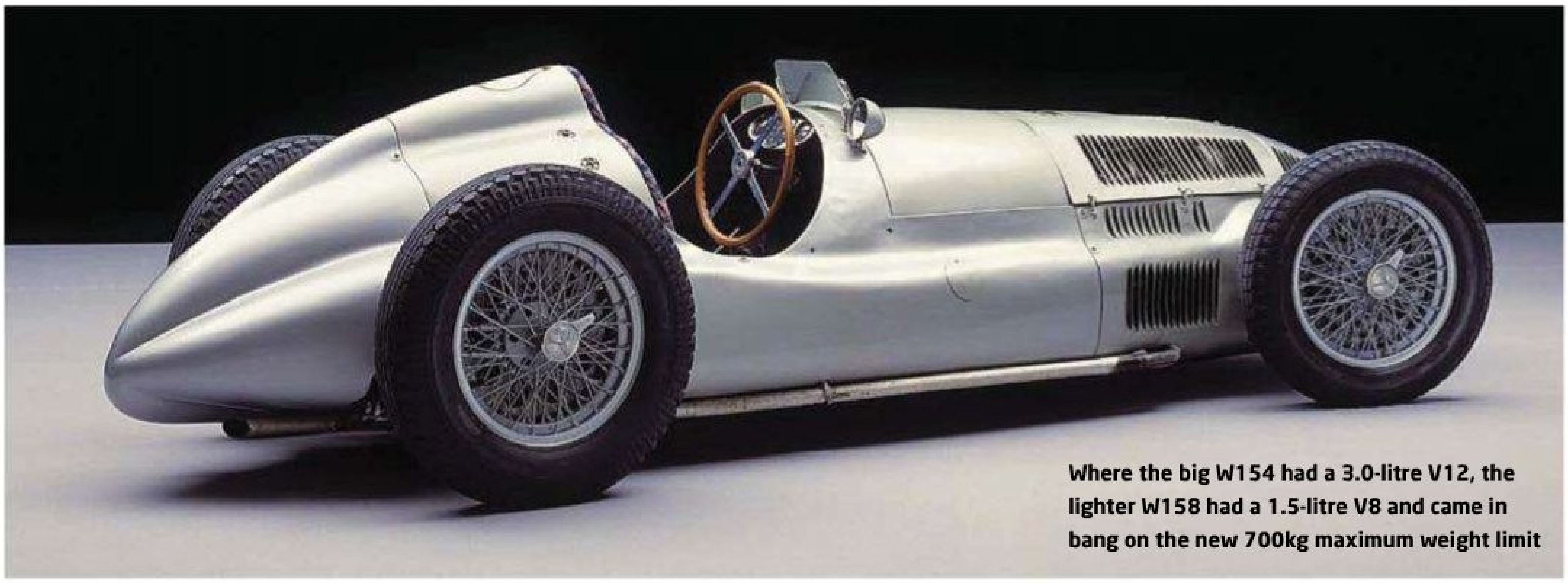
CYLINDER ARCHITECTURE

However, the little V8 engine used the same construction as its 3.0-litre sibling. Each cylinder was cast individually from F96G chrome steel. In fact, each cylinder casting incorporated the cylinder head. Also, near the top of the cylinder, the outside of the combustion zone was circled by rings that added strength and increased the cooling surface within the water jacket.

Further down was a broad flange that was welded to the same feature on adjacent cylinders making up a cylinder block. This flange was then used to bolt each block onto the upper faces of a cast alloy crankcase, with the remaining length of each cylinder projecting inside.

Around this structure, the water jackets and cylinder ports were fabricated from sheet steel. This allowed precise wall thicknesses to be selected to suit the requirements, while keeping weight to a minimum. The quality of the joints made was critical to the structure being water and gas tight, and corrugations were included at key points to accommodate expansion.

If Mercedes could ever be accused of overcomplicating anything on the M165, then it would have to be the lubrication system. The W165 employed no fewer than nine oil pumps within the engine alone and two more for the supercharger. Yet the irony is the big and little end bearings relied on splash lubrication for their oil supply.



Where the big W154 had a 3.0-litre V12, the lighter W158 had a 1.5-litre V8 and came in bang on the new 700kg maximum weight limit

All the oil pumps in the engine were pinion types and had specific functions. Just one pump supplied all the roller main bearings and two more fed the three plain bearings on each of the camshafts. The rest were strategically placed scavenge pumps to manage the waste from the three feed pumps. Two retrieved oil from the front and rear of the sump, ensuring effective pick-up under braking and acceleration, and a third drew oil from the valvetrain casing.

But that still leaves three more whose roles are rather less obvious. In fact, there was one on each end of the crankshaft to prevent oil leaking out onto the clutch at the rear or into the supercharger casing at the front. Finally, one more pump retrieved oil from the crankcase breather.

WEALTH OF RESOURCES

The car's designer, Rudi Unlenhaut, felt that it was preferable to use a battery of small capacity pumps and adapt them for individual requirements than to have a single larger pressure and scavenge pump to do everything. The cost of manufacturing so many more components does not seem to have been a consideration in the design process, giving an insight into the wealth of resources the team had available.

Yet, despite all this careful management of the precious lubricant, the car still carried 12 litres of oil in the system, suggesting oil consumption was a challenge over race distance.

It has to be said that the big end bearings, like the main

Car was designed and built in total secrecy in just eight months, something that was felt impossible at the time. Some carry over from the W154 helped

bearings, ran on rollers so pressure feed was unnecessary. Instead, oil escaping from the main bearings was collected by a rectangular trough in the outside cheek of each crank web and thrown toward the big end bearing by the centrifugal action of the spinning shaft. The little ends, or wrist pins, ran in a 19mm bronze bush that relied totally on splash thrown up by the crank.

So much oil was being thrown around that the pistons needed two scraper rings each, one above and one below the gudgeon pin. Made by Mahle, the pistons themselves were forged alloy and weighed just 244g each, including rings. They even experimented with plating the dome to reduce heat erosion.

"The cost of manufacturing does not seem to have been a consideration"

Valvetrain layout was conventional by modern standards, with two camshafts per bank operating two inlet and two exhaust valves per cylinder. The cams acted on finger followers to minimise side-loads on the stems. However, exhaust valve cooling came in for particular attention. Sodium-cooled stems are quite common, but Mercedes chose to use Mercury in its exhaust valves. Supports for the valve guides were welded to the cylinder head and the ones for the exhaust valve incorporated addition fins to improve cooling.

NATURAL FREQUENCIES

The car's designers went to great lengths when designing the valvetrain to avoid valve float at the 8250rpm engine speeds they were attempting. Valve control was by twin, concentric coiled wire springs, but the cam profile was carefully matched to the natural frequencies of the springs. This necessitated opening durations that were longer than ideal and this was with valve lifts of just 7mm for the inlet and 6mm for the exhaust valves.

Air from the supercharger entered the engine via induction ports between the cylinder banks and the manifold incorporated a blow-off valve to protect the compressor in the event of a backfire. Its charge was drawn through a multi-choke carburettor designed by Mercedes Benz and through two stages of a Rootes-type blower as introduced on the W154 the same year. Both stages used the same diameter rotors, but the capacities were varied through the first stage

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rotors longer than the second. Drive came from the nose of the crankshaft and the unit boasted yet more oil pumps, one each for pressure and scavenge.

At the other end of the crank, drive was trnsmitted via a 232mm, single-plate clutch. Despite the smaller engine size, inertia does not seem to have been regarded as important enough to change to a multi-plate device, although this apparent oversight could have been down to the time limitations.

The engine was skewed off the centreline in the chassis so that drive went down the left side of the car to the rear-mounted transaxle. On entering the unit, the motion was turned through more than 90 degrees, engaging with a pair of transverse shafts carrying five helical, indirect ratios. Drive was then transmitted from the centre of the driven shaft to a final ratio containing a ZF limited slip diff. Changing overall gearing required the final drive pair to be changed, which involved the disassembly of the gearbox.

OPTIMISING HANDLING

Much of the chassis design was modelled on the 3.0-litre car, including the twin, oval chassis tubes. Also details like the steering and front suspension were carried over from the W154 including geometry designed to promote understeer. With the amount of power the cars were generating, optimising the handling was a big challenge.

Whilst trying to deliver the power via a De Dion axle to the comparatively primitive Continental tyres, rear-end grip would constantly be at a premium. So the preferred way to achieve a balance seems to have been to shed front-end grip. The front suspension was a compact, double-wishbone arrangement with short arcs and limited travel. Its geometry seems to have been designed to go from zero camber at rest to significant positive camber in roll, progressively losing adhesion in the process.

Despite following the design of its bigger brother so closely, the W165 tipped the scales at 700kg, scraping in under the imposed maximum weight limit. By comparison, the W154 weighed in at 910kg.

Like its predecessors, the W156's suspension design promoted understeer, which, with the skinny tyres, required a very committed driving style

The Germans were unbeatable in the 1930s, and the W165 carried on the winning tradition that its predecessors, the W25, W125 and W154, started

Just how much power the W165 developed seems open to debate. In an immediately post-war document compiled by the allies, they quoted 278bhp on an exotic brew of methyl-alcohol, with a little nitro-benzole and other ingredients, equating to 186bhp per litre. However, Daimler-Benz now claims a perhaps more realistic 256bhp, or 171bhp per litre.

"An exotic brew of methyl-alcohol with a little nitro-benzole"

It was also expected to be more economical than its bigger stable mate, which chugged fuel at around two miles per gallon and could carry 105 gallons to fuel its thirst. In contrast, the W165 made space for just 55 gallons in two fuel tanks, one in the tail and the other in the scuttle. The locations were about more than just capacity and also helped manage the weight distribution during the race. The car even had a cockpit-mounted suspension adjustment the drivers could use to compensate for the change in weight.

That September, the German teams pulled out of motor racing altogether due to more pressing international events. The Italians took full advantage of the opportunity this presented and staged the event in 1940. Finally, an Italian car won, with Giuseppe Farina taking victory in the Alfa Romeo 158. It was a result that not only signified the end of Silver Arrows' golden era, but also heralded a new age of racing that would spawn the Formula 1 World Championship and a new, smaller, more nimble type of grand prix car.

TECH SPEC

Mercedes Benz W165

Engine
Configuration: V8, 90 degree
Capacity: 1495cc
Bore / stroke: 64mm x 58mm
Power: 256bhp

Valvetrain: four valves per cylinder
Included angle: 56 degrees
Camshafts: four (two per bank)
Connecting rods: forged nickel chrome steel [ECN25F]
Big end and main bearings: Steel race and rollers in a duralumin cage, double on third main
Cam bearings: plain white metal
Valve springs: double coil (85kg pressure)

Valve timing
Inlet opens: 40° 30' btdc
Inlet closes: 67° 30' abdc
Exhaust opens: 47° bbdc
Exhaust closes: 31° atdc
Inlet valve lift: 7mm
Exhaust valve lift: 6mm

Induction
Carburettor: Mercedes multi-choke
Supercharger: Roots-type, 2-stage
Boost: 2.6Bar
Ignition Single Bosch J08 ZEZ 52/6Q1 magneto
Firing order: 1-3-7-2-6-5-4-8

Lubrication
Dry sump capacity: 12 litres
Running temperature 75-80degC
Three pressure pumps, six scavenge pumps

Transmission
Single-plate dry clutch
Transverse transaxle, five speeds

Wheelbase: 2450mm
Track front: 1340mm
Track rear: 1280mm
Weight: 700kg


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Metal Mickey

Racing drivers are unique among professional sportsmen in that they are actively banned from practicing. McLaren's Human High Performance Programme offers a way to optimise their natural abilities

BY ANDREW COTTON

Racecars are basically pieces of hardware that are creatively stuck together to make a fast, light and hopefully efficient ground-based missile. Software makes the hardware work better, but overall, this is a package designed for repeatability – the ability to start, stop and turn with predictability that can be tweaked for efficiency.

All racecars, however, have one hugely unpredictable element to them, and that is the fleshy bit that sits in the cockpit. I am talking, of course, of the driver, a human being with all the failings that a member of our species can bring to a highly engineered and scrupulously thought out machine.

One bad judgement call, one slip of concentration, one helmet full of vomit (step forward Mr. Webber), and all the best laid engineering plans fall apart at the seams. In its futuristic building near Woking, UK, McLaren Applied Technologies has decided to attempt to quantify driver performance and begin a development programme to make the driver as fit, healthy and mentally agile as possible, and reduce the possibilities of making a mistake.

The programme, into which teams can buy, also helps with racecar design and engineering. Already the client base involves some of McLaren's rival Formula 1 teams.

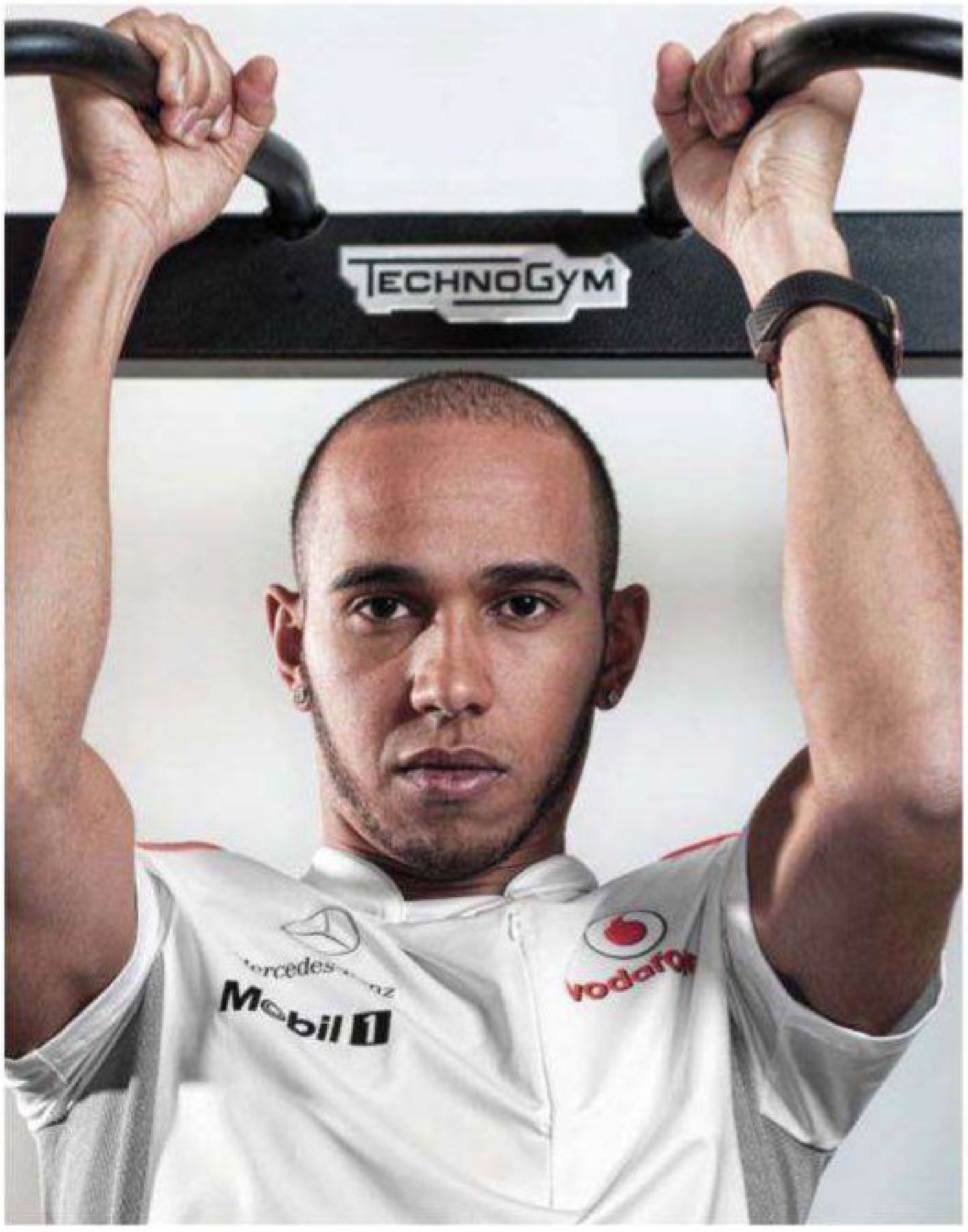
FITNESS FANATIC

McLaren's approach is nothing new. From the moment Michael Schumacher bounced around on the top step of the podium looking as though he could complete another grand prix distance as his rivals stood next to him looking unfit even to lift the trophy, it was apparent that Formula 1 had moved into a new era of fitness.

Coaches were employed, programmes designed, but McLaren's approach goes a little beyond that, and has opened its programme to customers after a seven-figure investment in the facilities. 'This is a programme that is integrated across three core skills – human driver performance, race craft and, more importantly, racecar design and engineering,' says Geoff McGrath, managing director of McLaren Applied Technologies. 'With those three together, we think we have a relatively competitive package.'

The target market for the programme is from GT3 upwards, and includes NASCAR, DTM, Formula 3, Sportscars and Formula 1. The idea is to help teams improve their results, attract more sponsorship and be able to justify their expense in a practical business sense. 'If they did it themselves and grew organically, it would be a flat path,' says Mike Phillips, head of motorsport at MAT. 'If you come here, you make a step change, and the result of that has to be an improvement on the track. A result of *that*, normally, is increased revenues.'

"three core skills – human driver performance, race craft and racecar design and engineering"



Aim: to maximise a driver's abilities to demonstrate their physical capabilities

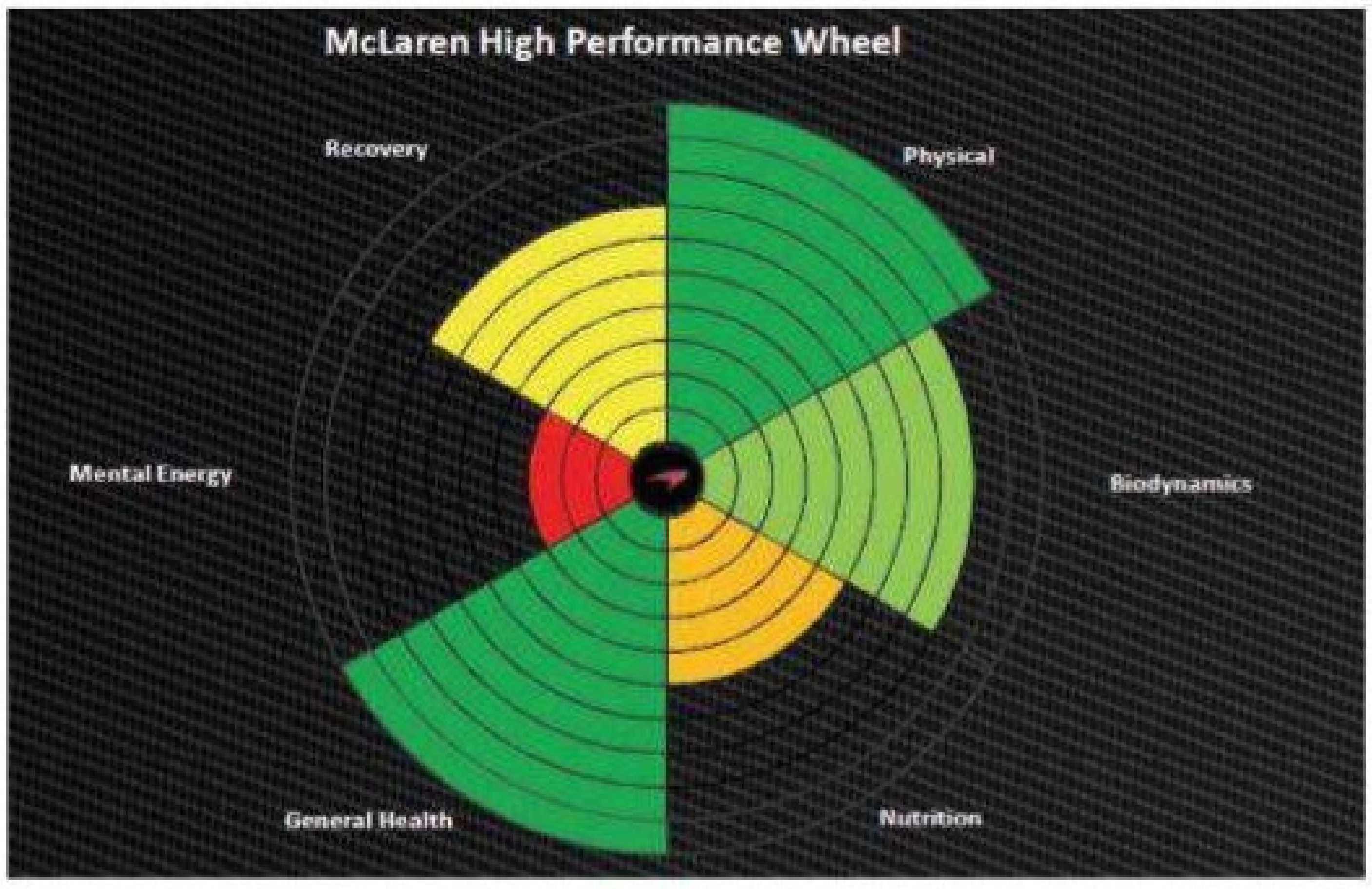
BLADERUNNER

Applying science to a driver sounds scary, as it will inevitably turn around drivers with more robotic qualities than human, but that is the point. If the car works best through repeatability, so should a driver. There are few other sports in which someone competing in a World Championship has only limited ability to train in their environment. From one week to the next, drivers may not get into the car after finishing one race, before practicing for the next. A football player may still train with his team, a sprinter may run, but a driver cannot get into a Formula 1 car and drive. Apart from the costs, it is a banned practice.

Track time, then, is at a premium, and so McLaren relies on its simulator to develop technical feedback, and a fitness programme to create a more complete driver.

'Motorsport's probably been relatively poor at really developing the physical abilities of the driver,' says Clayton Green, McLaren's Human High Performance Manager. 'High performance driving as a sport has relatively unique requirements compared to other sports. It is a complex task that requires high levels of cognitive function, as well as being coupled with an extreme environment in which to perform the tasks, which involve high levels of stress and physical exertion on the drivers.

'The Human High Performance Programme is designed to monitor and maximise a driver's



The 'Wheel of Success' shows instantly how a driver is performing in the six key parameters and any areas that require further development

VIRTUAL TRAINING

Part of the driver development programme is Mclaren's simulator. Far from the spider leg set up of Toyota and Wirth, it is a completely different device. McLaren's sits on a flat rail, giving side-to-side motion, but extremely limited front-to-back movement, and dampers on the side of the chassis help to give more feel.

This, says McLaren, is not a problem for Formula 1 development as the chassis is highly rigid, but a second simulator is being developed in the next room that will help to develop softer sprung chassis, such as those for GT racing, and eventually even production car development, too.

The simulator, therefore, has only limited application, and drivers have to go through a two-hour induction process to get over any sickness and to allow them to do some real work in developing the cars. As with all simulators, there is a limit to how effective they are.

'It is not like driving a real car, it cannot replicate the sustained *g*,' admits Dr Caroline Hargrove, who designed McLaren's simulator. 'You have to train yourself to abstract from driving from a real car. There is a phase of learning, normally two hours, so that you can see the changes in *g* and not sustained *g*. Once you are trained in that, you can do some useful work in a simulator. We worked really hard to make the models accurate. If you change the roll bar, for example, does it help? It has to be that accurate.

'There is a complete brake system that is identical to the car. We have to get the interface between the driver and the car as close as possible, so everything he touches has to be the same. Our body is very good at finding out what is different and why is something changing. We are currently reviewing our cueing of the stimulus system.'

The Formula 1 simulator, in a separate part of the building to the new customer programme, is 3D, though the drivers have had to adapt to working with 3D goggles, and a reduced depth of field. 'The only thing is that we tested the goggles and we don't think you have the depth of field yet,' says Phillips. 'Projector technology has come on leaps and bounds in the last few years, and we have to buy new projectors every six months. The Formula 1 team has a 3D system, so they buy something like 10 each time. But you still need the wind tunnel because the information comes from there to the simulator.'

"You have to train yourself to abstract from driving a real car"

abilities to demonstrate their physical capabilities and maximise their performance race after race during the season.

'Drivers need to have an incredibly well functioning brain. There is a lot of information coming at them, what they can see happening in front of them, around them, the team coming at them through their head sets. You have got to be able to process this very quickly, and at high speeds while not making any mistakes. As they become more fatigued over the course of a race, that impacts on how their capabilities function. When we head up through the categories, the forces increase.

'The neck, in particular, needs to be very strong, protecting the cervical vertebrae and the nerves coming out of it. Also they will maintain the field of vision - if you cannot hold your head to maintain your horizon, it will affect the information coming to you. The cardiovascular system needs to be very well developed. Heart rates can be up to 80 per cent of their maximum heart rate for the duration of a race, and there can be significant spikes in the heart race, far in excess of anything we could replicate here, and that is indicative of how stressful the environment is. The hormonal element drives the heart rate up, and the better we understand it, the better we can help them prepare for it.'

STRONG TO THE CORE

'They have to have a very strong core in the car. They have to stabilise their body against the g-forces, their lungs, ribcage and so on to be able to perform. The legs not only need to be strong for large amount of forces to apply the brakes, but they need to have very fine motor control to know how much throttle is applied. They need to accurately measure the forces that are applied every time.

'The same applies to the level of grip. They need to be very strong to resist the torque and the vibrations, have very fast reactions, very fine motor control and be able to process the amount of information from the instrumentation, which they might have to adjust on lap.'

McLaren's team has a 'Wheel of Success'. Six parameters are measured and scored out of 10, including physical, biodynamics, nutrition, general health, mental energy and recovery. It is clear at a glance how a driver is performing, where he needs to develop, and a separate online system helps McLaren to monitor drivers anywhere in the world.

'The physical side looks at how fit and strong the drivers are, biodynamics, their posture, movement, how they control their joints, any injury history, nutrition - not only what they are eating and drinking, but also hydration,' says Green. 'The environments in which they work can be hot, humid, they are layered with fireproof overalls and they can be sitting pretty much on top of the engine in a single-seat car. And in a closed car there is not much ventilation. If you are not hydrated, the amount of weight a driver can lose can impact on their performance.

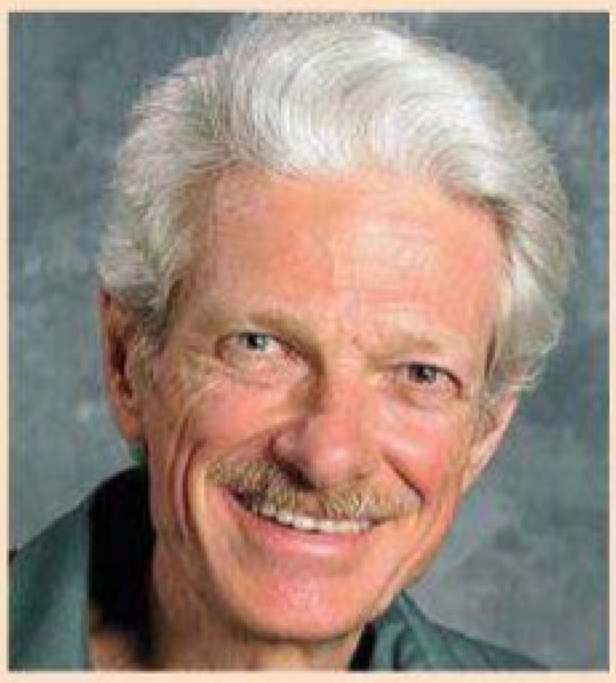
'If a driver gets a cold, flu or little dips in their immune system, it affects their ability to train and to perform at race weekends, so our general health programme assesses where they are at any point in the season, and we make sure they don't come down with colds.

'Racing requires good motor control and a lot of information processing, and much here goes towards maintaining good mental function for the duration of a race. There is a lot going on in the back ground with family, loved ones, and we are trying to help them de-clutter so they can focus 100 per cent on the matter in hand.

'Recovery looks at a driver's race season. The amount of travelling during a race season, even in karting, is substantial and as you get more international, you cross more time zones, get more jet lagged and the experience takes its toll on the body. You need to be able to recover quickly and prepare for the next race. If you don't, your performance will be affected at each subsequent race.'

Having the driver as a predictable part of the car could bring huge performance gains, and that is what McLaren's programme is all about.


ARROW



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Questioning the rule makers

Anti-dive, and the Lotus reactive ride height system

Q Current F1 news includes reactive anti-dive front suspension being declared illegal. Why don't they simply employ enough (100%?) anti-dive geometry to do the job? In other words, what are the negative side effects of running high levels of anti-dive geometry in road racing?

Also, can you please verify for me if this is an accurate statement: 'With anti-dive the axes of the upper and lower control arms are not parallel. When the suspension compresses, the upper balljoint moves further negative on the X axis of the car than the lower balljoint. This leans the spindle rearward relative to the chassis (adds caster). The torque of the brake caliper tries to rotate the spindle forward relative to the chassis (reduce caster), which results in the suspension extending. These countering forces are what makes anti-dive work: compressing suspension adding caster vs caliper torque trying to reduce caster.

Taking the last part first – what makes anti-dive as we know it work? What the questioner is describing is sometimes referred to as torque anti-dive. It is indeed related to the instantaneous rate of caster change with respect to suspension displacement. There is also thrust anti-dive, which relates to longitudinal, or x-axis displacement of the hub or wheel centre.

This conceptual framework applies if we think of the forces as acting at the wheel centre. I find it simpler to think of the forces as acting at the contact patch. In that case, all anti-dive relates to the instantaneous rate of longitudinal displacement with respect to suspension displacement, for the contact patch centre, with the brake locked. This rule covers all cases, even including an inboard brake with drop gears in the upright. The rule can be expressed by the following equation:

$$dF_z/dF_x = dx/dz \quad (1)$$

where,
F_z is jacking or anti-dive force induced in the suspension
F_x is longitudinal force at the contact patch
x is longitudinal displacement at the contact patch
z is vertical displacement of the suspension, at the contact patch

dF_z/dF_x can also be called the jacking coefficient for braking. On a kinematics and compliance (K and C) rig, we can measure dx/dz by cycling the suspension freely with the brakes locked and the sprung mass constrained longitudinally and laterally as it is moved vertically, and measuring longitudinal displacements of the wheel support pad. We can measure dF_z/dF_x by holding the sprung structure at fixed ride height (or a series of fixed ride heights) with the brakes locked, applying rearward force at the contact patch and measuring change in vertical load at the wheel support pad. Measured results will not follow the equation exactly. The differences between predicted and measured

The Renault R31 was fitted with an innovate anti dive system when it ran in testing at Abu Dhabi last year, the team did not plan on racing the concept at the start of the 2012 season

values will give us some indication of the compliances, clearances and frictional effects in the system.

When we are designing the car, or analysing an existing car from point measurements, for outboard brakes, the car has positive anti-dive if the side view instant centre (SVIC) is either behind the wheel and above ground or ahead of the wheel and below ground, or if the SVIC is undefined (side view projected control arms parallel) and the side view projected control arms slope upward toward the rear.

For inboard brakes, assuming no gears in the upright, the rule is the same, with one important change: the car has positive anti-dive if the side view instant centre (SVIC) is either behind the wheel and above wheel centre or ahead of the wheel and below wheel centre, or if the SVIC is undefined (side view projected control arms parallel) and the side view projected control arms slope upward toward the rear. Stated another way, the linkage or control arm system can only have torque anti-dive when torque reacts through it rather than directly to the sprung structure via a jointed shaft.

So anti-dive geometry in the suspension linkage must either create caster change with heave, or make the wheel move forward with heave. In the case of an inboard brake, only the latter of these will produce anti-dive.

It is worth noting that absence of caster change with heave (equal displacement at all four wheels and vertical translation of sprung mass) does not mean the caster never changes. Controlling caster change in both heave and pitch is very much like controlling camber change in both heave and roll – we can't have zero change in both modes. The best we can do is compromise so we don't have a lot of change in either mode. One recommendation I often make is to have the side view virtual swing arm length (SVSA) about equal to the wheelbase. That gives similar amounts of caster change per inch of wheel travel in heave (caster increase) and in pitch (caster decrease).

What limits how much anti-dive we can run? Two effects, basically. First, we tend to get wheel hop with large amounts of anti effect, of any kind, mainly at the point of wheel slip. Second, anything that makes the wheel move forward with respect to the sprung mass when the suspension compresses makes the suspension less able to absorb bumps. When the wheel hits a bump, it is best if it can move rearward as well as upward. If it has to move forward to move upward, that makes the suspension less compliant, and increases ride harshness and wheel load variation.

REACTIVE RIDE HEIGHT

Briefly, that's how anti-dive geometry as we have known it works. What is this reactive ride height control thing that Lotus

ANTI-DIVE – PUTTING PRACTICE INTO THEORY by Craig Scarborough

In the first few weeks of 2012, the FIA issued a technical directive banning brake torque reaction from affecting the suspension. This clarification came about as Lotus (formerly Renault) were found to be testing a form of brake-operated anti-dive to compensate for ride height loss under braking.

Rumours persisted about the system's existence from early 2011 and the system was eventually exposed by technical journalist, Giorgio Piola, at the final test for young drivers in Abu Dhabi in November. It was seen that the system used the brake caliper to compress a hydraulic circuit to increase the pushrod length when the car was braking. This solution skirted around several regulations, but was at first accepted as a legal solution for braking stability in 2010. Tested at various other points by Renault through 2011, the system was understood to have been planned for introduction in 2012 season. Its exposure lead other teams to submit their own interpretations of the system to the FIA, and this increased interest in the system lead to the clarification in January 2012. Part of the reason cited for the banning was the brake interaction affecting the car's aerodynamics, therefore the system constitutes a movable aero device.

Since the 2009 aero rule changes, F1 designers have sought to extract more and more downforce from setting the car up with large amounts of rake.

One of the inevitable compromises with a car creating several *g* under braking is that eventually front wing ground clearance will be eroded as the car pitches under braking and the sight of wings scraping the tarmac will set alarm bells ringing with the FIA technical delegates.

Methods to prevent the front end diving under braking are varied, and most react via some method of weight transfer or being constrained by heave elements in the front suspension. Both have other impacts on the front axle, when aero loads have a similar effect on ride height.

Lotus (still Renault at the time) set about designing a system that freed up the heave elements for aero loads, and having a separate system that solely compensated for dive under braking.

BRAKE-OPERATED SOLUTIONS

Inspiration for systems can come from anywhere, and motorcycles in the 1980s were a particularly rich source for brake-operated anti-dive solutions. Simplest in concept was the mechanical anti-dive system where the brake caliper pivoted around the front axle on a bracket. This was then linked to the unsprung yokes (triple clamps) and the torque reaction from the brake caliper created offset the forks compression when braking. Other systems used valves that were linked to the braking circuit, such that compression damping would increase when the brakes were applied. Honda had a similar solution called TRAC anti-dive, which used the movement of the brake caliper itself to operate the valve. These solutions provide at least part of the system Lotus are rumoured to have developed through 2011.

It is understood that the Lotus system uses a special AP Racing brake caliper matched to an upright. The mountings between the two allow a degree of freedom that compresses a hydraulic cylinder inside the upright. This, in turn, is linked internally to the pushrod mounting that extends to effectively increase the push rod length.

The system was readied

came up with, that has been recently in the news for getting banned by the FIA? How does it work? Would it offer advantages over conventional anti-dive? Would it be applicable outside of Formula 1?

The device uses a small hydraulic system, actuated by brake torque, to raise the front end a little bit, compensating for compression under braking. Rather than being attached to the upright in a completely rigid manner, the caliper is mounted to the upright on a bracket that can rotate with respect to the upright – somewhat like a brake floater on a beam axle. The caliper bears against a piston, or pushrod acting on a piston, in a small master cylinder attached to, or built in unit with, the upright. Under braking, the master cylinder sends fluid under pressure through a short hose to a slave cylinder built into the lower end of the suspension pushrod. With sufficient hydraulic pressure, the pushrod extends, raising the front ride height.

As such, an anti-dive effect is achieved, without any wheelbase or caster change in heave. If such a system is tested on a K and C rig, equation (1) will not apply. There can be a positive jacking coefficient without having a locked wheel contact patch moving forward when the suspension is compressed. In fact, if the suspension geometry provides zero anti-dive, as conventionally analysed, the system will show slight rearward motion at the contact patch as the hydraulics work, when rearward force is applied to the contact patch. The system will create a compliance. However, this particular compliance will be accompanied by an increase in wheel load if the sprung mass is not allowed to rise, or a ride height increase compared to behaviour without the system if the sprung mass is not constrained vertically.

The FIA banned the system under the rule prohibiting movable aerodynamic devices. Some have suggested that they should have used another rule that prohibits suspension devices primarily intended to influence aerodynamics. Personally, I think either of those is a reach, and the latter rule is highly ambiguous. Claiming that a suspension system is a movable aerodynamic device in the same sense as a movable wing or a sucker fan is baldly absurd. It may be that on a very smooth track, with ground-effect-critical wings and bodywork, the suspension does affect aerodynamics as much as it affects anything. But in that case, anything at all in the suspension is a device that influences aerodynamics. Certainly, a third spring in the front suspension is that. Those were introduced after the advent of wings, to limit pitch, and control how far front wings are from the ground. But they're legal.

"Claiming that a suspension system is a moveable aerodynamic device is baldly absurd"

Apparently, interpretation of this rule depends on a judgement of what the primary intent of the device at issue is. I would still say it's a big reach to say that control of aero properties is the primary function of any kind of passive anti-dive strategy, when cars having no aerodynamic downforce devices at all use various strategies to limit dive, and so do motorcycles. Formula 1 cars had anti-dive before they had wings. This is just a slightly different way of passively harnessing the forces in braking to reduce front suspension compression.

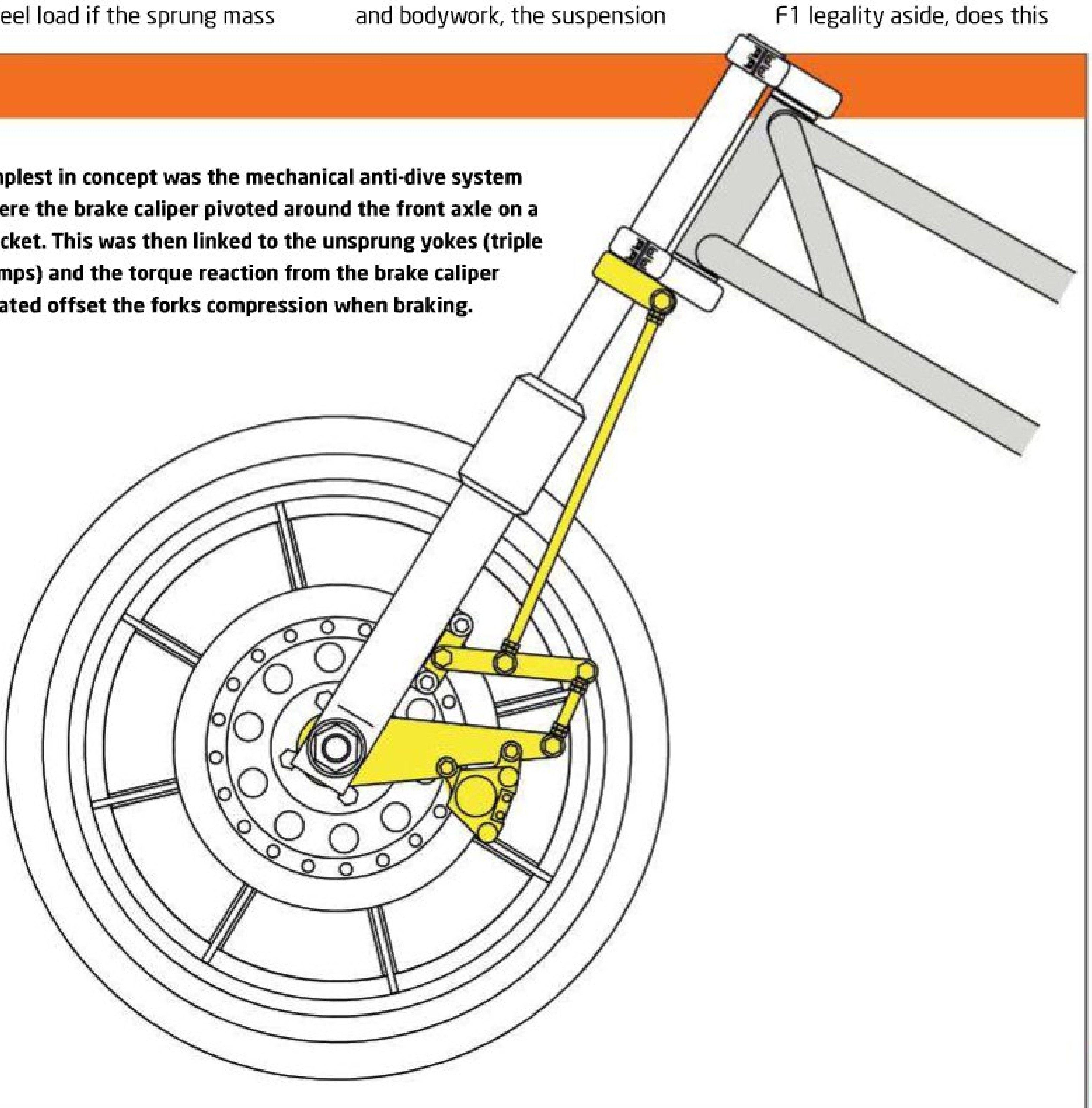
F1 legality aside, does this

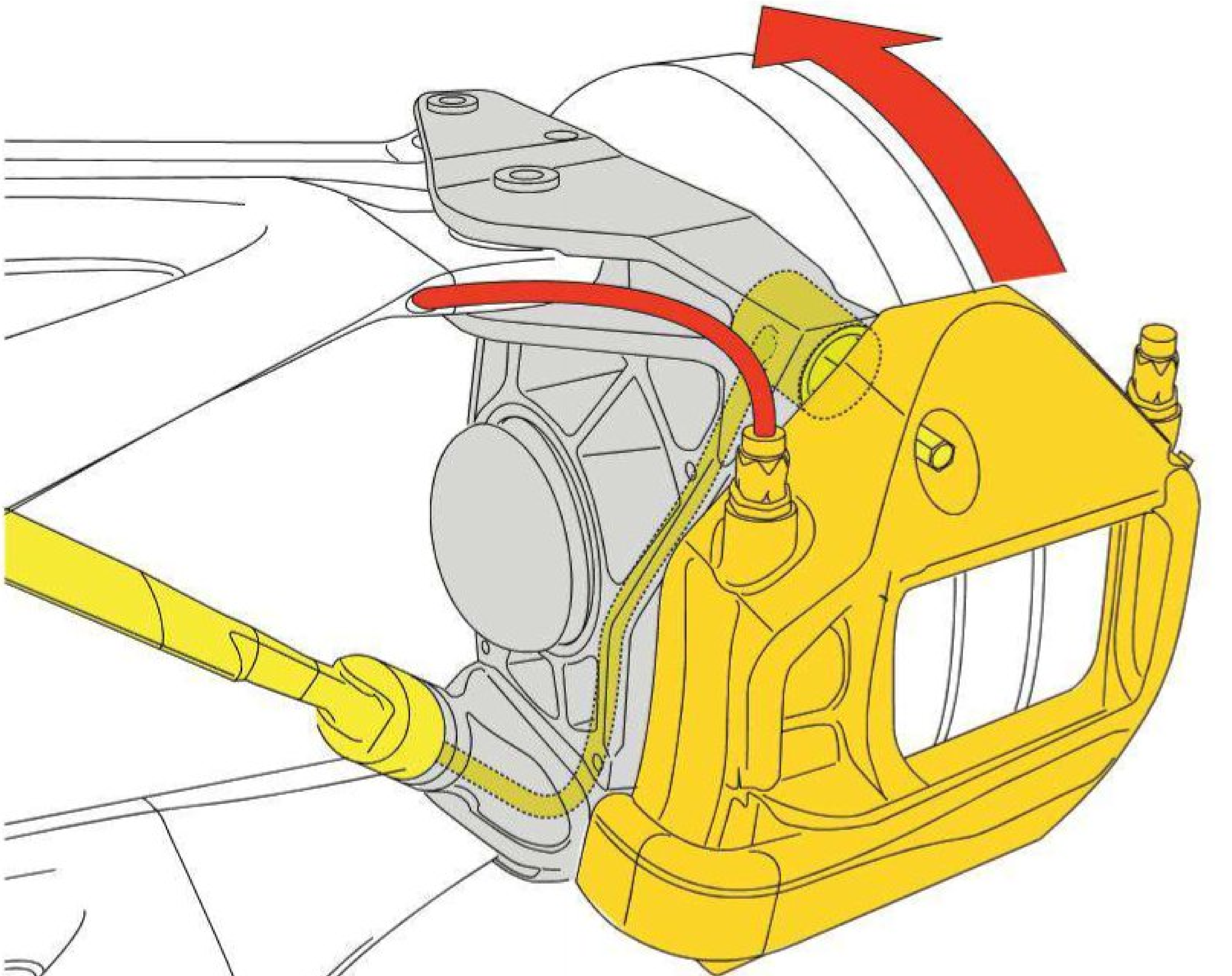
for pre-season testing in 2011 and tested at several points during the season before its discovery at the Abu Dhabi test. Initially, reliability was said to be an issue, with the hydraulic pressure causing issues with the upright. But, by the test at the season's end, the system appeared to be race ready.

The decision to use the movable aerodynamic device regulation to ban the system prevented long legal arguments on the interpretation of the system under a number of other rules around suspension and driver interaction. Many of which could have been argued by Lotus.

Teams, including Lotus, will continue to develop alternative solutions to pitch under braking. One area pioneered by Renault is passive hydraulically interlinked suspension systems. These are expensive and complex systems, so the loss of a cheap and simple technology seems a shame in today's resource-restricted F1.

Simplest in concept was the mechanical anti-dive system where the brake caliper pivoted around the front axle on a bracket. This was then linked to the unsprung yokes (triple clamps) and the torque reaction from the brake caliper created offset the forks compression when braking.





The Lotus system uses a special AP caliper matched to an upright. The mountings allow a degree of freedom that compresses a hydraulic cylinder inside the upright. This, in turn, is linked internally to the pushrod mounting that extends to effectively increase the push rod length.

idea offer functional advantages? Can it do anything that ordinary anti-dive cannot?

Lotus is saying this is all much ado about nothing, because they tested the system and didn't like the way it behaved, so they weren't going to race it anyway. That may be so, but I don't think the matter is as simple as that.

I would expect that, as with so many things, brake-reactive ride height modification can hurt or help the car, depending on the details of how it's applied and its interaction with other design and set up elements.

Although I would defer to actual experimental results on this, I am inclined to suppose that anything that produces a large jacking coefficient will cause wheel hop or chatter at the limit of adhesion, and also exact some penalty in ride quality and wheel load variation when braking, even if the jacking coefficient is obtained without caster or wheelbase change in heave. I would also expect that this propensity would depend on the overall jacking coefficient of the front suspension system – meaning the total from the brake-reactive elements plus any conventional anti-dive or pro-dive.

Most current F1 cars have little or no anti-dive or pro-dive. If we simply add a reactive anti-dive system to an existing F1 car, we would either end up with a fairly small effect (if the reactive system does not create a large jacking coefficient), or end up with wheel hop or chatter in limit braking.

"it is my opinion that brake-reactive anti-dive has a future"

But since everything in a chassis interacts with everything else, we don't necessarily get a meaningful read on an idea's true potential by simply bolting it onto an existing car and seeing if the driver likes it or if the lap times come down. What if we designed the car to have reactive anti-dive, and took advantage of the system's properties by changing other things?

For example, suppose we designed the front suspension with a side view instant centre near the vertical rear axle plane and well below ground. The wheel would then move rearward considerably as the suspension compresses, and the system would have considerable geometric pro-dive. Suppose we then combined this with enough reactive anti-dive to give us just a modest amount of net anti-dive. We would then have improved ride and reduced wheel load variation most of the time, with braking behaviour like other cars.

COMPLIANCE STRUTS

We would get this without the disadvantages of compliance struts as used in passenger cars to allow the wheel to move rearward on bumps. Compliance struts allow compliance caster change in braking and also in cornering due to the rearward force the tyre generates when it is steered and running at a slip angle. This in turn results in compliance camber change. Those effects are the reason compliance struts are not used on race cars. Even for a passenger car, where the benefits of compliance struts are deemed worth the penalties, the combination of pro-dive geometry with reactive anti-dive could allow really low impact harshness, and / or allow lower control arm compliance to be reduced, resulting in a handling improvement without ride penalty.

Reactive anti-dive is just as suitable for inboard brakes as for outboard ones. Ordinarily, the only way to get anti-dive with inboard brakes is to make the wheel move forward when the suspension compresses. With reactive anti-dive, we can have a wheel that moves rearward in compression, and any amount of anti-dive we want. In many cases, we might even be able to dispense with hydraulics. Hydraulics are pretty much inescapable if the brake has to steer with respect to the suspension, but if the brake does not steer and is part of the sprung mass, we will be able to get the effects we want with purely mechanical actuation.

Compared to conventional anti-dive, reactive anti-dive is a roundabout way of getting the job done, and it does inevitably involve using more parts. However, as with other roundabout ways of doing things, the extra bits afford a convenient way of introducing intentional non-linearities into the system's behaviour. With either hydraulic or non-hydraulic actuation, we can use pre-load springs, limiting springs or stops and linkages with rising or falling motion ratios to get all sorts of non-linear anti-dive. We can, for example, have anti-dive that is extremely aggressive for small amounts of brake torque, then drops away to near zero or even goes negative for the high ranges of brake force where we are likely to encounter chatter or wheel hop.

It is my opinion that brake-reactive anti-dive has a future, perhaps most of all for street use. In outlawing it for F1, the FIA is passing up an opportunity to have racing justify its existence by improving the breed.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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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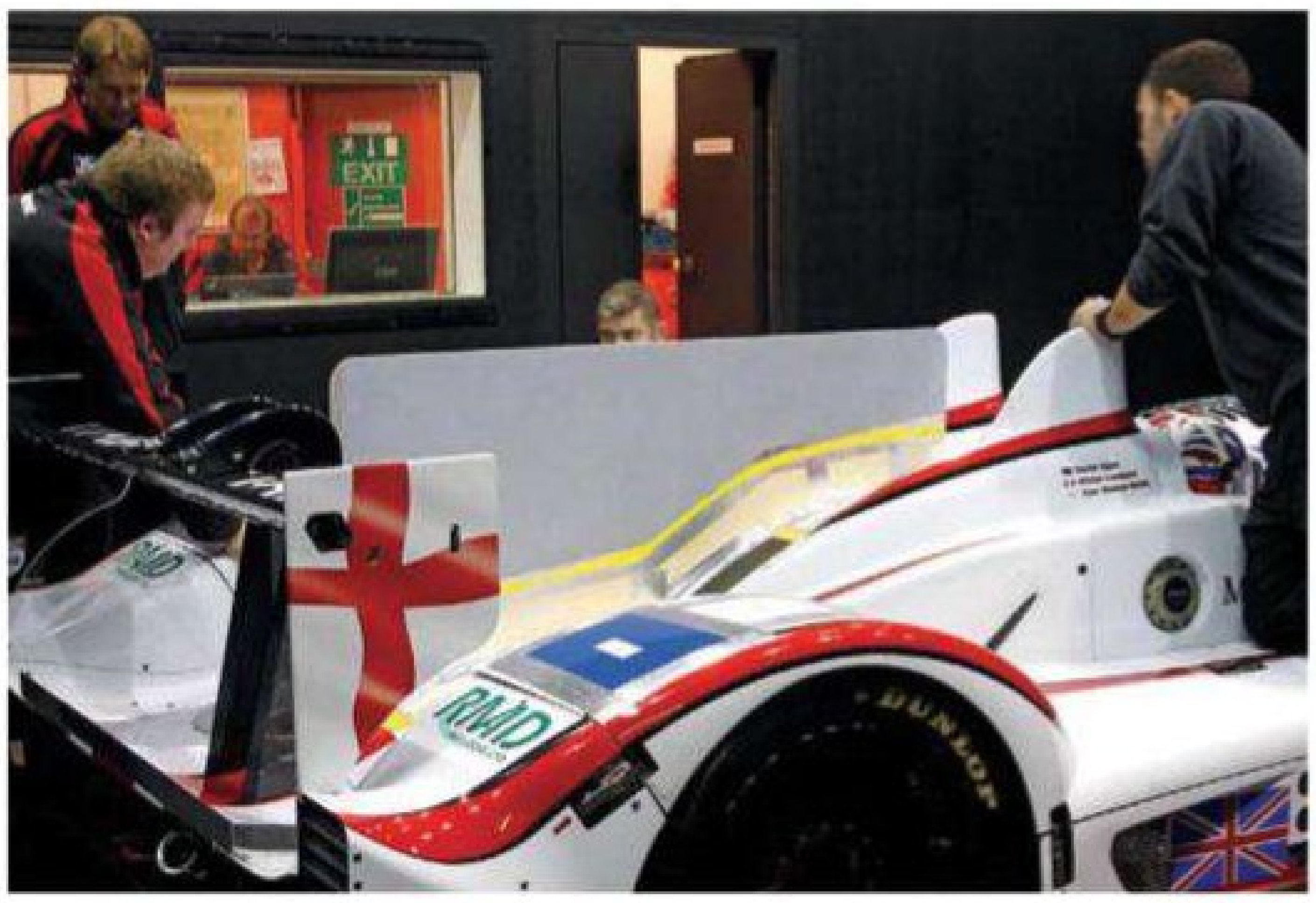
Fin, flaps and yaw...

The effects of 2012 rule changes on an LMP2 racecar

We continue our studies this month on the 2011 Le Mans 24 Hours and Le Mans Series-winning Zytek Z11 SN LMP2 Sports Prototype of Greaves Motorsport. The most obvious addition this coming season to the LMP2 cars will be the engine cover fin, bringing them in line with their bigger siblings in LMP1. At short notice, Greaves Motorsport managed to manufacture a prototype engine cover fin to the new regulation definition, and the plan was to evaluate its effects at a range of yaw angles.

All the configurations examined were tested across a representative range of four yaw angles from zero degrees (straight ahead) to six degrees (equivalent to the slip angle at which the tyres generated maximum grip). The effect of the engine cover fin was also evaluated at three different rear wing flap angles in order to derive a matrix of figures that gave a better understanding of the fin's effect over a relevant working range. The data are presented initially here in three graph plots, one for each flap angle tested, designated maximum, medium and minimum.

Comparing these plots reveals how total downforce reduced with reducing flap angle, although the one exception to this is the data point at maximum flap angle without the engine cover fin at zero yaw, which generated a lower -CL (total downforce) figure than at zero yaw with medium flap angle. It would appear that the rear wing



The 2012-mandated fin extends rearwards quite close to the rear wing

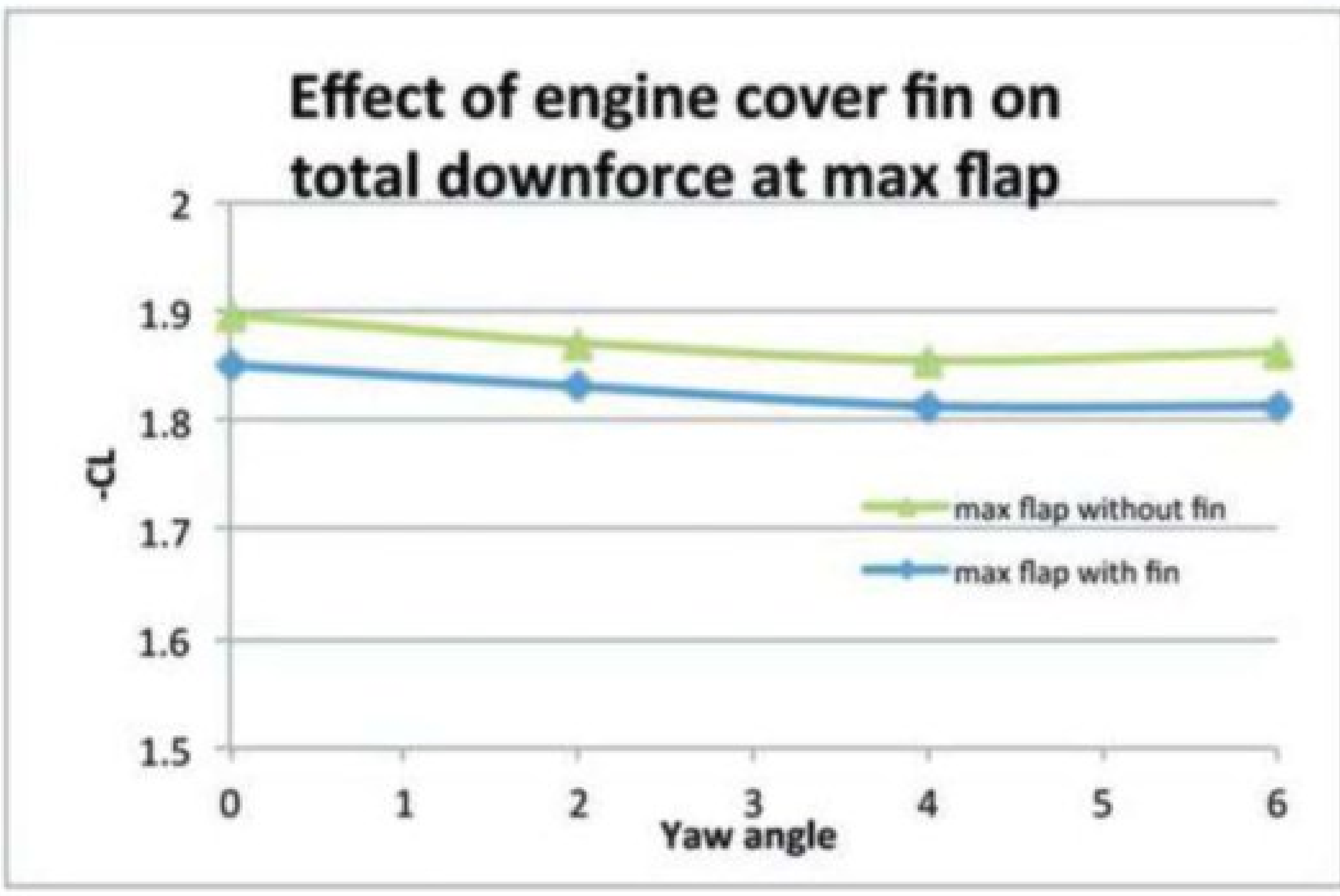
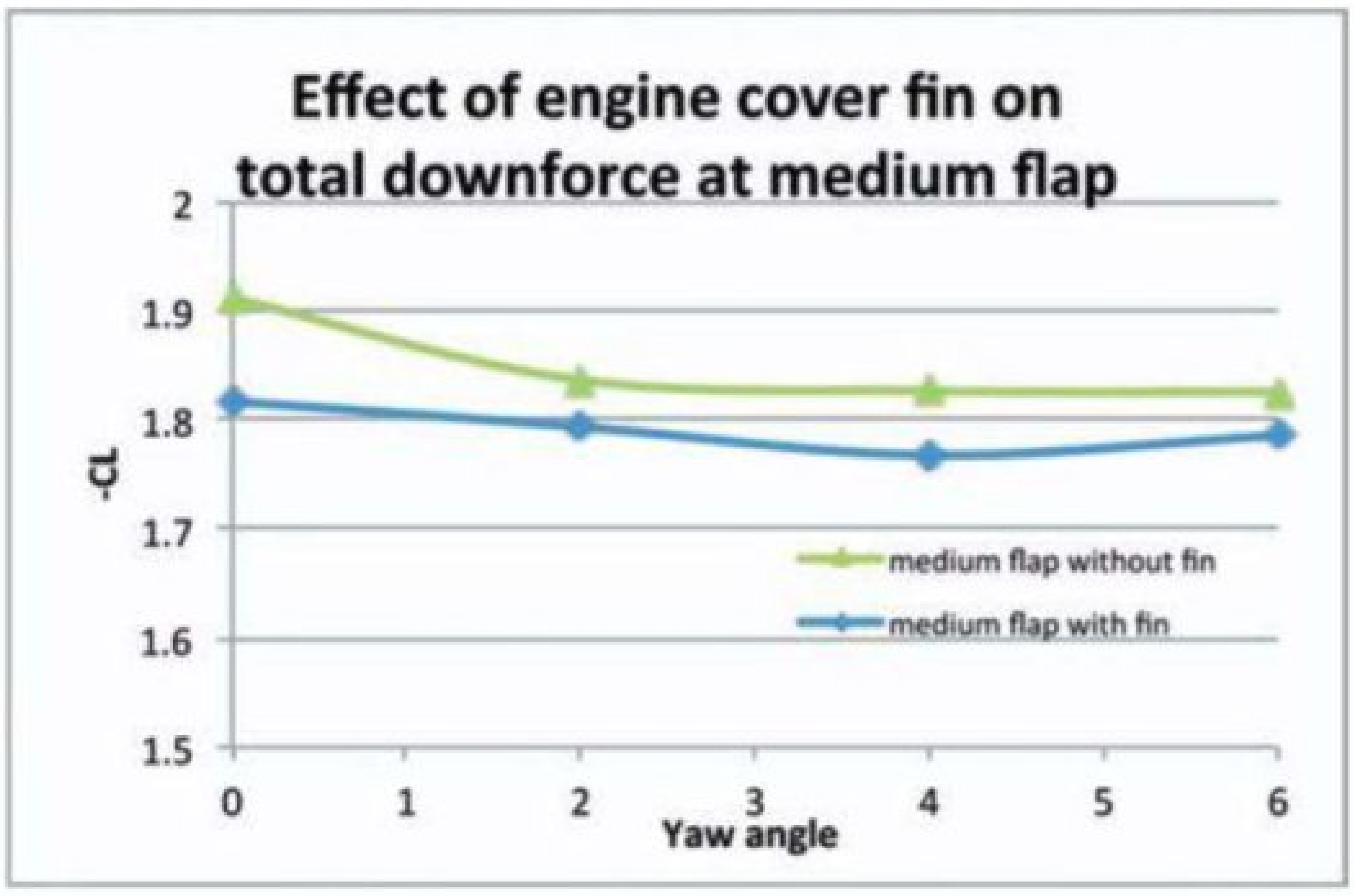


Figure 1



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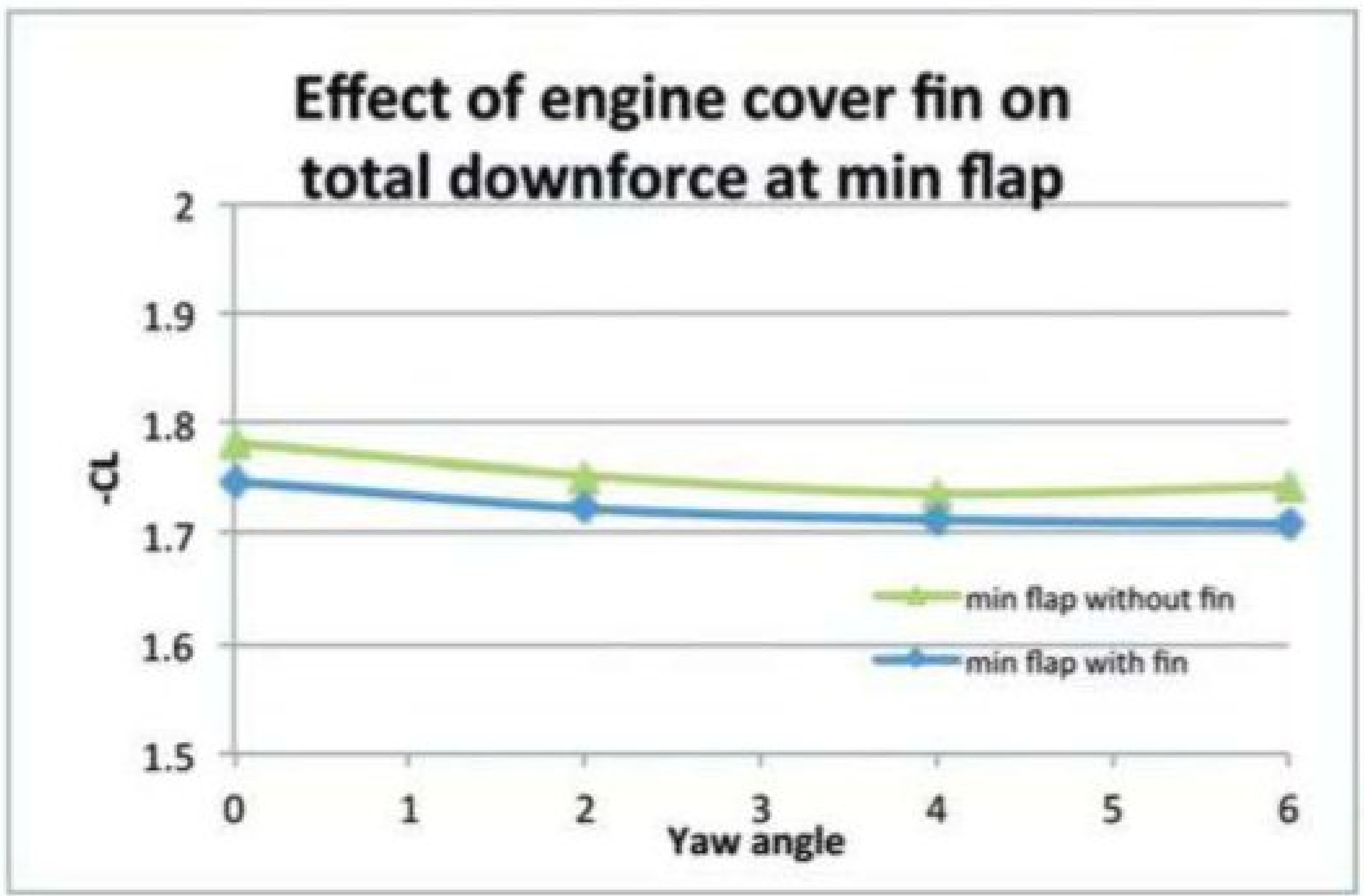

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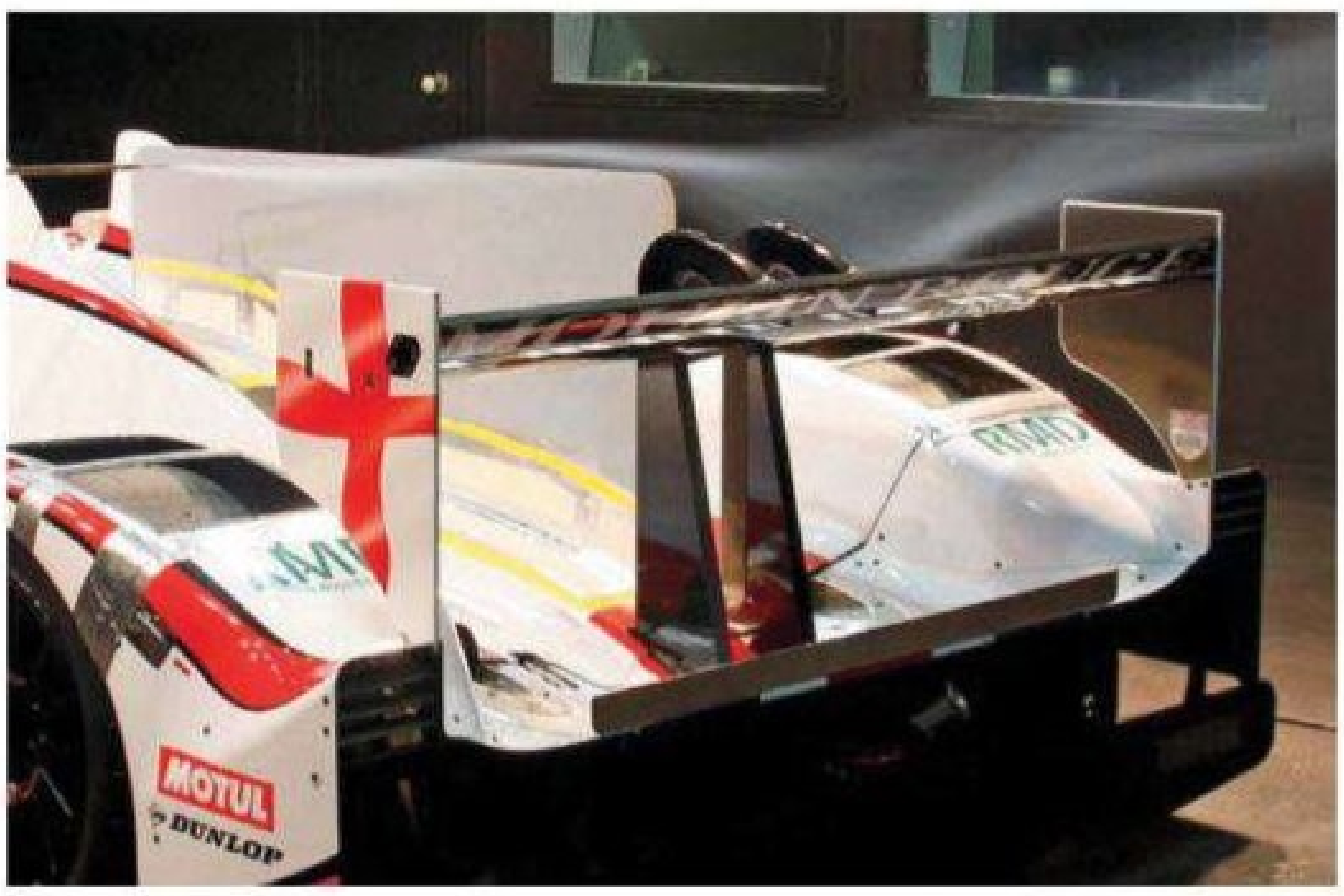


At yaw, the smoke plume can be seen to cross over the top of the engine cover fin before encountering the rear wing

was stalled at this flap angle in the straight ahead position, but was not stalled when running at yaw, which is an interesting fact to keep in mind.

The other obvious pattern is that downforce reduced in all cases as the first two degrees of yaw was applied, and then levelled off and even recovered slightly at the higher yaw angles tested. In most cases, this was the result of front-end downforce recovering as yaw increased. Generally speaking, rear downforce decreased in nearly all cases as yaw angle increased.

But looking at how the engine cover fin affected total downforce in each case, there was clearly a reduction in downforce at each yaw angle and flap angle tested, and the smallest effect of the engine cover fin on total downforce was at the minimum flap angle. In each case, however, there was a significant loss of total downforce and, after our part of the session ended, the team set about recovering the lost downforce arising from fitting the engine cover fin.

Another way of looking at the effect of the engine cover fin is to look at how aerodynamic balance altered across the same matrix of configurations, and three graphs, one for each flap angle, illustrate this most clearly.

Again, there are a number of patterns that emerge. Most obviously, the front percentage increased as rear wing flap angle was decreased (any other outcome would have been quite a surprise!). Secondly, in general the aerodynamic balance shift with increasing yaw angle is similar in each case, with an initial reduction in front percentage at the first two degrees yaw increment, which is then followed by a recovery in front percentage so that at six degrees the balance is not dissimilar to the balance at zero degrees yaw, even though as we saw above, total downforce at yaw is less than when straight ahead. Again, this 'balance recovery' is down to the front end of the car working better at six degrees yaw than at two and four degrees yaw.

But now looking at how the balance shift was affected by the presence of the engine cover fin, we can see that at maximum flap angle the balance was slightly more front biased with the fin across all yaw angles tested. At medium flap angle the balance was quite similar with and without the fin, although where there was a difference there was very slightly more front percentage without the fin. At minimum flap angle the balance was again rather more front biased with the fin.

In general one might have expected the balance with the fin to have been more front biased, on the assumption that when the car was at yaw the rear wing would be adversely affected by the fin. It seems likely that this effect is somewhere in the mix, but there are clearly other factors involved here as well, as shown by the plot at medium flap angle, which did not seem

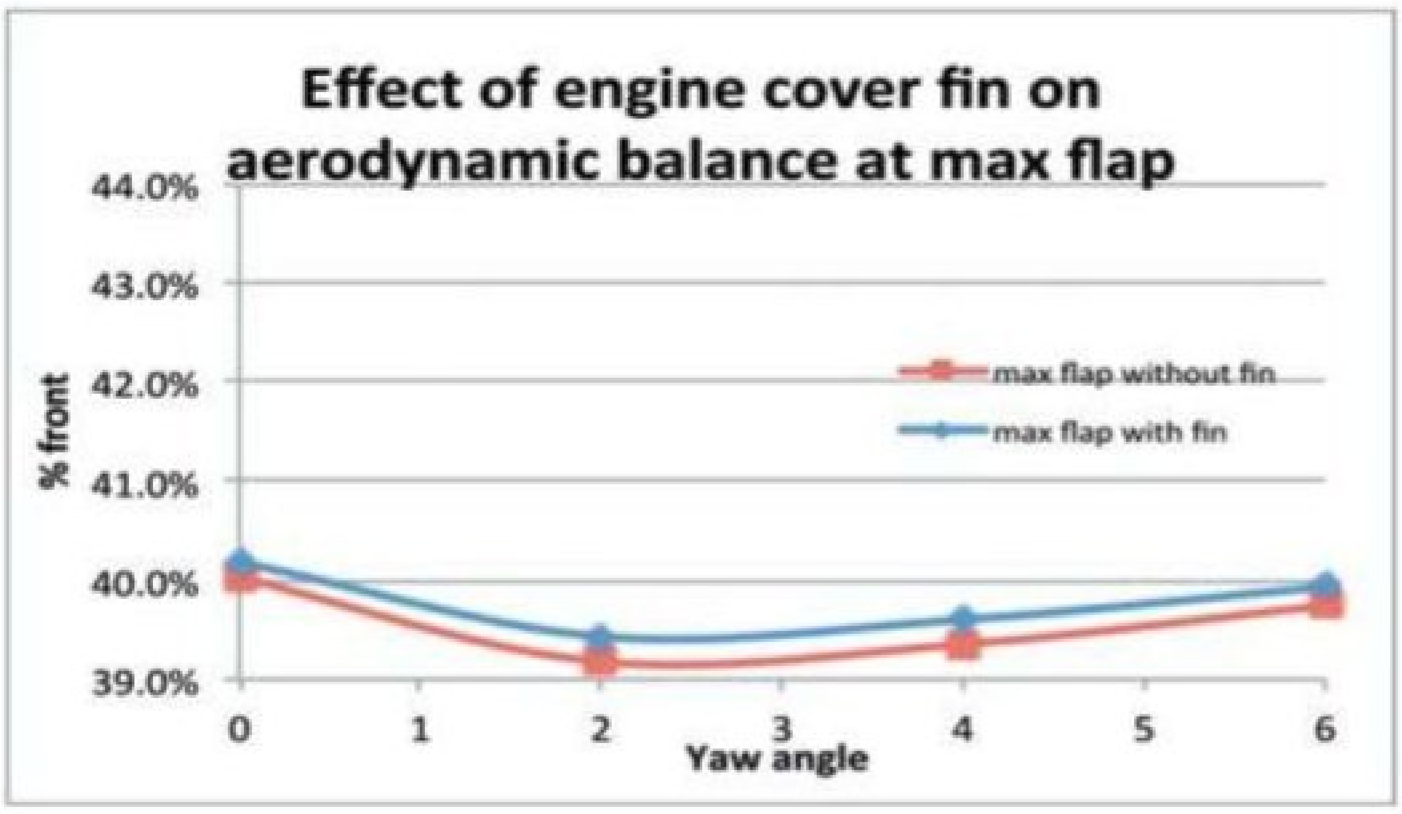
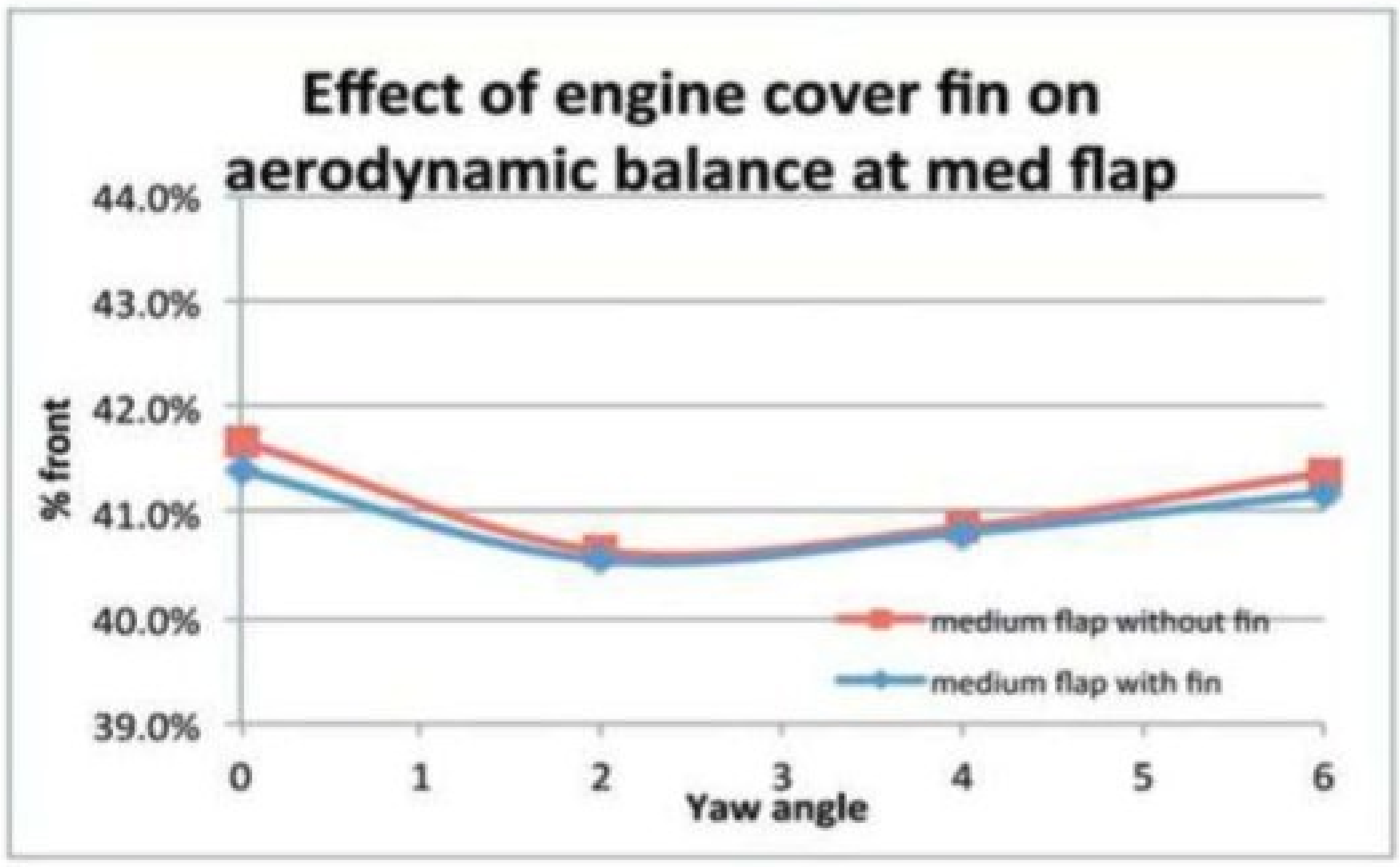


Figure 4



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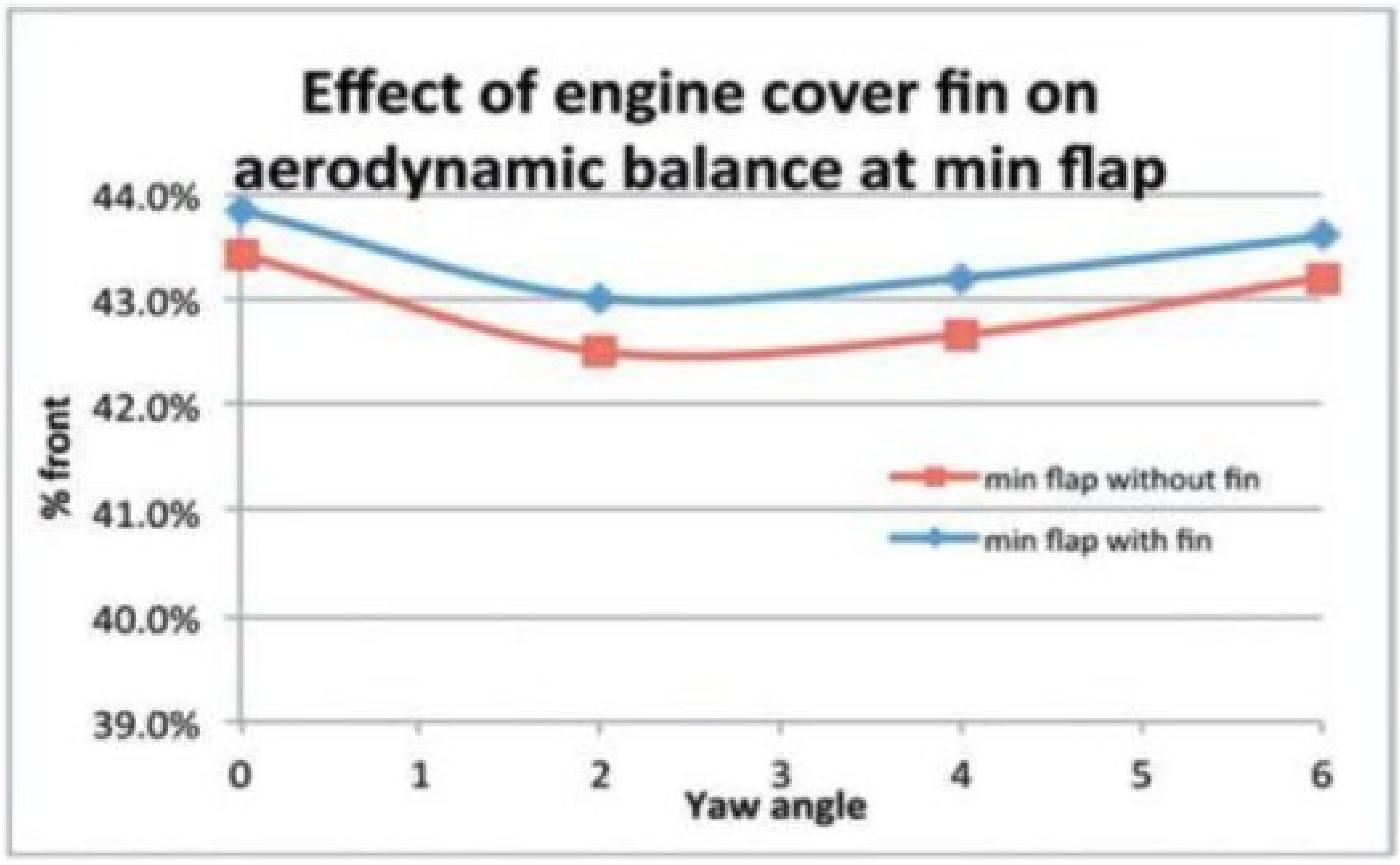


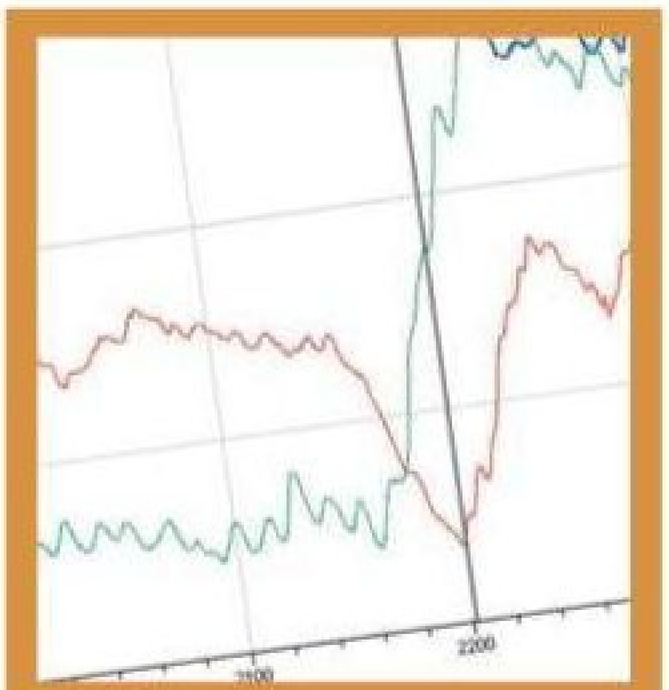
Figure 6

to conform quite to what one would have expected. Indeed, in the medium flap angle case it is hard to explain why there would be even a slight rearward balance shift at either zero or six degrees yaw by fitting an engine cover fin. Perhaps from the team's viewpoint, one should be content that the impact of the fin on balance in this, the 2011 'preferred specification', was relatively small.

Unfortunately, because the prototype fin the team had produced in such a short time was thought not strong enough to withstand testing at higher yaw angles, we were unable to investigate whether the fin's side forces and returning yaw moments would add yaw stability. Suffice to say, yaw moments (and roll moments) were slightly larger with the engine cover fin than without, but even at six degrees they were still miniscule.

More testing next month on some of the other 2012 mandatory modifications.

Racecar Engineering's thanks to Greaves Motorsport



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Potential gain

Using potentiometers to help determine the damping characteristics of a racecar

Understanding the behaviour of the suspension of a racing vehicle is a key element in gaining an advantage over the competition. This is especially important in single-make series where all the cars have the same components, and where the team that is first able to optimise the suspension parameters is always the one at the front of the grid.

When setting up the suspension of a racecar, the feedback from the driver is indispensible, but it can sometimes be difficult to quantify what the driver or car needs in order to perform at its optimum, and the quality of the feedback varies significantly between drivers. It is therefore useful to have a way of measuring what is actually going on at the four corners of the car.

The starting point for analysing suspension behaviour is knowing the position of each wheel. There are two types of sensors generally used for this purpose – linear and rotary potentiometers. Both of these have pros and cons and which one is chosen depends entirely on the type of suspension used and the engineer's preference.

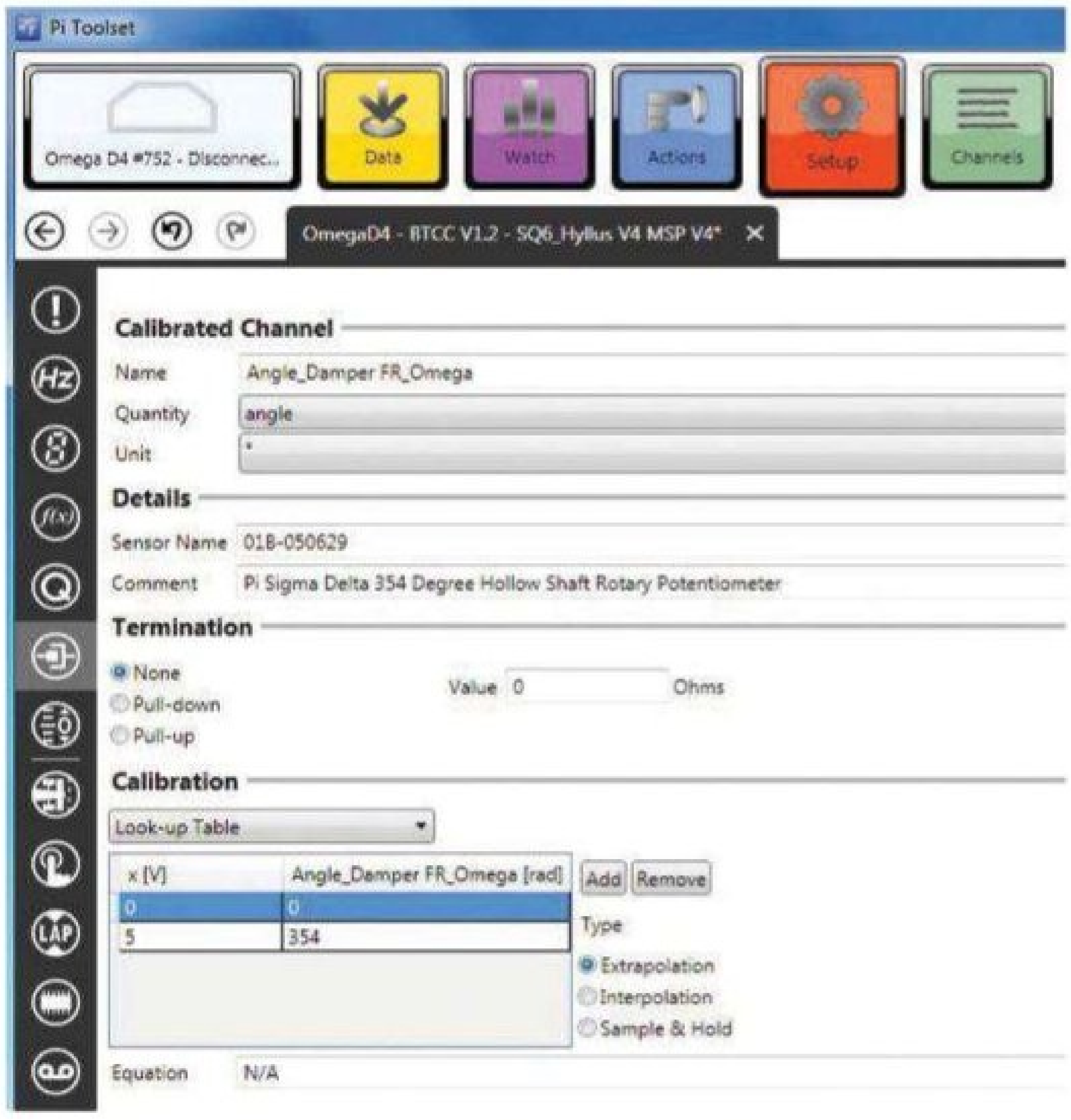


Figure 1: either a linear or rotary potentiometer can be used for rocker arm-type suspension. The linear sensors fitted in the picture below are green, while a rotary sensor would be fitted where the rocker arm is fixed to the chassis (marked by the red circle)

POTENTIOMETER TYPES

The rotary potentiometer tends to be preferred on suspensions with a rocker-type arrangement, where the movement of the rocker is measured as an angle that can be converted to the movement of the wheel based on the motion ratio.

The linear potentiometer is more often used to directly measure the movement of the damper itself. The movement of a linear sensor is not always 1:1 with the damper so it can be necessary to calculate the ratio of sensor movement to damper movement as it is sometimes necessary to compromise the fitment of the sensor in order not to interfere with the movement of the suspension.

The linear sensor is easier to understand and, with careful installation, can measure the damper movement directly. The rotary sensor, on the other hand, is smaller and does not get in the way when changing suspension components.

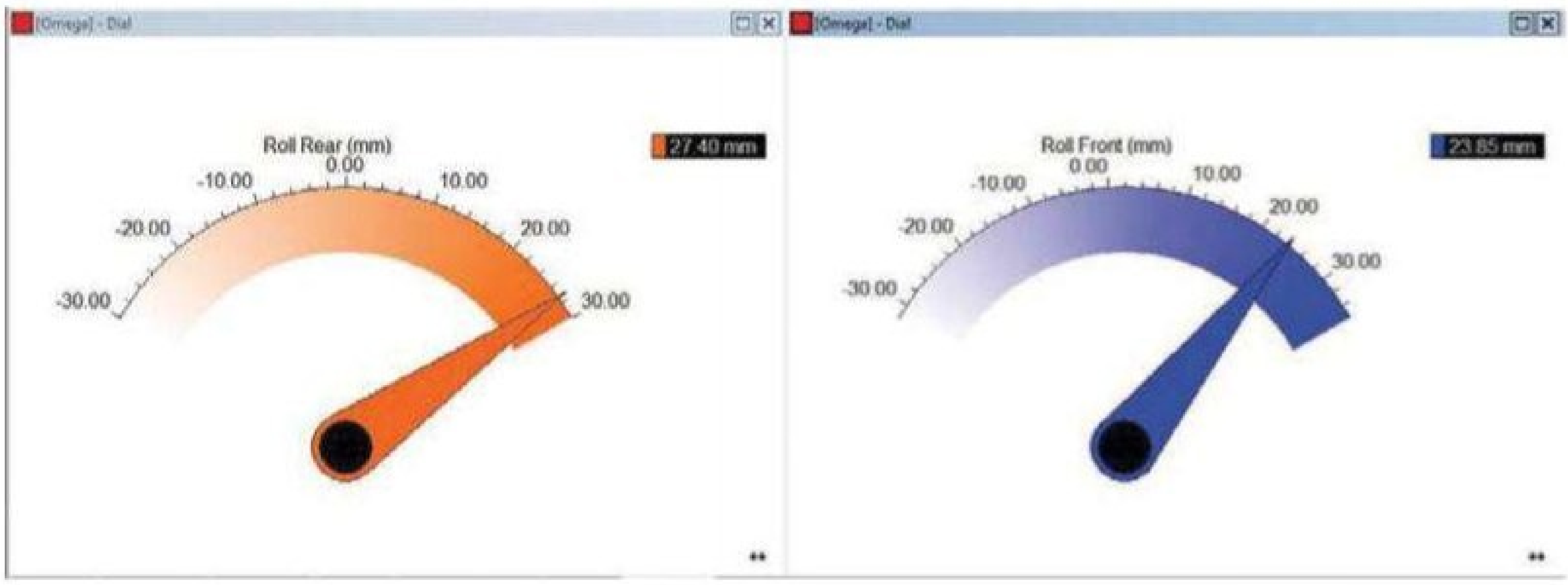
Once the information about how the sensor movement equates to the movement of the wheel is clear, the data logger needs to be configured to output the desired value. To do this, the initial calibration of the sensor needs to be set and, in many cases, a maths channel set up to record actual wheel movement.

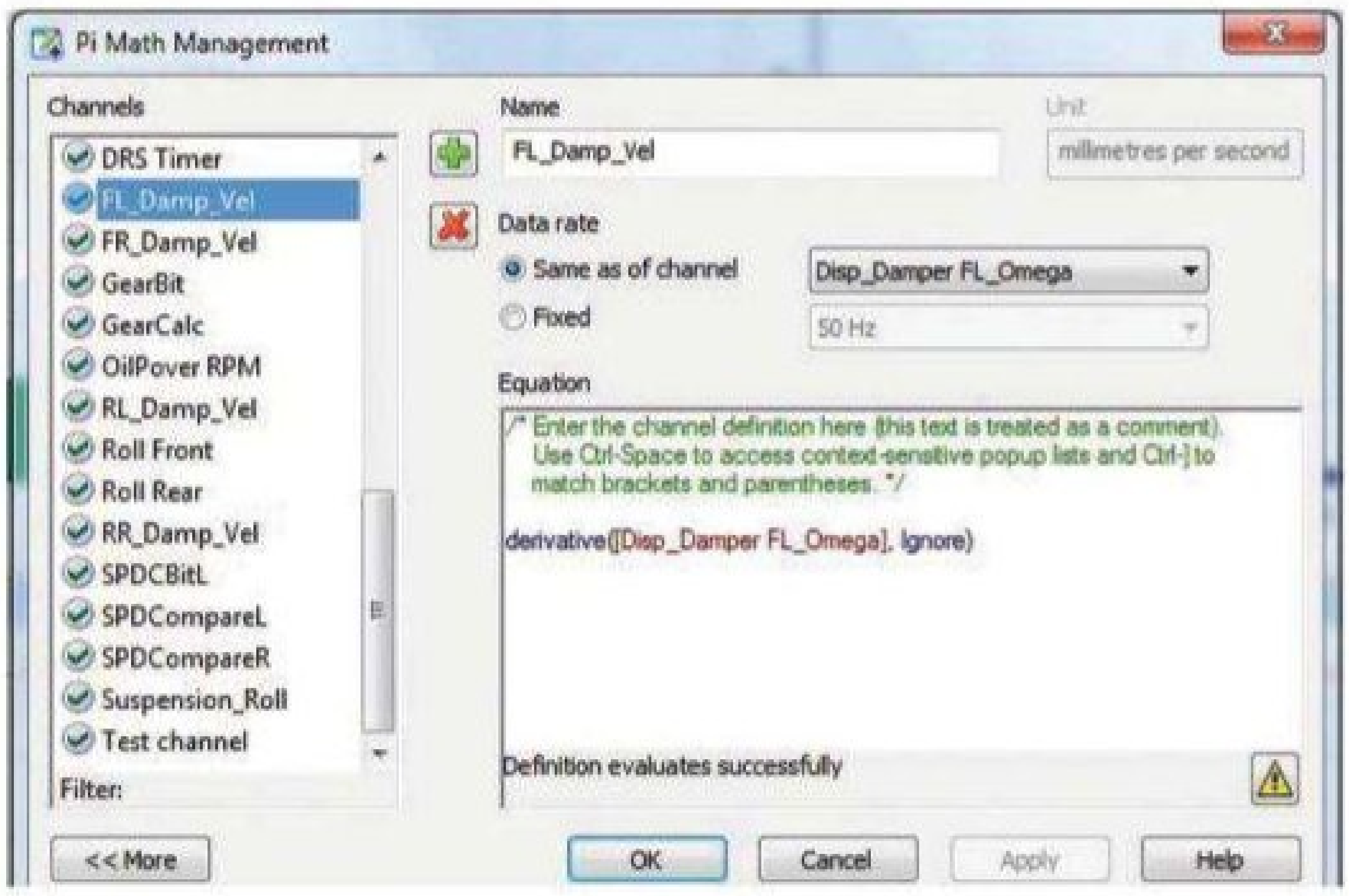
All that is now needed is to make sure the sensors are all giving us comparable values. To do this, the output must be zeroed based on a fixed criteria. Generally, the car will be zeroed either when the car is sat on the flat patch after the suspension has been set up or when the car is in the air with all wheels at full droop. It is important to make sure that the same method for zeroing is always used in order to keep data comparable. Good data logger management systems will have an easy method of zeroing sensors, either by a button press or through the software.

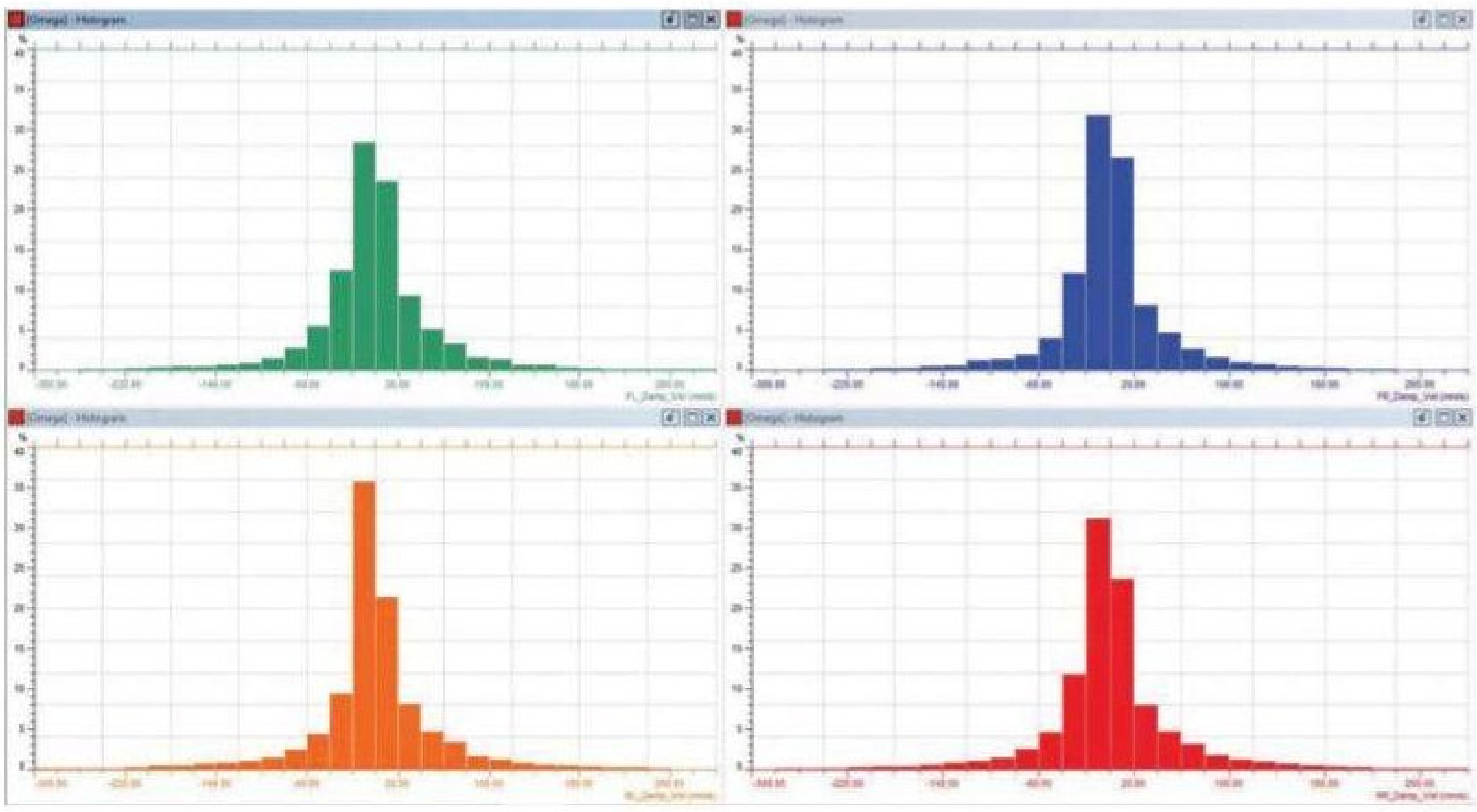
USEFUL PARAMETERS

Now it is possible to start calculating some useful parameters to analyse the suspension's behaviour. A simple start point is to look at the difference between left and right-hand side movements and see how the car is rolling. Equally, it is possible to determine the difference in ride height front and rear to see the rake of the vehicle. Being able to quantify roll is very important as any changes can now be documented fully and related to driver comments.

The next step is to look at the rate at which the wheels or dampers move. This can easily be achieved by differentiating the displacement of the wheel found earlier.







Now it is not only possible to look directly at the velocities of the wheel / damper movement, but also to move the analysis from the time / distance domain into the frequency domain.

When the wheel rates are moved over to the frequency domain there are two distinct areas of frequencies that we need to be aware of. First is the low-speed (5-25mm/s) range, which represents the movement of the vehicle on its suspension, such as roll and pitch. Then there is the high-speed range (25-200mm/s) representing the road surface, including bumps and kerbs. Note that hitting kerbs can produce some very high damper speeds, often over 200mm/s, in which case they should be considered as a special case.

DAMPING CHARACTERISTICS

Looking at the velocities at each corner of the car using a histogram provides some very useful information about the behaviour of the racecar. The bump and rebound characteristics can be seen on the graph either side of zero and the high-speed and low-speed areas can then be determined. This can help the engineer determine the damping characteristics of the car and what changes to make in order to improve the handling.

The subject of vehicle handling is enough to fill several books and there are indeed many good ones out there. However, understanding the wheel position and the rate of change of the wheel provide an excellent starting point for looking at suspension behaviour and should make stepping into further suspension analysis easier.

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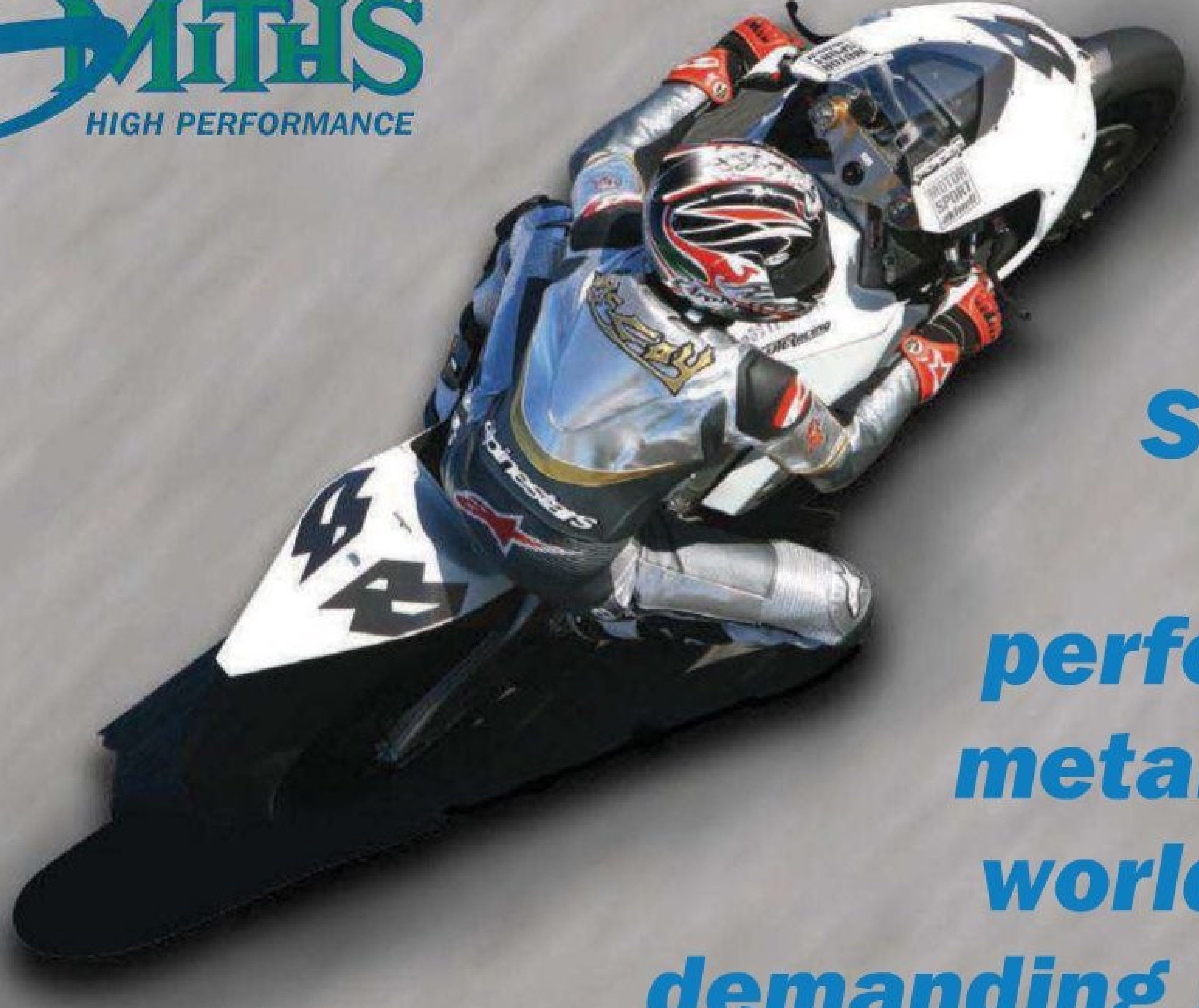


Daddy cool

Every aerodynamic alteration to a racecar will affect how the airflow passes over and through it, keeping the engineers in charge of cooling constantly on their toes

BY ALAN LIS

At the risk of stating the obvious, the primary function of the cooling system on a Formula 1 car is to ensure there is sufficient cooling capacity for the engine in an anticipated worst-case scenario. That being a high ambient temperature, a relatively low forward vehicle speed, a high level of on-throttle time on a, most likely, twisty track with debris accumulation in the radiator inlet ducts. Designing a system that can cope with such conditions is further complicated by a number of additional challenges and compromises.

Having established a baseline cooling requirement, the location of the inlet ducts that will feed air to the cooling system can be determined by the team's aerodynamics group. To a large degree, their position nowadays is a result of the Formula 1 regulations aimed at restricting generation of downforce on the underside of the car. All Formula 1 cars now have a sweeping curved area just above the undertray that takes fast moving air from underneath the cockpit and directs it out sideways to create a low-pressure region along the sides of the car. This helps reduce leakage around the step plane into the underbody by reducing the tendency of the airflow to spill around its edges.

"teams use CFD to simulate the optimum flow of water"

All current Formula 1 teams tend to run their cars with quite a lot of rake, which helps to give a big pressure signature near the leading edge of the sidepods. To achieve this requires a well defined leading edge, which pretty much obliges the use of an undercut below the radiator inlets and results in their location high on the sides of the monocoque.

The shape of the inlet will also be defined by the aero group, as will the length and section of the sidepods, while the team's composite structures group must determine how much of the space inside the pods is needed to accommodate the carbon crash tube side impact structures that are required to enable the chassis to pass the FIA side impact test. These considerations define the shape of the void into which the cooling system will be required to fit.

There are various ways of packaging the coolers. For example, the cores can be leaned forwards from vertical or canted horizontally and they can be flat or have compound angles to enable them to fit against the planes on the side of the chassis. Invariably, the aim is to squeeze the desired size of cooler into the available space while trying to reduce the aerodynamic deficit by making them as small as possible to allow the bodywork to

You can see the air flow pattern leading to the cooling duct on the McLaren MP4-27, critical area on the cars design

fit as tightly as is feasible.

Typically, Formula 1 radiator cores range in thickness from 35-45mm. In a water radiator, the fluid passage inside the core is divided to allow the water to be flowed along the back of the radiator until a short distance from its outboard end where the divider stops. The water can then spill around the end of divider and run back across the front of the radiator. This 'double pass' arrangement results in cooler air and cooler water at the front of the radiator, creating an advantageous mean temperature difference in relation to the back of the radiator and more thermally efficient cooling.

The 2011 HRT F111 has a fairly conventional cooling layout, with the heatexchangers sat in the sidepod at a slight angle. Positioning and shape of the radiators has a major influence on the cars aerodynamics

OIL COOLERS

Usually, the transmission and engine oil cooler is a combined unit that is similar in surface area to a water radiator because a Formula 1 engine rejects a high proportion of the heat it generates through the oil system, even though this is less efficient than water cooling. The position of the radiators in the car varies from one engine manufacturer to another. Some cars have water and oil on either side, some run water one side, oil the other. The oil radiator is usually a single pass unit.

Both water and oil radiators are made in aluminium to minimise weight, though an oil radiator is typically 50 per cent heavier than a water radiator, due to the use of heavier gauge material and a different construction method.

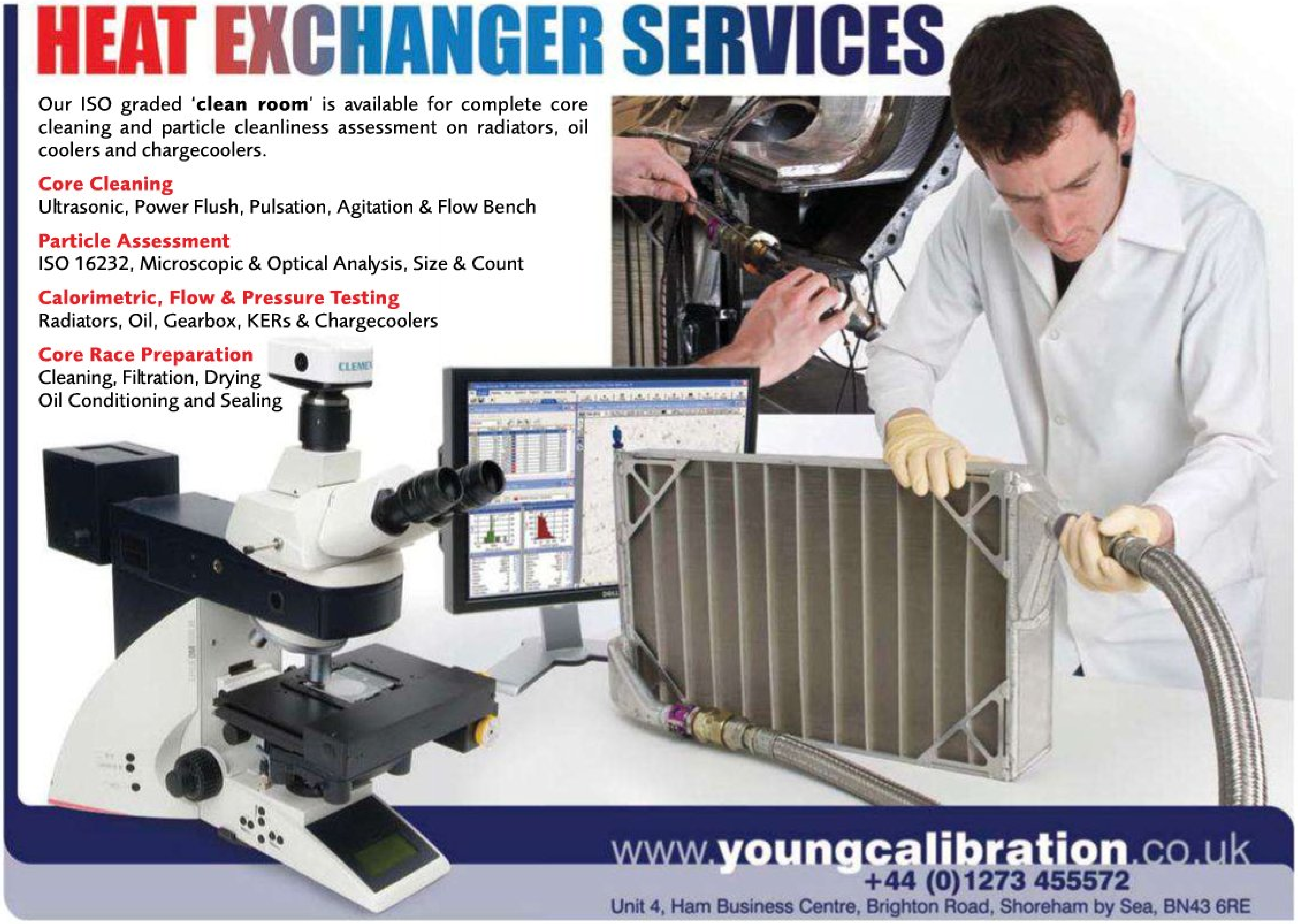
McLaren's 2011 car was launched without its bodywork allowing a view of a slightly more unconventional sidepod layout, the radiators sit at a very different angle to that of the HRT. Note the gearbox heat exhanger at the rear

The Formula 1 technical regulations allow water cooling systems to be pressurised to 3.7bar maximum, which increases the boiling temperature of the water to roughly 130degC. That allows the engine be run hotter before the water boils and creates hot spots in the cylinder head, which has a deleterious effect on engine performance. Some teams run an expansion chamber that has a piston in it to create a physical barrier between the air and water. While this allows the system to be pressurised, more importantly it means that the expansion chamber can be located lower in the chassis – typically on the floor of the car. The 3.7bar pressure limit is policed by a relief valve that is located at the part of the cooling system where the water pressure is lowest. To some extent the cooling system is rather like a central heating system. There is a pump, a boiler – in this case the engine – and a series of radiators. As in a central heating system, the pressure is highest at the outlet from the pump and lowest at the inlet to the pump.

The fins in a Formula 1 radiator core are razor sharp and look slightly thicker than household tin foil. Turbulators are built into the cores to create turbulence, which ensures that the airflow is not laminar and that it's not just the boundary layer of the stream of air running through the middle that gets hot. Similarly, there are steps in the water and oil pipes within the coolers that trip the airflow to ensure it becomes turbulent and exchanges heat.

"The 3.7bar pressure limit is policed by a relief valve"

The teams use CFD to simulate the optimum flow of water in and out of a radiator to devise a system that works as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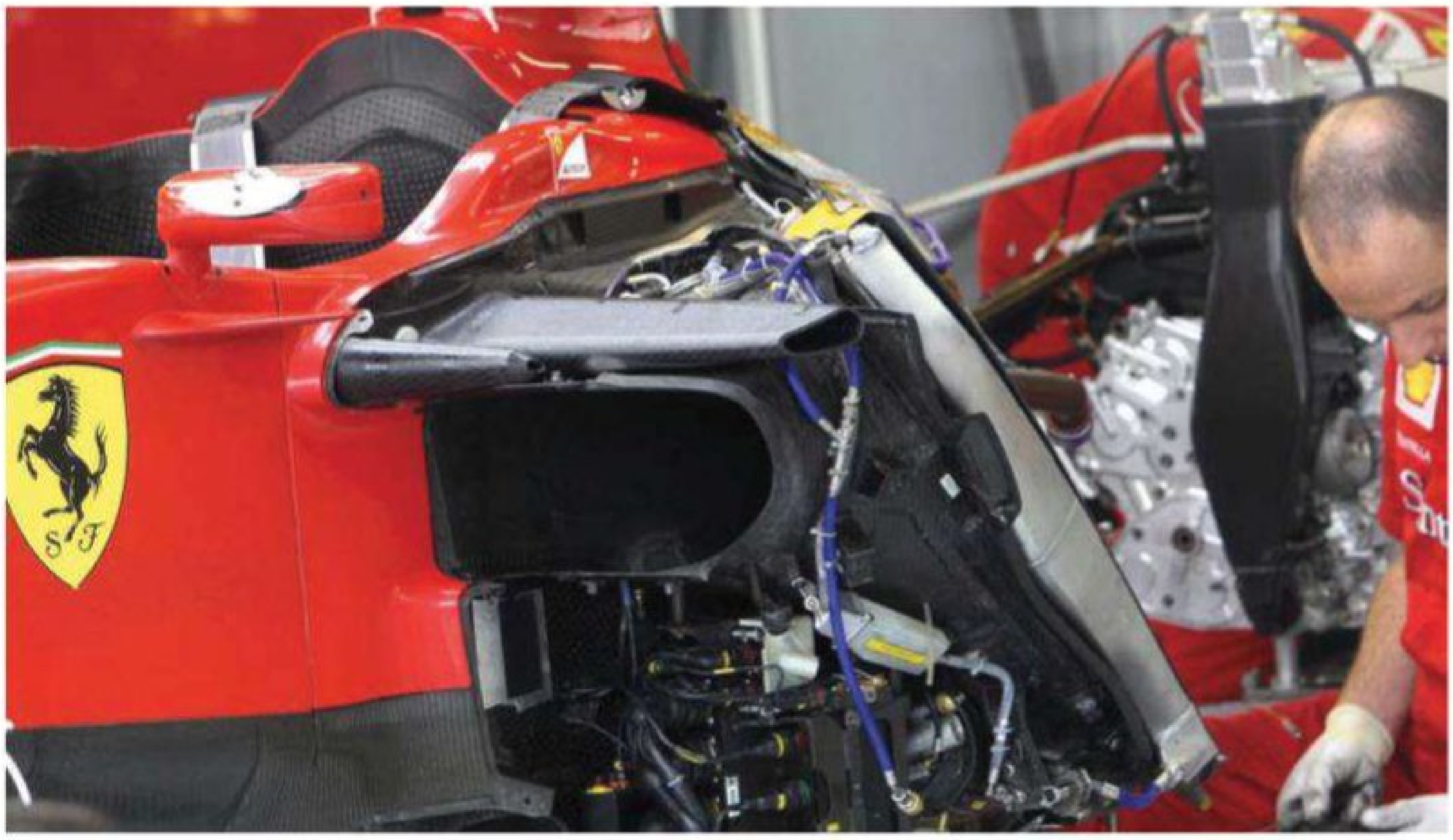
efficiently as possible, the aim being to make optimum use of the full area of the core. The core edges closest to the chassis tend to run coolest because they get the full blast of the airflow coming through the inlet. Moving away from that inner area, the radiator duct opens up and the airflow is more diffused so it will have less 'face' pressure and therefore less flow rate and less of a tendency for the air to want to pass through, resulting in problematic flow downstream of the radiator. After passing through the core, the low-pressure flow also has more difficulty exiting the sidepod because the flow that has come through the radiator near the chassis has greater pressure and velocity and has effectively grabbed all the access to the exit passageway. As a result, the airflow through a radiator tends to be skewed, and that's where the use of CFD in inlet duct and deflector design plays a big role. At some circuits, that challenge is further compounded by the need to run a debris catch screen in front of the radiator.

Curiously, Formula 1 cars don't tend to use ducting for the flow out of the radiators as much as Indycars or Sportscars. Typically, Formula 1 teams are more concerned with managing how that flow emerges in relation to the upper surface of the floor and the diffuser. That's why all Formula 1 cars have narrow 'Coke bottle' areas between the rear wheels and very tight exits for the heated air just above the diffuser. As the air flows from the back of the radiator towards that exit, it will also pass over and cool other components.

The shape of an F1 radiator core can be angle and twisted to achieve the optimum surface area in the limited space available, here the heat shieding around the rear of the car is clear to see



The location of the sidepod inlet duct is essentially fixed, with aerodynamic demands and the mandatory side impact structures defining its shape to some extent and its size. KERS components can also create issues

GREATEST DEMANDS

The races in Malaysia and Hungary typically make the greatest demands on a Formula 1 car's cooling system. Away from those races, some teams might look to reduce the size of its coolers by two or three rows as it's less efficient to blank off the inlet than to run tighter bodywork that allows the airflow an easier path to the rear wing. Teams at the sharp end of the grid will have a range of cores but, rather than size them to the demands of the hottest race, they prefer to use smaller cores for all the other races and run a deficit in the hotter races where they might use thicker cores. At the blunt end of the grid, teams tend to size their cores for what is needed for the full season, including the highest temperature races.

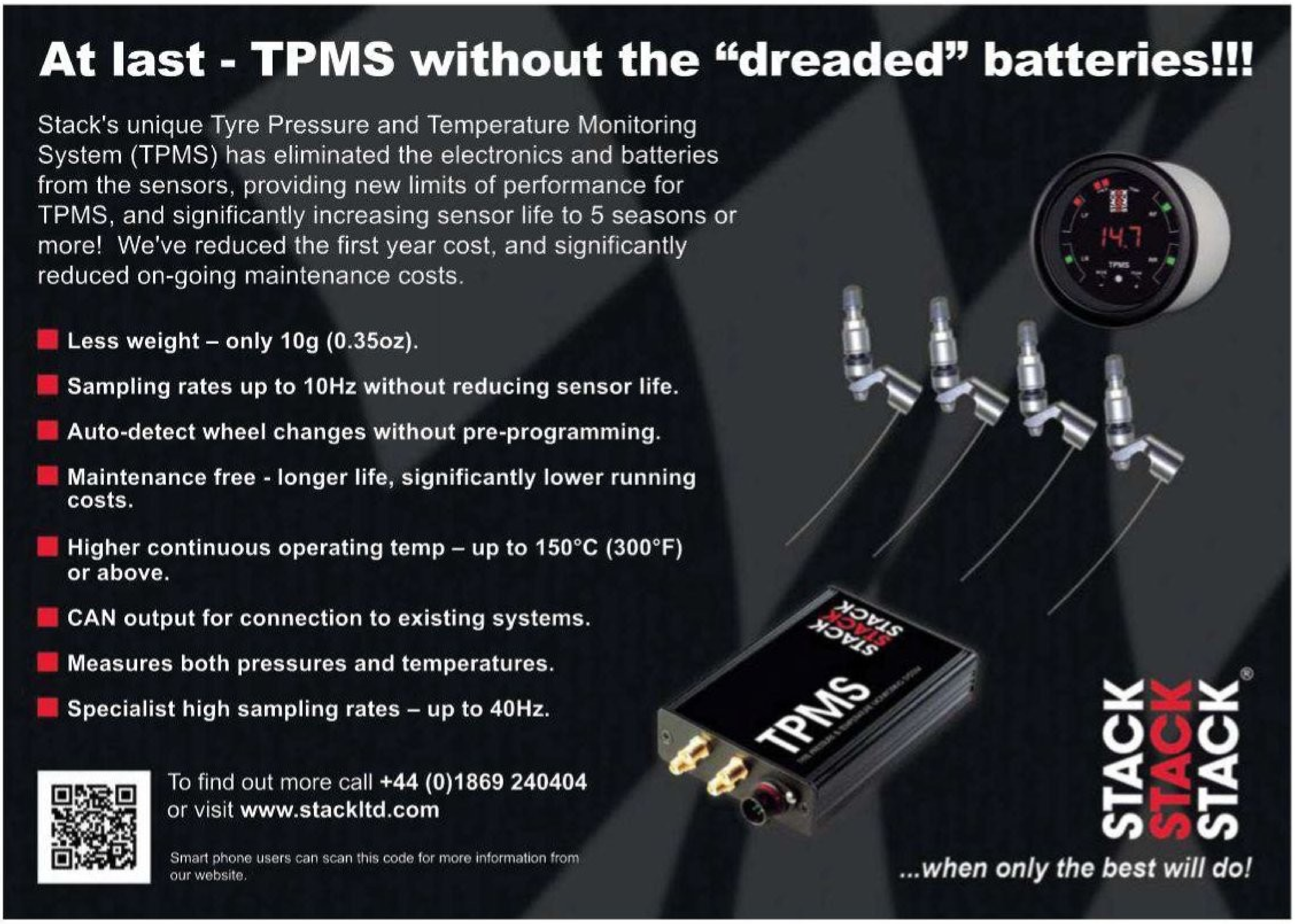
In the past, to adjust cooling for changing weather conditions teams would use tape to partially block the inlet ducts and pieces of wood or plastic to blank off some of the radiator surface. Carbon fibre blanking panels are used nowadays. These are panels shaped to cover the full face of the radiator and then, according to the amount of blanking required – 20, 40 or 60 per cent – oval or lozenge-shaped holes are cut in the panels.

"airflow through a radiator tends to be skewed"

On some cars, blanking is only applied to the oil radiator and it fitted to the rear surface of the cooler, primarily because it is usually open and it's therefore easier to access that area. To apply blanking to the front of the radiator would involve having to reach deep into the ducts. The blanking panels are usually fitted so they sit 1-2mm off the surface of the radiator to avoid the possibility of chafing problems.

If ambient heat is high, or there are overheating issues, a team might open up vents in the side panels of the car to allow some of that heated air out earlier in its passage, at the cost of compromising aerodynamics.

Aside from heat cycles, the normal wear and tear on Formula 1 radiator cores comes from a combination of being run at pressure and the vibrations they are subjected to. An example of a typical failure would be a cracked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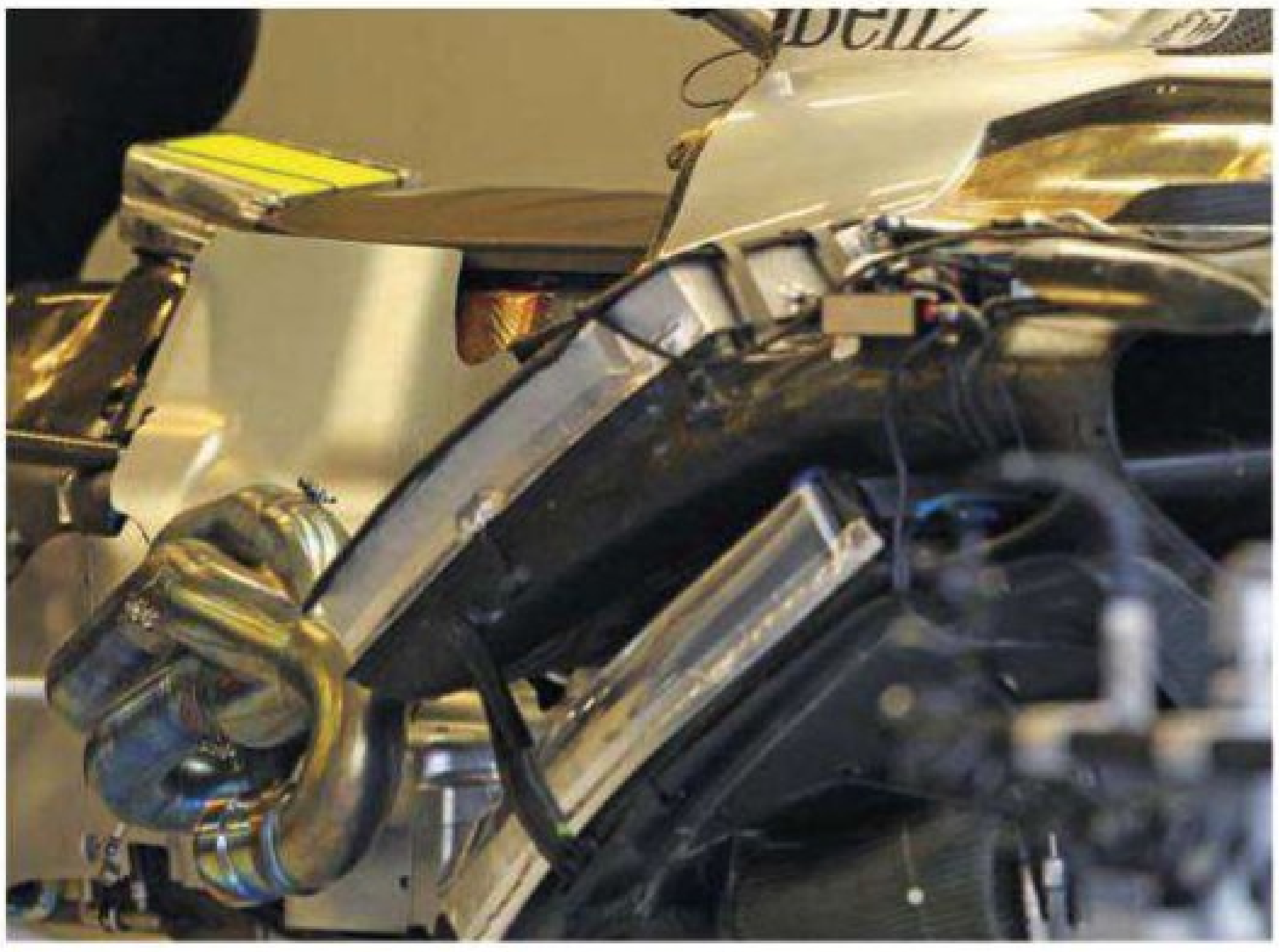
weld as a result of the car being bounced over a kerb. The better-funded teams will probably typically opt to change cores at shorter intervals to reduce the risk of such a problem, while the less well-funded teams might run a set for half a season before replacing them.

The introduction of kinetic energy recovery technology has increased the cooling demands placed on Formula 1 car design teams as an F1 KERS treats the battery pack incredibly unkindly. While the process is described as energy harvesting, in reality the charge cycle is more like a small explosion, in which megawatts of energy are channelled into the battery pack at very high speed, causing it to heat up rapidly to a high temperature. As a result, the lithium polymer battery packs that Formula 1 teams use need to be water cooled, meaning a further – albeit small – radiator, and its coolant, are required. This also has to be accommodated in a sidepod and fed with air.



With radiator core face velocities of 5 - 10 metres per second, water flow rates of 200 - 300 litres per minute and internal pressures up to 3.7 bar, a Formula 1 cooling system is a highly stressed environment

Under the current KERS regulations, the duty cycle of the electric motor is so short that, although it gets pretty hot, the intervals between use allows it time to cool off with minimal outside help, so the motor and other solid state parts tend to be cooled by air rather than a liquid.

TARGET FIGURES

Formula 1 teams tend to operate on a target temperature for the water and oil of around 100degC, with redundancy built into the system to accommodate a ceiling of around 130degC to provide a safety margin. This has to be achieved with typical engine oil flow rates in the region of 40-80 litres per minute and water flow rates of 200-300 litres per minute. Depending on vehicle speed, the air face velocity that the cores see is between five and 10 metres per second. Depending on air speed and core construction, the pressure drop through the cooler ranges from 4-16 millibars, while the temperature drop ranges from 6-10degC. An engine oil pressure drop of between 80-130 millibars is achievable, while the potential water pressure reduction due to the higher flow velocity is in the order of 400-700millibars.

The complex engineering that goes into cooling a racecar is a compromise between weight, aerodynamics and efficiency, but where the wrong balance of these can have an effect on lap times in other areas, if the cooling engineers get the balance wrong, it can be the difference between an engine lasting a race or going up in a puff of smoke part-way through.

The cost of unreliability

Putting some figures to the price of not finishing races

BY PAUL J WEIGHELL

Colin Chapmen, allegedly, once built a Lotus tube chassis that weighed less than the minimum amount of material calculated to meet the projected stress of racing. On its final race of the year the welds failed in series and the car circled the track, flinging out chassis tubes at every corner, before finally depositing its driver in an ungainly heap on the track.

Race-finishing reliability is often the poor cousin of performance. Some racers give reliability little more than lip service before talking about speed instead. Beyond the fact that one needs to finish in order to collect points, reliability seems almost to be discouraged as a primary concern, other than in long-distance racing, which even has its own name – 'endurance', presumably to separate it from 'performance' racing.

The perception that reliability is secondary and team members have told us that discussing possible reasons for future car failure may be perceived by their bosses as 'a negative attitude'. Reliability, however, is a study in its own right, and equally important to all areas of racing.

Formula 1 is not endurance racing, and it may suffer a little from the attitude that if the car fails in one race, it may be possible to catch up at another. Such an attitude can de-prioritise reliability. As reliability has improved, there may even be a tendency to become blasé about finishing races at all.

FINISHING SCHOOL

The number of F1 cars that do finish races has been increasing steadily. It is difficult to believe that at the start of the 1980s only 40 per cent of cars that made it to the grid also made it to the end of the race. Even six years ago, before FIA efforts to lower costs by making components last longer, the number of cars completing races was just 70 per cent. In 2011, however, with an F1 grid of 24 cars competing in 19 races, there were 63 DNFs (Did Not Finish), an average race completion rate of 84 per cent, which was more than double that of 30 years ago.

Historically, no team completed more than 85 per cent of its races in 2003, and only two teams completed more than 80 per cent that year. But in 2011, two teams exceeded 90 per cent completions. Even this improved rate of DNFs still translates into 14 per cent of cars failing to reach the finish line.

Analysis of the reliability data may shed light on this Cinderella subject. So we have compiled some statistics for discussion.

From the chart of Race Completions by Team overleaf, one can see the 97 per cent race finish record of Red Bull. Even Lotus-Renault, the worst team, managed more than 75 per cent, or nearly twice the average of just 30 years ago.

"In 2011, 14 per cent of [F1] cars failed to reach the chequered flag"

While accidents are not always avoidable, engineering-related failures frequently are, especially when drivers are warned to be careful, as in the case of Heidfeld in the Lotus Renault GPR31 in Hungary, 2011

THE DNF CORRELATION

The chart of Team Points vs All DNFs shows one red dot per team in a simple plot of total team points for the 2011 season against the number of times the team recorded a DNF, irrespective of the reason given for that DNF.

One clear message from the chart is that the top teams were in a league of their own, whilst the rest scrambled about far behind. That the top teams also tended to record the least number of DNFs is intuitively perhaps no surprise at all, but is there a real correlation?

The blue line on the chart shows a modest attempt to fit a trend curve through the data to see if there is a significant correlation between team performance and DNF. The value at the top right of the chart shows a statistical maths R-Squared figure of about 0.75. The nearer this value is to one, the better the correlation between trend and data. We are not so much concerned with the exact relationship shown by the curve, but only the quality of the fit to the data in order to demonstrate that a valid correlation is possible, ie that there is a significant pattern to the data and that it is not random. The 0.75 value shows us that it is a fairly well correlated data set and therefore that DNFs do tend to be quite significantly related to the overall ability of a team to score points. Again, that is as expected, but it is not such a trivial finding as it may seem.

There is, of course, a more direct and obvious relationship between collecting DNFs and losing points: 'In order to finish first, first one must finish,' as we all say, but even if each team had the same number of DNFs, the best performing team would still emerge as the points winner. That is to say, the ability to avoid DNFs can be totally independent of point scoring ability. Note from the chart that several teams scored less than 100 points each, but some of those teams had more than double the number of DNFs than other teams.

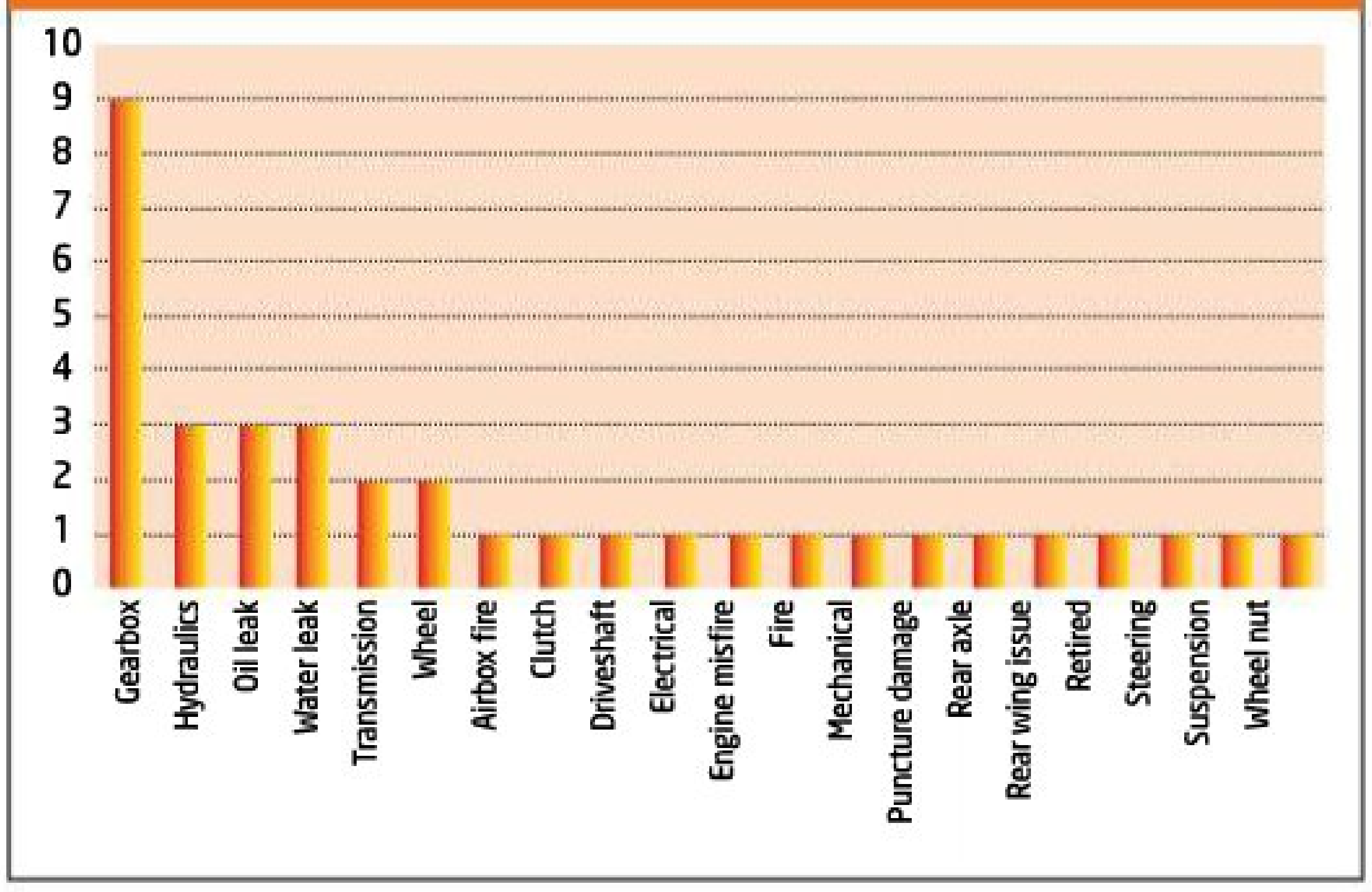
To look further into the data, it is helpful to divide the recorded DNFs into two major classes – accident-related and engineering-related. One might argue that teams cannot usually control accidents caused by the driver and that drivers cannot control car preparation before races.

Apportioning DNFs this way, 57 per cent are engineering related, compared to 43 per cent accident-related, although there were still plenty of those so perhaps drivers cannot avoid criticism altogether.

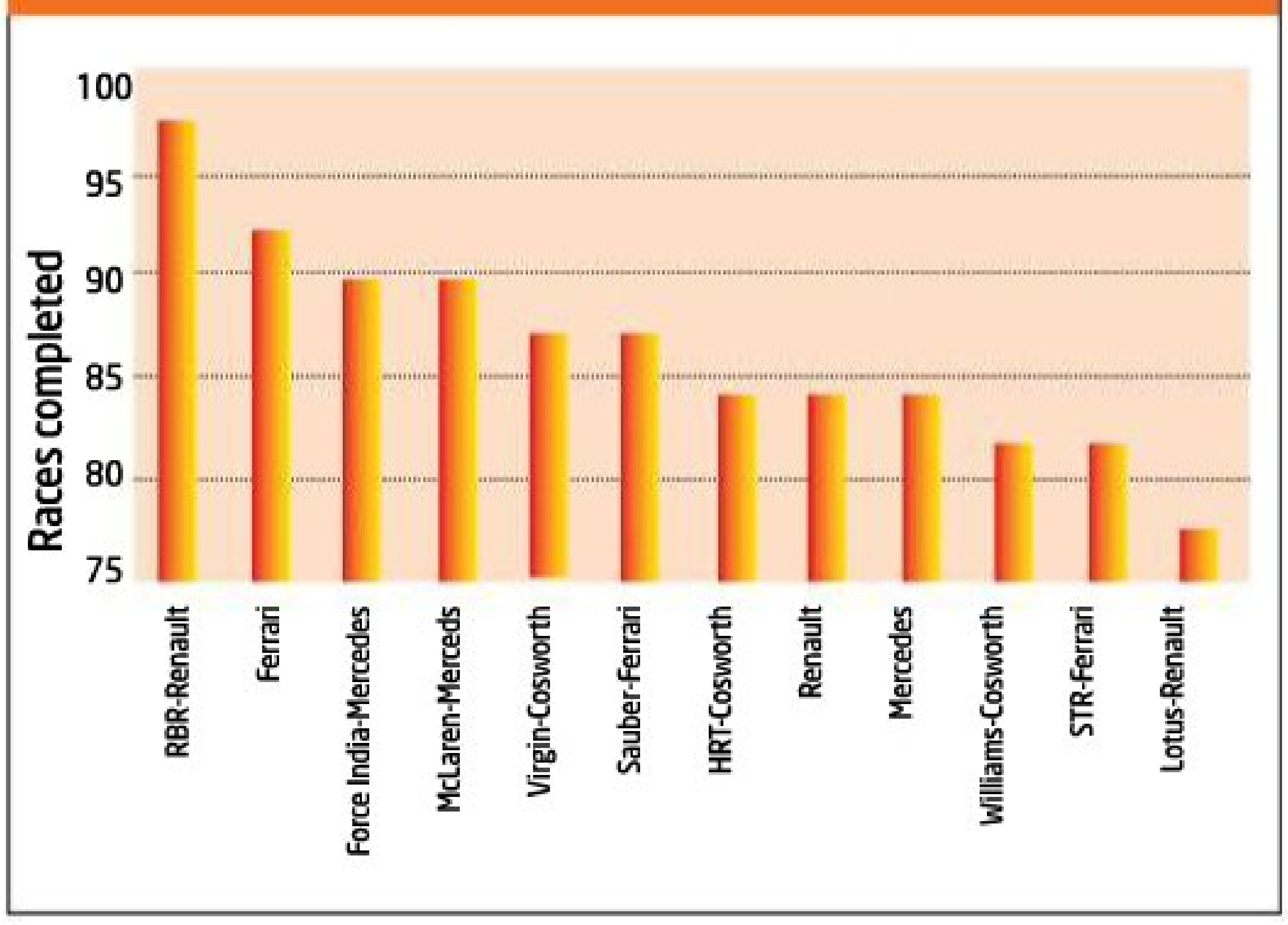
ACCIDENT-RELATED DNFS

Clearly, one cannot read too much into accident data because even a clear driver-initiated accident may then involve other 'innocent' drivers as an effect, and they are then also recorded as accident DNFs, but an examination of the accident-related data is still

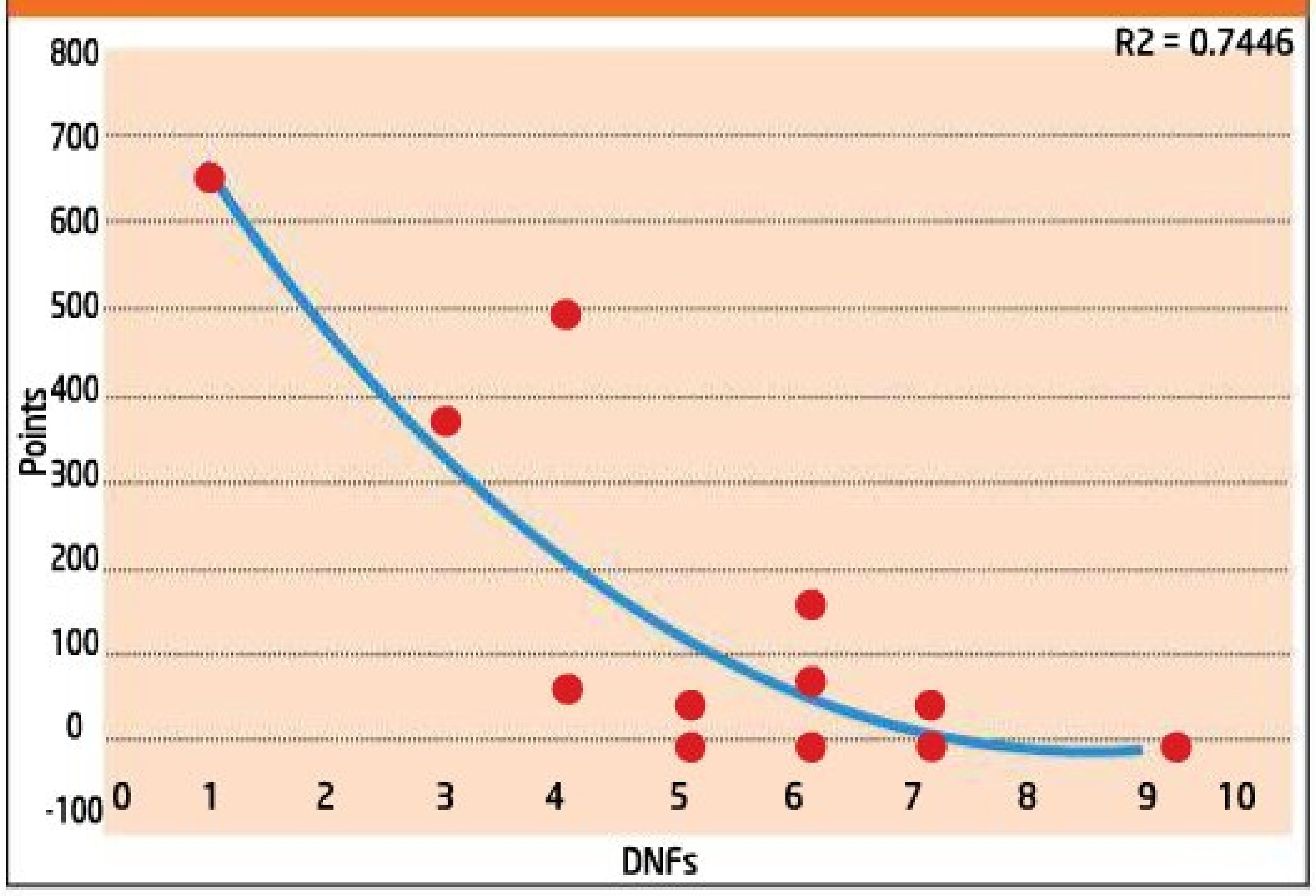
ENGINEERING RELATED DNFs



RACE COMPLETIONS BY TEAM



TEAM POINTS V ALL DNFs



"'better', more costly, drivers may not necessarily mean more race finishes for a team"

useful. Charting team points against accident DNFs we find only three teams who recorded one DNF each due to accident. Again, applying a modest trend curve to see if there is a significant correlation between team performance and accident reveals a very low R-Squared value of less than 0.05, which equates to a near random state and demonstrates that accidents really do tend to be accidental. This is unsurprising as one would assume the top teams would employ the best drivers, but the four low point scoring teams who had just as few accident-related DNFs confirms that accident-related DNFs are not significantly related to the performance quality of a team.

That view is enhanced by noting that most teams, suffered fewer than two DNFs each due to accident, i.e less than one per driver per team per year. In short, top teams can be involved in just as many accidents as teams from the rear of the grid.

The conclusion, then, is that 'better', and therefore more costly, drivers may not necessarily mean more race finishes for a team.

ENGINEERING-RELATED DNFS

In contrast to the accident data, the engineering data can tell a more interesting tale because we are given a breakdown of the reasons for the breakdowns!

Relying on the teams' own stated reasons for their DNFs perhaps being less than precise due to secrecy or pride, the trends are pretty accurate and where we have checked with the F1 teams, and they have responded, the data has been claimed and confirmed as accurate by them.

From the chart of Engineering Related DNFs above, and despite, or perhaps because of, the requirement for gearboxes to last more than a single race, it can be seen that gearbox failures are by far the most common causes of engineering DNF.

It is interesting to note, however, that nobody these days seems to cite 'engine' as a failure reason but one can, of course, suspect that hydraulics, oil, water, airbox fire, electrical etc. may well be engine-related, and of course engine misfire certainly is. Whether this is to spare the delicate blushes of the engine suppliers or is a genuine attempt to offer more detailed reasons for DNF is unknown.

The FIA rules for the new engine regime from 2006 contained several pages of rule changes that forced engine designs to be relatively simple V8s, as well as outlawing many technical advances and exotic materials. Historical data from eight years ago (2003 season) shows that engine failure was more common than gearbox failure back then, so the FIA engine rule changes, ostensibly introduced in the search for cheaper engines, seem also to have dramatically improved engine reliability. Since the rule changes, engine-related failures have plummeted. Much of that being due to the ability to turn engine performance levels down from examining the telemetry data and spotting trouble before it happens.

It now seems clear that while engines *per se* may no longer be an area of the highest concern, post-engine powertrain certainly is. If one wants to improve F1 reliability then gearbox, gearbox and more gearbox work should certainly be the focus.

Charting team points vs engineering DNFs, and again making a modest attempt to fit a trend curve to gauge the correlation of engineering failures to team points, this time the correlation R-Squared value of about 0.4 is a poorish correlation, but a lot higher than it was for the accident data. This is what one would broadly expect, of course, as better and wealthier teams may presumably be expected to implement sounder engineering simply because engineering reliability is more under team control than accidents on track.

Once again, there is a distinctive cluster of the top three teams and a wide and flat cluster below containing all of the rest. Charting team points against engineering DNFs for the mid-low grid teams, however, produces a pretty good trend (R-Squared = 0.67), demonstrating that improved reliability does indeed pay back in points at that level,

though it is not much use for the four teams that were clustered at the back of the grid struggling to get over the first hurdle for any sort of points reward.

"the damage caused by excessive zeal in any arena can be quantitatively estimated"

SACRIFICING PERFORMANCE

The big question, though, is whether it is worth sacrificing some performance if that would ensure more reliability, especially when your team is at the top end of the performance grid?

In 2011, Red Bull Racing suffered just one DNF when Webber was involved in an accident but, as we have already discussed, accidents tend to be random and therefore it is not easy to see how one can plan to avoid them with any useful degree of certainty.

McLaren-Mercedes, the second team, had four DNFs – two from Hamilton's involvement in accidents, preventable or otherwise, and two due to Button's car suffering hydraulics and wheel nut problems – both avoidable by pre-race engineering improvement it would seem.

Ferrari, the third team, had three DNFs – two from accidents and one from a gearbox-related failure (interestingly, the only gearbox-related failure of the top three teams, despite gearbox failure being the most common engineering-related DNF culprit in the grid as a whole).

If all those DNFs had not occurred either by accident avoidance through perhaps driving a little less adventurously, or by improving overall car engineering, would the results have been worth the possible reductions in performance which may have accompanied a little more prudence?

Without trying to minutely analyse each incident separately, as no doubt the teams did themselves, but instead taking a statistical approach across the entire grid by averaging the points scored by teams for races they did finish, we can get a broad estimate of the possible results, had teams managed to avoid their DNFs.

The table to the left shows the estimated results from avoiding DNFs, from which it can be seen that McLaren suffered most in points lost (58) from their DNFs. With perfect hindsight, then, is it easy to say that if Hamilton, for example, had a slightly more prudent driving style then perhaps?

Now, it is true that 2011 was a very unusual season, in that Red Bull were so far ahead that even if the second or third-place teams had finished all their races and achieved all of their estimated lost points, they would still not have caught Red Bull. However, in 2010 those 58 points would have made McLaren number one instead of Red Bull, and in 2009 they would have made Red Bull number one instead of Brawn. And indeed, in many previous seasons, just one fewer DNF would have changed the championship order, and any change is, of course, significant.

Even in 2011, Force India could have finished above Renault and STR above Sauber if they had both avoided their respective DNFs. The conclusion is that in most years, a DNF less here or there can make a notable difference, and the closer run the season the more the DNFs come into play, to count as much as pure track performance.

CONCLUSION

The situation is somewhat different in endurance racing. A single DNF is not only the end of the race, but may be the end of the season, too. You only get one annual shot at Le Mans, for example. The opposite is true of series like NASCAR where there are so many races that a few DNFs may make little difference over the course of a season. That may indeed be why NASCAR seems to be rather more of a contact sport than Formula 1, and why Le Mans may seem to some to be devoid of any wheel-to-wheel combat at all.

More reliable cars and more prudent drivers may never be as exciting as a Schumacher or a Hamilton barrelling into a turn, wheel to wheel with a competitor, or an engine turned up so far that it screams into your eardrums as it passes by, but the damage caused by excessive zeal in any racing arena can be quantitatively estimated and the sobering results perhaps used to persuade cheque signers to pay attention to race finishing, as well as to the outright lap performance so earnestly sought in today's CFD and lap simulation rooms.

In almost every F1 season one analyses, one less DNF would have resulted in a change in the final running order, as well as a significant cost saving

THE COST OF FAILURE

Team	Points	DNFs	Cost per DNF estimated	Season cost estimated
RBR-Renault	650	1	18	18
McLaren-Mercedes	497	4	15	58
Ferrari	375	3	11	32
Mercedes	165	6	5	31
Renault	73	6	2	14
Force India-Mercedes	69	4	2	8
Sauber-Ferrari	44	5	1	7
STR-Ferrari	41	7	1	9
Williams-Cosworth	5	7	0	1
Lotus-Renault	0	9	0	0
HRT-Cosworth	0	6	0	0
Virgin-Cosworth	0	5	0	0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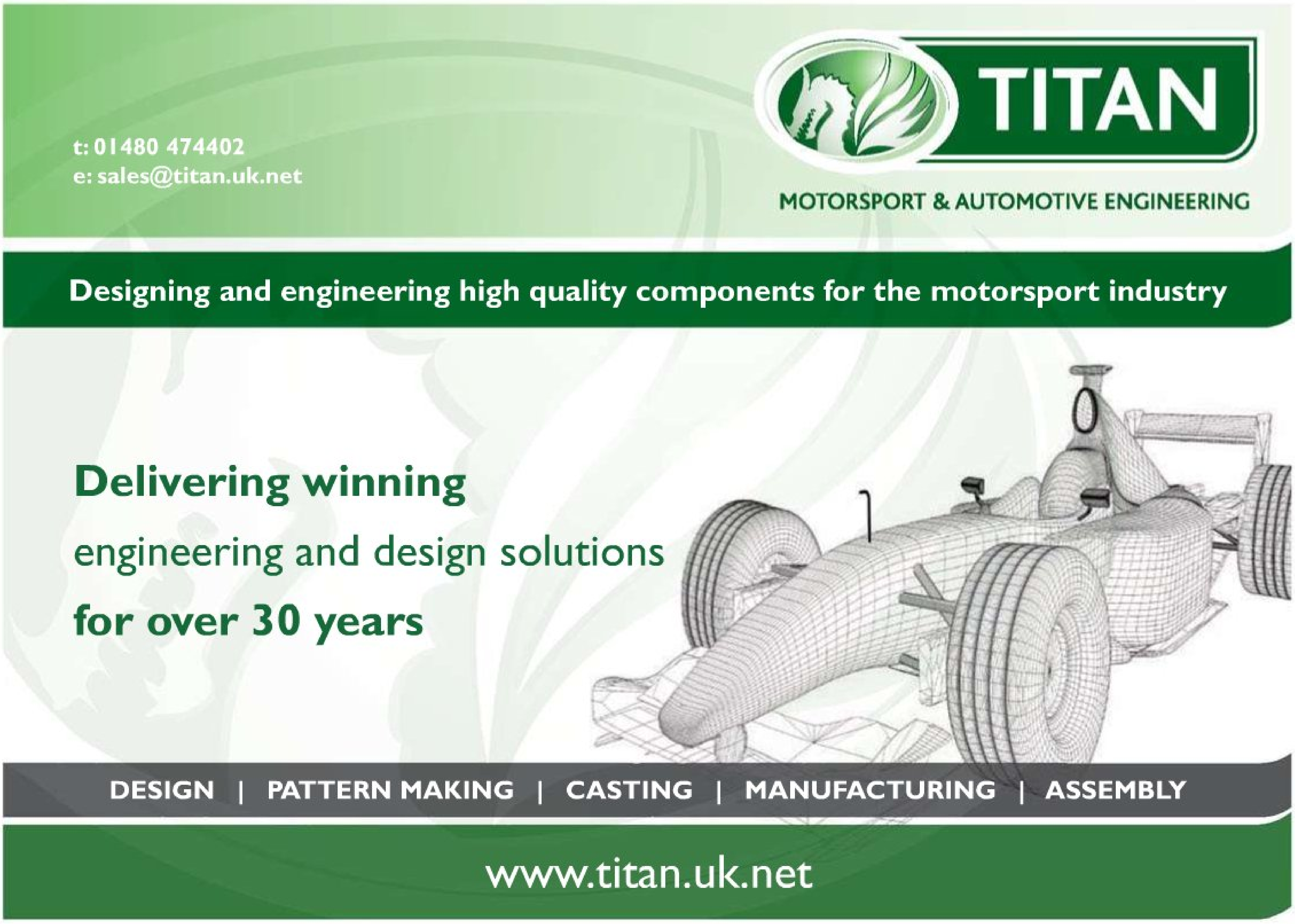
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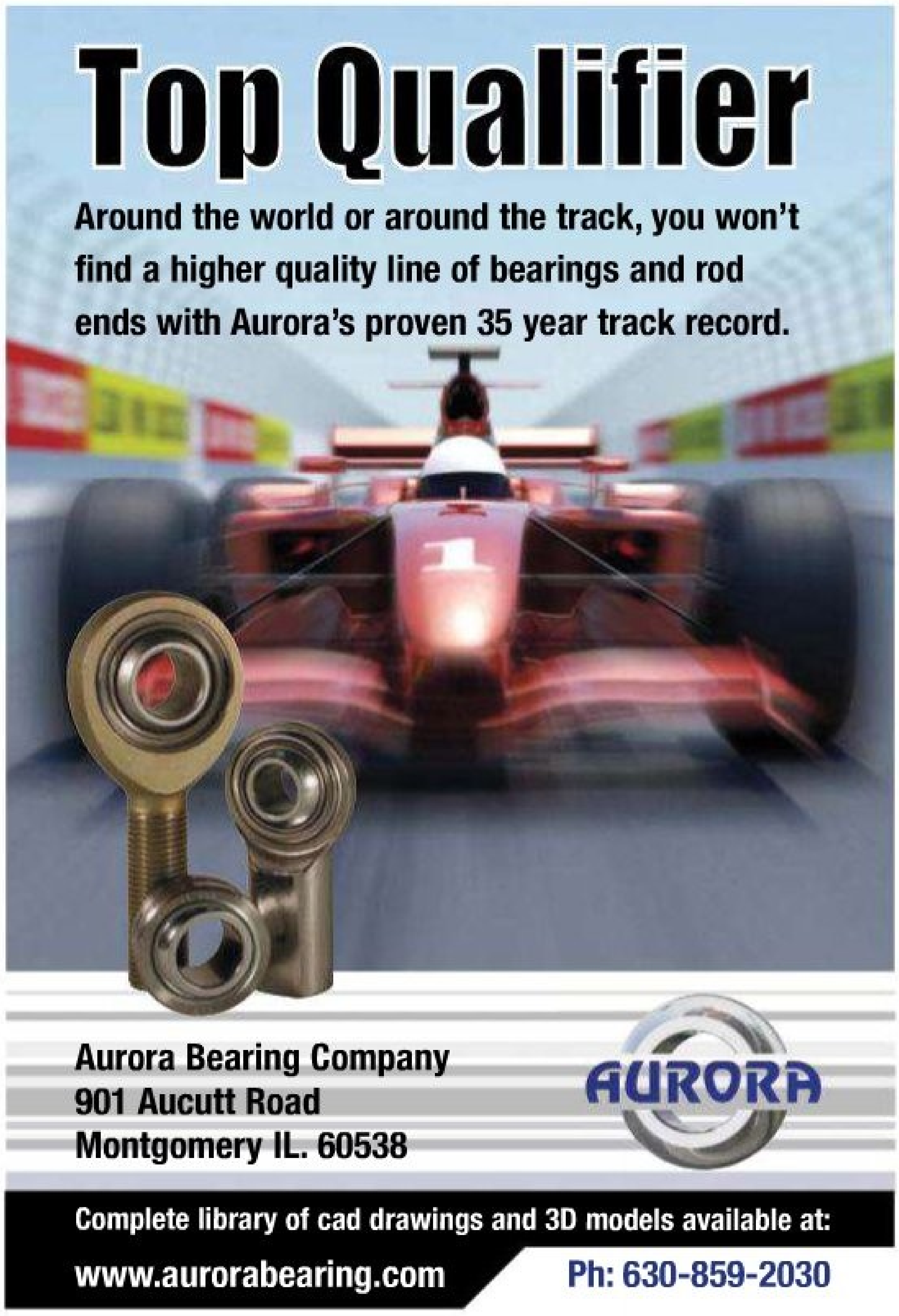
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Made in Thailand

It may be the first racecar to come out of the South East Asian country, but the 999 Supersport is a truly global product

BY SAM COLLINS

When Far Eastern motorsport engineering is discussed, most people usually think of Japan, or wonder when China will fully engage, but they almost never think of Thailand. At the PRI trade show in late 2011, a car was unveiled that showed this could be about to change.

The 999 Supersport is a single-seat, tubular-framed, 2.0-litre competition car aimed squarely at amateur racers. Christophe Martin, a French engineer who lives in Thailand, set up the company using his experience of European club racing. 'It came about as I was racing a car similar to this in France, and I imported it to Thailand, then changed everything,' he explains.

The 999 Supersport may be built in Thailand, but not for cost-saving reasons, French engineer, Christophe Martin, lives there

'Eventually, I decided to build an all-new model, and this is the result. We had to set up a manufacturing facility from scratch and we are really the first racecar manufacturer in that area of the world.' The Supersport may herald the start of a new breed of European designed, Far East-built competition cars, though Martin points out that the reason the Supersport is not built in Thailand has nothing to do with cost.

'You may think it is very cost effective in Thailand but it is not really, especially compared to China. Yes, it is cheaper than the US or Europe, but we're not trying to make a low-cost product. We would prefer to spend money where it needs to be spent. We save money on the labour costs but spend time to get a high level of finish.'

Jackson Stewart is Martin's North American partner and his firm, based near Willow Springs raceway in California, does the final assembly of the Supersport. He, too, goes out of the way to point out that, despite the car's unconventional manufacturing location, it has no impact on the quality of the product.

'Take the dampers on the car for example – they are proprietary and are actually made in Thailand. As a country, it prides itself on a very high level of manufacturing, and the damper manufacturer is actually a high-end producer of reasonably-priced products. It just happens that it is not a well known name in motorsports, but right now we are not looking to import components, we are looking to sell whole cars.'

"As a country, [Thailand] prides itself on a very high level of manufacturing"

Powered by the proven 2.0 litre, four-cylinder, turbocharged GM Ecotec engine, reliability will not be a problem

The car was clearly designed with ease of use for amateur competitors in mind and Martin specifically targeted the US market rather than his native Europe, simply because there are more gentleman drivers there. Stewart explains: 'The amateur racer is the target market and, for us, that is really a combination of the gentleman racer who wants to do a bit of NASA or SCCA racing and is tired of racing chequebooks, and the guy who keeps the car at a motorsports country club and does a load of laps for fun.'

The driver sits in the centre of the chassis because, 'in all proper racecars you sit in the middle,' says Jackson. Attention has also been paid to accommodating larger drivers in both width and height terms. 'If you offset the driver you run into clashes between the pedal box and front suspension, but in the centre of the car you simply do not have that issue. The driver's feet can go almost to the front of the chassis, and ahead of that is an FIA crash structure,' reveals Martin.

Mated to the tubeframe chassis is a 2.0-litre, turbocharged GM Ecotec engine, driving the wheels through a GM F35 five-speed 'box with a proprietary shifting system, though a 3MO full racing dog 'box is an upgrade option.

"The amateur racer is the target market "

Much of this philosophy shows up in the design of the car too – a tubular chassis, for example, was chosen over a monocoque for ease of use and repair. 'It is about durability and reliability and ease of manufacture, as well as ease of service and replaceability.

'We can sell somebody a replacement chassis under $8000 (£5000),' enthuses Stewart. 'The tyres on the car are actually slightly smaller than they could be to keep the driver fully engaged, too.'

'The car was originally designed for a motorcycle powerplant, but that proved to be totally unreliable,' Stewart continues. 'The complete drivetrain is proven GM parts, developed to 300bhp, and it makes it so stupidly reliable it is beyond belief. We have done over 3000 miles of testing at the Bira circuit near Bangkok, and lots at Willow Springs, too. But this is a motor that can easily be tuned to produce 450bhp. Then you can put on some bigger wheels and go hunting GT1 cars.'

The rolling chassis are shipped from Thailand to California, where the powertrain is installed by 999 Motorsport USA.

The suspension on the car is one area that all involved in the project are particularly proud of: 'The entire car has been designed in the computer. CFD, FEA, you name it, all that stuff. The suspension is purpose designed with no compromise. It is double wishbone front and rear, with coilover shocks and blade-type sway bars [anti-roll bars]. When you look at the multi-body simulation being run on the computer, it looks like we are running the demo programme, it is so perfect. You could save some money by using things like control arms that are interchangeable side to side, but that might compromise the geometry slightly, so everything is the best it could be.'

The Supersport has already been approved for the NASA STR2 class and its constructors are currently seeking approval by the SCCA. Stewart is also hoping to launch a spec series for the cars in 2013.

TECH SPEC

999 Supersport

Chassis: tubular spaceframe (4130 steel)

Bodywork: glass fibre / carbon; laminated windscreen; adjustable rear wing; rear diffuser

Engine: GM Ecotec turbocharged 2.0-litre four cylinder; Racecraft radiators and air - water intercooler; stainless steel exhaust

Max power: 300bhp at 5600rpm (225bhp with endurance ECU)

Max torque: 350Nm

Gearbox: Five-speed sequential; limited slip differential

Dashboard: LCD; programmable multi-function display

Front / rear suspension: double wishbone; adjustable anti-roll bar

Dampers: rebound adjustable

Calipers: front - six piston; rear - four piston

Brake discs: front - 320mm; rear - 285mm

Wheels: aluminium monobloc 18 x 8in front; 18 x 9.5in rear

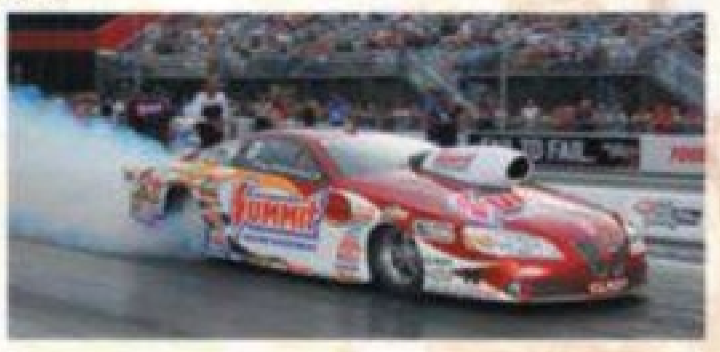
Tyres: 21/65-18 front; 24/65-18 rear

Dimensions:
Wheelbase: 2460mm
Front track: 1580mm
Rear track: 1540mm
Length: 4210mm
Width: 1850 mm

Weight: 950kg

Fuel cell: 55 litres

Safety: extinguisher, six-point harness, collapsible steering column, crash box



Of all the race series around the world, Touring Cars have embraced the global race engine concept most fully. The World Touring Car Championship is the latest to follow suit

Going global

What does it take to produce a global race engine? We spoke to specialists, Mountune, who have just been through the process with Ford

BY CHARLES ARMSTRONG-WILSON

Once they were the stuff of motorsport's brave new world. In reality, their impact was not so profound, but global racing engines [GRE] are with us and now dominate some areas of motorsport. In particular, Touring Cars have found the concept a good fit with their cars and their business models. So it was no surprise when Ford approached UK-based Mountune with a plan to produce just such an engine for the World Touring Car Championship.

The plan was to base the engine around the manufacturing giant's EcoBoost unit. It had the right capacity, number of cylinders and architecture. But how easily would it make the transition to motorsport? 'It had already been developed by Pipo into a World Rally Car engine,' says Roger Allen, general manager at Mountune, 'so that was our starting point. We were told Ford wanted to take it circuit racing so were asked if we could we take a look at it and see if we could get some cost out of it. Hindsight is a wonderful thing, and we needed to make the engine affordable, consistent with the WTCC business model.'

The project required a turbocharged, four-cylinder, 1.6-litre unit, breathing through a 33mm restrictor and boosted at 2.5 Bar. It was all very straightforward and well within Mountune's comfort zone. However, there were some additional challenges.

Firstly, the EcoBoost would be the first direct injection the company had developed into a race unit. Secondly, to comply with the rules of the WTCC, the engines have to go a full season without a rebuild, because an engine change mid-season will result in a grid penalty. Finally, just to keep them focussed, the deal was confirmed at the end of the summer and WTCC testing was due to begin in February. Fortunately, the company had Ford's full backing for development and three prototypes. After that, the production engines would be down to Mountune.

"The engines have to go a full season without a rebuild"

Of the original EcoBoost unit, only the production block and head remain, though the latter is now a Mountune-developed part. Output is around 310bhp with 400Nm of torque

The Essex concern threw its best people at the project, with company founder, Dave Mountain, taking the role of technical director. Paul Leeming became engineering manager, long-time Mountune stalwart, Cos Gauci, the engine designer, along with new man, Rob Turner, while Mark Yeldham did the dyno work.

Fortunately, to tackle the first challenge – longevity – the company could draw on its experience with Formula 2. Mountune supplies the Audi-based engines, and a condition from the customer was that they should be able to complete a season without being opened. It amounts to delivering 500bhp for up to 7000km. That experience was always going to be useful.

'Virtually every component has been re-designed and reviewed,' reveals Allen. 'Of the base EcoBoost engine, we use the standard block as a basis, while the cylinder head is a development of a standard part. The manifold is our own design and casting and the exhaust is made to our specification by Simpson Race Exhausts. We use Pectel management but with Bosch injectors.'

Pistons and bearings come from Mahle, and are used with an Arrow crank and rods from Carrillo. The cams are Mountune's own profile, ground by Piper Cams, and operate Supertech vales on Kauffmann springs. Mountune manufactured the dry sump lubrication hardware and the turbo is a Garrett WTCC item.

All development and testing work was done in house and Mountune will supply technical support at all WTCC races

The direct injection presented a bigger challenge. Mountune had a memorable encounter with DI a few years ago when it successfully re-worked a Volkswagen Touareg diesel engine to race at Le Mans. However, working with a DI petrol engine was new territory.

"Working with a DI petrol engine was new territory for the team"

'We did spend a lot of time last winter with a relatively standard Ford EcoBoost on the dyno, learning how to manage direct injection with help from Pectel and Bosch,' says Allen. 'They both contributed to our experience. You can get the power, but the big challenge is reducing the smoke level – a bit like a diesel programme. People don't like seeing smoke coming out of the back of cars, least of all manufacturers.

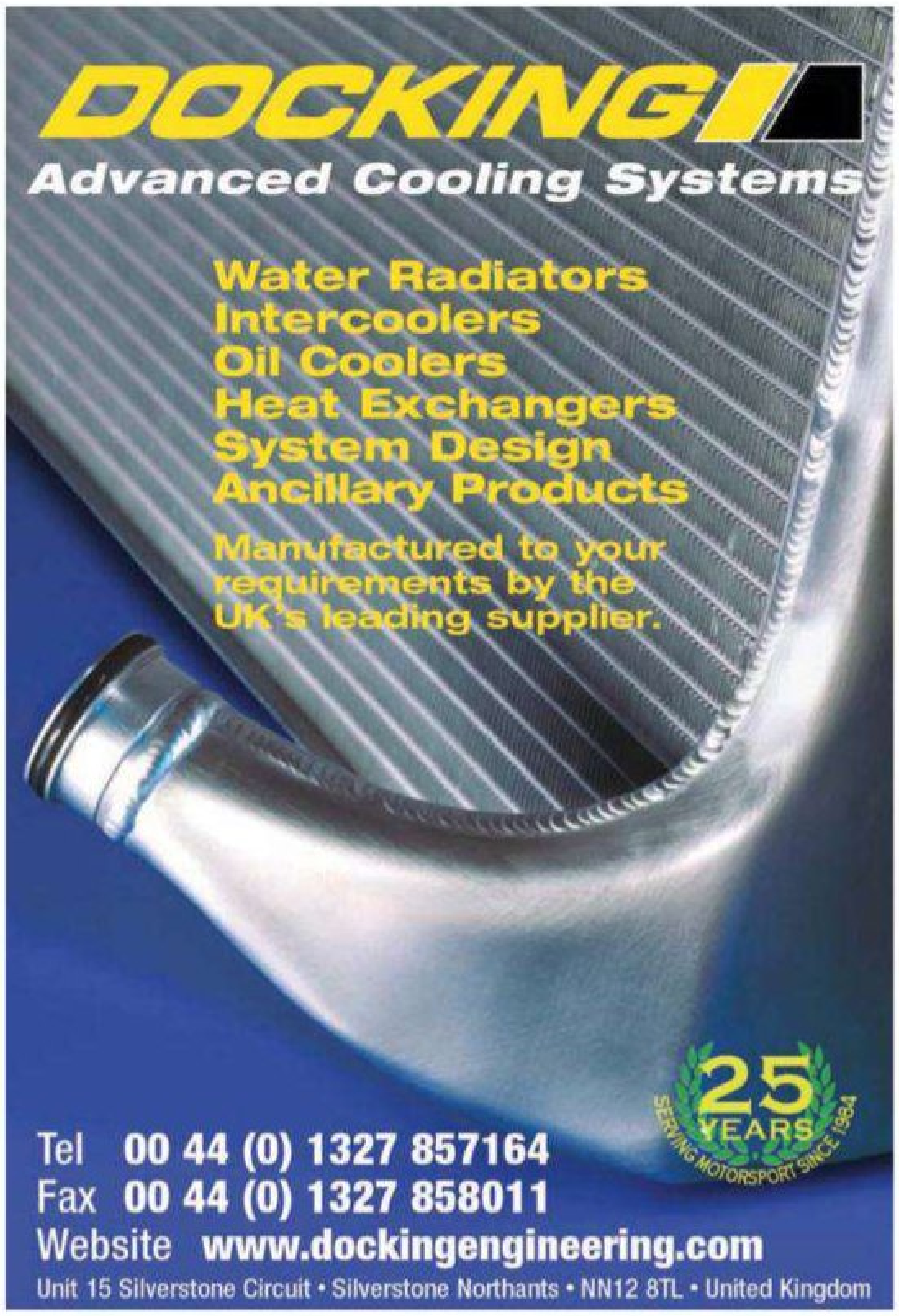
'We did some work with spray patterns for Bosch. That is obviously key. Also we have a fixed injector position and we sometimes found that it was shrouded by the valve. The solution was working out how to phase the injection pulse consistent with the burn.'

When *Racecar Engineering* spoke to the company in January this year, that process was still ongoing. 'When it ran for the first time we had banked quite a bit of experience, but calibration is taking a lot longer to do than a Ford port injection unit,' admitted Allen. 'It's been a sharp learning curve, but we are pretty much there now. We introduced some of our own strategies and the guys are pushing on having got the basic DI hardware around us and the strategies in place.'

As a result of the work invested, Mountune opted to work on a leasing business model that would allow it to protect its own and Ford's intellectual property. However, the company supply an engine dressing and installation package at a one-off cost for each car, and also offer a spares package that includes sensors, leads and a loom. 'We provide support with a technician from Mountune at all the races,' says Allen, 'and we have a spare engine should anyone need it.'

The first customer is Team Aon, whose Focuses are run by Arena Motorsport in the WTCC. However, the engine is also eligible for the Chinese Touring Car (CTC) series and local team, FRD Motorsports, will use the units. The CTC season is shorter so the engines are expected to run for two seasons before they need a rebuild.

Testing began on schedule in February with the first race at Monza in March. By then, a first batch of 10 engines should have been completed. It has been a project that stretched the experienced Mountune company, but in a good way, and it is confident that the results of a hectic winter schedule will not disappoint.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Working the tyre

The fundamentals of calculating wheel rates and damping ratios

BY DANNY NOWLAN

Over the last couple of months, a number of readers and colleagues have been talking to me and asking questions about damping. In particular, what has been cropping up has been the mechanics of calculating wheel rates and damping ratios. This has been very exciting for me because it shows that people have been genuinely thinking about this, and that's great. However, what it also shows is that people have been missing some intermediate steps on how to calculate and use damping ratios and wheel rates, so this is what we'll be addressing in this month's article.

Let me state from the outset that in doing this I'm going to be reviewing a number of matters I have discussed before in previous articles. Forgive me if this sounds like repetition but, from time to time, it's actually a good thing to go back over some important fundamental steps.

To kick off this discussion we first need to get our heads around the difference between a spring rate and a wheel rate. To illustrate, let's consider a spring / damper unit with a bell crank, as illustrated in **Figure 1**.

The reason I have illustrated with a bell crank is because it neatly shows the difference in the way the wheel and the damper moves. This is what is termed motion ratio and is the thing that separates the spring rate from the wheel rate. The spring rate is the rate of the spring and damper measured at the damper. The wheel rate is the rate the tyre is going to see, and this is dictated by the motion ratio and spring rate.

"The motion ratio defines the relationship of damper to wheel movement"

Let us now discuss the mechanics of how to calculate the wheel rate.

CALCULATING WHEEL RATE

To do this, we first need to determine the motion ratio. To keep this discussion simple, we'll assume linear motion ratios and springs (we'll discuss non-linear motion ratios a little bit later). The motion ratio defines the relationship of damper to wheel movement, and we can define it as in **Equation 1**. This tells us that the motion ratio is simply the slope of damper movement vs wheel movement. So, if the wheel changes by, say, 15mm and the damper movement moves by 10mm, the motion ratio is as in Equation 1.

There will be some who will define the motion ratio as wheel *and* damper movement, but I have always preferred to do it as damper on wheel because it gives a direct measure of the forces acting on the wheel.

Now that we know motion ratios, the wheel rate can be readily calculated. The wheel rate is given by **Equation 2**.

CALCULATING WHEEL RATE

Let's now walk through an example of how to do this. If we have a spring of, say, rate 140N/mm (about 800lbf/in) with a motion ratio of 0.75, the wheel rate is given by **part two of Equation 2**.

Remember, everything we do in this business is driven by working the tyre. What the wheel rate tells us is the spring rate the tyre is seeing. This is why it is so important to calculate this properly and why, while this might seem trivial, this is a vitally important skill to master.

The next step is knowing how to read a damper force curve correctly. To illustrate this, let's consider a typical force vs peak velocity curve, as in **Figure 2**.

You can be forgiven a multitude of sins in damping provided you read this right. The critical thing is to calculate the damping rate or the slope of this curve. This is the thing that counts in damping. So the calculation of damping rate is given by **Equation 3**. Here, C is the damping rate, dForce is the change in damping force and dVelocity is the change in damping velocity.

However, there are a couple of traps that I need to alert you on. First things first, be tight on your units, so forces in N and velocity in m/s. The damping rate unit is N/m/s. You'll hate me for this now but you'll thank me later. The second thing is to make sure you calculate this moving forward on the damping curve, not backwards.

That said, let's to do an example calculation using Figure 2, and we'll discuss what scale of numbers to expect. So, looking at Figure 2, where we have illustrated our slope, the damping rate at this point is given by **Equation 3 part two.**

I realise these numbers are a bit approximate, but what counts is the way in which we reached them, so we marched it forward and calculated the slope of the curve. That's all there is to it. The only trick was to multiply the damper readings by 10-3, which converts mm to m. Apart from that, it's pretty simple stuff. In terms of some rough rules of thumb, rates in excess of 15,000N/m/s are usually representative of low-speed damping when we want body control. Rates of 2000-5000N/m/s apply to high-speed damping when we want to filter bumps out.

CALCULATING DAMPING RATIO

At this point you might be thinking, 'this is all well and good but how do we tie this into a wheel rate?' Again, the answer is really simple. Remember equation 2 to convert spring rate to wheel rate? It's exactly the same for damper rate. This is given by **Equation 4**. So, for our example with a motion ratio of 0.75, the wheel damping rate is given by **Equation 4**.

Now that we know how to calculate both wheel spring rates and damping rates, we can now calculate damping ratios using the quarter-car approximation. Remember, the quarter-car approximation is a very powerful tool to estimate what our damping rates should

EQUATIONS

Equation 1

$$MR = \frac{\partial Damper}{\partial Wheel} \qquad MR = \frac{\partial Damper}{\partial Wheel} = \frac{10}{15} = 0.75$$

Equation 2

$$WR = MR^2 * SR$$

where,
- WR = wheel rate
- MR = motion ratio specified on damper on wheel
- SR = the spring rate at the damper

$$WR = MR^2 * SR = 0.75 * 0.75 * 140 = 78.75 N/mm$$

Equation 3

$$C = \frac{\partial Force}{\partial Velocity} \qquad C = \frac{\partial Force}{\partial Velocity} = \frac{410 - 141.5}{(25-10)*10^{-3}} = 17900 N/m/s$$

Equation 4

$$C_{WHEEL} = MR^2 * C_{DAMP}$$

where,
- CWHEEL = damping rate the wheel sees
- CDAMP = damping rate at the spring damper unit
- MR = motion ratio

$$C_{WHEEL} = MR^2 * C_{DAMP} = 0.75 * 0.75 * 17900 = 10070 N/m/s$$

Equation 5

$$\omega_0 = \sqrt{\frac{K_B}{m_B}}$$

Equation 6

$$C_B = 2 \cdot \omega_0 \cdot m_B \cdot \zeta$$

$$\zeta = \frac{C_B}{2 \cdot \omega_0 \cdot m_B}$$

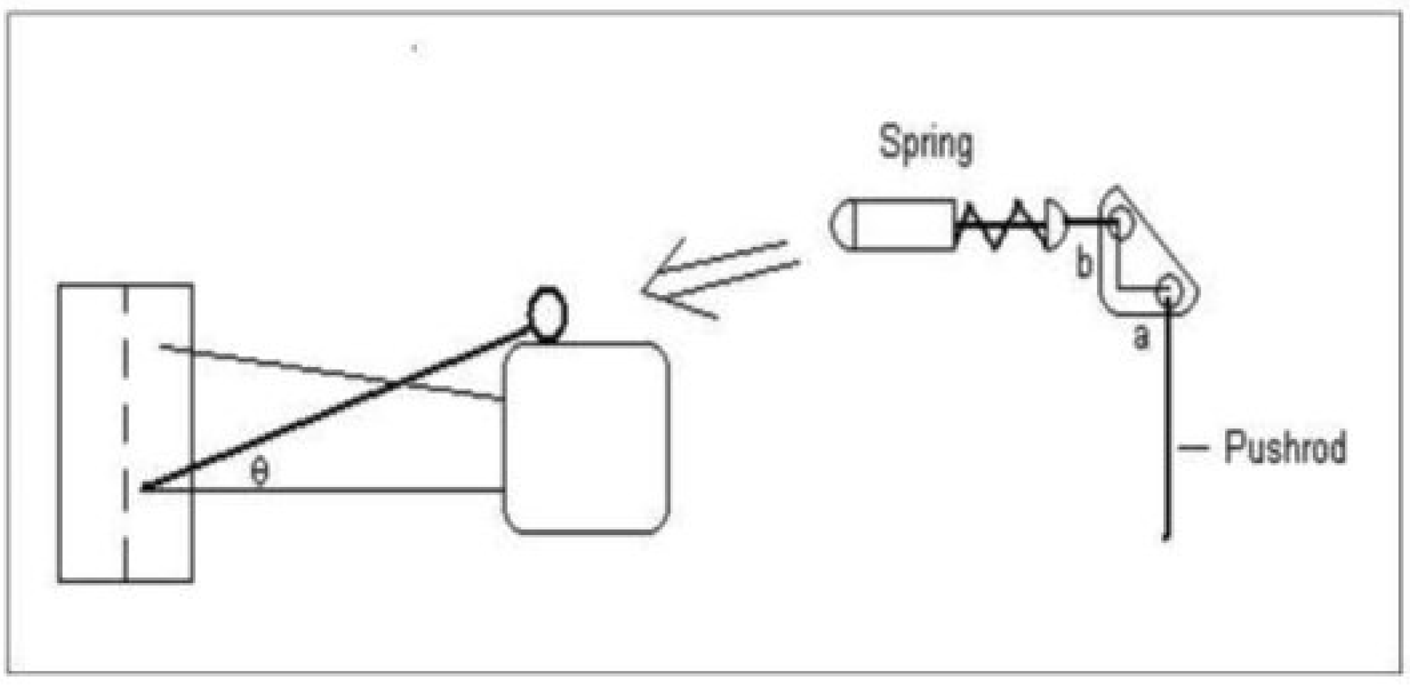


Figure 1: an illustration of a spring damper unit with a bell crank

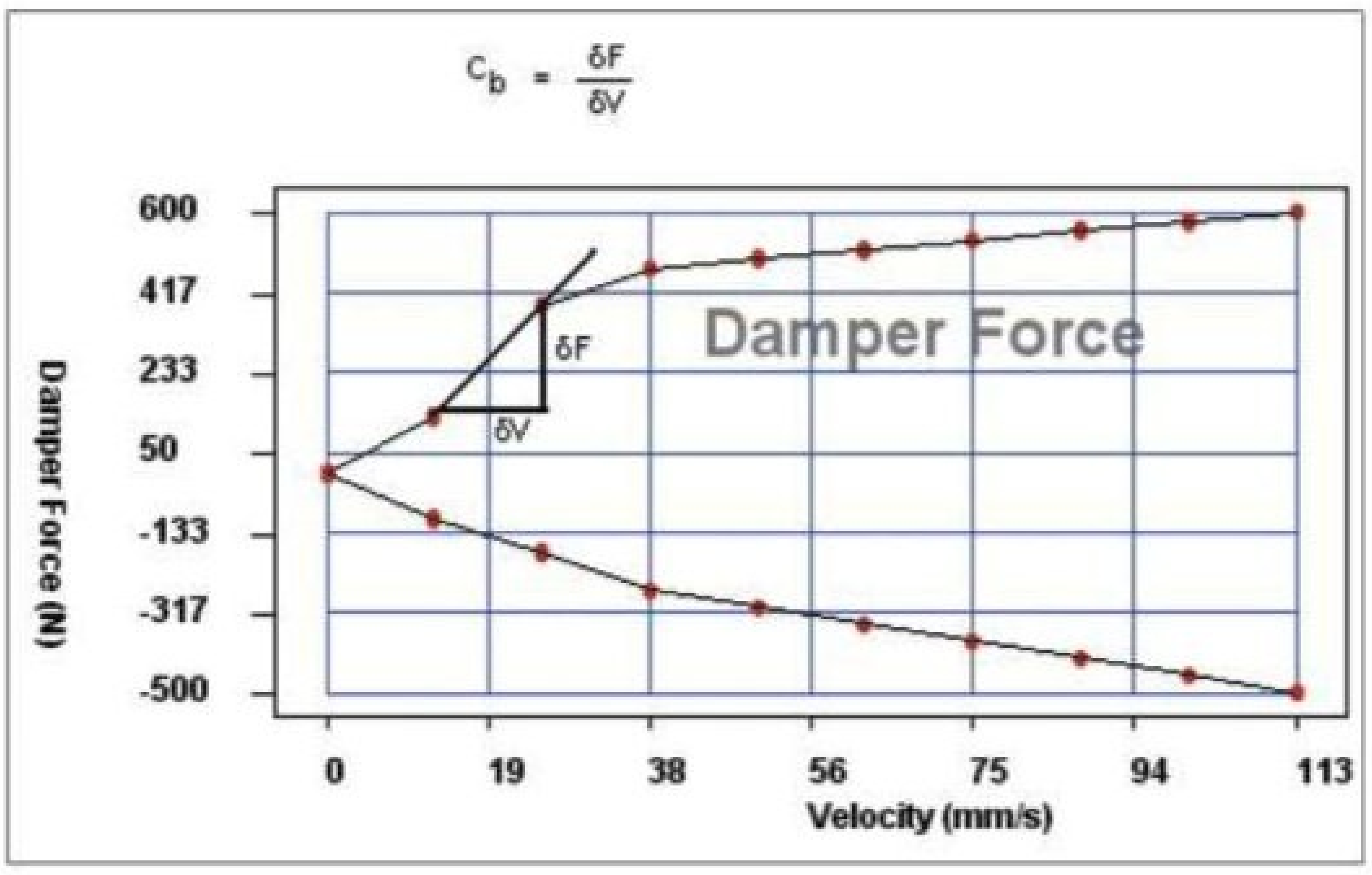


Figure 2: a peak force vs peak velocity curve for a damper

be and the spring rates we should be considering. To refresh everyone's memory, our quarter-car approximation looks like the illustration to the left.

The trick here is to visualise the spring / damper unit at each corner of the car. While this is obviously not the full story of what's going on with the car, it's a valuable building block to quantify the spring and damping characteristics of a racecar. Mathematically, the crux of the quarter-car method is the following **Equation 5** and **6**.

The power of the quarter-car model is that given a damping ratio we want we can readily calculate the damping rate we want. Once we know the damping rates, we can then turn around to a damper builder and see this is the damping curve we want. This is why this technique is so powerful.

So using the spring and damping rates we discussed earlier, let's do a worked example. When we calculate this, ensure our spring rates are in N/m and our masses are in kg. I realise this causes considerable consternation to some of my friends in North America but again, you'll hate me now and thank me later. Below are some rough rules of thumb for converting to N/m:

- **If the spring rate is in lbf/in multiply by 175.126**
- **If the rate is in N/mm multiply by 1000**

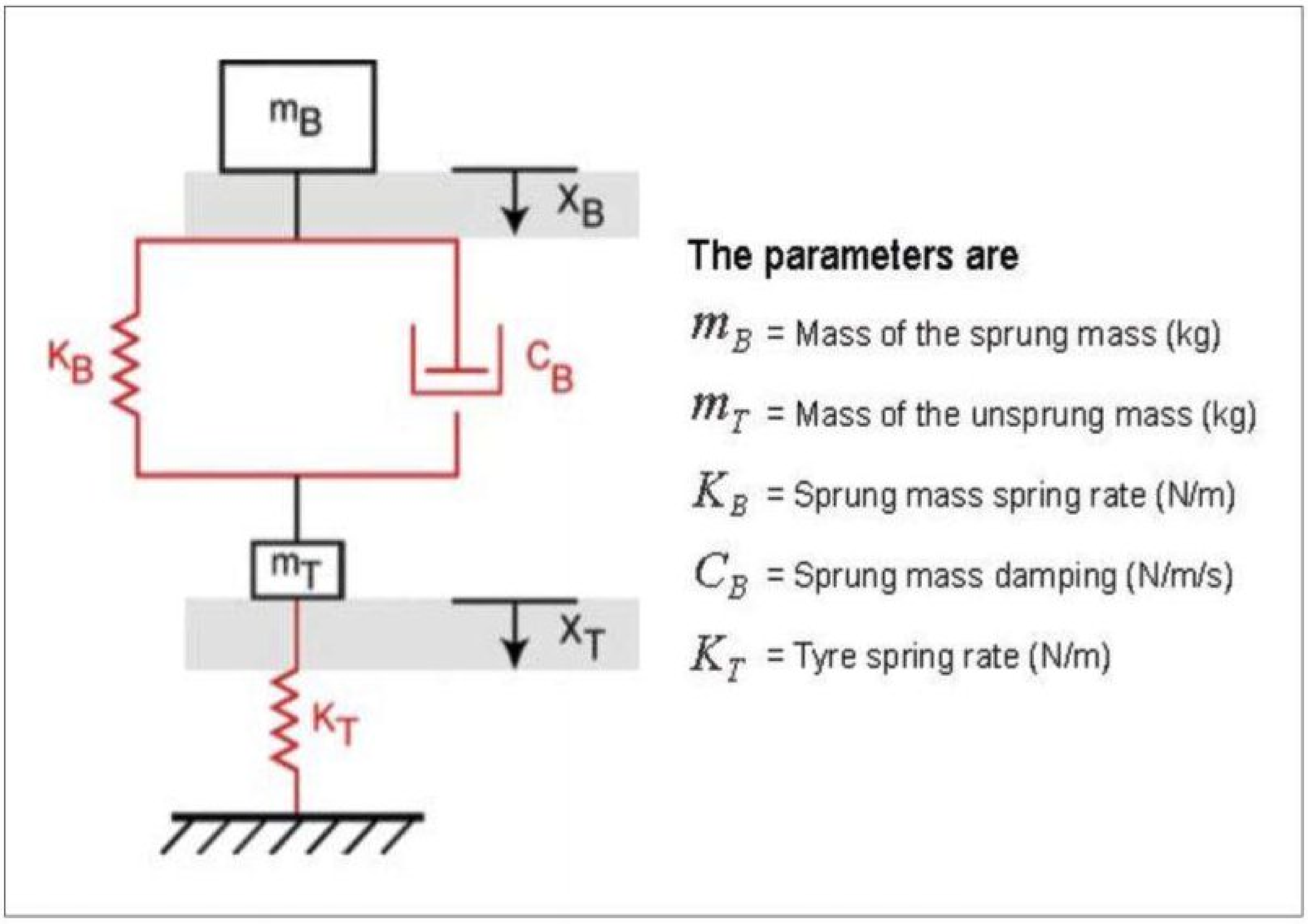
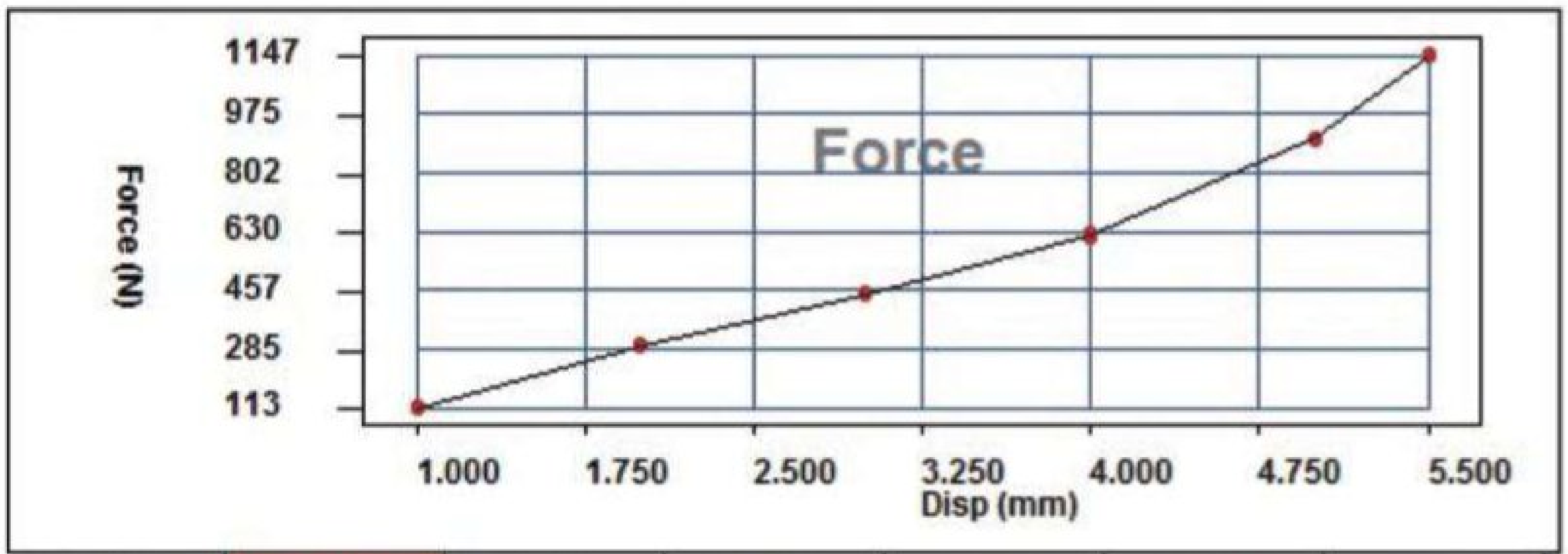


Figure 3: the quarter-car approximation



disp	1.000	2.000	3.000	4.000	5.000	5.500
Force	112.700	294.000	445.900	617.400	901.600	1147.000

Figure 4: calculating the spring rate of a non-linear spring

EQUATIONS

Equation 7

$$K_B = MR^2 \cdot SR = 0.75*0.75*140*1000 = 78750$$

$$C_B = MR^2 \cdot C_{DAMP} == 0.75*0.75*17900 = 10070$$

$$\omega_0 = \sqrt{\frac{K_B}{m_b}} = \sqrt{\frac{78750}{125}} = 25.1 rad/s$$

$$\zeta = \frac{C_B}{2 \cdot \omega_0 \cdot m_b} = \frac{10070}{2*25.1*125} = 1.6$$

where,
Kb = wheel rate of the spring (N/m)
Cb = wheel damping rate of the spring (N/m/s)
mb = mass of the quarter car.
ω0 = natural frequency (rad/s)
ζ = damping ratio

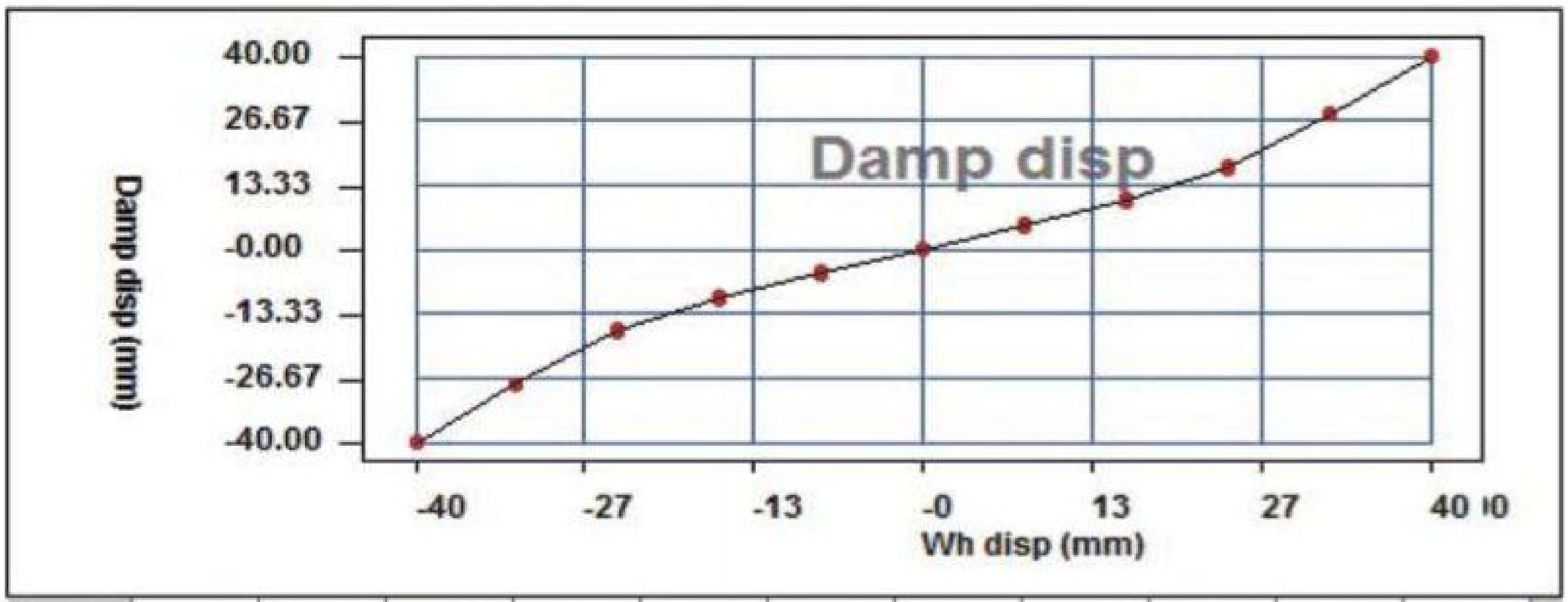
Equation 8

$$SR_{BR} = \frac{901.6 - 617.4}{5 - 4} = 284.2 N/mm$$

$$SR = SR_{BASE} + SR_{BR}$$
$$= 140 + 284.2$$
$$= 424.2 N/mm$$

Equation 9

$$MR = \frac{17 - 10}{24 - 16} = 0.875$$



Wh disp	-40.00	-32.00	-24.00	-16.00	-8.00	0.00	8.00	16.00	24.00	32.00	40.00
Damp disp	-40.00	-28.00	-17.00	-10.00	-5.00	0.00	5.00	10.00	17.00	28.00	40.00

Figure 5: non-linear motion ratio

So for our example here, let's assume a quarter-car mass of 125kg. Crunching the numbers we see **Equation 7**.

At this point you could be thinking, 'this might be great, but how do we use this?' Where we use this is understanding what the damping ratio is telling us. Again, this is going over some old material but recall our damping guide (see **Table 1**).

The damping ratio is telling what effect you want from your spring / damper unit. Remember, high values of damping ratio tell you we want to control the body. Low values tell us we are trying to filter out bumps and / or keep the wheel in contact with the ground. So when you calculate the damping ratios, you're effectively looking at the damper's fingerprint.

Also, the damping ratio will vary throughout the velocity range of the damper. This is a consequence of what we discussed when calculating damper rates. Remember also that damper rates will affect the damping ratio and this drives the behaviour of the damper. To illustrate this, consider an example I presented a number of articles ago where I calculated the damping ratios throughout the velocity range of **Figure 2**. In this case, the motion ratio was 1, the spring rate was 175N/mm, or a 1000 lbf/in and the quarter-car mass was 157kg. The results are shown in **Table 2**.

Table 2 presents some enlightening insights into what this damper is trying to do. First things first, the damping ratios from zero tell me immediately

Table 1: rough outline to damping ratios

Damping ratio range	What this applies to
0.3 - 0.4	Ideal for filtering out bumps
0.5 - 1.0	This deals with body control
1.0 +	This deals with extreme body control / driving temperature into the tyres

Table 2: damping ratios for damper presented in figure 2

Velocity (mm/s)	Damping ratio in bump	Damping ratio in rebound
0	1.24	0.95
13	2.03	0.6
25	0.616	0.707
38	0.175	0.31
50	0.167	0.286
63	0.174	0.31

this is a high-downforce car. The high damping ratios are telltale signs of this. The high damping ratios immediately suggest that body control is paramount. Looking at the bump at 13mm/s, the damping ratio jumps to 2.03. This indicates the damper engineer is trying to give some feel to the car, as well as load the tyres. Beyond this range, the dampers blow off to a low ratio to allow the car to ride the bumps.

"the damping ratio will vary throughout the velocity range of the damper"

In rebound from 13-25mm/s, the damping ratio is 0.7. This tells me body control is still paramount. Beyond that, the damping ratios blow off to 0.3, which tells me this is designed for the bumps. I encourage the reader to look at Figure 2 and, using the example we have presented, to re-work these numbers. Hint: when calculating slopes in rebound, use absolute values.

NON-LINEAR SPRINGS

The next question that must be addressed is how to deal with non-linear springs and motion ratios. Again, it's actually easier than you think. First, let's deal with non-linear springs. Where you will encounter non-linear springs is when using bump rubbers. All this means, though, is the spring rate changes. That's it and to calculate it is really easy, but to better understand it, let's consider the bump rubber that is illustrated in **Figure 4**.

Let's say this bump rubber is compressed by 4mm. Let's also say the base spring rate is 140N/mm. The spring rate of the bump rubber is **Equation 8**. So the actual spring rate at the damper is **Equation 8 part 2**.

I realise this is a bit of a trivial example, but it illustrates how straightforward this is. All we need to do is march forward on the look-up table, calculate the slope and that's how we get our spring rate. It goes without saying if this was the only active spring rate, we wouldn't need to add the other spring component.

CROSSHEAD

We also deal with non-linear motion ratios in a very similar way. Remember, at its core all a motion ratio is doing is measuring the slope of damper movement over wheel movement. Once you get your head around that, you can calculate for any given situation. So let's consider the non-linear motion ratio characteristic shown in **Figure 5**. If we want to calculate the motion ratio at 10mm of damper displacement, just like with the spring and damper, all we need to do is to calculate the forward rate. The calculation for this is **Equation 9**. It's as simple as that. In terms of units to calculate, you can choose whatever units you want, just make sure you are consistent when dividing.

The implications of these non-linearities are that when we encounter them, the damping ratios are going to change. There is no need to be nervous about this, it just reflects the physical reality that the wheel rates or damping rates have changed and we need to deal with it. At least you will have the language to describe what has happened.

In closing, I hope this resolves the methodology of how to calculate wheel and damping rates and it fills in the blanks on how to calculate damping ratios. The next step I leave to you. It's time for you to go back into your set up information and calculate this, and produce your own 'Table 2' for various set ups. Trust me, the results will be worth it.

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V8 Supercars on the up down under

Australia's premier motor racing series, V8 Supercars, continues to flourish. According to reports in the Australian media, V8 Supercar Commission chairman, Mark Skaife, has said he is speaking to two or three other manufacturers, and expects at least two to join the series alongside Nissan when the new Car of the Future is introduced in 2013. One of the manufacturers is widely expected to be Chevrolet, which has 'formerly expressed an interest in the series', says V8 Supercars Australia (V8SA).

While there is no concrete news on others, it is worth noting that representatives from Toyota, Kia and Hyundai joined Nissan at the original meeting with V8SA to discuss the Car of the Future plans back in 2009.

Toyota is currently the top selling make in Australia, with sales of 85,128 in 2011. It's followed by V8SA stalwarts, Holden and Ford, then Mazda, Hyundai and Nissan – the V8SA newcomer selling 33,973 units last year. Nissan has made no secret of the fact that it sees its Supercars involvement as a way of improving its sales in Australia. Nissan Australia managing director and chief executive, Dan Thompson, said: 'We are targeting number one importer status in Australia and already making progress towards that as one of the country's fastest growing brands. V8 Supercars will boost that momentum.'

Holden and Ford dominate V8 Supercars, but Japanese manufacturers, particularly Nissan, have them in their sights

In recent years, the V8 Supercar championship has been a two-way battle between Holden and Ford, but Nissan will now enter four cars to be run by Kelly Racing. Nissan and Chevrolet have both said they are attracted by the new Car of the Future regulations, which will put the emphasis on low costs, chiefly by stipulating some spec parts in the cars.

Nissan's last foray into Australian Touring Car racing ended in 1993 when, after a dominant three-year spell with its hi-tech Skyline GT-R, the rules were adjusted to outlaw the car.

Meanwhile, it's thought that three of Australia's domestic broadcasters are vying for the contract to screen the championship next year. This should significantly increase the value of the TV rights. The interest shown by Nine Network, Network Ten and Seven Network, as well as a number of pay-to-view organisations, could result in a fee of some A$300m (£204m / $324m), analysts say. Current broadcaster, Seven Network, which took over coverage in 2007, is paying A$168m.

Ugly politics and uglier cars will not scare off F1 sponsors

Formula 1's willingness to stage grands prix in politically sensitive countries will not put off prospective and existing sponsors, say industry experts – and neither will its new generation of ugly cars.

The sport has been under increasing pressure, notably in the UK, over its stance concerning the Bahrain Grand Prix, with Bernie Ecclestone insisting the race will go ahead, despite an escalation in violence in the Gulf state. The race was called off amid unrest last year.

Yet, while F1 continues to attract negative publicity about its willingness to go to Bahrain, motorsport sponsorship experts do not believe it will put potential or existing backers off. 'It's not going to help, but I think they view it as just one event out of 20, really,' motorsport sponsorship consultant, Nigel Geach, of Sports Marketing Surveys, told *Racecar Engineering*. He added: 'People who watch Formula 1, whether it's Bahrain, or China or India or the UK, watch the spectacle of the race, and they're not actually that interested in where it is.'

Ben Nichols, a former senior press officer for Lotus Renault GP, now at marketing firm Influence, agreed: 'I don't think it will put people off coming into the sport. It's an individual race and Formula 1 is a global product which, while it is a standardised product, it is taking place in different countries that have different cultures.'

However, it would be likely that some sponsors might not attend the race if it takes place, says Geach: 'Some sponsors won't want to go to Bahrain because of other reasons. I know of one American company that is not going because they do not want to, they say, put at risk their staff or guests.'

But the Bahrain situation is not likely to help in any way, either, and it's not a case of any publicity is good publicity, says Geach. 'Not with human rights and things like that.'

Meanwhile, it's been widely reported that Pirelli motorsport director, Paul Hembery, has said that the new stepped nose cars – the aesthetics of which have been widely condemned – might be a turn off for sponsors who see the look of the racecar as an integral part of the package.

Again though, Geach does not think it will be a problem: 'That's an interesting one, but I don't think so,' he says. 'The brand values of Formula 1 are huge, and all the research that we do shows that anybody associated with Formula 1 is perceived as global, trustworthy and premium, so I don't think the ugliness or the prettiness of a car is going to have any particular affect.'

Nichols agrees: 'As long as the sponsors are visible on the car, I can't see it being an issue.'

Recession hits European professional single-seater scene

The downturn in the European economy has started to hit entries in the professional racing classes, with many categories reporting a slow take up of seats and some expecting sparse fields for the 2012 season.

All of the professional single-seater formulae seem to be struggling to attract full grids this year, with GP3, Formula 2, GP2 and Formula 3 down on numbers from previous seasons.

The Formula 3 Euro Series and British Formula 3 Championship have both told *Racecar Engineering* they were looking at grids of around the 15 to 17 car mark – half of which would be older National Class cars in the British championship – while GP3 had just 13 confirmed entries at the time of writing.

A spokesperson for GP3 said the championship expected between 18 and 27 cars to run during the year, but it's perhaps an indication of the concern in the F1-supporting spec formula that it has recently added a driver and sponsor-friendly Monaco Grand Prix supporting race to its calendar. It has also relaxed its rules on the number of cars each outfit must run for the 2012 season. Previously, each team was contractually obliged to run three cars at every race, but the minimum team size at a race is two cars under the new rules.

Meanwhile, Formula 2 had officially announced just two drivers at the time of writing, but its coordinator, James Gornall, was confident there would be many more at the start of its season: 'We have more than that – we just haven't announced them yet.'

Numbers are down across the grids, though the feeling is buoyant for 2013

Gornall did, however, acknowledge that the recession was starting to bite: 'Everything is pretty slow, for all championships. Last year, many of the grids were filling right up at this time. This time last year I believe GP2 was absolutely full [at the time of writing it had 15 confirmed entries].'

Formula 2 believes it will have a full grid of 24 cars by the start of the season, Gornall saying that it expected to profit from drivers unable to find budgets for more expensive categories: 'People are waiting longer before they make their decisions, and there are fewer people around with money to spend. There will be people who have never got more than £100,000 of sponsorship in their lives who are trying to do GP2 right now. It's not going to happen for them, unfortunately. But eventually people get realistic and go to where they know they can race.'

It's not just the upper reaches of the ladder that's experiencing difficulties either. Lisa Crampton, general manager of British F3 and Formula Renault, said: 'It [the recession] is hitting now. It is going to be a difficult year in Formula Renault, but we know we should be able to bring things back together in 2013.'

NASCAR's track operator sitting pretty

International Speedway Corporation, the track-owning arm of NASCAR, has seen its profits increase for 2011, but it does not expect to see a similar increase in 2012.

The publically traded company, which is 71 per cent owned by the NASCAR-controlling France family, recently announced a 4.3 per cent increase in profits from its core areas of operation.

ISC's overall profits increased 21.4 per cent from US$54.5m in 2010 to US$69.4m in 2011. But it reported that its profits from core operations – that's not taking into account equity investments, tax settlements and write-downs of assets – rose 4.3 per cent from US$73.2m to US$76.5m.

However, it's not all good news, as ISC also predicts its 2012 profits will either stay the same, or will decrease by seven per cent. This seems to be largely because it expects a decline in revenues from satellite radio rights. The new contracts signed to carry NASCAR and ISC's Motor Racing Network programming amount to much less for 2012 because past contracts included bidding by XM and Sirius Satellite Radio, which merged in 2008.

ISC also revealed that it has cut down the number of seats at nine of its 12 Sprint Cup venues, a move that is a result of widening the seats. But it says this has actually helped advance ticket sales: 'Adjusting sellable seating capacity at our major motorsports facilities that host NASCAR Sprint Cup Series events is another initiative designed to regain a more normalised advance ticket sales trend,' ISC said. 'The reduction of sellable capacity, which is primarily achieved by providing improved seating for our fans, is enhancing the overall guest experience.'

BRIEFLY

Civic duty

Honda is to develop an all-new engine for its recently announced entry

into the World Touring Car Championship. The company plans to take in a number of WTCC races later this season, widening its effort into a full two-car campaign in 2013. Italian team, JAS Motorsport, is to run the Civic, which will be based on the new five-door model. Mugen will manufacture a bespoke, 1.6-litre, turbo engine, to be developed by Honda R and D.

LMP1 points tweak

The FIA has altered the rules for this year's inaugural World Endurance Championship in the hope of livening up the chase for the manufacturers' title between Audi and Toyota – the latter of which was persuaded to step into the breach after Peugeot's shock withdrawal. The new rules say that only the highest finishing car in LMP1 will collect manufacturer points, while only the six best scores – which must include Le Mans – will be counted. The regulations for the drivers' championship, and for other classes, remain unchanged.

Nova and out

Super Nova, for many years a fixture on the penultimate rung of the international motor racing ladder, will no longer be a part of the GP2 field in 2012. Its place on the grid will be taken by Auto GP team, Lazarus, which has secured backing from Venezuela for its first GP2 campaign. Super Nova had an illustrious history as an F1 feeder formulae and, for a time, was the dominant force in Formula 3000, GP2's predecessor.

FIA's rallying call for new promoter

The FIA has stepped in to end the uncertainty that's been a mark of this year's World Rallying Championship and has put the position of promoter of the WRC out to tender.

The move comes after talks with TV company, Eurosport, over it promoting the championship broke down in February. The winning bid is to be announced on March 30. The WRC's previous promoter, North One Sport, had its contract terminated when its parent company, Convers Sports Initiatives, went into administration.

The FIA said: 'The FIA is calling for expressions of interest to identify candidates interested in getting involved as an agent, a promoter or an investor in the promotion of the FIA World Rally Championship with a view to concluding a multi-year contract.

'The series is widely regarded as one of the most significant international motorsport championships and is supported by some of the world's largest [motor] manufacturers.'

Some order has already been brought in to the recently chaotic world of WRC, though, with the news that the FIA has signed up Stage 1 Technology (S1T) as timing supplier for the rest of 2012. Simon de Banke, S1T's managing director, said: 'This is great news. Everybody's had quite a stressful start to the season, so to get this deal across the line in what is an exceptionally short space of time is a fair reflection on how much everybody wants it to work.

'I would like to pay tribute to the speed and ability with which everybody in the FIA has worked to expedite this. And for their foresight and support of the championship in taking the leadership to get our systems back online.'

With potential to reach vast audiences worldwide, the World Rally Championship contract offers an exceptional opportunity for exposure

SEEN 2013 FORD FUSION SPRINT CUP CAR

The 'win on Sunday, sell on Monday' words of Henry Ford were very much in the air as the Blue Oval unveiled its 2013 NASCAR Sprint Cup racer, alongside the Ford Fusion on which it is based.

Ford's Cup racer is designed very much with the intention of bringing brand identity back on track. 'We wanted Fusion to be the car that helped return 'stock car' to NASCAR,' said Jamie Allison, director, Ford Racing. 'I think fans, when they see the car, are just going to smile and cheer. It is going to re-engage them with the sport and make the sport better because there is just something natural about seeing racecars on track that look like the cars in their driveways.'

Ford's new Fusion is set to go head to head on the track with Toyota's Camry, which is currently the USA's top-selling road car. The last version of Ford's Fusion was the third biggest seller in 2011, behind the Camry and Nissan's Altima.

The Charlotte Speedway launch marked the third time Ford has simultaneously unveiled production and NASCAR versions of a new model. The first dual launch came in 1968, with the Ford Torino, while the second came as recently as 2006, with the then newly-introduced Fusion.

The new NASCAR Fusion entries will be tested throughout 2012, in preparation for their competition debut at the 2013 Daytona 500.

BRIEFLY

Denso fined

Motorsport and automotive parts company, Denso, together with Japanese car parts supplier, Yazaki, has been fined $548m by the United States government for price fixing. The fines follow what's been described as the biggest ever investigation by the US Department of Justice's anti-trust division. Car parts makers have come under increasing scrutiny after a spate of acquisitions caused concern about uncompetitive practices in the industry.

Channel surfing

Spanish broadcaster, Antena 3, which is a part of the Grupo Planeta publishing concern, has clinched the TV rights for Formula 1 in Spain. The agreement, which is for 2012 and 2013, was acquired after incumbent Spanish F1 broadcaster, La Sexta, failed to pay the first instalment on its €45m deal for this season. Sky Deutschland has inked a deal to continue showing live F1 racing in Germany throughout 2012.

Turn 2 gets dicey

NASCAR venue, Kansas Speedway, has recently opened a casino at the track. The $411m facility, which is a partnership between track owner, ISC, and Penn National Gambling, has created 1000 new jobs. The gaming area is on a single 95,000sq.ft floor overlooking turn 2.

Amsterdam: sim' city

Simulator manufacturer, Cruden, has relocated to an all-new, purpose-built headquarters in Amsterdam. Cruden will manufacture all of its Hexatech and Hexathrill 6-DOF simulators and simulator components there, while developing new products such as 'multiple guest interactivity' rides for the attractions industry.

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Hi-tech machinery at cutting edge of recovery

Sales figures from machine tool maker, Yamazaki Mazak, seem to suggest that hi-tech manufacturing, including that which takes place in the automotive sector, is on the up in the United Kingdom.

Mazak, which is the world's largest machine tool manufacturer, has reported record sales in 2011 and states that it now has strong confidence in the growth of hi-tech manufacturing in the UK, claiming the sector is very much 'open for business'.

UK sales director, Tony Saunders, confirmed that the order intake for 2011 was 60 per cent higher than in 2010, and 16 per cent up on the pre-recession peak experienced in 2007. 'In the first half of 2011, sales were driven by the need for productivity improvements,' Saunders said. 'Customers needed to increase their machining capacity and replace old, inefficient equipment in order to service the demand they were experiencing. This was a positive sign and confirmed that the market was heading in the direction we predicted in 2010.'

Record sales in 2011 indicate that manufacturing is growing in the UK

Saunders added: 'The latter half of the year saw continued sales growth across the breadth of our product portfolio, from CNC lathes to horizontal machining centres and larger multi-tasking machines. From mid-year onwards, we began to see much more strategic investment, which is a clear sign the market has confidence.'

While aerospace proved to be the busiest sector in 2011, the automotive sector also increased significantly and Mazak maintained a strong presence within the general sub-contracting and the oil and energy markets.

Saunders said he believed that hi-tech manufacturing success could help lead the UK out of the recession: 'We are optimistic that the confidence we are seeing will continue to translate into sales and market growth throughout 2012. Hi-tech manufacturing is bucking the trend and leading the UK towards recovery.

HRT move into Magic Box

Spanish F1 team, HRT, is to forsake its relatively new Valencia base to set up shop in Madrid's Complejo Deportivo Madrid Caja, but rumours of an impending buy out of the team by the world's richest man appear to be wide of the mark.

HRT will move into the state-of-the-art facility - which translates as 'Magic Box' and is a well-known tennis venue - in stages throughout this year and it will eventually take up some 11,000m^2 of indoor space at the home of the Masters 1000 Madrid Open.

The move will be just one of many changes for the team, which was taken over by Thesan Capital in 2011, as it has also been replacing a large part of its technical team after many of the 2011 team left with Colin Kolles when he departed HRT last year.

Talking of the move, new team principal, Luis Perez-Sala, said: 'We've been working hard for months and establishing our permanent headquarters was very important. Finding a space in which we could all work together was vital, in order to optimise work and generate a good team feeling, a sense of belonging.'

Perez-Sala also said that the entire team will not be based at its new HQ for some months yet: 'When the adaptation of the facilities is completed, and every department starts working under the same roof in a few months, we will only have one step left to take, which is to have the design department in Madrid, too. All this implies not only becoming a place to feel identified with and carry out activities for the team, its sponsors, suppliers and fans, but also an important reference in technology and R and D in the centre of Madrid.'

Meanwhile, according to German publication, *Die Welt*, the world's richest man, Carlos Slim, is looking at buying the team. The story seems to be based on the Mexican's involvement in F1 with the Sauber team, and it suggests that Thesan bought HRT just to sell it on to Slim.

However, the story does not quite stand up as the Carlos Slim involved in F1 is not the world's richest man - Carlos Slim Helu - but his son, Carlos Slim Domit. The former has had very little involvement in racing, while the latter has paid for Sergio Perez's seat at Sauber.

Sponsorship news: deals done and stickers stuck

The end of the off-season saw a flurry of activity in the motorsport sponsorship market on both sides of the Atlantic.

Force India has announced the arrival of a new sponsor into F1, Brazilian car parts manufacturer, Aethra, which is said to be keen to increase its brand awareness around the world, especially in India and China. Aethra is one of the largest auto parts manufacturers in Brazil and is active in the sectors of automotive components and tool making, and all its revenues come from car manufacturers.

Caterham has a new sponsor onboard too, SIBUR, the largest petro-chemical company in Russia and Eastern Europe, which has arrived with driver, Vitaly Petrov.

Another big F1 deal was Santander's extension of its contract with Ferrari, which will now continue until the end of the 2017 season. The Spanish bank's relationship with Ferrari began in 2010, it coming onboard at the same time as Fernando Alonso, whose contract with the team expires in 2016.

Meanwhile, Japanese watchmaker, Casio, has extended its deal with Red Bull Racing and will now have greater visibility on both the cars and team clothing, while sister team, Toro Rosso, has extended its deal with Falcon Private Bank, a Swiss wealth management specialist.

In NASCAR, supermarket chain Walmart, which has been courted by NASCAR owners for many years, has finally taken the plunge, announcing a one-race deal with Turner Motorsports at Daytona in July.

American Ethanol has agreed to continue its relationship with Richard Childress Racing for 2012, while Penske Racing has also announced a sponsorship extension with brewer MillerCoors. Earnhardt Ganassi Racing has had its sponsorship from Belkin, Liftmaster and Banana Boat extended to cover a third car in selected races.

Also in NASCAR, Joe Gibbs Racing has negotiated contract extensions on the part of all three of its main Cup sponsors: Home Depot, FedEx and M&Ms.

INTERVIEW – LISA CRAMPTON

Lisa Crampton is general manager of British F3 at SRO, where she also looks after the Formula Renault and Clio Cup championships. She was formerly promotions and events manager at Abu Dhabi Motorsports Management, and before that worked for the Speedcar Series. She has also worked as events manager at Dubai Autodrome.

Q. How are the grids looking for British Formula 3 this year?
It's looking sustainable. Healthy would be having more than 20 cars on the grid, and unfortunately in this day and age, that's a big ask. I think we're going to be looking at around 17 cars, of which more than half will be the new-spec Dallara – the F312 – and we'll have other cars joining us for our feature events in Europe, such as Pau, Spa and Monza.

The older cars, the F308s, will go into the National class. They will all run Neil Brown Engineering-prepared Mugen Honda engines. The engines will be tuned down. If they ran unrestricted Mugen Hondas they would be as quick, or even faster, than the new cars, but Neil will look after them to make sure they're competitive, but just a little bit off the new car.

Q. With five new cars, Carlin has a large slice of the grid this year. Is that a problem?
It is and it isn't. I mean, we see this exact same issue in many other categories. There is always going to be a dominant force. Everyone goes through a cyclical time at the top. We saw the same over in Europe with ART Grand Prix and then Signature, and it just means that everyone is trying that bit harder to beat them. That said, yes, five cars is a lot for one team, but we're also not in a position to do what they do in Formula 1 or GP2, where you can only have two-car teams.

Q. How have the teams welcomed the new Dallara F312?
The car has been welcomed with open arms. It's a big update in terms of design, technology and safety standards. It looks very modern and I think it needed that. It needed a little bit of a face lift.

Q. What's the current budget for a season of British Formula 3?
It can vary greatly, but I would benchmark it at half a million pounds. Some seats will go for more, some will go for less. With the National Class I think they were trying to cap it at about £300,000 ($475,000).

Q. Why do you think F3 has been so successful?
It's got a lot of history, and there are a lot of good drivers who have come through it. You also still have a lot of people at the top of motorsport who, while not really being ambassadors as such, will still voice their opinion that Formula 3 is really where a driver needs to be. If someone sticks out in F3 you know they're going to do well. If you've gone through Formula 3 it's like going to university. Even if you haven't won, you've come through and you've learnt how to set up a car, you've learnt how to change a car – otherwise it's all single make. It's not an accident that F3 has more graduates in Formula 1 than any other category.

Q. What about the engineers going through F3?
There are so many engineers who have come through Formula 3 and moved up to Formula 1. If you've worked for any of the British Formula 3 teams and you're going for an F1 job, I think you'd stand out.

Q. How hard has GP3 hit British F3?
I think it hit the Euro Series more than us, particularly last year. It was the shiny new toy. it was on the F1 package, and there are a lot of drivers out there who think: 'oh, if I'm racing in the F1 paddock, they'll notice me. If I'm standing in front of Bernie, one day he'll actually talk to me.' But...

Q. How important is TV coverage?
We're on Channel 4 and we're on Motors... But it's interesting, I don't have a lot of drivers coming to me worried about TV slots. But with Clios, if I took them off live TV I would kill my entire grid! Formula 3 doesn't lose anything from the television coverage, it's not the be all and end all.

Q. How is British Formula Renault looking this year?
We have about 10 or 12 cars. If you were to run F3 with just the new cars it would be the same, but the problem we've got is that you can't run the older cars in our championship, so effectively there's no B class. And finding 16 to 18 full-season drivers nowadays just doesn't happen like it did in the '80s, '90s and the better half of the 2000s.

DHL pulls plug on GP

The Australian division of DHL, the German-managed global logistics group, pulled out of its new title sponsorship of the Formula 1 Australian Grand Prix less than a month before the event in Melbourne, for reasons that have not been explained. Andrew Westacott, the CEO of the race promoter, Australian Grand Prix Corporation (AGPC), has instead turned to Qantas CEO Alan Joyce, who has signed a one-year contract.

The news has served to refocus attention in Australia on the deeply controversial cost to the tax-payers in the state of Victoria of the loss-making event, which has four more years to run on its current contract.

Qantas supported the inaugural Formula 1 event in Adelaide in 1985 and acted as its title sponsor between 1997 and 2001. It resumed in this role in 2010 and 2011 but then pulled out for its own financial reasons, while remaining involved as a secondary sponsor.

However AGPC's hastily arranged Qantas deal is understood to be on the basis that it will not pay extra in direct sponsorship. If such is the case, it will not cover AGPC's lost revenue at a time when the event is under increasing attack from groups representing the tax-payers who, in the final analysis, provide the funding.

Last July, the Victorian government published a financial impact report showing that, for an investment in the 2011 race amounting to approximately A$50 million (US$53.5m), the state valued its benefits at $39 million (US$41.7m).

Victoria's major events minister, Louise Asher, confirmed that the government will begin negotiations with Formula One early next year to extend the contract beyond 2015.

DHL's decision means that it will not be involved in Formula 1 as a title sponsor, having branded last year's Turkish Grand Prix, which has new been dropped from the schedule.

Apprentice – youth hired!

The British Government has said it is to open up a £250m funding pot for companies willing to take on apprentices.

Motorsport businesses, and others, will be allowed to bid for funding to run apprenticeship schemes, and will be given the power to design, develop or buy the vocational training programme that suits their needs.

The money available will be from a fund of £50m to start with, but will rise to £250m if the scheme is successful. It will be diverted from colleges and other training providers and given directly to firms whose bosses successfully apply for grants by showing how their staff and potential employees will benefit.

Meanwhile, the Institute of Mechanical Engineers in the UK has warned of a dangerous shortfall in the amount of engineering graduates in the future after figures from British university admissions body UCAS showed an overall 1.3 per cent drop in students applying for engineering degrees.

Colin Brown, director of engineering at the Institution of Mechanical Engineers, said: 'The drop in applications for engineering degrees may be small, but is hugely worrying as we need young engineering talent more than ever to help the country's economy pick up. If we are to recover we need engineers to help boost manufacturing industries.'

German GP up for grabs

There are now serious doubts over the bi-annual Formula 1 German Grand Prix on the Nürburgring, which has alternated the event with the Hockenheimring since both venues ran into difficulties paying Formula 1's fees. The event in the Eifel forest is now without a promoter and Formula 1 CEO, Bernie Ecclestone, is clearly anxious to find a solution, having a German world champion and a major German factory team in his retinue.

After months of discussions, the Rheinland-Pfalz provincial government (who invested €330 million ($434m) of public money when the company took over the administration of the circuit) has thrown the Nürburgring event wide open by terminating a 30-year lease on the venue that was granted in 2009 to a purpose-formed company, Nürburgring Automotive. However, it insists it wants the German Grand Prix to continue at the venue.

In response, Nürburgring Automotive directors, Kai Richter and Jörg Lindner, threatened legal action against the government, asserting that they had improved their company's financial prospects by negotiating a new deal with the Formula 1 group to host the race every other year.

Ecclestone, meanwhile, told the *Rhein Zeitung* newspaper, 'If the government finds a new partner who agrees to have the race, then I'm more than happy to agree to a new contract. What we can make possible, we will make possible.'

RACE MOVES

Dominic Harlow, formerly chief race engineer at the Force India Formula 1 team, has now moved to Williams, where he has taken on the position of senior operations engineer. Harlow had been at Force India since its Jordan days in 2005, and he had held the position of chief race engineer since 2007.

Thomas Mayer has been appointed chief operating officer at the Lotus Formula 1 team, taking the position formerly held by Patrick Louis – who has been promoted within the organisation to chief executive officer. Both men will work alongside team principal **Eric Boullier.**


LAT

James Key

James Key is no longer the technical director at the Sauber Formula 1 team. The Swiss team says the development of its 2012 car will now be in the hands of its heads of department in its aero, design, performance and operations divisions. At the time of writing, there were strong rumours that Key was about to join the motorsport division of Lotus cars, where he's expected to work on the Evora GT3 project.

Jacky Eeckelaert has left the HRT F1 team. Eeckelaert was in charge of the design of the 2012 car, having taken over the role after **Geoff Willis** left last summer. He has been replaced by **Jean-Claude Martens**. **Simon Jenkins,** formerly head of production, has also left HRT. His position has been taken by **Dave Campbell**.

Mike Gascoyne is now the chief technical officer of the Caterham Group. Gascoyne is now responsible for key technical initiatives in Caterham Group's motorsport activities (F1 and GP2), Caterham Cars, Caterham Composites and Caterham Technology and Innovation. **Mark Smith**, Caterham F1 Team technical director, now leads the F1 team's technical division day to day.


LAT

Mike Gascoyne

Tony Dowe is now performance director at Australian V8 Supercars team Kelly Racing. Dowe, a former managing director of TWR's US arm, is vastly experienced and has worked in F1 with Ensign, Brabham, Wolf, Ligier and Arrows. He has also served as a representative on the FIA's Sportscar technical working group.

DTM outfit, Audi Sport Team Rosberg, has hired **Ossi Oikarinen** as its technical director. Oikarinen has spent the last 14 years in Formula 1, starting at Arrows before moving on to Toyota, then BMW Sauber, before finishing his F1 career at Ferrari, where he was leading test engineer. The Finn replaces **Andreas Roos** in the Rosberg role.

Dr Joseph Mattioli, the founder of Pocono Raceway, has died at the age of 86 after a lengthy illness. Mattioli, who was also chairman of the board at the track, was a medic in the US Navy during WWII before becoming a successful dentist. He founded the raceway at Pocono in the early 1960s.

Tony Furr is now crew chief for **JJ Yeley** at the newly established Robinson-Blakeney Racing NASCAR Sprint Cup outfit, the pair reuniting after working together earlier in their careers. The team says Furr has been hired to coordinate and direct the all-new operation. In addition to its maiden season of Cup competition, Robinson-Blakeney Racing is also racing in its 12th Nationwide campaign this year.

NASCAR Camping World Truck Series team, SS Green Light Racing, has snapped up **Bryan Berry** to work as crew chief on its no 08 Toyota, driven by rookie, **Ross Chastain**, this year. **Joel Martino** also joins the team as truck chief.

Veteran NASCAR crew chief, **Richie Wauters**, is now a team owner in the NASCAR Camping World Truck Series. Wauters Motorsports will run rookie, **Paulie Harraka**, in the Truck series, a category in which Wauters has a good record as a crew chief, having scored 18 wins.

Terry 'Richie' Snyder is the new crew chief on the Joe Denette Motorsports no 24 Chevrolet that runs in the NASCAR Camping World Truck Series. Snyder's racing career spans more than 10 years and he has extensive experience building suspension. He served as a fill-in

RACE MOVES

truck chief on Johnny Benson's 2008 championship-winning team.

NASCAR Camping World Truck Series team, RAB Racing with Brack Maggard, has appointed **Chris Rice** as crew chief for the no 09 Toyota driven by **John Wes Townley.** Rice has been with the organisation since July of last year and had been working as director of special projects.

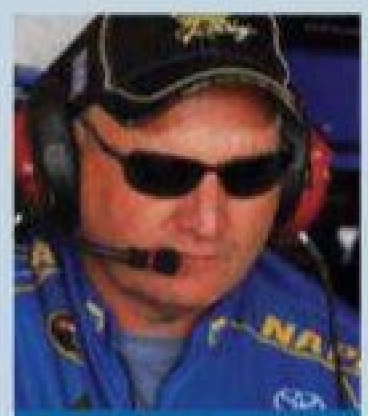
LAT

Ryan Pemberton

Tommy Baldwin Racing has hired **Ryan Pemberton** to oversee its no 36 car in the NASCAR Sprint Cup Series. Pemberton started out sweeping floors at Roush Fenway Racing and worked his way up to a Cup Series crew chief post in 1997. Most recently, he has served as a crew chief at Red Bull Racing.

Veteran NASCAR Nationwide Series crew chief, **Brad Parrott**, is to oversee Tommy Baldwin Racing's no 36 Chevrolet as the organisation makes its first foray into the second-tier US Stock Car category this year. Parrott, who also has Cup experience, has taken 18 wins in Nationwide.

Shaun Goff has taken over as team principal at Wakefield-based Ginetta racing team, Optimum Motorsport. Goff replaces **Ron Linn** in the position, who is stepping down to concentrate on other business interests. This year Optimum will be expanding its efforts to Britcar and the British GT Championship, as well as staying in the Ginetta Challenge.



LAT

Pat Tryson

Ben Nichols, the former senior press officer for Lotus Renault GP, has joined Influence, a specialist London-based marketing and communication agency. He will be responsible for driving the media activity across Influence's key clients in the sporting sector, as well as helping activate the company's sponsorship accounts.

NASCAR has bolstered its marketing department, promoting three of its current team and taking on three more people. **Scott Warfield** has been promoted to director of NASCAR Media Group / entertainment marketing communications, **Amanda Ellis** to senior manager of NASCAR competition communications, and **Jason Christley** to senior manager of NASCAR competition communications, developmental series. The new personnel are **Kurt Culbert**, **Zack Albert** and **Matt Ciesluk**.

Former FIA international steward and Motor Sports Association (MSA) board member, **Howard Lapsley**, has died at the age 82. In 2009, Lapsley was presented with an MSA Lifetime Achievement Award in recognition of his contribution to British motorsport.

German race engineering guru, **Erwin Derichs**, has died at the age of 68. Derichs started his motorsport career with Ford, before becoming involved with the Eifelland Formula 1 project. He formed his own motorsport engineering company in 1973, based close to the Nürburgring, and went on to build his own F3 cars, before more recently becoming involved in the historic motorsport scene as a driver and engineer.

NASCAR's chief marketing officer, **Steve Phelps**, has been named as *Adweek* Sports Marketing executive of the year. He was voted for by editors and subscribers on the publication and he finished ahead of executives from the NFL, NHL, The Olympics and Nike, among others, in its annual Sports Media and Marketing MVPs poll of readers' favourite sports media and marketing figures.

Pat Tryson has joined NASCAR Sprint Cup outfit, Front Row Motorsports, to work as the crew chief on David Gilliland's no 38 Ford. The move will also allow interim crew chief, **Derrick Finley**, to return full time to his role as director of competition at the organisation. Tryson most recently worked for Michael Waltrip Racing, where he served in crew chief and consultant roles.

Moving to a great new job in motorsport and want the world to know about it? Or has your motorsport company recently taken on an exciting new prospect? Then send an email with all the relevant information to Mike Breslin at bresmedia@hotmail.com

Tyre deals rubber stamped for 2012 season

Among the tyre deals signed off in the run up to the new season was Firestone's agreement to continue as the tyre supplier to IndyCar until at least 2014.

Firestone has been the sole tyre supplier for IndyCar since 1999 and Randy Bernard, IndyCar's CEO, welcomed its continued involvement: 'Firestone continues to be a great fit for our sport, carrying on a 100-year old tradition that began at Indianapolis Motor Speedway'. The company will also supply the second tier Indy Lights series.

Elsewhere, Pirelli's tyre deal with the FIA GT1 and GT3 European Championship has been confirmed, while Kumho has won the contract to supply rubber for the Auto GP single-seater championship. From this season, all Auto GP teams will be required to use two compounds of tyre per weekend, as is the case in Formula 1.

On the Le Mans front, French tyre maker, Michelin, has announced it has delivered the first set of specially designed race tyres to the Project 56 Delta Wing team. The Delta Wing front tyres are just 10/58-15, or less than 23in tall, with a tread just 4in wide. By contrast, the 2011 Le Mans-winning Audi R18 used taller and significantly wider 36/71-18 Michelin front tyres, approximately 28in tall and with nearly 14in of useable tread width.

'The difference in tyre size is stunning,' said Michelin ALMS technical team leader, Karl Koenigstein. 'You could fit three DeltaWing Michelin front tyres inside a Michelin Audi Le Mans Prototype front tyre.'

Meanwhile, Avon Tyres says it is introducing a quicker and more consistent tyre for this year's British GT Championship, unveiling the fourth generation of its GT racing tyre since it took over as sole supplier and title sponsor to the series in 2006.

Avon Tyres, which are manufactured by Cooper Tire Europe, has also signed an agreement to be title sponsor of the MSA British Hillclimb Championship this year. The company says a new pricing structure for its competition tyres has been designed, specifically with the aim of attracting new entry-level drivers into the exciting, no-holds-barred championship.

OBITUARY – ROGER DOWSON

Former British Touring Car Championship team owner, Roger Dowson, well known for his part in Mazda's foray into the BTCC in the early 1990s, has died at the age of 67.

Dowson first became involved in motorsport when he joined the Standard-Triumph competitions department in 1967, having previously worked at Armstrong Siddley. After that he moved to Triumph's experimental engineering department, working on the development of the Stag, TR7 and Dolomite Sprint.

It was with the 'Dolly' that he hit the tracks, helping the likes of Gerry Marshall in his spare time by building race versions of the Sprint and eventually setting up Gerry Marshall Racing with the tin top great in 1978.

His own eponymous concern, Roger Dowson Racing, was established in 1982, building and running Group A MG Metros and a Ford Sierra RS500 before the tie-in with Mazda began in 1990, when his company developed the first MX5 one-make racer.

The BTCC with Mazda followed in 1992, with first the 323F and then the Xedos 6, before he made a move into the flourishing historic racing market. Since the mid-2000s he had worked with Delta Motorsports, the company run by his son, Simon.

Roger Dowson 1944-2012

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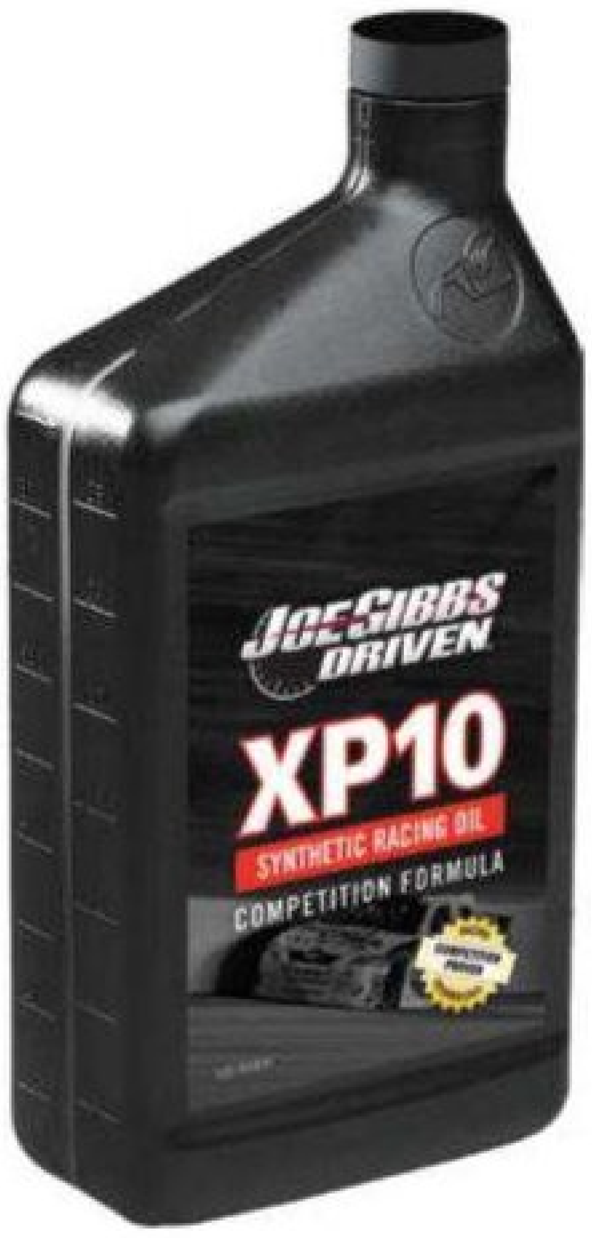
LUBRICATION

Gibbs XP10



The Joe Gibbs Racing team is probably unique in the world of motorsport, thanks to the fact that it blends its own lubricants. More importantly, it makes these oils available for purchase, under the Joe Gibbs Driven brand. This means that racers, especially those using flat tappet V8s, can benefit from the same R and D processes as the Joe Gibbs Sprint Cup team. The latest development is XP10, a fully synthetic race oil, developed in response to problems encountered while running cars at Superspeedways. The team found that they were experiencing high oil temperatures, resulting in component wear, when running in close proximity to other cars at these tracks. The problem was traced to a loss of viscosity in the oil as temperatures increased. The solution was to develop an oil formulation using a new generation of synthetic base oils and additives. The result is oil with the same viscosity as the previous 0/10W oil, but that maintains its stability up to 280degF and beyond.

See www.joegibbsdriven.com for more information

DATA CAPTURE

Texys flexible sensor

Tyre temperature sensors are not a new idea, but sensor specialist, Texys, has come up with a fresh take on the concept. The company has developed an infra-red temperature sensor array, featuring between three and eight sensors, mounted on a flexible PCB. This flexible circuit board, coupled with a new, slimline sensor, means that the units can be installed to view both the tyre tread and bead. The sensors have a temperature range of -20-200degC, feature a 6-16V supply voltage and are compatible with CAN bus 2.0a electrical systems.

See www.texense.com for more information

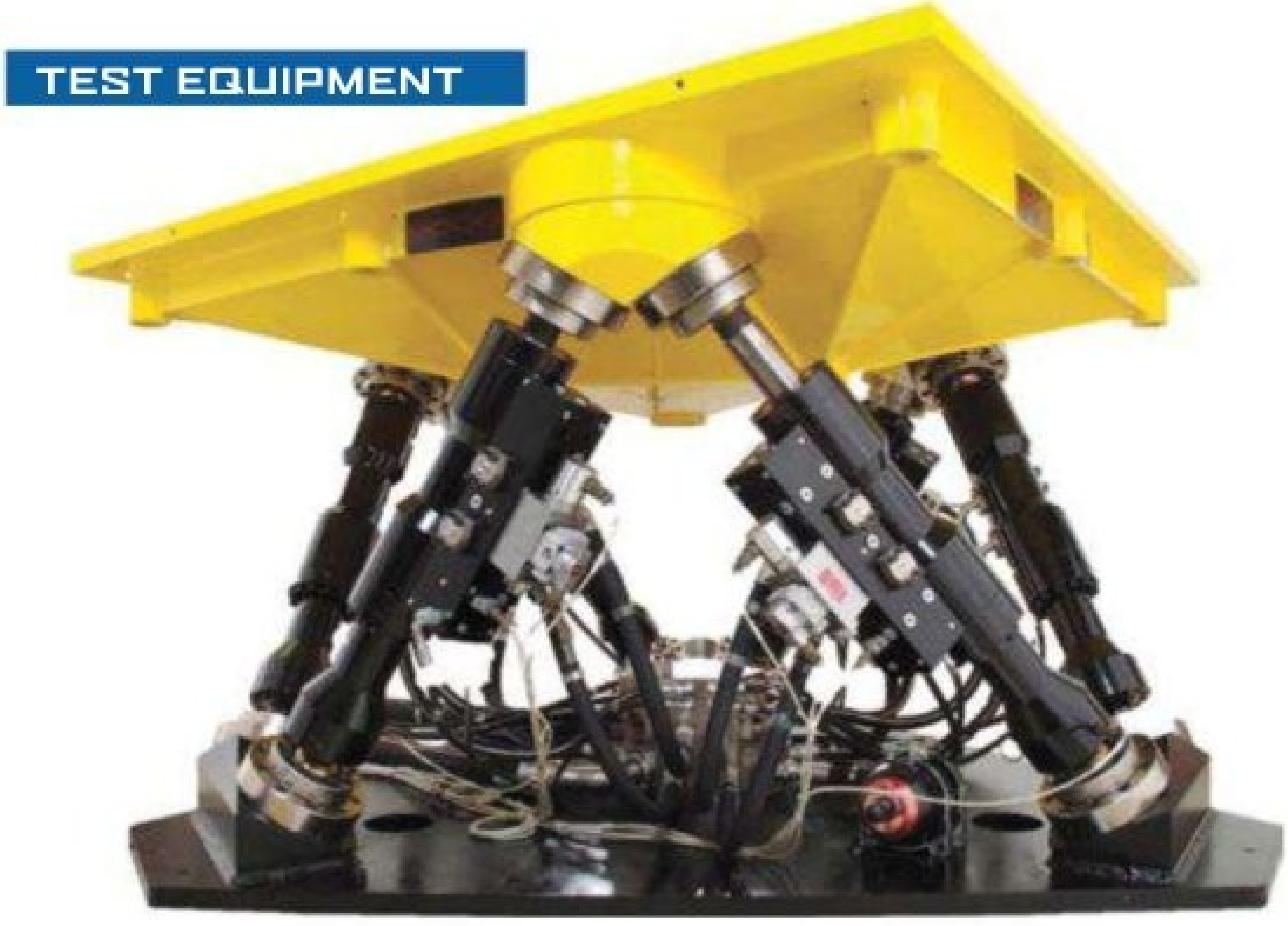
LUBRICATION

Torco grease

Lubricant supplier, Torco, has recently released a new, waterproof lithium grease for use in harsh environments. The grease is said to provide excellent shock load protection, temperature stability and corrosion protection. Being a waterproof formula, the grease is ideal for use in extreme applications such as rallying or off-road racing. The grease is available in an 8oz tube, ideal for tucking into a mobile tool chest.

See www.torcousa.com for more information

TEST EQUIPMENT



Moog simulation table

Moog, a company well known for its high precision hydraulic valves, has designed and manufactured a hydraulic simulation table, based on the its latest line of hydraulic test actuators. The new design is said to offer more capability than a conventional orthogonal system, (a table moved by actuators mounted on its base and sides). The Moog table is a six-legged hexapod with two equilateral triangular frames set one above the other, offset at 30 degrees. Each apex of the top triangle is connected to the two apexes below it via actuators with hydrostatic bearings. The table gives users a frequency of response up to 100Hz and can handle payloads up to 680kg (1500lb). These capabilities allow the system to simulate real-world conditions when testing individual components such as axles, engines and cooling systems.

See www.moog.com for more information

PIT EQUIPMENT

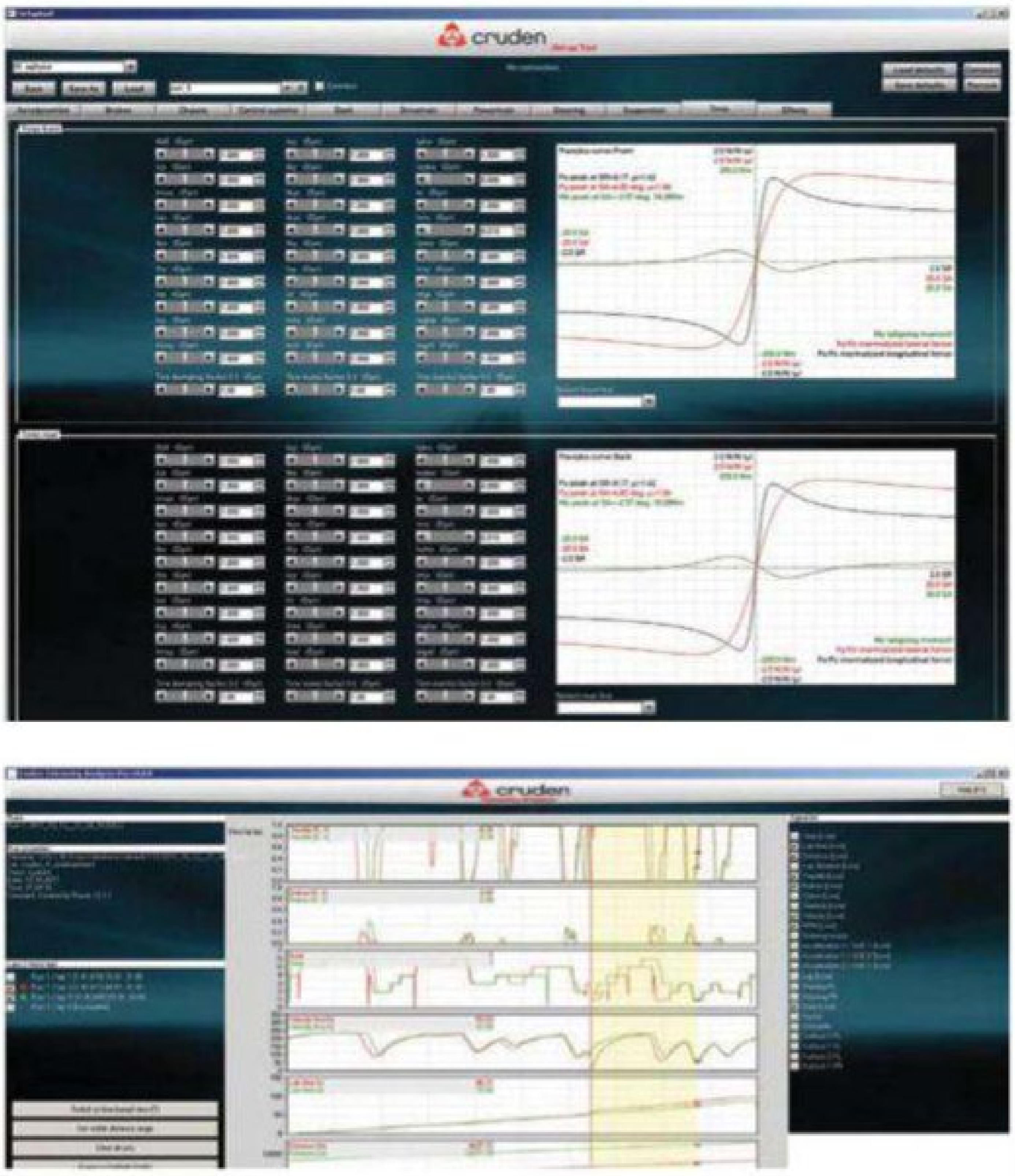
DEI quick fix tape

Quick fixes are not normally the sort of thing associated with racecar engineering, but sometimes needs must. Just look at the quantity of racer tape on show at Le Mans! 'Quick fix tape' is the latest product from Design Engineering Inc, who specialise in a host of heat protection and sealing products. This is one of the rare products we have actually been able to test and it does exactly what it says on the tin, plus a few other jobs as well. So far we have used it to seal up a leaky radiator hose, when a replacement was not readily available. Additionally, it worked very well for sealing electrical connections, preventing ingress of water and providing support for the cables. The tape is not sticky, it bonds to itself and is self-curing, and doesn't leave a residue when it is removed. DEI state that it can withstand a temperature range of -60-500degF and insulates up to 8000V. Overall, a worthy addition to any trackside tool box.

See www.designengineering.com for more information

SIMULATION

Cruden uprgrades



Advanced simulators are increasingly being used for in-depth engineering tasks, as well as driver training. One simulator manufacturer, Cruden, has recently increased the suite of tools available to engineers for use with its simulator products. These included a new chassis set-up tool and a telemetry analyser.

The Set-Up Tool allows engineers to change vehicle settings such as shock absorbers, dampers, wing settings and throttle mapping, amongst many other parameters, whilst the simulator is being driven, avoiding the need to stop the test and re-set the simulator.

The Telemetry Analyser allows race engineers, racing drivers and driver coaches to evaluate vehicle model performance and driving style as the simulated run takes place, or after the session as a download. Instant feedback from data such as lap and sector times, speed, throttle, brakes, steering angles and gears, in addition to many other vehicle parameters, can be used to maximise valuable simulator time.

Additionally, with interfaces to PiToolBox, MoTeC, Bosch Windarab or Magnetti Marelli Wintax software available, engineers can analyse simulated telemetry channels as if recorded from the real car and overlay them with actual data logged on track. All the new upgrades are available as an optional extension to Cruden's Racer Pro simulator operating software.

See www.cruden.com for more information

HARDWARE

C&R pressure relief valve

NASCAR's 2012 rule changes, aimed at reducing tandem drafting at Superspeedways, have resulted in a number of new products intended for teams racing in the Sprint Cup. Notable amongst these is a new coolant pressure release valve (PRV) from Indianapolis-based C&R Racing.

The valve has the same external packaging as the company's first generation version, but has been revamped internally. The new version uses a flat-bottom piston inside the valve with a quadrilateral o-ring, instead of the tapered piston with a round o-ring used in the first generation valve. This provides improved sealing, coupled with less chance of the valve sticking. The internal spring has also changed from a coil spring to a stainless steel wave spring, which produces a more accurate cracking and re-sealing pressure. Additionally, the second generation PRV requires only two springs (of different rates) to cover all pressure settings from 25-75psi, instead of having a different spring for each pressure setting. The final improvement is the additional of a large area filter screen to improve flow though the valve.

See www.crracing.com for more information

PIT EQUIPMENT

Paoli Red Devil pit gun

Air gun specialist, Dino Paoli Srl, recently unveiled its new Red Devil air gun, aimed squarely at the NASCAR market. At the time of writing, the Paoli Red Devil had not yet been approved for NASCAR competition, but the company has begun the approval process at the NASCAR R and D centre. A handful of the top Cup teams have been working with Paoli to develop the gun and, if given the go ahead from NASCAR, Paoli guns will be seen in competition this season.

The Red Devil has a number of advantages over traditional pit guns, notably an increase in speed and torque, alongside a decrease in vibration over traditional designs, which is particularly apparent at higher air pressures. The company achieves this by using a new hammer mechanism inside the gun. The mechanism is precisely balanced as it spins, and the hammer and anvil engage in a different way to a traditional air gun, resulting in reduced vibrations. Additionally, the gun's air chamber has an advanced air exhaust from the motor, which allows it to spin to over 15,000rpm at 200psi and produce more than 500Nm at 14,200psi.

See www.paolipitstop.com for more information

Wide angle

More than just a branch of the Formula 1 team, Caterham Composites aims to take its knowledge gained in Formula 1 to a far wider audience

Caterham is best known as the manufacturer of small, lightweight sports cars based on the Lotus 7, but in 2012 it joined the Formula 1 circus with its own team. The company has always been linked to Lotus, so it seems fitting that the team known as Lotus Racing in 2010 and Team Lotus in 2011 is now called Caterham. But owner, Tony Fernandes, has much more in mind than churning out a bunch of Lotus 7 replicas, a whole new group of companies has sprung up around the F1 team and the car company, the newest of which, Caterham Composites, is all about technology transfer.

'It is a separate company to the F1 team, but it is part of the same group,' explains Phil Hall, the firm's managing director. 'It was an existing consultancy, based in Cologne in Germany, and started in 2007, when me and my business partner decided to leave the Toyota Formula 1 team. The company we set up was called Composite Designs, and the idea was to follow composite materials into different areas of industry.

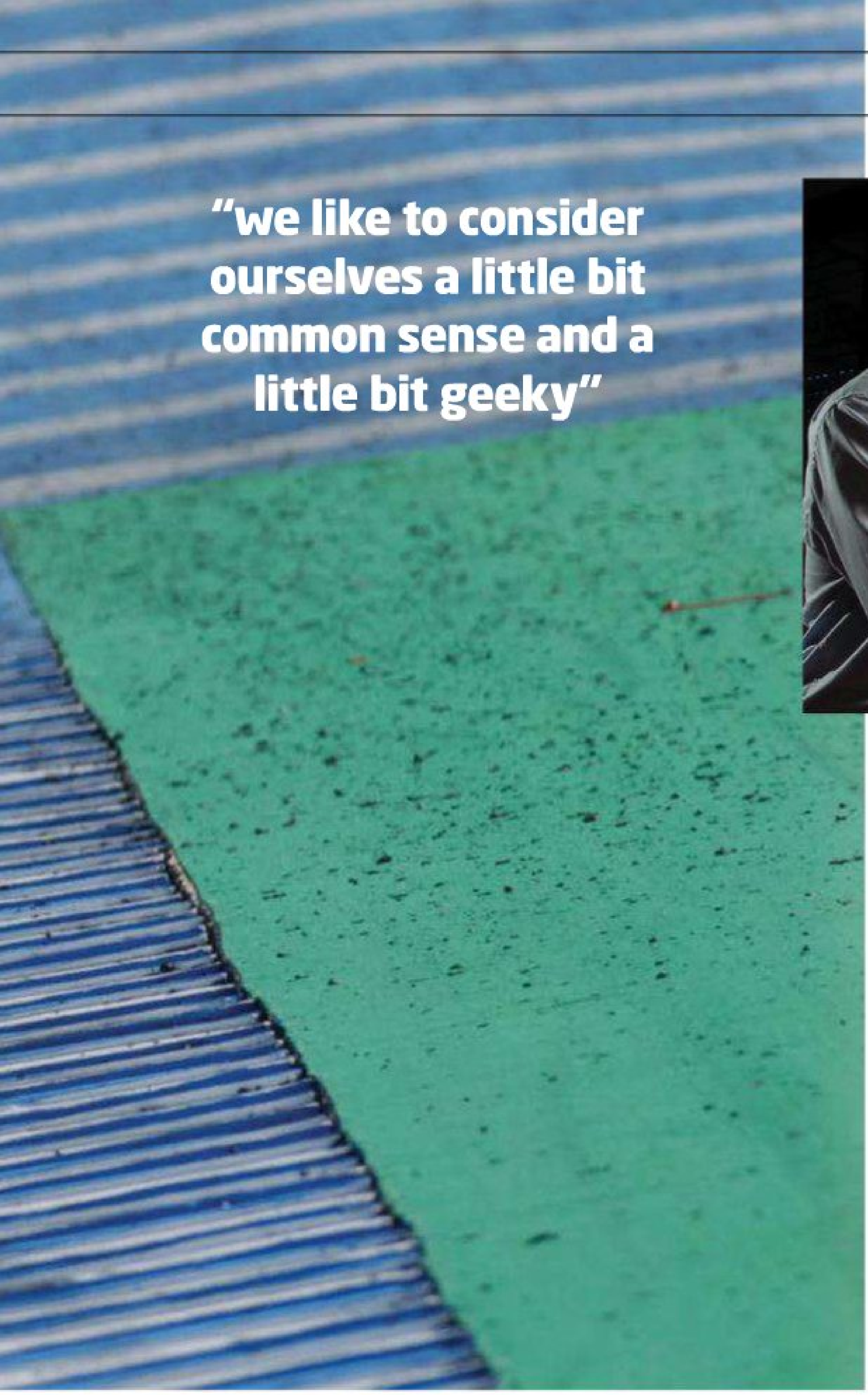
'We could see the automotive side growing, as well as the aerospace sector, but medical and marine were also of interest.' It worked. Soon the clients were signing up and, most famously, the company was integral in the design of the Lotus T127 Formula 1 car. The small operation caught the eye of Air Asia owner, Tony Fernandes, who acquired the company and made it an integral part of the Caterham Group.

'We are focussed on design and simulation of composites, and many see that as a bit of a black art,' explains Hall. 'We realised we could make it more accessible and de-mystify how to design and engineer with composites. People were, and still are, using it as what we call 'black aluminium' and that really isn't the most efficient way to use these materials. With composites, you need to think about using materials in different ways.'

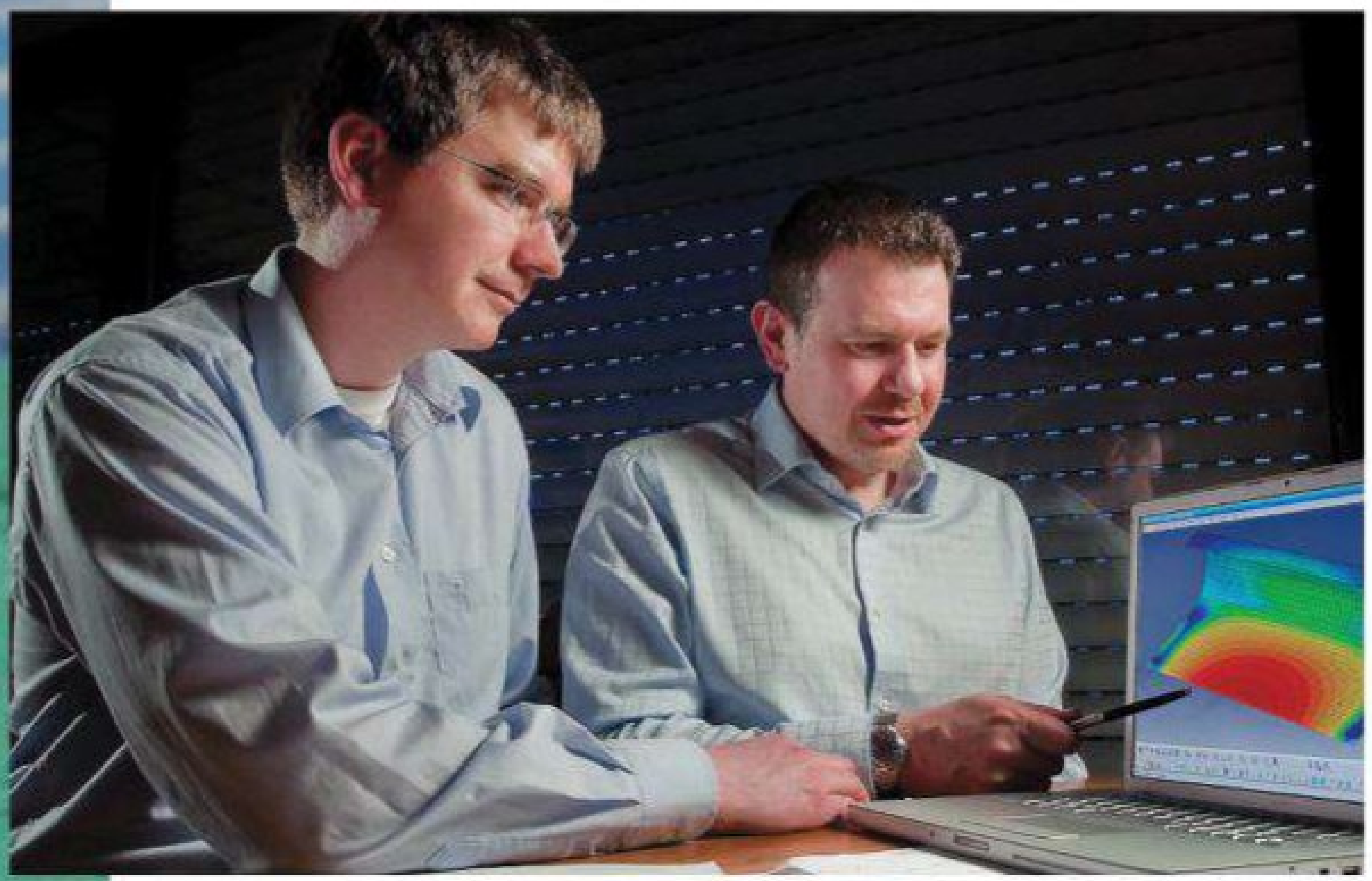
"de-mystify how to design and engineer with composites"

To improve the ability of the office in Cologne to do this, Caterham has signed a deal with Altair Engineering. 'You need to think about using the material's strengths, and that means a lot of computer-aided engineering, applying orientations for different load paths. So we use a lot of advanced simulation tools. We now have a full time Hyperworks consultant and can access their huge knowledge base. We can also feed back to them on some of the practical elements of composites, whilst they tend to live in the virtual world. We like to consider ourselves a little bit common sense and a little bit geeky at the same time,' he enthuses.

'We have these complex optimisation algorithms running to work out where you really need carbon and where you don't. We can then work out that you don't always need to make something out of carbon fibre, but could make it out of titanium, steel or aluminium instead. It's about lightweight construction and intelligent use of materials. Carbon fibre has limitations, dealing with multiple load paths and the third direction. In plane it is very good, but when you



"we like to consider ourselves a little bit common sense and a little bit geeky"



get into complex, out of plane loadings it gets more difficult to handle the load paths, and that's where you tend toward a more isotropic material such as aluminium, which you can load in all sorts of directions. But you can design both together to engineer that out, and that's the key. It's something we learned from Formula 1.'

That experience is key to the development of Caterham Composites and is the firm's main sales point, as it's the only freelance composites consultancy that has designed a Formula 1 car in the last three years.

'Formula 1 is a great learning platform. It lets you try all sorts of things. Every two weeks you are not allowed to fail, but in between you can do all sorts of development programmes. At Toyota, we were very lucky that we had access to this huge facility with all the rigs we ever needed. It was an engineer's dream to work there. You did all sorts of things, but one of the main areas we have developed from the knowledge gained was simulating dynamic crashing. Now we can simulate a nose box and, instead of building 16 noses and getting one through the crash test, we can now just build two or three and that is not easy to do. It is still very difficult to simulate as it is such a chaotic event, with many mechanisms of failures.'

Mike Gascoyne is a company shareholder and CEO, as well as being the chief technical officer of the Caterham Group, and he was instrumental in turning Composite Designs into Caterham Composites. 'They wanted to grow their company, but it was difficult for a very small private company to get some of the bigger customers through the door. So it became a lot easier as part of the Caterham Group. It was a better fit, and with a lot of those projects we were able to back it up with instant clients.'

That said, the original business model to grow the company outside of motorsports remains. To this end, Caterham Composites will be taking over the production facility at the Formula 1 base in Norfolk in August, once the team has re-located to its new Leafield home.

'We now have autoclaves, a clean room and we can plug it all into the back of our operation in Cologne. We can offer everything from a small part to a turnkey solution. There will be a lot of work on the new Caterham road car range, but we are not going to be designing thousands of series production parts. In terms of motorsport, we can offer a full car.'

Gascoyne explands on this, keen to show that his new operation is every bit the match for other similar operations in England. 'We can build everything up to and including a Formula 1 car. We know that because we have done it and you will not find a tougher environment and timescale than that.

'Formula 1 is going to lead the Caterham Group. The road car sales will be based on the fact that we are an F1 team, and the consultancy is is all about having Formula 1 knowledge and transferring that to other industries. One of the things about being a Formula 1 team is having access to all of the resources that are not normal for a company this size. Having a big marketing arm and access to a wind tunnel, CFD super computer and seven-post rig is not really achievable otherwise. But all Formula 1 teams have these things and they are very often under-utilised because they are only developing one product per year. It makes sense to use them in other areas.'

As he has been promoted inside the Caterham Group, Gascoyne will be spending a little less time on the Formula 1 project and looking to develop the other areas further, and it's clearly a challenge he relishes. 'It's nice to have something fresh to get stuck into and the Group is expanding rapidly. We already have a number of projects, but there is a lot of secrecy about some of them. We can say that we're doing aircraft internal components, working on some weight saving things and that there is the new range of Caterham road cars. While in motorsport, we are working with a number Formula 1 teams and doing some DTM work.'

"in terms of motorsport, we can offer a full car"

Caterham Composites looks like it is here to stay, and it is known to be working on lightweight flying vehicles and a racing yacht. It is also the first full service composites racecar constructor to come to the market since the collapse of Reynard, and that must surely be a good thing for the industry as a whole.

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Opportunity knocks

International motor racing appears on television and in the newspapers to be a slick operation, but behind the scenes, there have been many strange experiences at racing circuits. At Enna Pergusa in Sicily, Jean-Marc Gounon fixed his Ferrari's starting mechanism with a hammer, Tom Coronel educated the Sicilians in the first language of international motor racing, and my favourite was the Russian drivers, who toasted their WWII victory over Germany with a bottle of vodka in the hotel car park, leaving their German team manager, who liked a drink, in a quandary.

This year, Stephane Ratel has finally broken into the Russian market with a race in September, and I cannot wait to go. The idea of GT cars ploughing around a track just outside Moscow is as attractive as watching a Lamborghini lap Ceaucescu's palace in Romania.

The last time I went to the Middle East, I got stuck there for five days as an Icelandic volcano erupted and grounded all European flights. Now, I admit that being stuck in a five-star hotel, paid for by British Airways, was a luxury. At the time, however, we didn't believe we would be getting home for several weeks.

As a result, the inventive world of motor racing swung into action. Planes were chartered using team sponsors, flights were taken to the foot of Italy, where a colleague caught a train and spent three days on it. My plan was to get to the Ukraine, buy a car, and drive it across Europe. Sadly, I was talked out of it by the Ukranian contingent of my extended family. It is one of my few regrets in life. Instead, I got bored, booked a flight to Jordan, and made my way home from there.

If the US Grand Prix goes ahead in Austin, Texas in November, I will go. I may, this time, steer clear of the Armadillo Club, with an eight foot concrete armadillo outside and a good ol' boy in leathers and a Stetson playing a pink guitar on stage inside the venue, but I reckon it will be good fun nonetheless. Doubtless the circuit will be in slightly better nick than the car park of the Reliant Stadium, home of the Houston Texans. Watching a Ferrari ALMS car pitting in the disabled bay was a highlight of that year.

As MIA Chairman Chris Aylett points out elsewhere in this magazine, this is a time to go and explore the new markets. As Europe struggles economically, and variuos Grand Prix are under threat, Argentina has recently discovered a huge amount of oil on its land, and the South American region has always been passionate about motorsport. Personally, I loved Curitiba in Brazil, more than Interlagos, where even a brief walk in the street would be hazardous.

While the Korean Grand Prix was certainly not the most popular on the calendar last year, the stories from hacks and teams who were put up in 'love hotels' gives a little insight into the vague chaos.

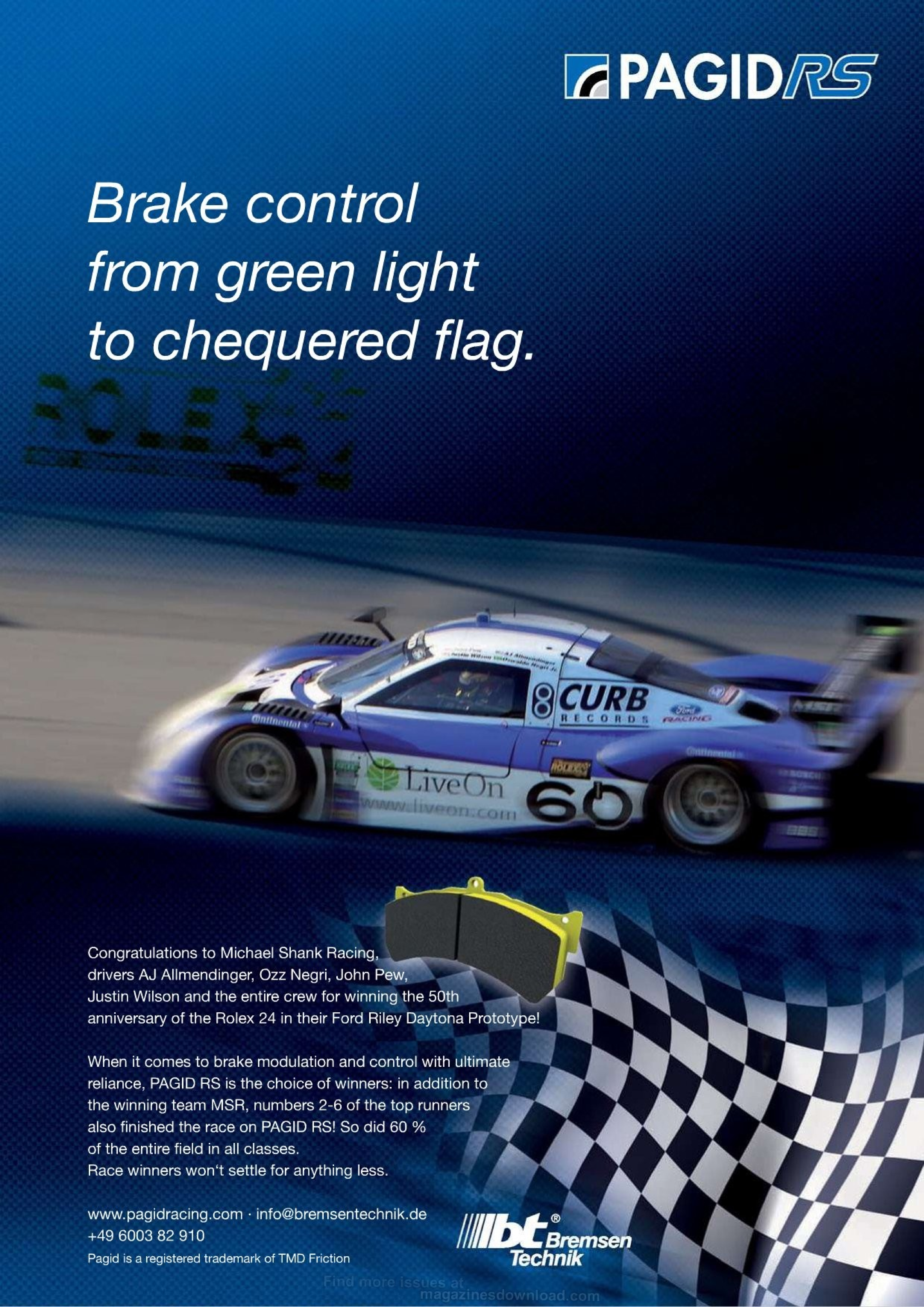
Right now, though, the interest seems to be coming from the Far East. Nissan has entered the Australian V8 Supercar series, the first time since 1993 that it has raced there, and is steadily stepping up its global racing programmes. Toyota has come to endurance racing, Subaru has joined the Super GT ranks this year, and others are sure to join. What next?

"the interest seems to be coming from the Far East"

Well, the Chinese seem to be getting very interested all of a sudden. Remy Brouard, a former general manager of the ACO, who also likes to race in the Spa 24 hours occasionally, is in charge of building business for the French club in China. According to Brouard, millions of new licences are being issued every month. It is a huge market for the European car manufacturers, and it is only a matter of time before they start to create cars that are interesting on a global market. Having attended races in Zhuhai, and watched the development of the circuit over the past 15 years, the track will never get a grand prix, and now even has lost Sportscar racing. That contract has been won this year by Shanghai, but the Formula 1 track will not have the same aura as Zhuhai in the early development days. Then, when it was gunning for a grand prix, journalists literally had to connect their own plug sockets in the press room and one meeting of track staff took place in the press room and ended with chairs being thrown. As new markets prove valuable commercially, from a purely personal perspective, I'll go to as many new venues as I can.

EDITOR
Andrew Cotton

Correction; In the March edition of Racecar Engineering, we stated that the cost of the Quaife 7-speed gearbox was £9000. It is in fact $9000, £6000. We would like to apologise for any inconvenience caused.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