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McLAREN MP4-27

The evolution of a Formula 1 title contender

GP3 power hike

Feeder formula to benefit from increased performance

Nissan unveils V8

First look at Australian Car of the Future engine

Lola collapse

In his words: company chief explains what really happened


DUNLOP

To turn or not to turn?

Understeer can be the bane of a racing driver's life

Just as 'E' is the most used letter in the English language, 'understeer' is surely the most used word in racing – seemingly cropping up more or less everywhere.

Turn-in understeer, power-on understeer, mid-corner understeer, off-brakes understeer, slow change of direction etc. Transition understeer, sous-virage...as many flavours as a good ice-cream.

There are even regional varieties, such as 'push' in the US. Indeed, upon starting work in Japan, I found a heretofore unspotted example: 'under-over', which in the racing vernacular there, meant oversteer induced by turn-in understeer. This is not made up – it does indeed exist.

So why are we plagued with this event? If I had one cent for every time the epithet has been heard in my presence I'd be living it up on a sailing yacht, sipping iced-espresso and admiring some pulchritudinous bodies for later approach.

Road cars are designed to be directionally stable, and few – if any – regular road users have an understanding of vehicle dynamics, and would be safer perched on some nag. Hence, when driven to the edge of the handling envelope, turning a road car involves a lot of steering lag and a bulletproof rear end to ensure it will stubbornly head straight on.

This is very useful when a driver on the way to the shopping centre is confronted by an obstacle which leads to brakes being slammed on. Keeping the whole shebang straight is a good idea, as a loose rear end would command counter steering, not something that's in everyone's armoury of driving skills.

Ploughing into an obstacle head on also facilitates the deployment of airbags, and the proper functionality of controlled collapse of the structure, safety-belts and the rest of the panoply of driving aids (or rather, crashing aids.)

In racing, that dreaded word is everything you don't want. Directional stability means it won't turn very fast, tending to plough on as the car keeps from being nimble. This is a particular asset in oval racing, where being tail-happy can make you visit the wall head-on, and the need for responsiveness is lower, attested by the steering ratio (up to 20:1, compared to the usual 9: 1 in formula cars). And they do go a bit faster in corners...

Now, God never created any animal that walked on its front legs. Four, or eight, or even more, yes. Rear legs, ditto. The subtle balance between all steering inputs given by steering wheel, throttle pedal and brake pedal depends on transient behaviour, and this is where all the driver's abilities come to the fore.

Steady state behaviour of the car can be corrected easily by the engineer, through shifting aero balance, weight transfer front/rear or weight distribution, as seen on ovals, which doesn't seem to be as critical as driver ability, but in all other classes the use of the inputs sits squarely with the driver.

Giving them what they want, therefore, is fundamental to the recipe for fast laps. This is true to the point that if you ignore vehicle dynamics, which tell you what the best setup is for maximum GG graph values, it can actually be faster purely because the driver has unusual habits.

"If you ignore vehicle dynamics, which tell you the best setup for GG values, the car can be faster"

GLOSSARY OF USEFUL TERMS

Understeer/push is when you hit the wall with the front of the car.
Oversteer/loose is when you hit the wall with the rear of the car.
Horsepower is how fast you hit the wall.
Torque is how far you take the wall with you.


SUPERTECH

Crunching E numbers

The brand new Formula seems to be short of one vital ingredient: logic

There is a peculiar type of conversation that can readily be eavesdropped on all around the world. It is especially prevalent in public houses, bars, saloons and on long flights. One of the conversational participants suggests an idea which on the face of it sounds utterly brilliant and impossible to fault in any way, like teaching a monkey to ride a Segway for example. Those involved in the conversation enthusiastically discuss details of the concept and eventually when the evening (as such discussions tend to take place after dark) comes to an end, everyone heads their separate ways, buzzing with thoughts and ideas related this great new thing that they've discovered at the bottom of a pint glass.

Then, in the morning, they wake up and realise that the idea was frankly a bit stupid, and utterly unworkable.

Another location where such conversations are heard is around boardroom tables, where lots of enthusiastic people start to brainstorm a new project, such as Formula E, FIA's new all-electric racing series for example. Now, whether you like the idea of electric cars or not, it's clear that there is a demand for all-electric motorsport in all sorts of markets, so the question really is how should professional motorsport tap into that demand?

It's at this point that one of the aforementioned types of conversation took place, when the organisers of Formula E sat down to thrash out the details of the new series.

Put yourself in their shoes. Imagine you could come up with a brand new World Championship from scratch. What cars would you use? What would they look like and where would you race?

The FIA is keenly aware that it's missing out on the youth market, the internet-savvy, smartphone carrying, app installing, Facebook using kids of today, and hopes that Formula E will engage them. They want the cars to look wild, sound good and be seen in all the right places, and that's not purpose-built race circuits.

The races will be held all around the world with Rio de Janeiro the first to sign up, and other bids are expected to be announced soon in internationally renowned locations like Monte Carlo and er, Cheltenham (in the south-west of England). All of the races will be run on urban courses built especially for Formula E. During the races, which will probably be around 40 minutes in duration, every car will need to make a pit stop. Not though to change tyres, or batteries. Nope, in Formula E the drivers will get into another car during the pit stop. So, for every driver in the race a team will actually need two cars.

This is the point in one of those conversations I mentioned earlier when it all seems to get a bit too far-fetched. Formula E wants a 20-car grid, so that means each two-car team must buy four cars and ship them all around the world. The cars themselves will be far from cheap either. They'll generally be purpose-built chassis, albeit to an approximation of F3 technical requirements, but the EV powertrains will be hugely expensive, and I suspect the cars will cost around $1m a pop (and remember you need two of them). So just who is going to pay for all of this? Some manufacturers may be interested. Toyota and Nissan both spring to mind immediately, but the bulk of funding will have to come from the usual sources: drivers, and the rich fathers of drivers.

"The FIA want the cars to look wild and to sound good"

This is where this concept falls down. It will likely cost more than a season of GP2 or F3, but won't have the benefits of those classes. So why would a driver take part in Formula E? Indeed, why would a manufacturer? There are already high performance EV projects such as the Nissan Leaf NISMO RC and the Mitsubishi i-MiEV Evo. Why did Formula E's organising team not accommodate these projects?

One great positive is that Formula E will not be a spec class. Formulec will supply the official car, but anyone can design and build a car to meet the regulations, which could open the doors to new names such as Mirage (no not that one) of Italy, which has already shown off its new all-electric open wheeler, although this wasn't built specifically for Formula E. Indeed a new multi-chassis Formula is great and just what the industry needs, but I think perhaps while the overall goal of Formula E makes sense, the execution of it hasn't been properly thought out. In its current form, it'll be far too expensive and it lacks sustainability.

That last point is especially important. Sustainability is a buzzword all over the place these days, rather replacing the previous buzz phrase of 'green'. But flying 40+ cars around the world, to race on incredibly expensively constructed street circuits, just doesn't cut it.

I hope that the powers that be at Formula E will sit up and realise that it is the next morning, and they got a bit carried away with the idea. An electric racing championship is a good idea, but I think its time for a sanity check.

Formula E will not be a spec class, encouraging manufacturers to build chassis, but the category will be expensive

It's all in the detail

The trend-setting McLaren MP4-27 has been a race winner in 2012

BY SAM COLLINS

McLaren's MP4-27 is a good racecar. That much is obvious. By the end of the European racing season it had won more Grands Prix than any other car, yet the unpredictable nature of the 2012 season meant that it headed into the championship showdown not topping either of the World Championships.

The car has been consistently competitive throughout the year, although according to Paddy Lowe, McLaren's technical director, 'it doesn't always feel like we have been at the front. It has been quite a tough year just trying to get that consistency, but everyone has struggled in the same way. You tend to focus on the challenges you have faced yourself, rather than how others have fared. We have learned a lot along the road, but it is all driven by trying to keep the tyres in the right window.'

Indeed the characteristics of the revised Pirelli tyres are something that surprised many teams in the paddock, including McLaren. When the MP4-27 was launched, much of the focus was on recapturing some of the downforce lost due to rule changes related to exhaust position and usage.

'Every year, we sit down and want to design a race-winning car,' says McLaren's director of engineering, Tim Goss. 'We didn't have the quickest car at the start of last season, but we did everything possible to build the quickest car possible this season. We set ourselves very tough and ambitious targets and the car was a complete re-work from nose to tail. Everything on the car was changed.

'I think there's very little that we've carried over. There's a few pieces of the fuel system, but otherwise I think just about everything on the car has changed. We've worked extremely hard at producing a very integrated aerodynamic and design package. Our main objectives for the 2012 season were to optimise downforce

despite the changes to the blown floor, and to improve our understanding and utilisation of the Pirelli tyres, which were new to us last year.'

While almost the entire car was new, the concept was still evolutionary as the 2012 car carried over components from its predecessor, the MP4-26, including the in-house carbon fibre gearbox (built by McLaren and supplied to Force India), the 2.4-litre Mercedes-Benz HPE engine, and many of the smaller components.

McLaren's 2011 car, the MP4-26, was also a race winner and had some very distinctive design features including a sidepod shape. For the 2012 season, this concept was dropped, but not because it did not work.

'Last year's U-shaped sidepod worked very well indeed with what we were trying to achieve with the exhaust layout,' explains Goss. 'It was all intended to create more down wash to the rear end, and it performed particularly well. This year, at a fairly early stage, we set about a different approach to both the external and the internal aerodynamics of the car. Once the exhaust regulations had started to become clearer, it was quite obvious to us that the U-shaped sidepod no longer fitted in with

The 2011 MP4-26 featured a distinctive U-shaped sidepod concept, but late changes to the exhaust regulations saw McLaren abandon it. Overall the MP4-26 was a strong basis for the MP4-27

both the internal aerodynamics and some of the external aerodynamics that we pursued early on. So it works, it worked very well last year, but it's actually just not suited to what we're trying to achieve this year.'

Indeed the whole U-shaped sidepod was defined by the blown diffuser concept, something that was not widely reported at the time. It was all about channelling the air flow, and in turn the exhaust plume, down into the space between the inner edge of the rear tyre and the outer edge of the diffuser.

But the FIA outlawed the low exhaust exits used on the 2011 cars and the engine maps crucial to the off-throttle blowing (see V22N7). 'The regulations around the exhausts became very prescriptive: the exhausts must now exit within a very tight space at the rear of the car in order to minimise their aerodynamic influence,' Goss explains.

'The final 100mm of the exhausts must be cylindrical – so they can no longer be oval, or flattened – and must be sited at a particular vertical and horizontal angle – between 10 and 30 degrees upwards. That's to direct the exhaust exit away from the floor. They have the inevitable impact on the flow-fields around the rear of the car, yes. In previous years, the exhausts exited directly into the rear corner of the floor. We can't do that anymore so, as you'd expect, that changes the flow characteristics at the rear of the car. The knock-on effect is that all of the aerodynamic devices at the rear of the car have had to be re-designed.'

The MP4-27 features fairly conventional rectangular sidepods, at least when viewed from the front. 'The rule changes put the exhaust position right in the middle of the U-channel,' explains Lowe. 'Having to have the exhausts in the middle of that channel destroyed that approach, so this years sidepods are a lot more conventional.'

The rules also meant that McLaren had to come up with an entirely new exhaust concept. Whilst the rule changes saw off one approach to the blown diffuser, the concept itself was

Key to the design and development of the MP4-27 is the 'Coanda' exhaust. It has been copied by most of the teams on the grid, and channels the exhaust plume to give the effect of a 'cold blown' diffuser

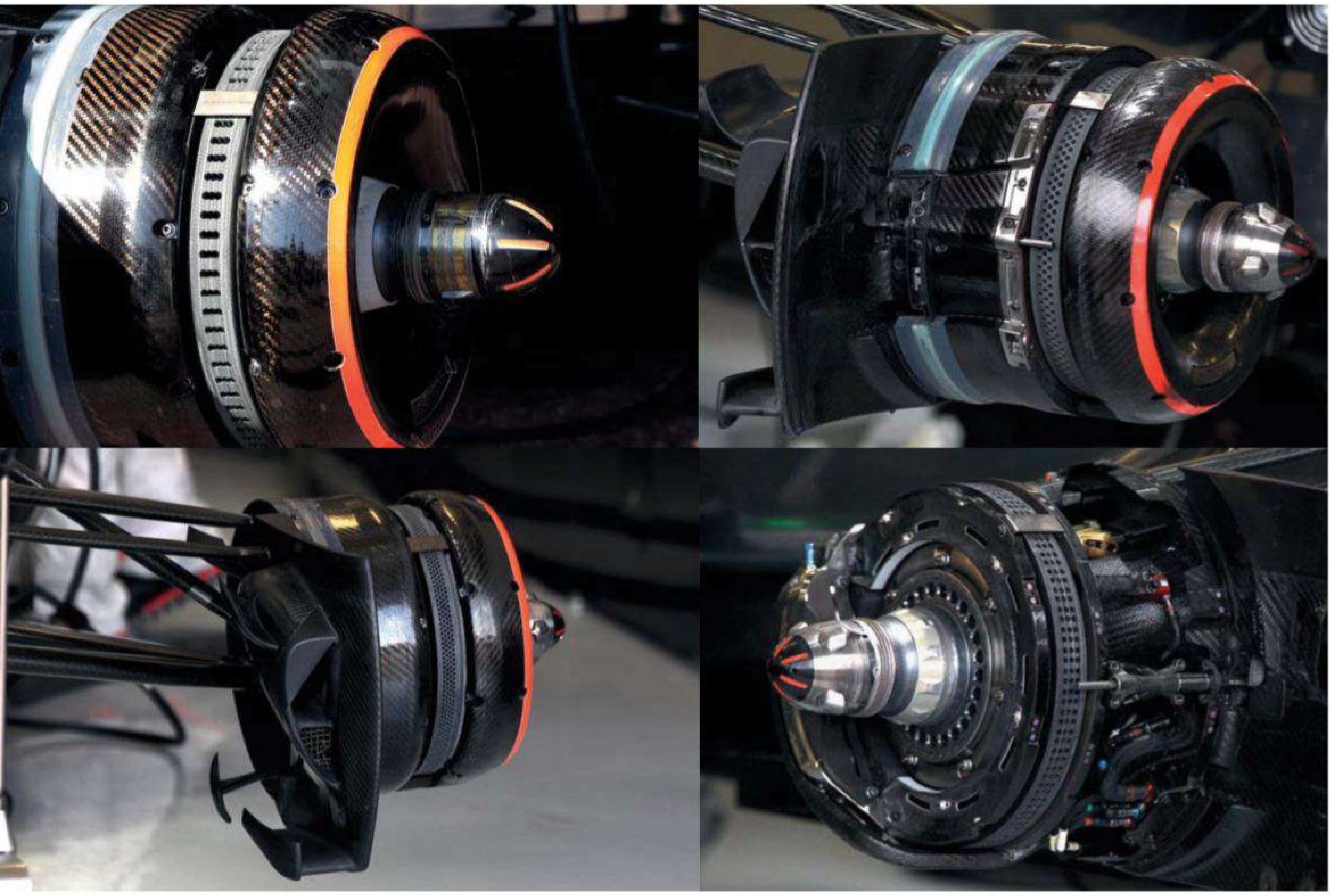
not outlawed. 'Blown diffusers in themselves have never been defined, and therefore were also never banned,' stresses Lowe.

'That's an important point to make. What we were doing last year was exploiting the exhaust to deliver a huge amount of aerodynamic performance and for this year, that performance has been severely reduced by changing the rules around exhaust exits and engine mapping.

'Are people still generating performance from the floor, including some elements of exhaust-generated downforce? The answer is yes. We are doing that and I think most of the teams are to a greater or lesser extent. It's a direction where you can find some performance, but it's not anything like as extreme as it was in 2011.

'Whether it is in the spirit of the rules or not is unimportant. There's no such thing as the spirit of the rules. It's a term often used, but the rule book is text that has a meaning, and you decide what that meaning is and you work to it. There's no headline regulation that says 'above all else, you've got to remain within the spirit of what was intended'. I'd like to think that we were the pioneers of this blown-floor concept. We were first, along with Sauber this year, to come out with exhaust designs to do that, and most of the teams on the grid now have it.'

The MP4-27's exhausts exit the bodywork via a bulge in the rear portion of the sidepod. A small channel behind the exit itself, and the overall shape of the sidepods themselves, channel the flow to that crucial area at the rear of the car's floor. In fact, the main focus of the car's aerodynamic design since it was launched at the start of



Brake cooling and disc design has been a key area of development on the MP4-27, as McLaren struggles to control the temperatures of the Pirelli tyres. Here we see four different patterns of drillings on the discs. The image on the bottom left also shows the complex devices in the brake duct areas

Failures in McLaren's in-house carbon fibre gearbox (also supplied to Force India) have cost the team some points

the season has been about the four corners, and in particular the tyres. Pirelli revised its compounds for the start of the 2012 season and the result has been some of the best racing in Formula 1 for a long time.

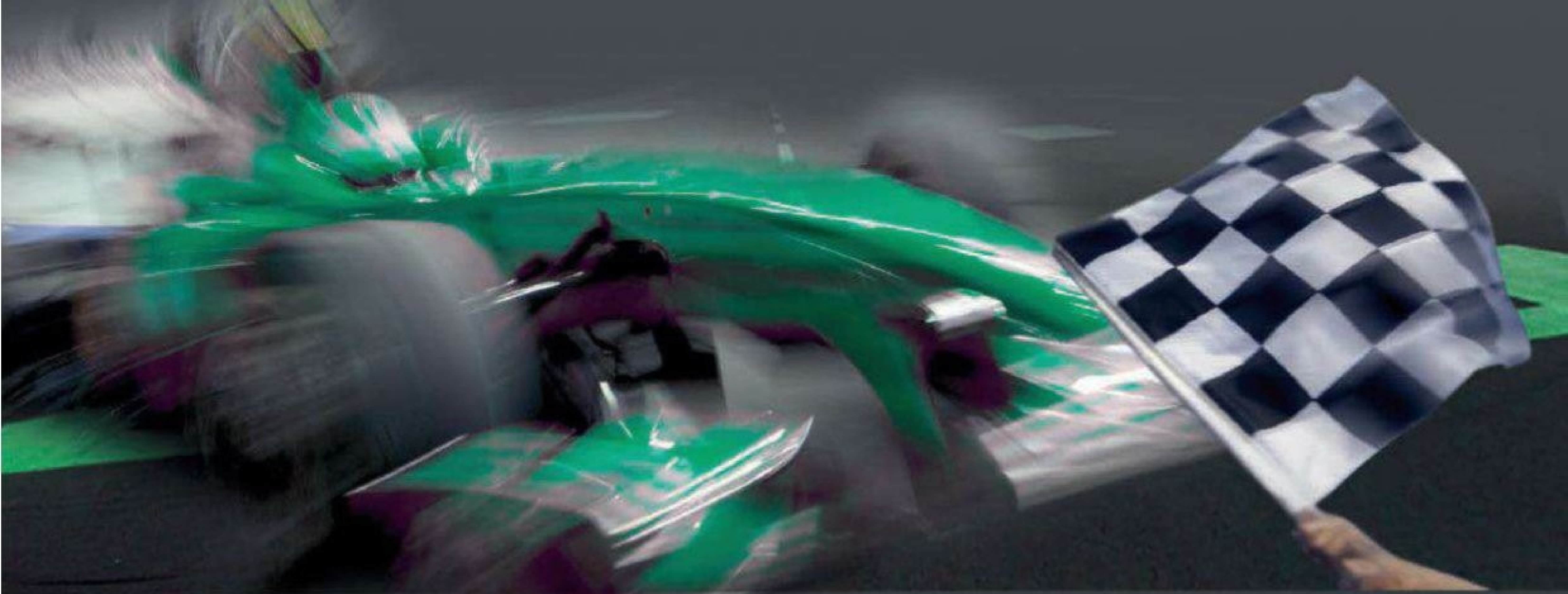
'I think the effort to get on top of the tyres has increased during the season, as they have proven far more critical than expected,' admits Lowe. 'I doubt Pirelli predicted how critical the tyres would be this year. The changes to the tyres over the winter seemed to be reasonably small, but the impact has been dramatic. Indeed I'm not sure Pirelli understand it themselves.

'A great example of the races being dominated by tyre conditions, and in particular tyre temperatures, was Malaysia. Jenson [Button], came out into clear air on a new set of tyres from near the back and had some extraordinary pace, as his tyres were in the correct temperature window.

'As soon as he came up on some traffic, and didn't get past immediately, you lose that temperature and you spiral into much lower performance – to the extent that the drivers you catch up can start to leave you behind again.'

Aerodynamic elements have been developed or redeveloped to improve how the car works its rubber, notably the brake ducts (see sidebar), as Lowe explains. 'You may call them brake ducts, but in reality they are air ducts as you no longer need them to just cool the brakes.

'It was something F1 went away from in the regulations as it was too difficult to police, so we use those devices to generate aerodynamic downforce, as well



as cooling the brakes and calliper, and a big thing is controlling the rear tyre temperature. We are certainly measuring a lot more and putting a lot of work into that corner, especially looking at the air ducts. Whilst we develop all of the car all of the time, we have put extra effort into the air ducts and the area around it.'

This optimisation goes to a great level of detail, even to the drillings on the brake discs themselves – something McLaren has worked on extensively in 2012 with the designs frequently changing.

'It can be simply down to driver preference which brake they want, but its all part of this optimisation of the corner cooling packaging,' explains Lowe. 'We have different styles of disc drillings which impact the cooling, but also the behaviour of the brake, and drivers have different preferences for brake fluid and brake feel. One disc may be more controllable and the other more aggressive in initial attack, but with a different consistency.

'With different types of material and geometry of cooling holes you can get different characteristics.'

NO BIG DEAL

Of course the most distinctive thing about the McLaren MP4-27 is the look of the car. It is one of only two on the grid (see p22 for the other one) that does not feature a 'hump' in the nose. This is because for some years McLaren has used a comparatively low nose on its cars and continued this concept into 2012.

The rules on nose height and chassis height led to the stepped noses of rival cars, which overall have a higher chassis. Whilst the difference is obvious to they eye, it does not seem to have much impact on the time sheet.

'We don't regret doing the low nose,' explains Lowe, 'but we are an outlier in this respect. It is one of these things that looks very dramatic, but it's just one thing of thousands on the car – there others that are not as obvious with a much higher influence than the nose.

The chassis and nose height are something you decide on very early, as they are fundamental to the rest of the design.

'We are not unhappy at the route we took. Is it the best? I don't know. It is the route we have gone, so it's like asking

IN-RACE BRAKE COOLING ADJUSTMENT

After the switch to Pirelli tyres, a lot of care has been required in managing degradation in rear tyre construction. This drop in tyre performance happens when the tyres fall out of their operating temperature window because they are running too hot, or too cold. McLaren has been active in understanding this problem and, over the past year, has developed an innovative method of controlling tyre temperature via its relationship with brake temperatures. it has an adjustable brake duct set up and this can have an impact on tyre temperature.

Formula 1 carbon brake disc temperatures can peak at over 1000 degrees centigrade. The discs being 278mm diameter inside a 305mm wheel means that there is little space between the two, so heat inevitably passes from the disc into the magnesium alloy wheel. By altering the flow of heated air coming from the periphery of the brake disc, the amount of heat passed into the wheel and tyre and can be altered.

Teams already tune brake cooling with different inlet scoops, but these tend to stay fixed from the qualifying laps of a race onwards (wet races excepted). If the team wants to alter brake, and thus tyre, temperatures, during the race they're usually prevented from doing so by *parc fermé* conditions. However, McLaren has fitted an adjustable window in the rear brake ducts. A mechanic can adjust this in the pits to tune the brake and tyre temperature to suit conditions via a control near the fuel filler.

To do this, McLaren have altered their brake cooling design from most other teams. More typically, the round brake drum cooling ducts exit the airflow from the brakes through the rounded outer face of the duct. This then passes out through the wheel spokes. McLaren's brake discs vent through openings in the outside of the brake drum, with its outer face closed off from the disc. So, all the hot air flows between the duct and the wheel before exiting through the wheel itself.

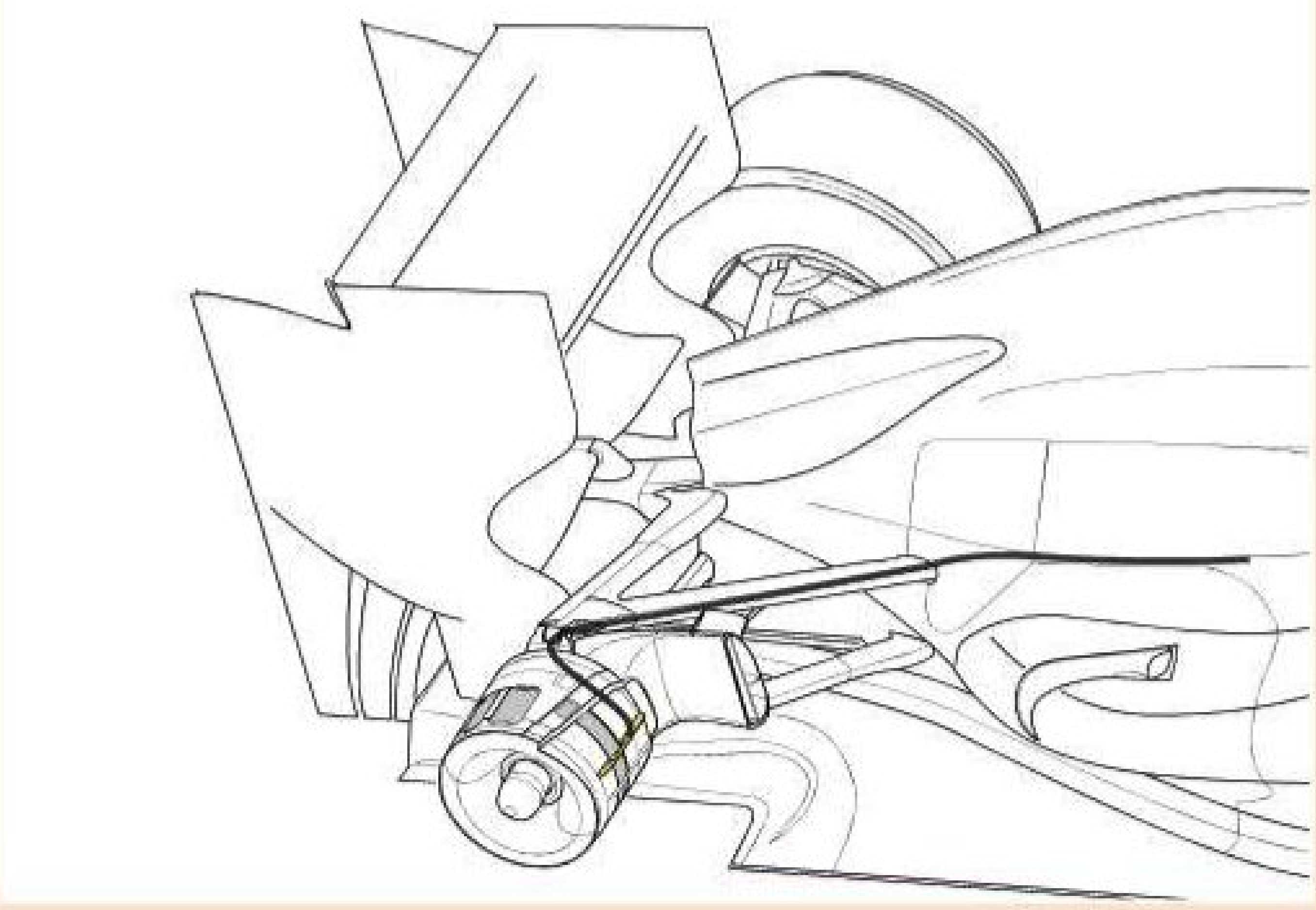
To accommodate this flow, McLaren's wheel spoke arrangement has been altered. The Enkei wheel features 29 drillings around the face of the rim, with the more conventional spokes positioned inside them. The air flow from the brakes is also directed through these drillings. With this set-up, the heated airflow has far more contact with the wheel, both as it passes towards the spokes, and from the spokes themselves, which have more surface area to absorb heat.

Changing the brake ducting will alter the amount of brake cooling: opening the duct will allow more heat to escape and reduce brake disc temperatures and vice versa with closing the ducts. Adjusting the rear brake temperature may not be the sole reason this season. With changing tyre balance and KERS usage, the rear brakes have been prone to overheating. But the more likely benefit is the effect of the brake heat altering tyre temperature. As the brake heat passes through the smaller set of drillings in the wheel, which has a greater surface area than the more usual 8-10 spoke wheel, allowing more heat to transfer into the wheel.

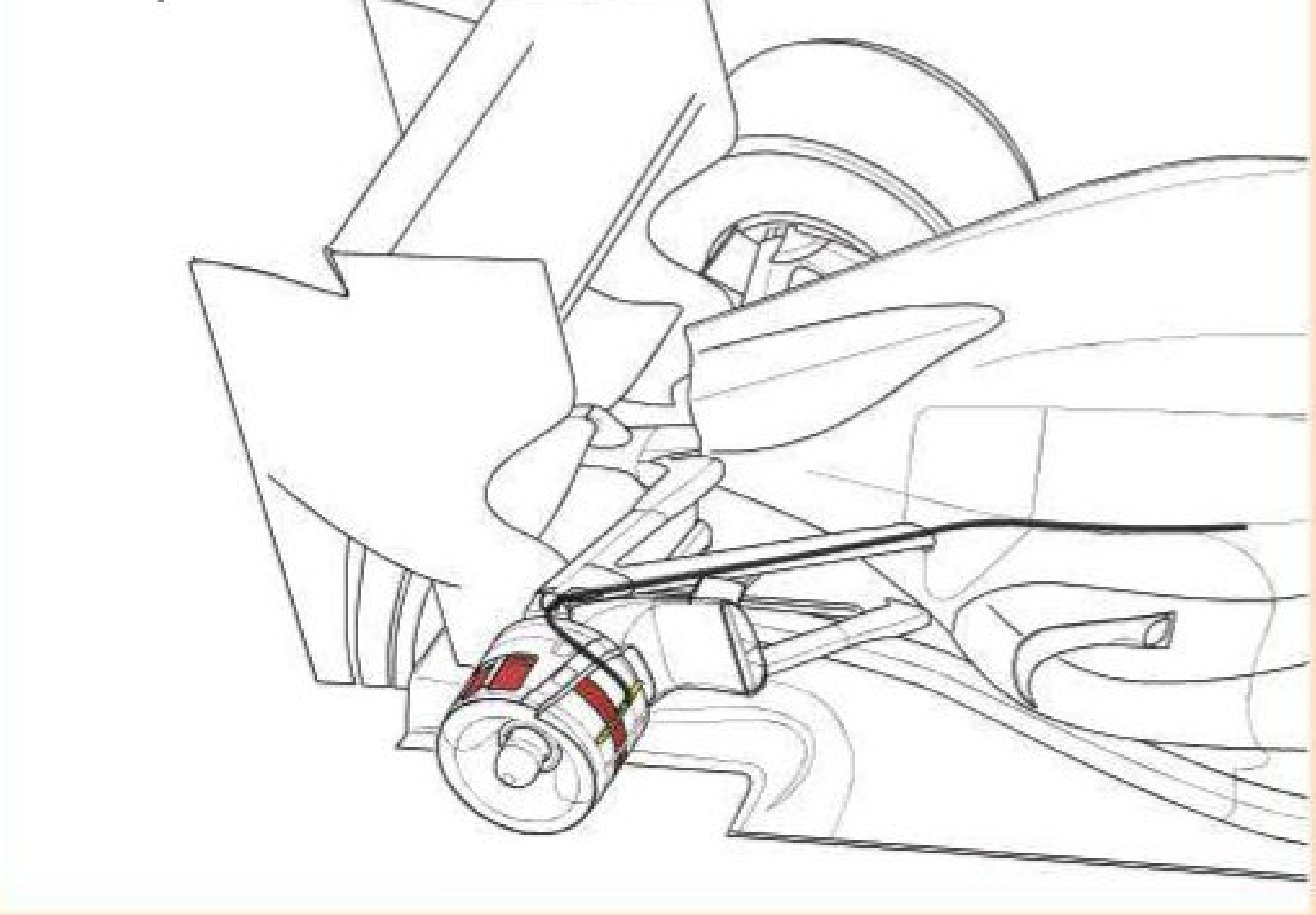
Heating the wheel will transfer heat into the tyre; this will be useful when the driver is struggling for tyre temperature. The contrary is reducing the heat transfer into the wheel to reduce tyre temperature when the driver is struggling with heat-related degradation.

Craig Scarborough

Duct closed



Duct open



Sidepod wings first trialed by Sauber and then Red Bull appeared on the McLaren after the summer break, taking the place of small turning vanes

is my front wing the best? I don't know if it makes as much downforce as the Ferrari front wing, but it's the wing we have. The nose gets a level of attention it does not deserve because everyone can see it, but it's just not a big deal.'

The MP4-27 won on its debut in Melbourne and has since taken wins at Montreal, the Hungaroring, Spa and Monza [correct at time of going to press], alongside a good number of podium and points finishes. Heading into the closing stages, a McLaren driver is fourth in the championship and the team is second in the constructor's table. And it would certainly be topping the latter, had it not been for a small fuel system issue in Italy, and two unwanted interactions with other cars (those of Maldonado and Grosjean in Valencia and Spa respectively) and a gearbox failure for Lewis Hamilton in Singapore having set pole position time and led the race comfortably.

Despite this, McLaren is broadly upbeat about the season to date, with the car on balance the best all-rounder this year. 'The thing we are most proud of on this car is the exhaust design,' concludes Lowe. 'We put a lot of effort into that. It's always nice to see the other teams, with all of their engineers working on the same problem, come back and conclude that your concept is the best and copy it. That's a great compliment.

'But the opposite applies if there is something on another car that you have to pick up and the other team gets there first. It's not good and there have been a few of those too, but nothing substantial.

'In general, though, I am really proud of this car,' concludes Lowe. 'It's done well, came out of the box and got two front rows in the first two races.'

'The biggest thing we are proud of on this car is the exhaust design'

The core mechanical components of the MP4-27 were carried over in modified form from the MP4-26

TECH SPEC

MCLAREN MP4-27

Chassis: McLaren-moulded carbon fibre composite, incorporating front and side impact structures

Suspension: Inboard torsion bar/ damper system operated by pushrod and bell crank with a double wishbone arrangement

Brakes: Akebono six-piston calipers, carbon fibre pads and discs

Transmission: In-house longitudinally-mounted carbon fibre, seven-speed quick-shift; carbon fibre clutch

Electronics: McLaren Electronic Systems. Including chassis control, engine control, data acquisition, dashboard, alternator, sensors, data analysis and telemetry

KERS: Mercedes HPE

Tyres: Pirelli

Radio: Kenwood

Batteries: GS Yuasa Corporation

Steering: In house PAS

Wheels: Enkei

Weight: 640kg (inc driver, tank empty)

ENGINE SPEC

Mercedes FO 108Z

Type: Naturally aspirated V8; 90-degree cylinder angle; electronic injection and ignition, NGK plugs

Valves / valvetrain: 32 / pneumatic

Fuel: ExxonMobil (5.75% biofuel)

Lubricants: Mobil 1

Bore: 98mm

Weight: 95kg

They threw power at it... Lots of power

Organisers decided that the GP3 series needed something special, and so boosted engine performance by 120bhp

BY SAM COLLINS

Below Formula 1 there is an ever increasing number of single spec, open-wheel racing class, often dubbed feeder series. GP2 is the most successful, having produced thirteen of the 25 drivers who have raced in this year's Formula 1 world championship. In 2010, buoyed by the ongoing success of GP2, the series organisers decided to introduce a new class for younger drivers and dubbed it, predictably enough, GP3. Like GP2, the grid was made up of Dallara-built, single spec open-wheelers run by professional racing teams. Power was delivered by a two litre Renault engine producing around 280bhp.

For three years this format worked reasonably, with one driver having graduated to Formula 1 by the start of the 2012 season, but the organisers felt the need for change. 'Like GP2, we work on a three year cycle so it was time for us to update the GP3 car and define a new machine,' explained GP2 and GP3 series Technical Director Didier Perrin. 'Along with that we have decided to change the positioning of the series, as we felt that the gap between GP3 and GP2 was too large. The target for GP3 is simply to get the driver well prepared for GP2, then after that for F1 and we thought we could do it better.'

The way Perrin and his team decided to close the gap between the two series and help the drivers prepare for the step up is disarmingly simple, they threw power at it. Lots of power. Renault's 280bhp inline four has been replaced by 400bhp 3.4 litre V6 from English firm AER.

It is very loosely based on the firm's P25 V6 model, which itself is based on the production block of the Nissan VQ35 engine. In road car application it is fitted to the Nissan 350Z. Over the years AER has extensively re-engineered this engine (originally for use in the Nissan World Series). The re-engineering includes a bespoke dry sump conversion, bespoke pistons, connecting rods, crankshaft, camshafts, valve gear inlet system. In P25 spec the engine is good for up to 500bhp.

'The base engine from AER is something they developed a long time ago, which is a guarantee of reliability, but the top of the engine, cylinder head, and injection is a bespoke design for our requirements,' adds Perrin. 'This engine is able to give even more power. But we wanted a very narrow window for variations between individual engines as we wanted it to be fair. To get the engines to stay equal through the year we de-tuned it a little bit and decreased the power to make sure that they are all even and reliable.'

A FULL REDESIGN

The reworked engine features a new drive-by-wire system, new inlets, cams and pistons; essentially a full redesign. But the work seems to have paid off and early testing has gone well according to Perrin: 'The key thing in choosing the AER engine was the ability to deliver the desired power at reasonable cost and with good reliability. AER has huge experience and that was a guaranteed way of getting what we wanted. We looked at it, and other engines, just over one year ago and this engine was the best all round solution. The testing so far has shown a perfect reliability, and the performance is exactly what AER predicted.'

"the key thing was the ability to deliver the desired power at reasonable cost and with reliability`"

Increasing the power and displacement in a car as small as the GP3 chassis required some significant additional updates to the chassis design, something the well known team at Dallara tackled to Perrin's specification.

'Having decided to reposition the series and fit the larger engine, we had to work on the results of that. For example the car is now longer as the engine is larger, and that extra length is not just down to the block, but the whole installation. It adds around 100mm in total. But the whole rigidity of the car has improved because the architecture of a V engine is better for that than a four cylinder. We had to look around the rest of the car as well as under the engine cover, and keep the budgets under control, so we have decided to retain the chassis and suspension of the car, but the monocoque will be updated in terms of safety and all of the tubs will be sent back to Dallara. Anti intrusion panels will be fitted, and it will meet the F1 regulations in that respect, so that's a

The overall look of the car is based on the GP2/11

Despite having more power the downforce levels are the same as before

Increased driver protection was a priority with new side panels

The AER V6 engine had bespoke heads and a major overhaul for GP3

big step forwards in safety. The gearbox and suspension are the same, with minor adjustments for the higher speeds, the wishbones will be reinforced, the uprights are new due to the higher top speed, and there is increased braking force. The car is 30kph faster in a straight line, so the forces are much higher. Of course we have therefore had to improve the brakes. It has larger calipers and a new design of discs, but we have stuck to steel discs rather than carbon discs for budget reasons.'

These updates have impacted the mass, but according to Perrin not its basic characteristics: 'We made sure that the weight distribution is exactly the same as the existing car, but overall the car is a bit heavier with the reinforced tub, around 8kg. The brakes are heavier too, and as the car is 100mm longer you have more bodywork, and that makes it all heavier so overall. In total it is 20-25kg heavier than the original car but it has 120bhp more so it does not matter.'

COST INFLUENCE

Budgetary concerns were a significant factor in the design for the new car, with many technical decisions being directly influenced by the cost. But, as with the engine, reliability was equally important. 'We didn't want to take any risks, we wanted people who were experienced and products that were reliable,' says Perrin. 'The gearbox, for example, is identical to the old car, but the bell housing is of course different as is the final drive. We have changed that to allow teams to retain the same gear ratios, so whilst the engine rpm is different they should be able to use the current ratios. The operational costs have been a major factor in the design process and that is a great example.

When we defined the gearbox we considered having a higher torque so that in future we could increase the engine performance without changing the cluster. Now we have done that and the teams don't need to buy anything new. We always try to consider the teams and the long-term future of the series, we try to make things as easy and cheap as possible for our teams.'

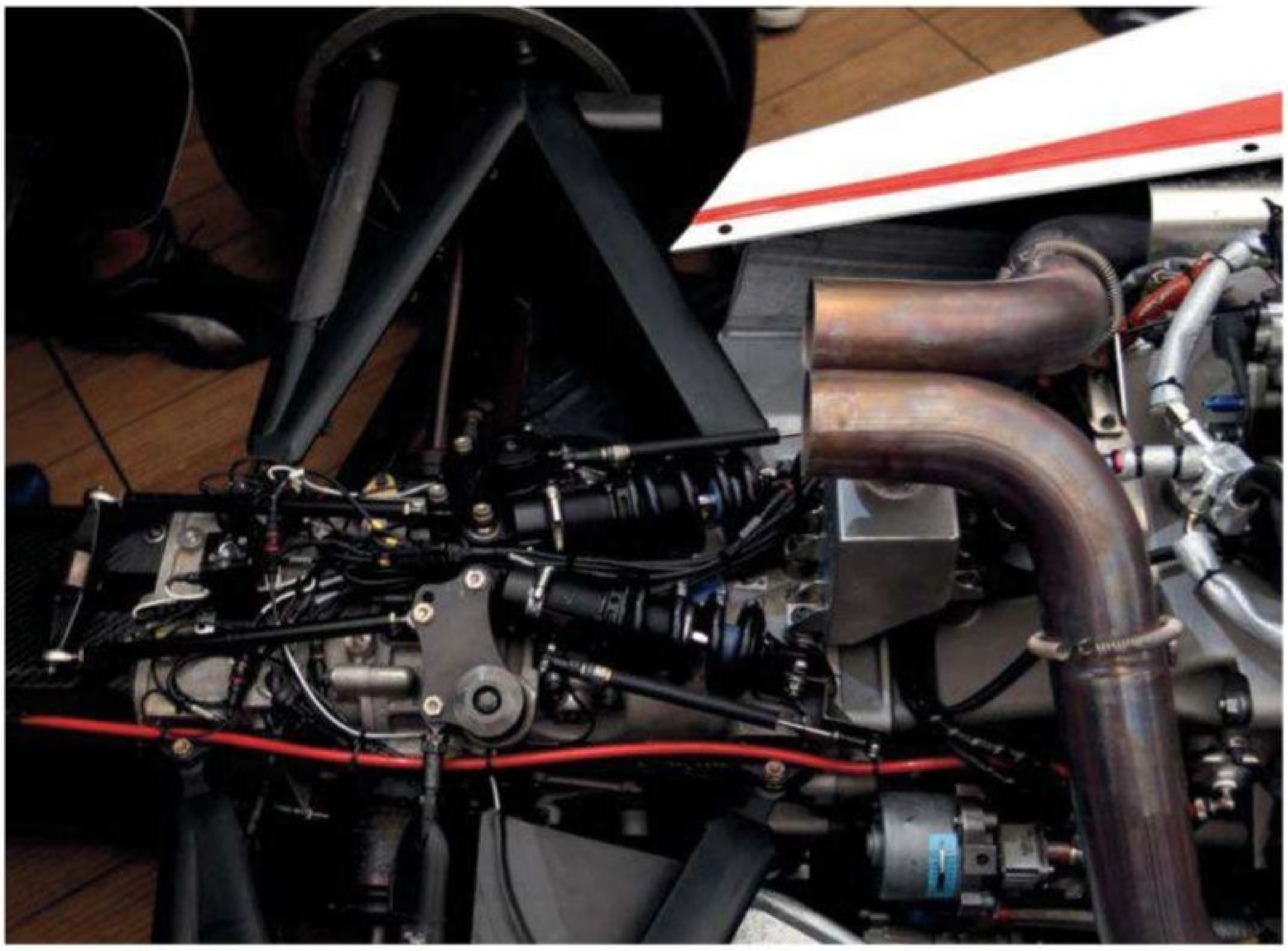
Making things easy for the teams was exactly the opposite to what Perrin wanted to do for the drivers, and this becomes immediately apparent when you look at the car's aerodynamic package. 'We could have made the new car a lot faster, but it is at least three seconds a lap faster. Some series are focused on lap time, we are not we want a car with a similar power to downforce ratio that they will find in GP2, instead of increasing the downforce and sticking the car to the track. We want to see what the drivers are able to do, so we want it to be difficult for them to drive.

'With the aero we have decided to keep the downforce levels exactly the same as the original car, because we wanted to increase the power to downforce ratio. The tyre size will not change. We want the car to be harder to drive, more selective, and our test driver Ben Hanley was surprised when he first drove it, saying that the drivers are going to have to take care of the throttle pedal as it's a lively car to drive.'

BELT AND BRACES

Once the redesign of the car was completed Perrin and the team from Dallara took a belt and brace approach to the aerodynamic package, making sure it is predictable at the higher speeds that the car will run to. 'We have made sure that the centre of pressure is in the same place as

"the idea is to get the driver used to the sort of tyre behavior he will find in GP2 and F1`"



Due a heavier car with higher aero loadings the wishbones of the GP3/13 have been beefed up

it was on the original car and we designed it for that. On top of all the CFD and wind tunnel work that Dallara has already done, we will do two full days of straight line testing to check the aero performance. We want to supply the teams with an aero manual validated on the track and which will give them no surprises with the aero data,' explains Perrin.

If an extra 120bhp and no increase in aerodynamic grip was not enough of a challenge for the drivers, Perrin has been pushing tyre supplier Pirelli to make the 2013 GP3 tyres more closely resemble the notoriously tricky Formula 1 rubber. 'We will keep using the same dimension and make of tyres but the compounds will change to cope with the higher power,' he explains. 'The idea is to get the driver used to the sort of tyre behavior he will find in GP2 and Formula 1. This means replicating that narrow peak of performance of the tyres we see in Formula 1, as well as the sharp degradation. We have insisted on tyres that degrade. It is important for the driver to learn how to manage the tyres as they will do in F1.'

SEX BOMB

Finally Perrin wanted a car that had a lot more sex appeal. The look of the original was not universally popular and the sound had been likened too that of a Volkswagen Beetle by some people. That has all changed with the new car.

'It had to be much more sexy too that was really important, first because, for a driver, it will be sexy to drive with the extra power, which means that they will have fun. Second it had to look sexy so we have changed some body parts to make it look like a scaled down GP2 car and as you can see it is much more sexy. Finally it has to sound more sexy and it really does, the sound is very important and it is a sexy sound, we have made a huge step forward with the V6 engine note.'

The Dallara GP3/13 will make its race debut as a support for eight of the 2013 rounds of the Formula 1 World Championship and will remain in service until 2016, when it will be either replaced by an all new model or very heavily upgraded for the second time.

RUNNING THE GP3/13

'What makes a good GP3 team is consistency' claims Didier Perrin, the GP3 Series Technical Director. 'They must be very serious and have a consistent approach. We try with Dallara to give them the best information possible, and they will get everything they need to feed into an up-to-date simulator. This new car will respond to setup changes very much in line with what you expect on a racecar. It's a classic racing car in that respect that responds properly to setup.

'From a mechanical set up point of view, we allow the teams to got to the rig to map the car, but using the rig will be banned at the first race as it was in the first cycle of GP3 and it is the same in GP2.

'We provide a range of springs, and the teams can do what they like within that range. They have to use valves in the damper that are in a range we also supply, but the range is big enough that they can get the benefit of rig testing.

'As the teams have yet to take delivery of the new car they are impatient to get it, when you give a new toy to an engineer especially one with more power he can't wait to play with it!'

TECH SPEC

Dallara GP3/13

Class: GP3 2013-2016

Chassis: Dallara sandwich carbon / aluminium honeycomb structure with side impact panels

Aerodynamics: Front and rear wings - carbon structures designed by Dallara

Bodywork: Carbon - Kevlar - Glass composite structures designed by Dallara

Safety: FIA F1 2006 safety standards, front side rear and steering column impact tests, front and rear roll hoops, impact structures and monocoque push tests. Improved head protection. Wheel retainer safety cables

Suspension: Front and rear double steel wishbones, pushrod operated, twin dampers, helicoidally sprung suspension, adjustable ride height, camber and toe two way front and rear adjustable Koni dampers front and rear adjustable anti-roll bar

Transmission: 6-speed longitudinal sequential Hewland gearbox, electro-hydraulic command via paddle shift from steering wheel, pure two pedal car - clutch paddle on steering wheel, on board starter, Hewland ramp differential

Wheels & Tyres: O.Z. racing wheels - front rims 13" x 10" - wide rear rims 13" x 12.5", GP3 series specific Pirelli slick tyres

Steering: Non assisted rack and pinion steering system, XAP carbon steering wheel with dashboard, marshalling display, gear change and clutch paddles

Brakes: Brembo

Composites: Dallara with Delta Tech materials

Camera: New generation roll hoop, nose cone and face shot camera pre-equipment

Fuel cell: FIA specification

Dimensions:
Wheelbase: TBA
Overall length - 4571 mm
Overall width - 1885 mm
Overall height - 1063 mm (FOM camera included @ 20 mm front and rear ride height)
Overall weight - 655 kg (driver on-board)

Performance:
Maximum speed 295kph (estimated)

Target locked

Marussia's MR01 missed pre-season testing and only began wind tunnel testing one week before the start of the season. The team now believes that it has the beating of Caterham

BY ANDREW COTTON

The start of the 2012 season saw a change in the Formula 1 regulations that introduced new crash tests and an insistence that teams pass each of the 18 tests before being allowed to take part in pre-season testing.

In the Marussia camp, the year didn't start well. The MR01 failed one of the tests and didn't pass the final one until a week before the first race in Australia, where Timo Glock and new driver Charles Pic became embroiled in a competition with HRT to see who could prop up the grid in qualifying. As it happened, it was Marussia that had the honour, but only because HRT failed to qualify either of its cars at all.

Pic in particular went into the season completely unprepared - his only sight of the 2012 car was a single day at Silverstone on Pirelli's demonstration tyre and his pre-season testing was undertaken in one of the team's old MVR-02s from 2011.

In previous years, the car was designed solely in CFD without correlation in the wind tunnel. Former Renault technical director Pat Symonds joined Marussia at the start of 2011, and in July effectively took over the same role at the team, and immediately started to change the methodology behind the design of the car. Now, with the tail-end of the season approaching, Symonds reckons that the Caterham team is beatable.

The team moved to the Marussia Technical Centre in Banbury, bringing the entire team under one roof for the first time. Last year they secured an agreement with McLaren Applied Technologies

"It was heavy – the big thing was to get weight off the car"

to help it progress, and with an aerodynamic team of just 28 personnel – led by Richard Taylor and that number including model makers, designers and aerodynamicists – efficiency in the personnel was going to be the only way forward.

The decision was taken to stick with the Cosworth engine as it was proven, and the team was only two years into a three-year contract. As a financially mindful team, they didn't want to spend the money buying its way out of the agreement. A link with Xtrac provided a new gearbox and, most importantly, the team set about improving the aerodynamics to produce a worthy mid-field competitor in year one of the MR01.

Mid-season, the team was rocked by an accident at Duxford airfield in which its new test driver, Maria de Villota, crashed into a support vehicle, an incident which resulted in her losing the use of her right eye. The team satisfied itself that there were no car-related issues that led to the accident, and cleared its chassis to continue to race in 2012.

AERODYNAMICS

From the start, the aero maps for the Marussia MR01 were as expected, and downforce was therefore not the primary concern of the team. At Monza in September, with a new aero package on the car and at a track where the Cosworth customer engine was not expected to be the strongest in the field, the two Marussias nevertheless qualified within a 10th of a second of each other, comfortably inside the 107 per cent time, signifying a huge leap in performance compared to the start of the year.

The team has brought new elements of the aero package to every race this season, and is starting to advance up the grid, offering a real challenge to the Caterhams. In Monza, Pic finished the race 10.9s behind Vitaly Petrov and 11s behind Heikki Kovolainen.

'Mechanically the car was fundamentally OK,' said Symonds. 'It was a little heavy, and old-fashioned, it was not state-of-the-art, but if it had aero on it, the rest was more or less acceptable. The big thing was to get weight off the car, and to get some minor detail design.'

That minor detail design included switching from a pull rod to a push rod rear suspension, tidying up the rear of the car, and concluded from an investigation into the frontal aerodynamics that the much-maligned platypus nose on the majority of cars offered little, if any, advantage.

'It was obvious that this was going to be the norm, but we couldn't get better performance from it,' said Symonds. 'We pushed things to the limit to see if it would open up an area for us, but we couldn't find it. In Silverstone we lowered the nose even further, and got a gain from it, but there was very little in it.

'I think a lot of people did it hoping to open some areas.'

With that decision taken, the switch to a dry sump, and a joint development programme with Xtrac for the gearbox casing on which the rear suspension was mounted, Marussia began to turn their attention towards its methodology.

The Manor Motorsport team knew how to engineer a car, and there was clearly nothing wrong with the ability of the squad, but the results were not being achieved.

The problem, said Symonds, was the lack of wind tunnel

The MR01 started the season with a conventional exhaust exit but was later fitted with a Red Bull style soultion

testing time, and ahead of the season set about rectifying what he saw as the car's biggest flaw – the aero package.

The first time that the car saw a wind tunnel, it was just one week before the Australian Grand Prix. The 2011 car was used to provide a baseline against the 2012 car, which, since March, has added an estimated 15 per cent more downforce, worth between 1.5s to 2s per lap.

'That is 15 per cent delivered to the car,' says Symonds. 'What has been delivered in the wind tunnel is a lot more, but that will go on to the 2013 car.'

The advantage of more downforce was that the car worked the tyres better, although there is still a long way to go to achieve the same performance as even the midfield runners. 'We think that we're understanding the tyres better now, getting the car to the sweet spot,' said team principal John Booth.

'We're starting to understand it. The cars that have higher downforce, at tracks where it's difficult to get the temperatures where you want them – those with higher downforce get there easier than we do.'

Weight distribution was critical. The 2011 car simply had the weight that it was born with, but the team has worked hard on reducing that in order to be able to place ballast.

A relaxation of the strict weight balance regulations might have helped, as was rumoured over the winter, but this didn't happen, leaving the teams without the resources to run KERS at a disadvantage. 'Without KERS we would've had the chance to use the weight distribution better, but the FIA have been quite clever in tightening up the weight distribution band when KERS was introduced,' said Booth. 'With the Pirelli tyres, 65 per cent front bias was the way to go, but we could never get anywhere near that.'

'We had to shift a bit of weight rearwards to regulation requirements, but it wasn't a big deal,' said Symonds.

'We're carrying a lot of ballast compared to last year but we're sitting on the same weight as everyone else, there is only a margin of one per cent by regulation.'

KERS

At the start of the year, the team sat down and worked out that a KERS system would cost in the region of £4m-£6m (US$6.5m-9.7m) and instead decided to spend that money in the wind tunnel. That saved on the complexity and weight of the car, and allowed them to tidy up the rear end. 'To spend [that money] in the wind tunnel would have led to a greater gain than four tenths of a second, so that was the maths that we did,' said Booth.

"I know the Renault figures from 2009, and we weren't even achieving those"

For Symonds, the calculation was even more stark. 'When we looked at the aero figures, they were years behind where we should be,' he said. 'The FIA changed the regulations in 2009, and I know the Renault figures from 2009. We weren't even achieving those. I didn't want to add complication and there was no cost benefit [to KERS].'

ENGINE

With both Williams and Marussia using the Cosworth engine, Caterham having bought their way out of the contract at the start of the year, there were some differences of opinion.

While Williams pushed for top-end power from the British engine manufacturer, Symonds preferred torque. The problem was that the team was second in the wish-list queue, rightfully so given the results. Instead, it was able to play with exhaust exits and inlets, and improved the delivery of power.

'There were subtle changes, but Cosworth have provided bloody good value for money,' said Symonds.

The team has announced that it will stick with the Cosworth engine in 2013 – extending its contract for a further year – and says that it will run with KERS next season, bought from Williams and which is already configured to run with the unit.

Before then, Marussia expects that – at some point this season – it will be in a position to challenge Caterham.

TECH SPEC

Marussia MR01

Class: F1 2012

Chassis: Carbon fibre monocoque

Dampers: Penske

Suspension: Carbon fibre double wishbone with flexure joints, push rod actuated Penske dampers front, pullrod rear

Steering: In house designed hydraulic PAS

Transmission: Xtrac Aluminium seven-speed, mounted longitudinally

Engine: Cosworth CA N/A 2.4 V8

Dampers: Penske

Clutch: AP Racing

Brake discs: Hitco Carbon - carbon

Wheels: BBS

Fuel cell: ATL

Electronics: Braille battery, MES ECU and Dash

Weight: 640kg (including driver)

Dimensions:
Front track: 1800mm,
Rear track: 1800mm
Wheelbase: 3300mm

Who needs a stick shift?

Paddle shifts may be everywhere today, but there was a time when they were a challenging concept and it took a tough player get the idea accepted. John Barnard was the man who put his job on the line to make it happen

BY CHARLES ARMSTRONG-WILSON

Nearly every single-seater racing driver at the top of their game will have been brought up on racecars with paddle shifts. They are near universal in Formula cars, and the state of the art in most purpose-built racecars of all types. Yet 25 years ago, even grand prix drivers had to contend with an H-gate stick shift, a concept that can be traced back to the end of the 19th century.

Even in its final form it imposed a number of compromises on the car and driver. To change gear the driver had to take one hand off the wheel. Also, the gearlever required a space big enough to allow a driver's fist, wrapped around the lever, to move through the full throw of the lever uninhibited. As aerodynamics forced ever-tighter packaging, this often resulted in a blister on the side of the cockpit.

But the compromises went even deeper as John Barnard recalls. 'I don't like compromises and I was keen on was getting a package that had the fewest possible,' he says, remembering the time when he was recruited by Enzo Ferrari to be technical director.

'One thing that annoyed me was trying to get a gear shift system that did not give you lots of compromises in the chassis, the engine and the gearbox. We had chassis that had a single fuel cell behind the driver and routing gear shifts around that became a problem. I thought: "Get rid of the gear linkage, it's a bloody nuisance. All I need is some buttons on the steering wheel, I can still have a clutch but instead of shifting a lever I'll get the driver to push a button."'

Barnard came to Ferrari on the back of three drivers' and two manufacturers' titles at McLaren. His stock was high and there was a lot of expectation. However, his arrival was not universally popular. Another Englishman, Harvey Postlethwaite, was already at Maranello, but he'd quickly become immersed in the Italian culture and the Ferrari way of doing things. In contrast, as Barnard says, 'my job was to bring the English way of doing things – the way we'd been doing it at McLaren.'

In the process he'd been funded by Ferrari to set up a facility in the UK, slyly named Guildford Technical Office (GTO). Here they were designing the chassis and manufacturing the performance-critical carbon components like the monocoque and the steel wishbones.

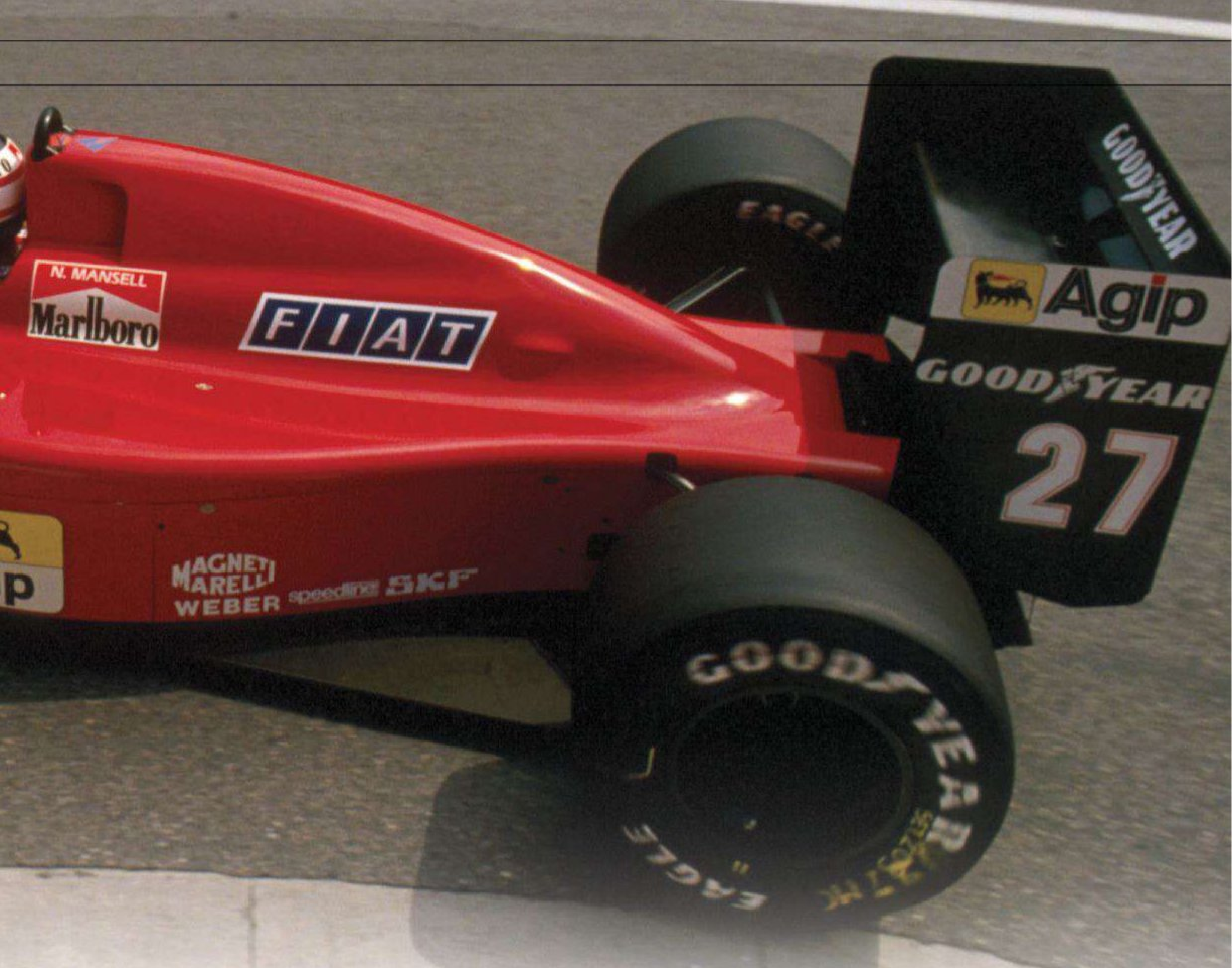
BEATEN ON THE BUM

He admits he also arrived in Italy with some baggage. 'I had a reputation for always doing something new,' he says. He had already designed Chaparral's first ground effect car and Formula 1's first carbon monocoque with McLaren. 'It became a stick that has beaten me on the bum,' he admits, reflecting on the expectation it generated. 'But I was always looking to make a significant step.'

Fortunately, with his new gear change concept, he had an ally at Ferrari in Fosco di Silvestro, the head of the transmission department.

'Fosco started talking to consultants regarding hydraulics. He designed a system and they built one based on the 1986, six-speed gearbox.' The unit used the same selector layout as the stick-shift car, but with hydraulic pistons on the selector rods. These naturally defaulted to neutral but, depending on where the hydraulic pressure was fed, pushed the selector rods one way or the other. The hydraulic control was by Rexroth valves, operated on the press of a button by a separate electronic control unit solely for the transmission.

It was deemed it could work, although it was a long way from where it ended up on its first race in 1989. It proved the concept, but time was catching up. Plans to go from a turbo car to a normally aspirated one a year earlier than the rules



dictated had to be canned as Barnard struggled to build up his design strength at Guildford. So the 1987 turbo car, the F1/87, started another season as the F1/87/88C. Meanwhile, behind-the-scenes work was progressing on the 639 with its normally aspirated V12 and the first electro-hydraulic, semi-automatic gearbox.

'Knowing I could do without a linkage, I designed the car around this idea so the monocoque was a lot narrower around the driver compartment,' Barnard recalls. 'That car wasn't even out to the maximum width. It was the first with the aero shape that the 1989 finally car raced with; very waisted, streamlined.'

It was finally wheeled out for a first test in the late summer of 1988 and featured gear selection paddles, one for up and one for down. 'The interesting thing with that test,' says Barnard, 'was we had a hydraulic clutch operated by the system, but the driver could operate it with a paddle. Having worked on it for a year it became apparent that many more things were possible which never really entered my mind at the beginning.

'Once you get going you start to see all the options that are available, software-wise, and what you can do when you control clutch and gears etc. There are an enormous number of options. Things like over-revving became a thing of the past. Once the electro-hydraulic gearbox came along, missed gears and engine over-revs went by the board.

'Having got the system into reality and software writers writing software, it became apparent that there's no reason why we shouldn't run this thing fully automatically. So that's what we did at the first test of the 639: a fully automatic run. The guy accelerated, the engine reaching max revs and the thing shifted up, and shifted up and shifted up. It was great.

'The problem we had was the downshift, because we didn't have electronic throttles or any way of bringing up the engine revs. So the downshift was far too brutal. Come the first race in 1989, the driver took control of all the shifts up and down. On the downshifts he had to get the engine revs right like on a manual car. That was the most difficult side initially.'

Barnard made another discovery. 'With a stick shift it was normal for a driver to come barreling down the straight, arrive at a corner and go from sixth straight to second without using the other gears. Initially I didn't know whether we would need to do that which was why we started with actuators on the individual selectors instead of a sequential system.

'It would enable us to select any gear and it didn't have to be sequential. But it became apparent immediately that the speed it could shift compared with a driver meant you could come down from sixth to second in pretty much the same time as you could go from sixth to second in one hit manually. It became apparent during that first serious running in 1988 that there was no need for a non-sequential arrangement. The drivers might say "I could shift faster with a manual," but you can't, mate.'

Around this time, Enzo Ferrari died and responsibility for the team fell to Vittorio Ghidella of the company's owners, Fiat. Barnard and his team had started refining the unraced 639 to become the 640 for 1989 and

"If you can show me it's a complete disaster then you can tear up my contract"

it was still designed around the electro-hydraulic gearbox concept with no gear linkage.

'Ghidella fancied himself as the next Enzo,' says Barnard. 'He came to me and said, "I can't afford a disaster. Is this idea OK? Is it safe?" I said I think it's the way to go but he wanted a mechanical version. I didn't agree because we didn't have the capacity. We were flat out at end of the season preparing for 1989.'

Barnard was meant to have the final say. 'My contract said I was technically in charge. I said, "the chassis is not intended for gear levers – you can't get a gear shift in." However, it got down to a serious situation between Ghidella and me. I went to Maranello with my lawyer and they sat down with us and their lawyer and they were up all night talking about our contracts.

'In the end I put my contract on the line and said, "If you can show me it's a complete disaster then you can tear up my contract." It was a pretty healthy contract that still had a year to run, and it wasn't something I wanted to do. But I was so adamant that this is the way I wanted the car and I was willing to put that on the line.'

Inside Gerhard Berger's Ferrari 640 (top), and Nigel Mansell takes John Barnard's paddle shift system for a spin during the 1990 season

Barnard went back to England, and heard on the grapevine that they were building a mechanical version anyway around a 640 chassis. 'Nigel [Mansell] was on board by then and had been spending time at GTO. We sat him in the monocoque and explained the principles of the slim design. Over in Italy Nigel was asked to drive the mechanical car. After a few laps behind the wheel he got out and said, "Give me the paddle shifts." And that was the end of that.'

'What happened then was we went testing in Brazil in the 640 and it looked pretty quick, but kept breaking down. And, of course, it was reported back to Italy as a gearbox problem.'

The problem was the new V12 engine. It had four main bearings and they allowed the crankshaft to whip. 'The nose of the crank was wobbling around although they had to use high-speed photography to see it,' reveals Barnard. 'The alternator was driven off the front of the crankshaft which would chuck the belt off so the alternator would stop. We only carried a tiny battery and the first thing that stopped was the gearbox control. Then the driver would come in saying the gearbox had stopped and that was how it was reported. They didn't know what was happening and it was some time before this was discovered.

'The thinking was that it works and it's good, but it's not reliable, and for a while it looked like they were going to tear up my contract. Then Nigel qualified well for the first race in Brazil and team manager, Cesaré Fiorio, said, "Based on what happened in testing there's not much chance of us finishing is there? Why don't we put half a tank of fuel in and make a show of it?" I said, "Yeah I know but you never know your luck. Perhaps we should fill it up." Then we won the bloody race. That win was much needed by me in more ways than one.'

'After the first test one of the guys at Maranello said "We've done something like this before when [Gilles] Villeneuve was here. We built a hydraulically actuated system. He tested it once at Fiorano and we said, What do you think? And he said, 'I can't see anything in it really, give me the manual.' That was the end of that – we went back to gear levers and rods." Unless you bully these things forward, a lot just go into a back office drawer somewhere and never see the light of day.'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Going for gold

McLaren have used the technology they've developed in motorsport and applied it to the Great British Olympic team

BY CHARLES CLARKE

McLaren Applied Technologies is fast becoming renowned for its diversification into walks of life other than motorsport. Under contract to UK Sport, MAT played a key role in the British Olympic programme. It worked with athletes to ensure success on the track, field and in the sports halls of London.

Since its foundation in 2004, MAT's list of challenges has included such diverse sports as field rugby, wheelchair rugby, track cycling, canoeing, sailing and athletics. In most cases this is mainly about the sporting approach, rather than equipment design or engineering support. One of the key value added aspects from McLaren is in the instrumentation of the athletes, their equipment, and the collection of sporting data using the same kind of telemetry that they use at the race circuit.

'The same kind of approach to data collection and telemetry in Formula 1 can be used to monitor virtually any other sport,' says Geoff McGrath, MD of McLaren Applied Technologies. 'The expertise in data analysis gained from Formula 1 can also be applied to other sporting data.'

This makes sense for the more traditional racing sports such as track cycling, where fractions of a second count. However, MAT has applied data analysis to the physical development of the individual athletes, too.

The bursts of power produced cyclist Chris Hoy were measured and analysed, and training programmes were developed to ensure peak physical performance for the medal events.

MEASUREMENT TOOLS

Using data helps the team to understand when athletes are performing at their best and when they're starting to fatigue. Trainers can then take the data into the race where they can establish what their optimum stroke / per minute rate should be in order to go for gold.

The process gathers and measures small margins, and aims to optimise the race strategy to maximum effect. When you consider that some of the winning margins in the Olympic Velodrome were measured in thousandths of a second, getting a better appreciation for the sporting data is a real competitive advantage.

Data isn't just gathered to monitor immediate performance, however. It can also be used to inform the athlete in the way that they train and, based on performance levels over a long period of sustained activity, can predict the optimal way of undertaking a sporting event.

In the same way that a long-distance runner makes a steady start and reaches a cruising speed to take into the final sprint, athletes can actually develop a customised race profile for an individual athlete based on their

McLaren's expertise on and off the track has allowed it to help make strides in other sports, and not just on wheels performance at different times in the training cycle.

The management of resting periods is also critical to optimisation of the recovery procedure, and can follow a similar path to driver fitness to ensure peak physical performance. At the Olympics in the summer, British runner Mo Farah had just over a week in which he competed in three gruelling distance races: the 10,000 final, plus the heat and final of the 5,000m. Having access to recovery data allowed him, and others, to manage the recovery period in an optimal fashion, so that he could start his next race in the best possible shape.

Injury prevention is also part of the work in the various sporting endeavours that they are involved with. Particularly in the team sports, the objective is to manage and monitor training to allow the athletes to reach peak performance, but not train so hard that they are actually causing themselves lasting harm by overtraining.

DATA RECOVERY

Collecting an infinite data stream is relatively straightforward. Where MAT excels is in the analysis of the data and being able to put that into practice. Since the early days of finite element analysis it was fairly common to generate a 400Mb file containing the analysis results of a relatively simple structural analysis.

Turning a 400Mb file of numbers into pictures and animating the deflection profiles to show the changing stresses is part of the art of post-processing analytical data. Engineers have been doing this since the 1960s, although today's computational power leads to more detailed images.

The benefit of this experience allows the engineers to develop data analysis and interpretation tools that can tell a coach at the track side in the Velodrome in a matter of seconds what he needs to know. In the early days of sports science, emphasis was placed on the analogue elements of the athlete and much concentration was made on sports psychology and diet.

When medals come down to thousandths of a second, data is valuable

With no need for supercomputers, velodrome cyclists can benefit hugely

Nowadays there is a wealth of digital performance data that is not being harvested.

McLaren has adapted how the racing information can be managed and manipulated so that it is useful at the side of the track where decisions have to be taken in seconds. There is no room for the desktop or deskside computer alongside a cycle track, so the data management and interpretation has to be conditioned for a laptop, tablet PC or iPad. This requires an app to allow coaches to apply the data in a meaningful fashion on a mobile device. The delivery and the interpretation of the data is more important than the ability to collect it.

PRIVATE HEALTHCARE

One of the iconic moments of Danny Boyle's summer Olympic ceremony was the recognition of the National Health Service, and here again MAT has carried out extensive work. Patients can be monitored and their progress documented so that a higher level of monitoring can be achieved with a significantly lower level of patient / doctor or patient / nurse interaction. Sensors can be used to monitor vital signs and interpreted remotely.

In the same way as McLaren was monitoring elite athletes they were monitoring children in the intensive care unit at Birmingham Children's Hospital, watching for fluctuations in their vital signs before they become alarming to medical professionals.

This also allows them to establish a patient profile and discover the true baseline for that individual patient so that any subsequent data gathered can be compared, rather than applying data to an arbitrary standard range rather than an individual patient. It also allows you to get a better picture of the recovery process. By having discreet vital sign sensors, it reduces the necessity for patients to be wired up constantly to local monitoring devices. The remote sensors allow the patients to walk around and still be monitored remotely, even after they've gone home.

This, in part, explains Vodafone's link to the Formula 1 team as the mobile phone company provides network services and data links, using their mobile communications technology in the medical and Team GB applications.

A significant outcome at the Birmingham Children's Hospital was the fitment of an ambulance with remote monitoring equipment. This allows the doctors back at base to monitor a patient in transit between hospitals or to monitor a patient inbound to the emergency room at the hospital from an ambulance call-out.

TRACKER BALL

In the wheelchair athletics, particularly basketball and rugby, standard GPS monitoring wasn't working inside a sports hall environment. MAT and Ubisense, a Cambridge-based manufacturer of precise Real-Time Location Systems (RTLS), developed a solution that could track the movement and position of individual athletes or teams

"Mo Farah had needed to train and recover for three gruelling distance races in seven days"

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on indoor and outdoor courts, pitches and at training grounds.

The system, integrated with Ubisense's RTLS technology, is designed to help professional coaches review and refine the performance of players at the top of their game in sports including tennis, football, netball, ice hockey and horse riding.

The system tracks the position of athletes in real-time and delivers precise location information to a performance analysis dashboard. Working indoors and outdoors the technology frees up coaches to focus on performance improvement. Using the solution they can dynamically observe dwell time, player velocity and coverage across courts and pitches. Coaches can also conduct detailed post-play analysis using aggregate movement data and iso-movement analysis for each individual player so feedback can be given, facilitating continuous game improvement.

Using a network of RF tags and sensors, the dynamic position of athletes could be observed multiple times per second, to within 15cm of their true location – something that was unachievable with other location systems.

'The system we have developed with McLaren Applied Technologies enables sportsmen and women, and their coaches, to scrutinise individual performance and team dynamics to an unprecedented degree, so training programmes can be adjusted for success,' says Richard Green, CEO of Ubisense.

McLaren's workshops are typically spotless a carry over from the Formula 1 mindset (top), the development of the Venge 'bike leant heavily on the racing team's technology (middle), precision is everything for MAT (above)

'Our technology already makes an enormous difference in manufacturing, giving world-leading brands visibility of key business processes. It's fantastic to join up with McLaren and take this technology into a brand new arena.'

One important use is for wheelchair basketball users, for whom the system creates a 'snail trail' showing how fast they are going, when they are resting and rapid changes in acceleration. This enables coaches to tailor training programmes more closely to the demands of the event and analyse if the improvement needs to be made in the training of the athlete or the development of the chair.

'We have also done some work with players who don't use equipment, such as the England rugby union squad,' says McGrath. 'McLaren developed a system that could monitor the players' vital signs in real-time, from sensors in the players' shirts, while they were training to give a picture of the load on their muscles and nerves.'

'The more data you have, the better the prospects for techniques like predictive analytics. There is no way you can do this without the data, so for individual athletes this is a real competitive advantage – the competition can't possibly replicate this approach unless they have the capacity to gather and interpret the data. The real added value and competitive advantage is in the data.'

SIM IN WAITING

Nothing has been done so far in McLaren's Formula 1 simulator, but such is the wealth of mathematical models that already exist, it is not beyond the bounds of possibility to be able to simulate the mobile train crash that is wheelchair rugby in a simulator. Similarly there hasn't been any engineering assistance given, but again it's not beyond the bounds of possibility to suggest that specialist components might be made in the future for competition wheelchairs in the same way as parts of being made for the track and road bikes.

The kind of Roger Bannister moment, often regarded as a moment of inspiration and determination to break the four-minute mile, has these days given way to a much more scientific approach to sporting endeavour. There will always be room for Roger Bannister moments, but if a little more scientific approach to training and competing is adopted, the whole sporting community and all of Team GB benefits, not just a few celebrity athletes.

All the gold medals at the recent Olympic and Paralympic Games didn't happen by accident. Data collection and telemetry was very much part of the process. With all the technological successes of Formula 1, applying motorsport telemetry techniques to other sports was a very small step that has already produced very big dividends.

"McLaren developed a system that monitored the players' vital signs through sensors in the players' shirts"

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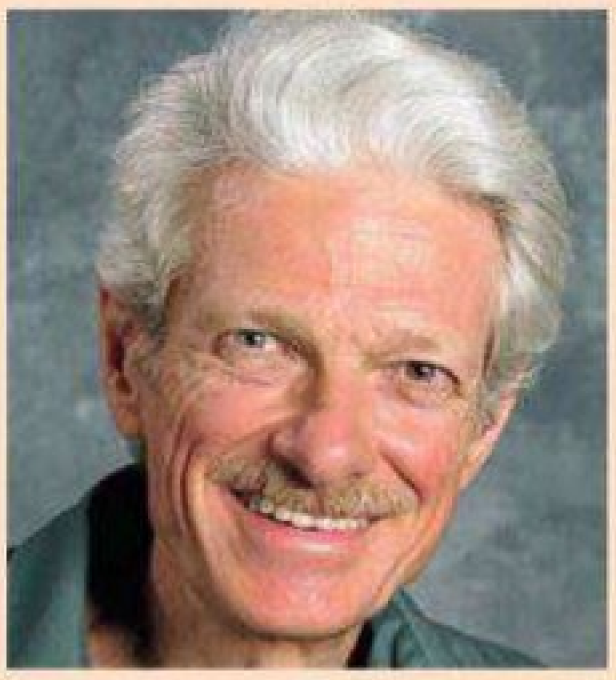

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The future of anti-dive?

Mark Ortiz on the Catch-22 of active suspension to counter dive

Q **Geometric compliance *should* improve the most central aspect of grip: tyre adhesion. That much seems obvious. I've not, however, seen any test results that support the concept. Have you? The system developed by Lotus seems overly complex and potentially unreliable.**

My thought is to use torsion bar front springs. Placing hydraulic cylinders at the fixed ends of the bars, rigged to rotate the bars appropriately in response to change in brake-line pressures, would counter brake dive and facilitating geometric compliance. Your comments?

I don't know of any experiment to test the hypothesis that an improvement in tyre adhesion occurs when the tyre can move rearwards when it encounters a bump – but it definitely reduces ride harshness. That leads to a reduction in acceleration and jerk of the sprung mass, something that should reduce load variation at the contact patch.

Reduced load variation at the contact patch helps because, to a substantial degree, the tyre's frictional performance is limited by the periods when it has the least normal force, and the value of that minimum normal force lessens as load variation increases.

It is not impossible to raise the front of the car, or raise the front and lower the rear, using fluid displaced by application of the brake pedal. However, this requires the driver's leg to do the work of displacing the system involved against a load. The driver's leg will have to do this in addition to applying the brakes.

This means that there will be an increase in pedal travel, pedal force, or both. If the slave cylinder is in series with the ride spring, and maybe also if it is in parallel, changes in spring loading will be transmitted to the pedal. The result of all this? When braking, the driver will feel bumps in the road through the brake pedal.

"Any form of active suspension is illegal in most forms of racing at present"

It would be possible to have acceptable force and travel at the pedal if the brakes are power-assisted. However, any power assist for the brakes is necessarily powered in some manner by the engine. If the brake system is also set up to extend or compress the suspension, we then have engine power being used to do this, making the system a form of active rather than passive suspension, and therefore illegal in most forms of racing at present.

I recently had another person contact me, wanting to know my opinion of a roll-compensating system that operates off the steering. I won't divulge how this person proposed to effect this, but it amounts to a similar idea but applied to cornering and roll, rather than braking and pitch.

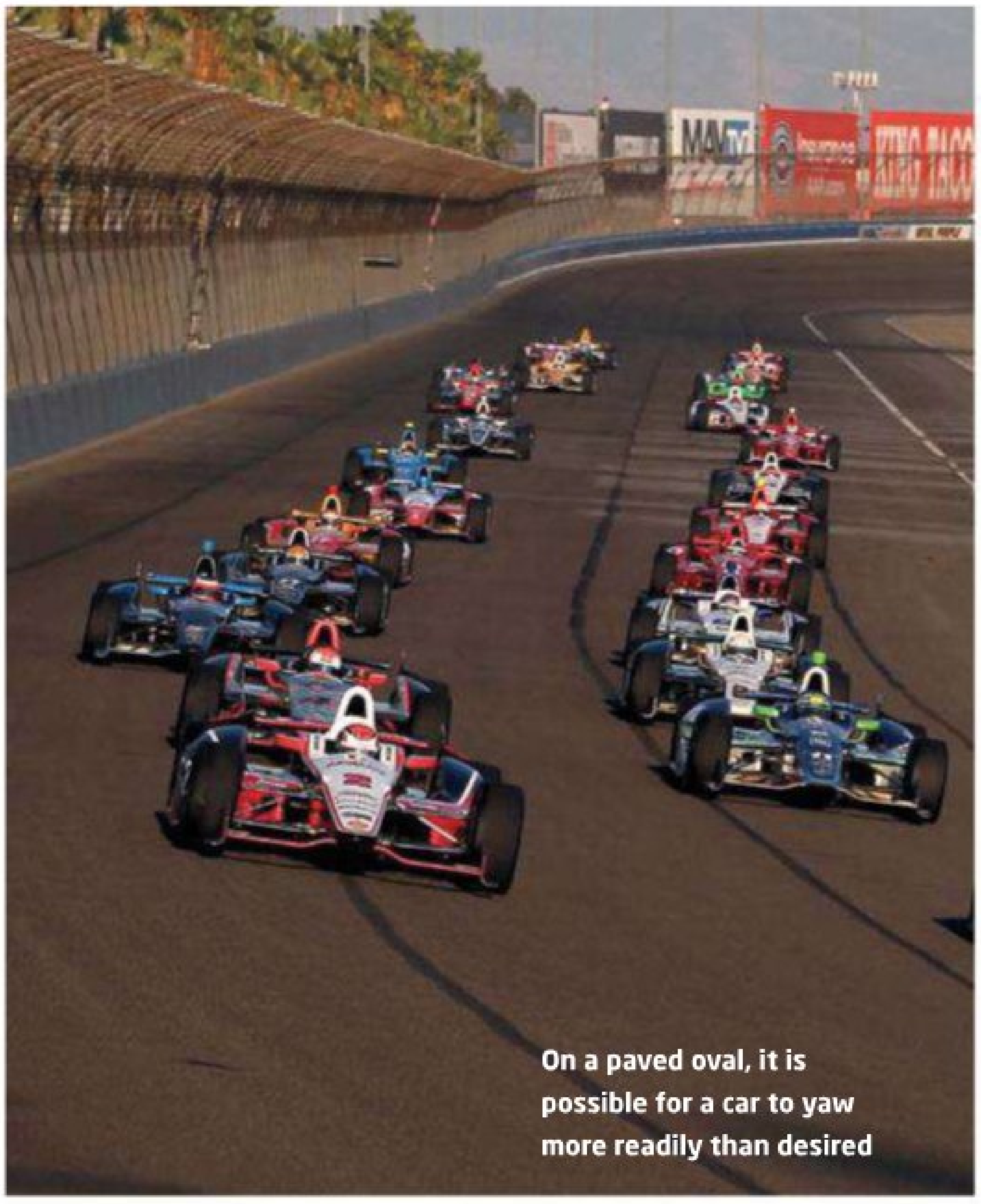
Where it is allowed, active ride-height control can definitely be used to modify pitch, heave, roll, and / or warp behaviour of a suspension system, with or without the use of additional springing.

This does offer some advantages. However, in most cases we will want to keep such a system separate from the brakes, steering, or throttle, and instead have it controlled in response to output data from the accelerometer.

Weighty issues

Mark Ortiz considers the trade off between weight balance and handling

Q Does more front weight help turn-in? Some people I talk to claim it does, but doesn't more front weight add understeer, therefore making the car less willing to turn?



On a paved oval, it is possible for a car to yaw more readily than desired

Turn-in is the most complex aspect of car behaviour to analyse. So much is going on at once during the process, and so many things affect it, not least driving style and subjective perception.

We can't even necessarily say that in all cases we are trying to make the car rotate more readily, or achieve higher yaw acceleration or jerk. On high-speed paved ovals, or when trail braking into a large-radius turn on a road course, it is entirely possible for the car to yaw more readily than the driver wants – to be too free, or loose, or disposed toward oversteer. So we can't necessarily assume that a car that yaws with more alacrity on turn entry really does have 'better' turn-in properties.

However, when people speak of 'better' turn-in, usually they mean that the car initiates a cornering manoeuvre more readily – that it is easy to get the car rotating.

If that is what is meant, we can consider good turn-in as being the greatest possible yaw and lateral acceleration and jerk, in response to a step-steer input (say, the initiation of a test-track J-turn) at constant vehicle speed, taking the wheelbase / track midpoint as the car's origin. To maximise this, at least in theory, we want the centre of mass as far rearward as possible, and we want the polar moment of inertia in yaw about the centre of mass to be as small as possible. The reason for the latter should be pretty obvious, but the former may require some elaboration.

In response to an abrupt steering input, the front tyres run up slip angle faster than the rears, as the car accelerates in yaw. As yaw velocity builds, so does centripetal velocity, but at a lower rate. As the car settles into steady state, centripetal acceleration builds to a maximum and holds it, while yaw acceleration falls back to zero (yaw velocity becomes constant). During the first part of this process, the front tyres can be thought of as accelerating the car in yaw about the centre of gravity (cg), and at the same time accelerating the cg laterally or centripetally about the rear axle. That's a bit simplistic, because the rear wheels start building slip angle and cornering force at the same instant as the fronts – just at a slower rate – but it is useful to imagine the front wheels trying to rotate the car about the rear axle. For a given angle of yaw at the track / wheelbase origin, the cg sees a smaller angle of yaw if it is further aft.

Theoretically, at the other end of a J-turn, we have a step de-steer input, and then the effect reverses; the rear wheels can be imagined trying to generate yaw deceleration about the front axle, while still maintaining centripetal acceleration at the origin. Here, a cg further aft should theoretically reduce yaw acceleration.

But this isn't how people actually drive race cars. In the real world, people usually enter an abrupt turn either on the brakes or using engine braking to toss the car. That means we have influence from brake balance, differential behaviour, and driving technique. People also exit under power, with speed building. A real race car enters a turn under combined lateral, yaw, and rearward acceleration, a highly variable set of ingredients.

'In the real world, people usually enter an abrupt turn either on the brakes or using engine braking'

So if, for example, a driver says the car turns in better with a light fuel load in the rear, is that because the rear tyres are closer to lockup as he trailbrakes? Is it because the car's polar moment of inertia in yaw is reduced? Is it because the static front percentage is increased? All of those changes are occurring at once, but theory would suggest that the first two are producing the effect reported.

If a car turns in more readily when ballast is moved forward, we need to ask; where was the ballast before, and after? Was it far to the rear, and moved closer to centre? Or was it near centre, and moved away from centre, to the front? Was the brake bias changed when the ballast was moved, or not?

Then there is the effect of the differential (or locker, or spool, as the case may be). If the device in the middle of the rear end has a tendency to resist differences in rear wheel speed and make the car go straight, that may in some cases have less effect when there is less rear wheel load.

When the front tyres make more force, even if it is true that they have more inertia to overcome, their forces may be better able to overcome the understeer-inducing effects of the diff, locker, or spool.

Finally, it is possible that if a car has more front percentage, the suspension may have more geometric roll resistance at the rear, relative to the front, to prevent excessive steady-state understeer. This may in some cases enhance turn-in.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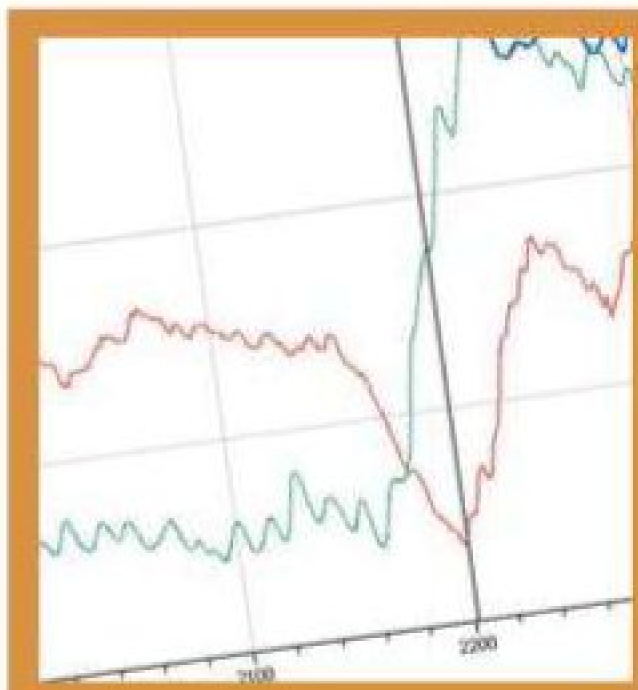

Databytes gives insights to help you improve your data analysis skills each month as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems. Plus we test your skills with a teaser each month

To allow you to view the images at a larger size they can now be found at www.racecar-engineering.com/databytes

Temperature measurement

What happens to a racecar when the heat is on

The environment in and around a racecar can greatly influence the performance of the car and therefore needs to be constantly monitored. Knowing the temperature of various components and fluids is not only critical to the vehicle health, but can also hold the key to unlocking more performance. For example, the air box temperature directly influences the performance of the engine and monitoring this value will help to make the car go faster. Similarly the temperatures in the exhaust, brakes and tyres hold equally valuable information. But how is it possible to monitor these temperatures and what considerations need to be made when measuring them?

The most commonly used temperature measurement devices in race vehicle applications are semiconductors, resistance temperature detectors (RTDs), infrared temperature sensors and thermocouples. They all have different characteristics that are suitable for various applications.

The semiconductor is a relatively low cost and easy to use sensor, but does have disadvantages when it comes to accuracy, which is rarely better than around 5°C. The semiconductor temperature sensor has integrated circuits and is identical to microprocessors in construction. Their principle design is based on the semiconductor diodes having temperature sensitive voltage and current characteristics. These are popular measurement devices for fluid temperature measurements such as water and oil as they are generally easy to mount in pipework and their accuracy is good enough for the application.

The RTD is a very stable and accurate type of sensor, and quite possibly the most accurate of those discussed here. It is, however, quite expensive and can be fragile. This type of sensor utilises the principle of different resistance of metal depending on temperature. The most common type of RTD sensor is the platinum resistance thermometer (PRT). The practical operating range of such a sensor is -250degC to 850degC and, depending on the type, can have accuracy between 0.03degC and 0.3degC. The most frequently used sensor is the PT100, which takes it name from the fact that at 100ohm the temperature is 0degC. The RTD sensor is effectively a resistor, and in the case of the PT100, it has a very low sensitivity, 0.385ohm/degC. This causes issues with accuracy as the resistance in the leads to the sensor affect the measurement. The most common way around the low sensitivity is to use a pull-up resistor and in many instances the data logger can be configured to do this. A good example is the Pi Sigma Elite that handles the RTD sensor

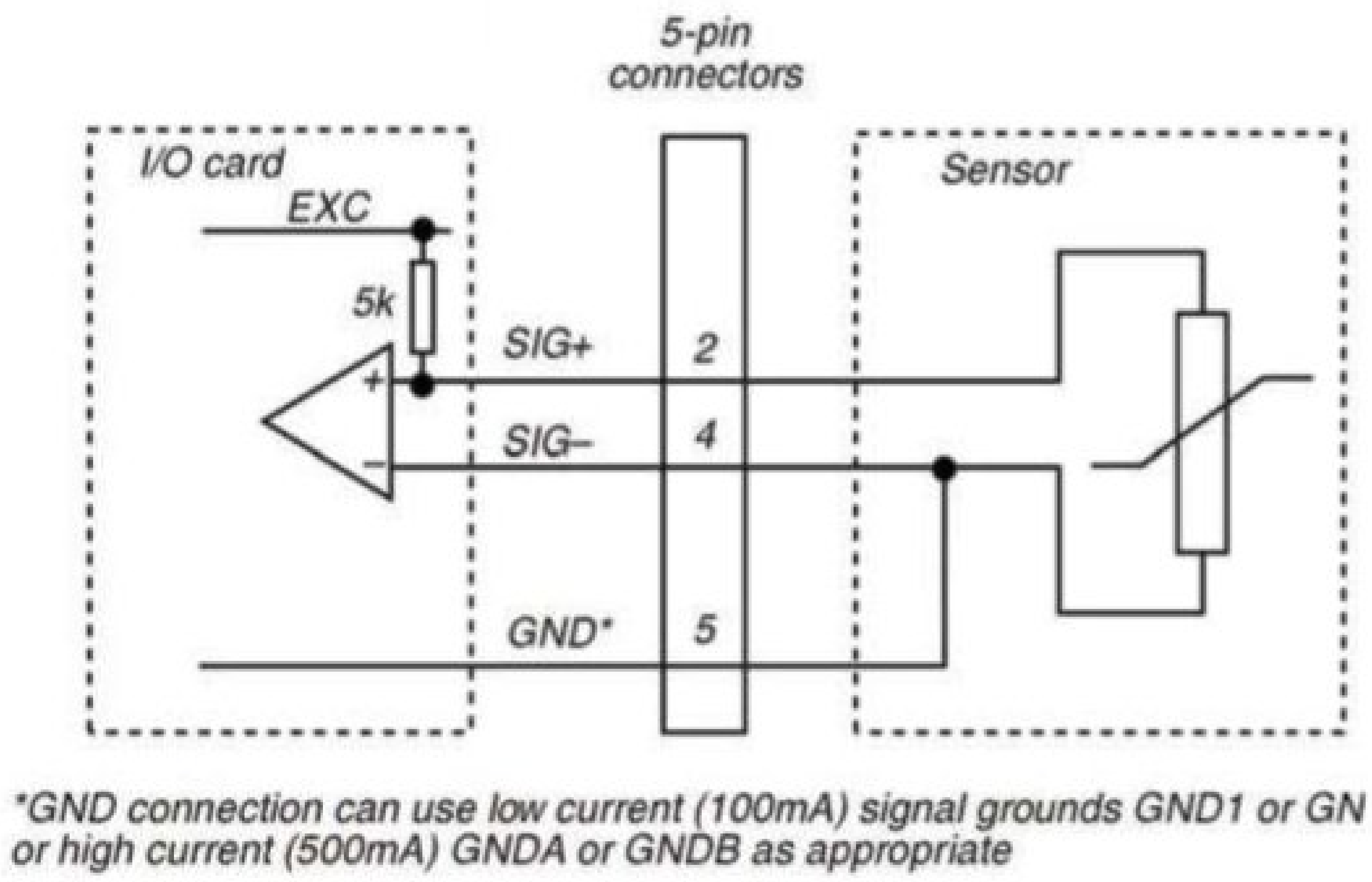

Figure 1: Three wire RTD sensor connection

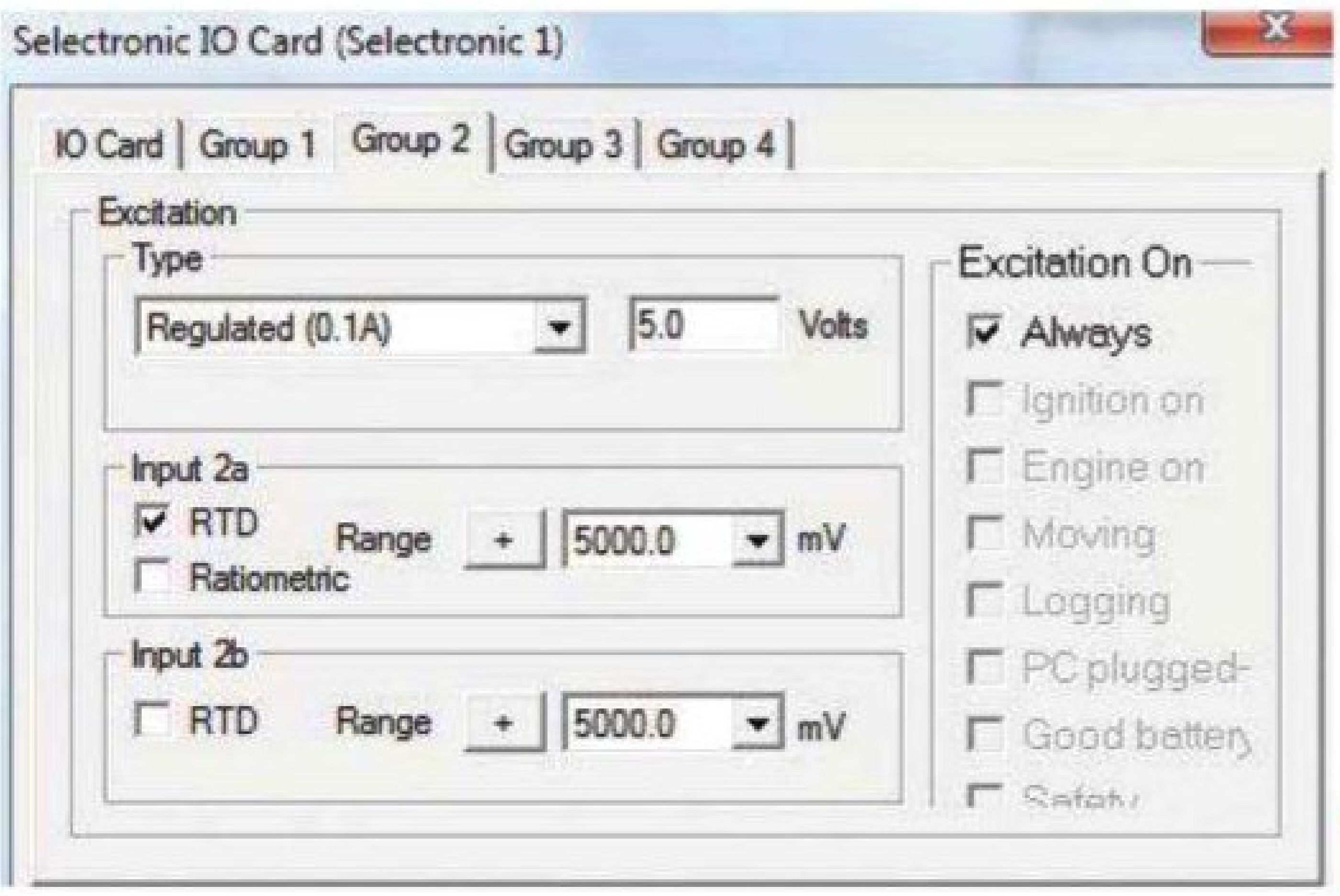

Figure 2: Specific configuration of an RTD sensor for Pi Sigma Elite systems

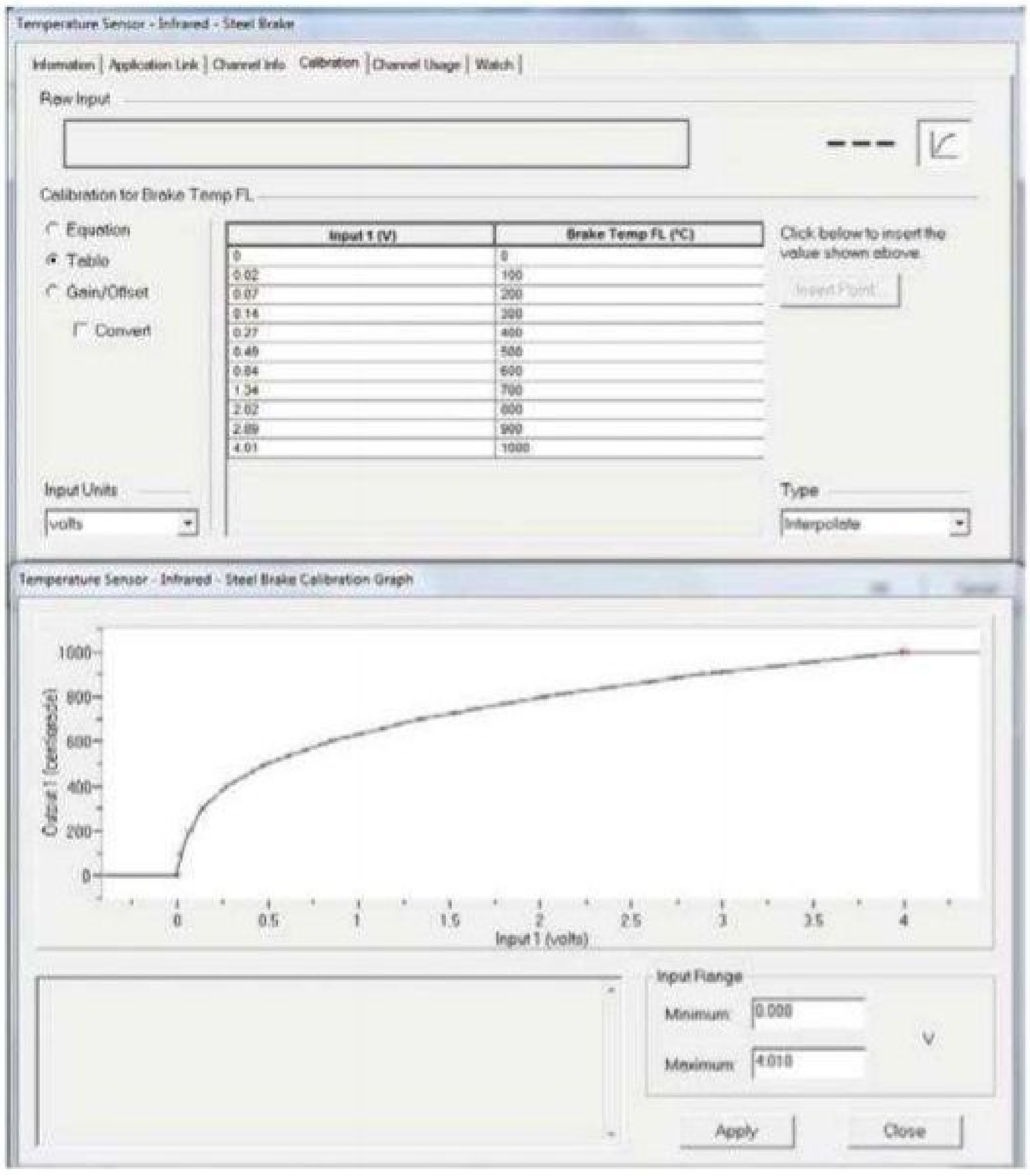

Figure 3: Infrared brake temperature calibration curve. Note that below 350degC to 400degC the accuracy is significantly reduced

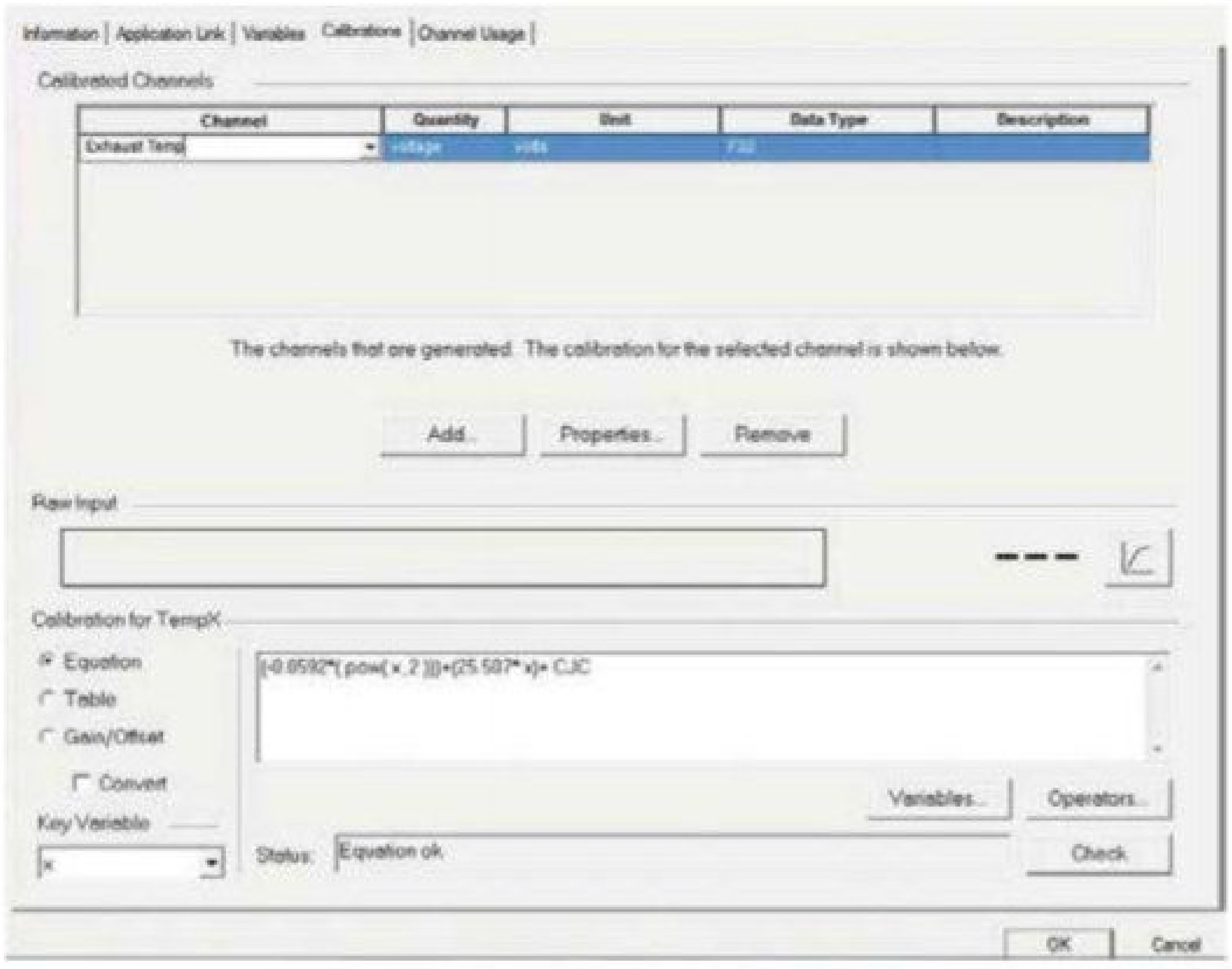

Figure 4: Thermocouple calibration equation using internal data logger temperature values as CJC. Note that the input used must be able to read minute voltage changes

connection as shown below. The configuration software then needs to be set up to handle this type of sensor.

There are two useful things to take into account if high accuracy is needed from an RTD sensor. The first is self-heating. If the excitation current is too high, there is a danger that the sensor heats up. Recommended values are less than 1mA, as this way the sensor output and signal-to-noise ratio are reduced, but at the cost of reduced resolution. The second is that two different compensation curves exist for the PT100 sensor. The European curve at 0.358ohm/degC and the American curve at 0.392ohm/degC is based on higher purity platinum.

Infrared temperature sensors are used to measure the surface temperature of components and are an excellent solution for moving parts or wherever a non-contact temperature measurement is needed. These types of sensors measure the temperature based on thermal or blackbody radiation. This is effectively a measurement of the infrared energy emitted by the object. The most common temperatures measure with infrared sensors are tyre temperatures and brake disc temperature. These are two vital components for the operation and tuning of a racecar, and have therefore become a standard fitment for many teams. In addition, the infrared type of sensor can be used to measure clutch temperature or any engine surface temperature deemed necessary to monitor.

For motorsport applications there are two temperature ranges that are generally used. 0-300degC for tyre and clutch temperature, and 0-1000degC for brake temperatures. It is very important to choose the correct temperature range for whatever is being measured with these sensors, as the relationship between voltage output and temperature is not linear, and therefore the lower voltage regions are almost impossible to measure accurately as the calibration graph in **figure 3** indicates.

Thermocouples are a very popular choice for temperature measurement. They are cheap, reasonably accurate (error of around 2degC can be expected) and cover a wide range of temperatures (-200degC to 2000degC). Thermocouples are based on the principle that the junction between two metals generates a voltage that is a function of temperature. In theory it is possible to make a thermocouple out of almost any two types of metal. There are, however, a number of standard types, the most common one being a K-type which has a wide operating range, -200degC to 1300degC and a 2.2degC accuracy.

The voltage output of a thermocouple is very small. It's in the millivolt range, which does mean that it requires no excitation voltage. But equally this also means that measuring the voltage is difficult as we are then in effect creating a second thermocouple junction. This junction is traditionally known as the cold junction and is assumed to be 0degC in standard thermocouple tabled. Maintaining the cold junction at 0degC can, however, be tricky – especially in a racecar. Therefore the cold junction temperature, no matter what it is, can simply be compensated for in the calibration equation. The example in figure 4 shows a clever way of connecting a thermocouple directly to a high-end data system and using the internal temperature of the unit as the cold junction compensation (CJC). This compensation technique works, as both wires of the thermocouple attach directly to the data system unit and should therefore be at the same temperature. It's worth noting that any error in the cold junction compensation will be carried over in the measured temperature.

Not all data systems are able to accept such a low voltage input and therefore a thermocouple amplifier is needed, which in essence turns the thermocouple into a standard analogue sensor.

As with any measurement technique, there are pros and cons to each method and sensors. When it comes down to it the choice of which technique to use must be based on what needs to be achieved.

CHALLENGE

Temperature is generally a slow-moving value. What is a good way to represent these values in a data logging system, and how could trends over the course of several outings, or even days, be seen?

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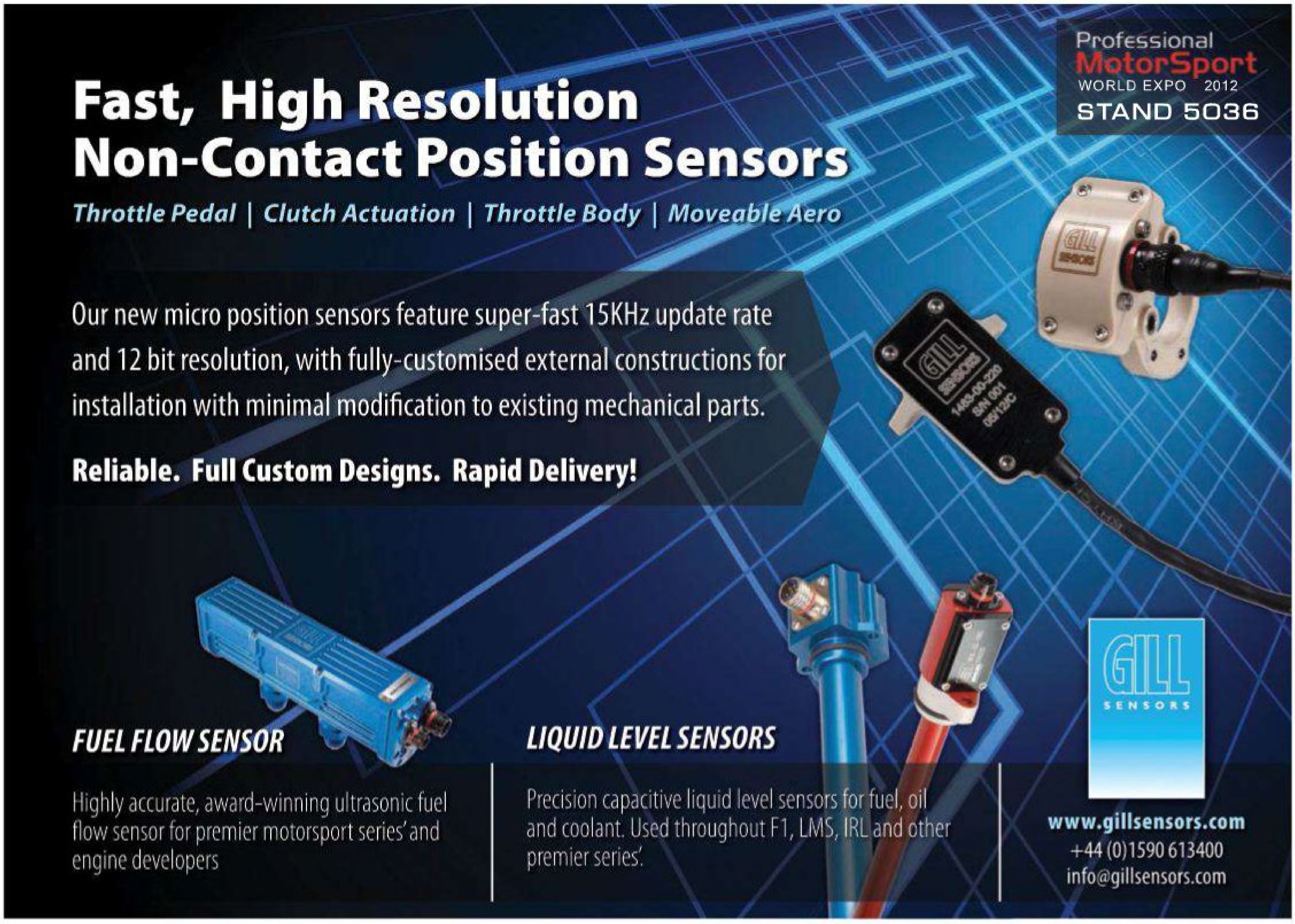
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Balancing act

The 2007 Honda RA107 is the most recent Formula 1 car *Racecar Engineering* has evaluated in the MIRA wind tunnel

The 2007 Honda RA107 wasn't the most competitive car in its day, but it's always a privilege to get your hands on any Formula 1 vehicle for evaluation in the MIRA wind tunnel, and this was no exception.

Three years ago we tested a (then) 10-year-old Benetton B199 (V19N7 to V19N10), so let's start our review of the privately owned 2007 Honda RA107. Bought by Bjorn Arnils and Nadine Geary at auction, the purchased car was missing only the steering wheel and engine. It presented us with a fascinating opportunity to complete a dozen experiments squeezed into this all-too-brief session. In half a day we were not able to answer all of our questions. I doubt we could do so with half a year!

BASELINE

Let's start our review of the Honda RA107's data by comparing it with that of the Benetton. Aerodynamic regulation changes between 1999 and 2007 limited the rear wing to two upper elements instead of three. The outer front wing sections saw a height increase of 150mm, the rear wing was shifted forward by 150mm, and in 2005 there was a reduction in the side rear diffuser volume. These changes were clearly intended to reduce downforce, so how did the two cars compare? **Table 1** reveals all.

Table 1: comparison of baseline coefficients of the Benetton B199 and Honda RA107

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Benetton B199	1.000	2.205	0.873	1.332	39.58%	2.205
Honda RA107	1.046	2.201	0.831	1.370	37.76%	2.104

As ever, keep in mind that although 'trip strips' were attached to the wheels to simulate the effect of wheel rotation, the MIRA wind tunnel has a fixed floor, so our downforce data will have been underestimated. However, the comparisons in the same wind tunnel are obviously valid.

Interestingly, then, the cars started out their respective sessions with almost identical downforce levels, but the Benetton was able to achieve this while also generating 4.4% less drag. So was this an occasion when the rule-makers had managed to stay ahead of the aerodynamicists? Not necessarily, because a glance at the front and rear lift coefficients shows that the Honda was generating more rear downforce than the Benetton despite using the mandatory two-element rear wing. And although the Honda's front flap was at maximum angle, the %front value was still well below the 40 to 45 per cent level one would have expected in order to be in tune with the likely static weight distribution. This suggests that the car's set-up, perhaps with respect to ride height or perhaps even the front wing itself, was not matched to this rear wing. One would have expected it to be possible to find a balance. Adding downforce at the front would obviously have increased total downforce but probably not drag, at least not by much, so the Honda may not have been behind the Benetton, and may even have been ahead.

TALES OF YAW

Before any changes were made to the baseline configuration, the Honda was run through a range of yaw angles from zero to six degrees, in two-degree increments. The effects on the aerodynamic coefficients and on balance are shown in **figures 1 and 2.**

Below: The Honda RA107 Formula 1 car in the MIRA full-scale wind tunnel.
Below right: The Benetton B199 in the MIRA wind tunnel in 2009

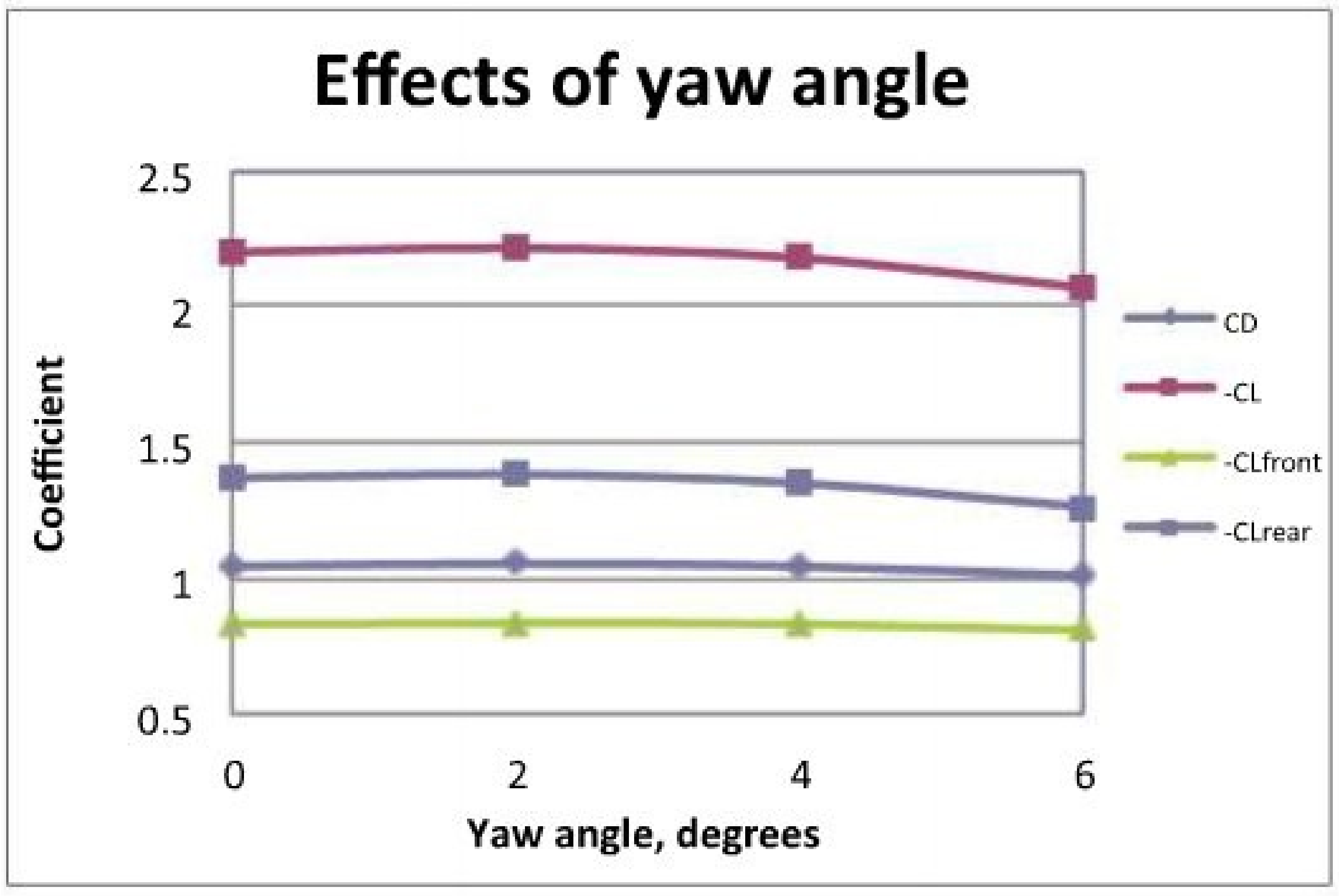

Figure 1: the effects of yaw angle on the aerodynamic coefficients

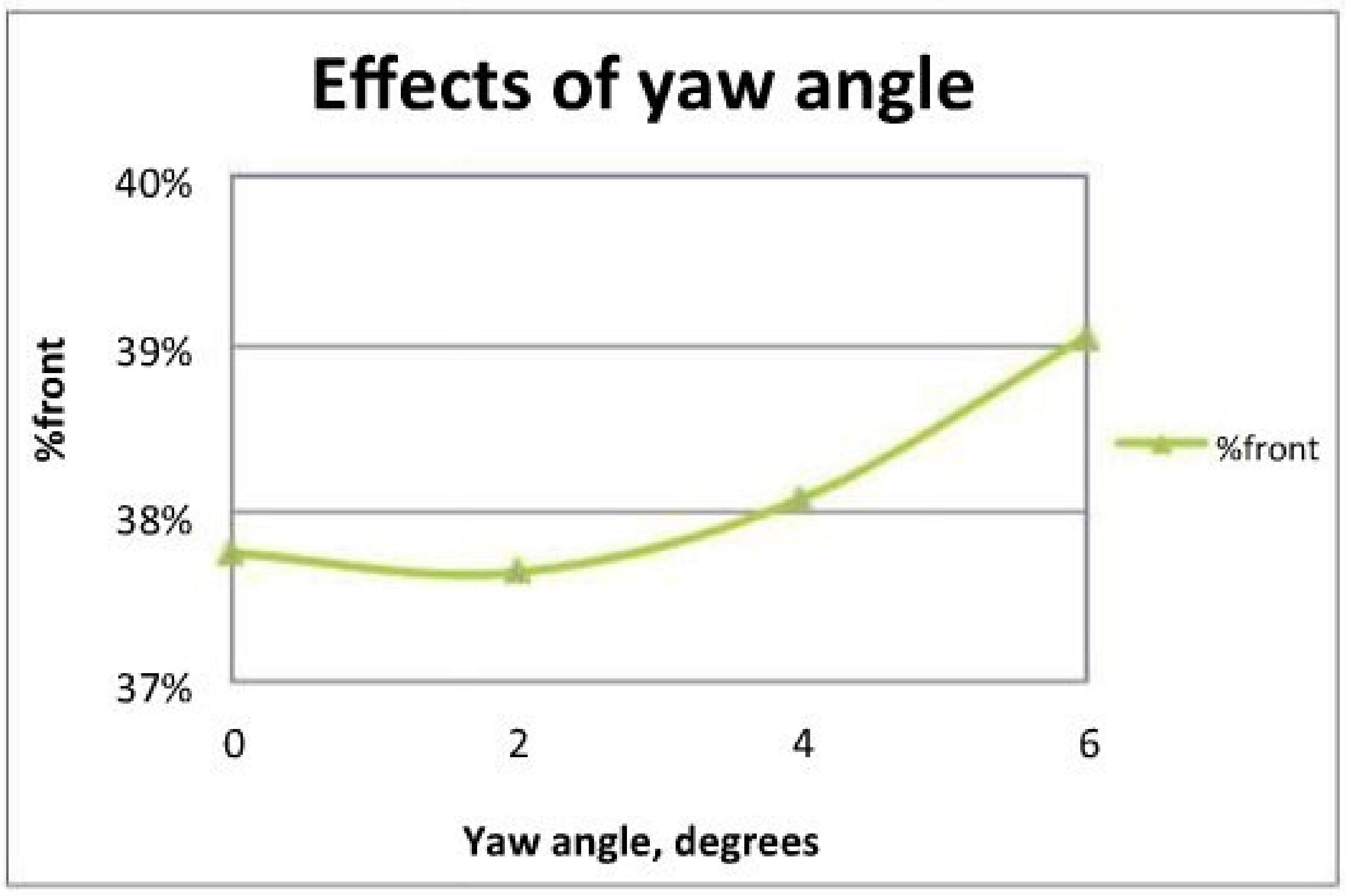

Figure 2: the effects of yaw angle on aerodynamic balance

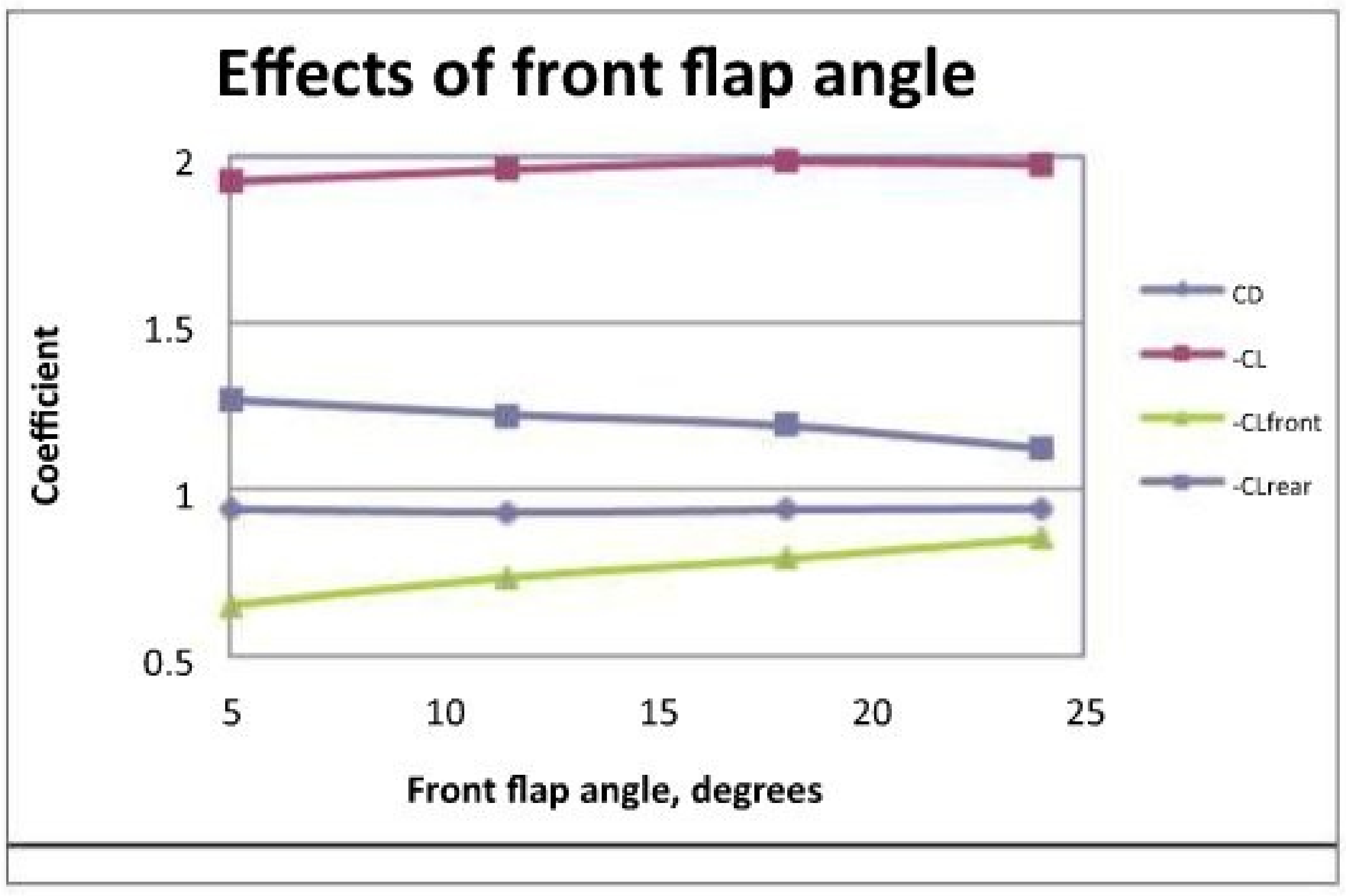

Figure 3: the effects of front flap angle on the aerodynamic coefficients

There are a number of interesting observations to be made here. First, total downforce actually peaks when the car is at a small yaw angle. Second, although front downforce increased very slightly as yaw angle was applied to the car, most of the downforce change was at the rear. Was this the result of the rear wing or the underbody (or both) changing performance at yaw? There is no way of knowing from wind tunnel data. However, the third observation to make is that, from this data, it would appear that the car has been optimised in the zero- to four-degree yaw window, with minimal coefficient or balance changes occurring until yaw exceeded four degrees. At six degrees yaw, the car's balance shifted to the front, which would tend to make the car oversteer once 'out of shape.'

Table 2: comparison of the Honda's data with original and alternative rear wings

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Original	1.046	2.201	0.831	1.370	37.76%	2.104
Alternative	0.943	1.977	0.853	1.123	43.15%	2.097

Removing the rear wing that was fitted at the start of our session

Replacing it with an alternative rear wing brought interesting results

WHAT CAN BE SWITCHED?

One of the early configuration changes was a switch to an alternative rear wing that the owners had brought along, there being no provision for adjustment on either of the rear wings available. **Table 2** illustrates the result of the rear wing swap.

There was a substantial decrease in rear downforce with the alternative wing, and a %front value that would probably have been closer to a balanced set-up. This suggests that this front wing might not have been the highest downforce option that was available back in 2007.

UTILISING THE FRONT

It's always useful to sweep adjustable wings across their working range to ascertain the effects on balance. The data for the front wing sweep with the alternative lower downforce rear wing are shown in **figure 3.**

We can see here that total downforce peaked with the front flaps at 18 degrees, where the maximum angle available was 24 degrees. This was not because of any loss of performance of the front wing at its maximum angle, as the -CLfront plot line shows, but rather that the decline in rear downforce with increasing front flap angle was not linear, there being a slight levelling off in the -CLrear plot line when the front flap was at 18 degrees before it declined again at 24 degrees. Note, too, that drag barely altered across the range of front flap angles, and that there was actually an initial *decrease* in drag as flap angle was increased. The value was virtually the same with the front flaps at 24 degrees as it was with the flaps at five degrees.

We'll have more next month on the Honda RA107.

Racecar Engineering's gratitude goes to Bjorn Arnils and Nadine Geary.


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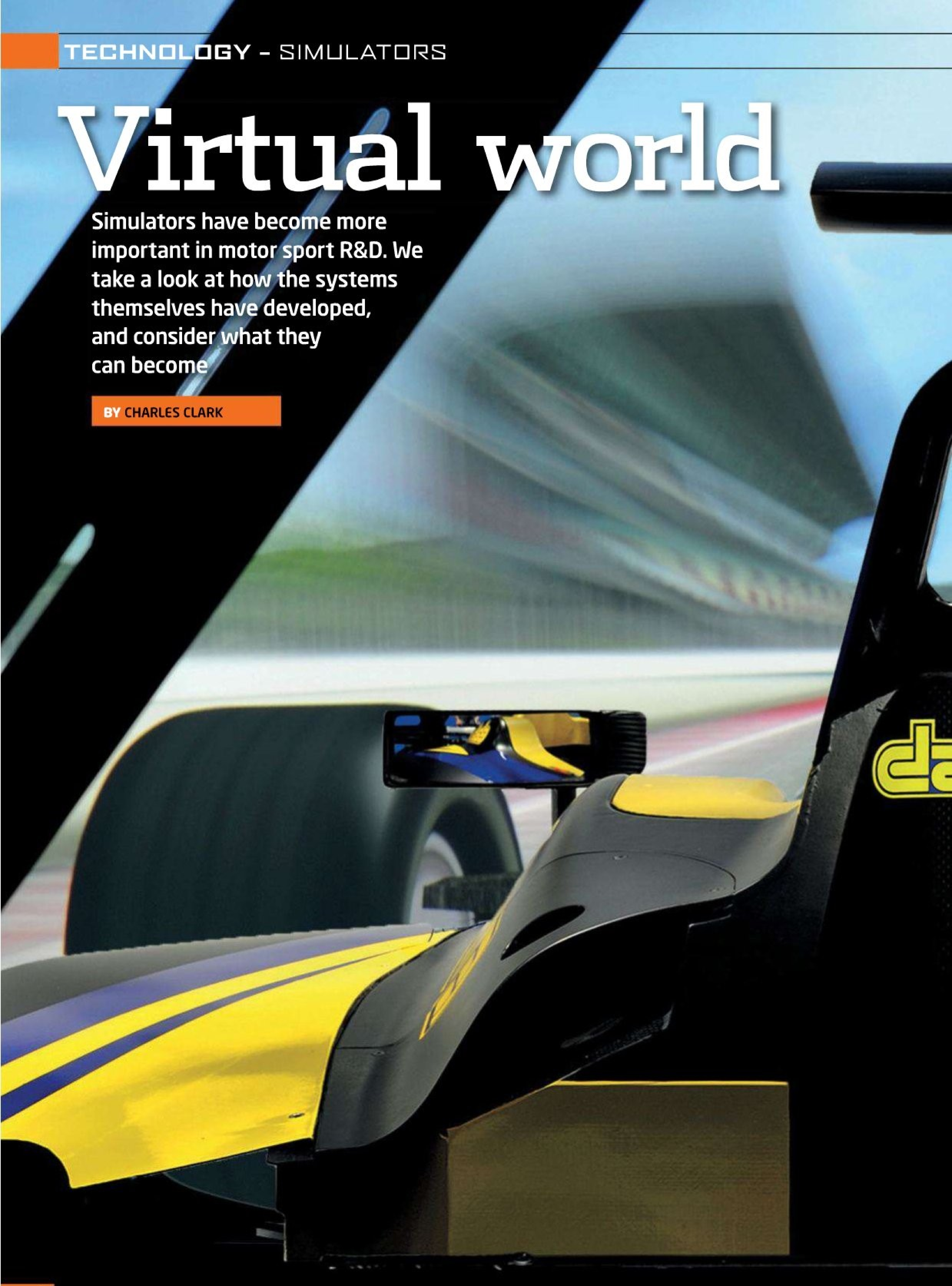
Virtual world

Simulators have become more important in motor sport R&D. We take a look at how the systems themselves have developed, and consider what they can become

BY CHARLES CLARK



Simulators have evolved into very useful design / development tools because of the progress in computer power and visual displays, track simulation, tyre simulation, and the improvement and the evolution of the mathematical systems models of the cars. Today where there is very rigorous correlation between the simulator and the track test.

In all the major teams and the motorsport consultancies, the sophisticated simulators are doing car development rather than training drivers. It has even been reported that some Formula 1 teams are getting better feedback from a simulator test than they do at a track test.

In these times of restricted testing, simulators are used more for track preparation. The team learns to trust the mathematical models it develops for its cars, so much so that they can change components in the model. With consistent drivers, they will be able to tell whether the change is an improvement or not just from the simulator run.

A good simulation relies very heavily on a very sophisticated, and well-developed, mathematical model of the car, and all its components, as well as the track itself. In most cases when you've 'calibrated' your simulation against an actual car, and track data, it's possible to extrapolate using the simulator, producing very predictable results on the track.

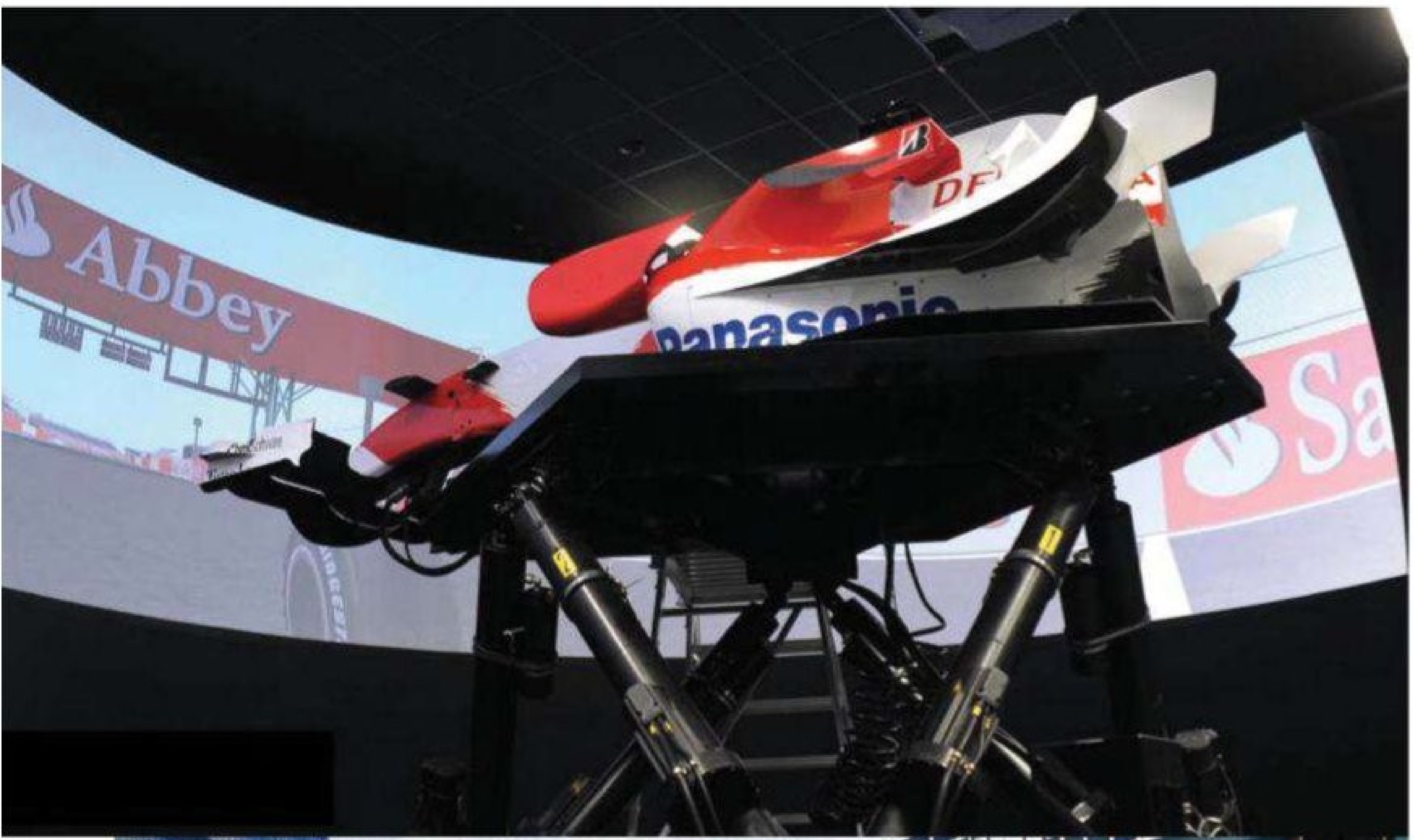
However, in the middle of all of this there is the driver, and he has to feel the car in the simulator like he feels the real thing. Despite the high levels of data that teams put in, if the driver, that flawed sensor, cannot feel the car in the right way, the data that comes out is useless. So, much effort has been made in making the driver feel as though he is actually in the real thing.

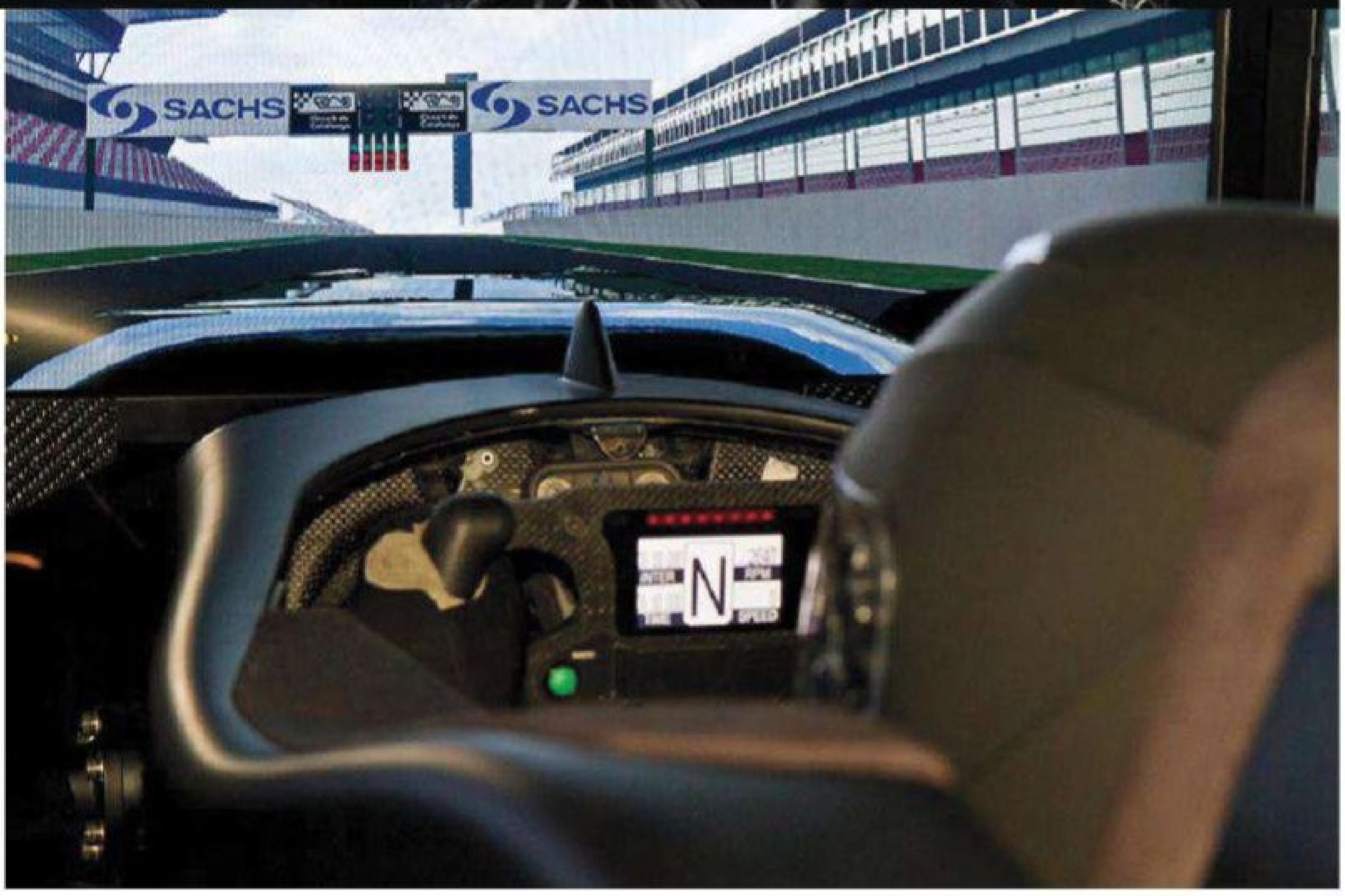
THIRD DIMENSION

There is much better virtual reality immersion technology available today using 3D projection. 3D gives the driver much better feedback over and above what can be achieved with 2D, in much the same way as HDTV is such an improvement in television technology.

3D gives the driver better immersion, which improves levels of feedback he can give to the engineers. In recent years the first Cruden 3D system in motorsport was installed at Wirth Research in the UK. The system uses 3D projection and a total of six projectors, three each for the left and right eyes. However, 3D projection has advanced so much in the interim that if this system was being specified today it would only use two projectors.

"The motorsport simulators have the images rendered at the very last second, because it's not always possible to predict what the next frame rendition will be"





Much of the development has gone into the circuit and kerbs, at the expense of the visual cues around a track

3D projectors have increased in sharpness. 'At the time we did the Wirth installation, we used two projectors for each channel and we had to add an extra one each side because they couldn't use stereo,' says Frank Kalff, commercial director of Cruden. 'In current proposals, we are specifying one 3D projector per channel rather than having two 3D projectors per eye. The manufacturers are developing the hardware and software to enable this kind of progress. Everybody benefits from these improvements in technology. Sharper images, less tearing, decreased latency all combine to produce a better experience of the user.'

Cruden has a partnership with Projection Design, one of the leading manufacturers of projectors. There are different projection technologies for different applications. Simulator displays tend to be a bit more letterbox than, say, video wall displays. The motorsport simulators have the images rendered at the very last second, because it's not always possible to predict what the next frame rendition will be. The simulator software has to render the image depending on what the driver does in the car. The display engine has to do all the calculations at the very last second and there's not enough computer power available for them to produce very photorealistic renditions in this time-frame.

Simulator manufacturers are trying to get the best photorealistic quality possible in the circumstances, and the time available to render the images. Even the most powerful rendering engines cannot render scenes to fill a large 220-degree screen that quickly. 'Things are improving all the time but the computer power just isn't there yet,' says Kalff. 'TV ads, although they are computer generated, are pre-rendered, and so the software knows what's in the next frame before it renders it.'

LIGHT SOURCE

Cruden sources 3D Lidar (Light Detection And Ranging) data from multiple sources to produce their track models. Track models are essentially a mesh that comes from a point cloud generated by the Lidar scanner. The mesh is very precise for the track and the kerbs, but is less precise for the surrounding scenery. The scan data also gives the locations for the surrounding topographical 'landmark' elements so the driver has his usual reference points. The more accurate the scan data, the more computation is involved in processing the simulation. Track data accuracy is always a trade-off between the kind of accuracy required and the length of time it takes to calculate the simulation.

As happened in CFD, which reached the point where results were so accurate that they didn't need to improve the fidelity, the challenge was to produce results in a faster timeframe. Laser scanners and various other pieces of technology were introduced long ago, which managed to capture the topological characteristics of the tracks to a reasonable accuracy. Now it's a matter of building tracks as fast and as cheaply as possible.

'We have synthesised many processes together using laser scanning, Lidar and various other stereo and other optical techniques,' says Nick Wirth, founder and owner of Wirth Research. 'Tracks are a living thing. Ground moves, drains collapse, tracks get resurfaced and so the challenge for us is to rebuild the track data as quickly and economically as possible.

'It's a never-ending process trying to do it cheaper and cheaper, while maintaining the fidelity of the data. We are automating the process more and more and it seems to be working.'

The main interest in building track data is the surface and kerbs that the car runs on. The peripheral data and landmarks surrounding the track are of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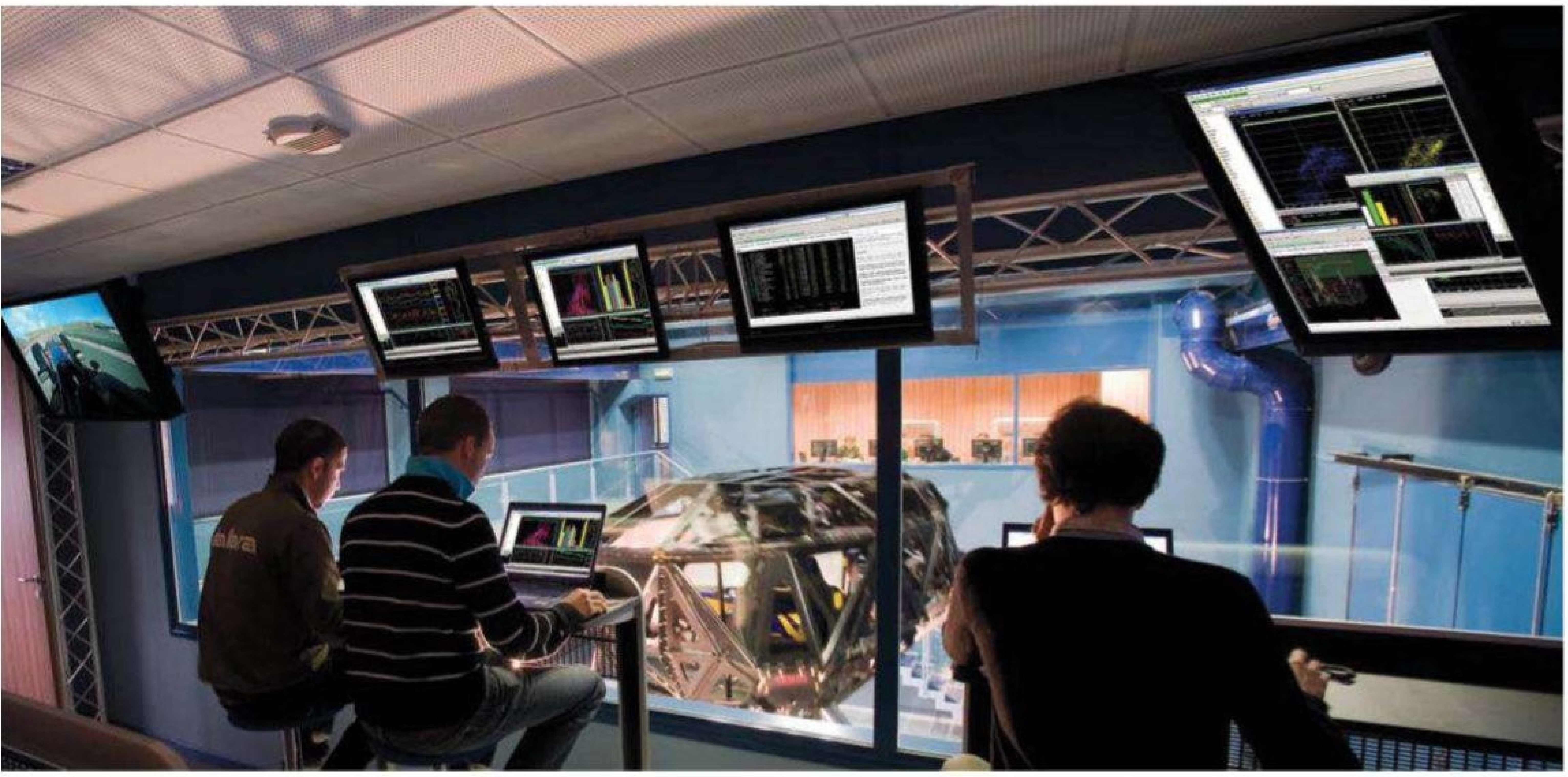

3D simulators require far greater computational power, but the future could lie in head-up displays that will increase the sense of reality

less interest, although they are important to driver references. Drivers are very fussy, and they notice lots of small details outside the track, which they use as points of reference. As the image resolution increases, it is important to be able to improve the quality of the less important data.

PHOTO REALITY CHECK

Future challenges, according to Cruden, are the continued efforts to get to photorealism, whether it's for 'on board' or 'off board' projection or on screens. Cruden does all three. 'In the future it's easy to see the screens being replaced by goggles or head up displays,' says Kalff. 'The resolution problem will go away, because the images will get so small that it's possible to interact with the environment in the virtual reality kind of way, inside the helmet. Also head tracker systems are beginning to be talked about so that the rendering engine can predict what the next frame is by taking into account where the driver is looking.'

Wirth adds: 'Cruden is a good company that we like working with. We installed one of their first 3D systems about three years ago. In our opinion 3D is a lot better than 2D, but in the end it comes down to driver choice. We pioneered the use of 3D with Cruden and the partnership has gone from strength to strength.'

A 3D system requires twice the computing power over a 2D system, as it requires images for both eyes separately. It also doubles the computing requirement, but it's worth it for the increase in fidelity.

MIND GAMES

As anyone who has paid extra to watch a 3D film will attest, the one disadvantage is that you have to wear glasses of some kind. Some drivers find them uncomfortable and would prefer to use the 2D system. It is a simple switch just like on your TV set to go in from 2D to 3D.

'The human brain is quite good at recognising 2D images and converting them into 3D in the brain, especially when it comes to recognising landmarks around familiar circuits,' says Wirth. 'The majority of drivers that use our facility tend to prefer 3D but there are a few that don't.

'Simulation in all its forms underpins my design philosophy, so I was very interested to observe from the sidelines the birth of what we call 'driver-in-the-loop' design. About ten years ago, Williams and McLaren started investing very heavily in simulator technologies. We decided we needed to move in that direction but we were constrained by small company budgets in the early stages.

'We initially investigated aircraft simulation technology, as that had almost 50 years experience in that area. Looking at aircraft simulation at the top end, and video games at the bottom end, there was a lot of information about what was possible. It allowed us to home in on the right kind of hardware quickly. That, coupled with the falling prices, made sophisticated simulation more affordable.'

"3D gives the driver better immersion, which improves levels of feedback he can give to the engineers"

MOTION PLATFORM

Wirth was a firm believer in using motion platforms, which weren't very trendy at the time. The early Williams and McLaren systems were not motion-based. Wirth looked at the six DOF Hexapod-style platforms that they were using for a new aircraft simulation. Cruden was able to put together some relatively affordable hardware, which seemed to have the frequency response and the capability that Wirth needed for a reasonable cost. Cruden was also willing to work collaboratively and share source code and other intellectual property to allow Wirth to customise the system. This allowed them to use all their experience in vehicle modelling, so that they could continue developing the software and the techniques as the system evolved.

'We took delivery of our first system in 2006,' says Wirth. 'It's been a very interesting journey. We weren't a racing team so we had no need to train drivers, but it very quickly became apparent in our development that the drivers were finding it very, very useful. Throughout the whole process we've had a very talented and very patient driver in David Brabham, whose contribution to the development of the


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system cannot be overstated. His contribution has been at the heart of simulator development from the very beginning, and continues to help us today. A lot of our success, and the reason why people like our simulator, is largely due to David's input.'

Wirth also rented out their facility at one point. Before they got directly involved in Formula 1, they had four teams using their facility during the same period in 2008. This was during the time when there were lot of new tracks coming on stream, like Singapore and Valencia, and surprisingly some of the larger teams weren't able to run race simulations on these circuits.

DIVERSITY

Wirth has a number of different models that can interface with its simulator, and they can have a number of different models running on the simulator at the same time. This is mainly due to the fact that they've been developing a thermal tyre model for a number of years. 'This has quite a big computational overhead, and we found that you have to run a tightly controlled parallel process where you have multiple processor cores running individual tyre models and various other sub-models on the car,' says Wirth. 'In this way you can accommodate multiple inputs to the simulation.

Simulation came into the mainstream as Pirelli came to Formula 1 and the teams had to create their cars around an unknown quantity. 'This was a very expensive and

CLAYTEX

The key component any simulator session is the simulation of the 'system' being examined in the simulator. By system we mean the assemblage of all the system components. In the case of a racecar, we have suspension, dampers, springs, antiroll bars, steering, aerodynamic and braking components and tyres. It is possible to include characteristics of the drivetrain, as each different engine / gearbox configuration has an effect on the simulation, particularly in the case of hybrids and energy recovery systems.

This all sounds very complicated, and it is, but to help us we have some very well developed system modelling codes that can help us. The good thing is that, with a system modeller, you are building up a simulation model by aggregating the effects of all the components of the system. The more components you can model the closer to 'real life', the system becomes and the more accurate the simulation.

A basic way to look at it is that a system modeller is a time based modeller that uses physics- based solvers to reconcile 'systems', whereas FEA and CFD are spatial modellers, again using physics, but these help us to understand what is happening internally in a volumetric sense.

System modellers have been used to examine road traffic accidents forensically, determining who was travelling where and at what speed, based on the known outcome. They have also been employed by games developers to provide realistic animations.

Claytex is an engineering consulting company specialising in systems engineering, applying systems technologies across a wide range of industries. They distribute tools, develop Modelica libraries, and can help define and implement systems engineering processes using model-based design.

Claytex distributes for the Dassault Systèmes (developers of the CATIA CAD software) portfolio of systems engineering tools which includes Dymola, Reqtify, ControlBuild, AUTOSAR Builder and CATIA Systems.

Dymola is a world leading multi-domain modelling and simulation tool. It enables engineers to visualise a joined up, seamless understanding of vehicle architecture and dynamics, and allows them to simulate everything from control system design to driveability. This enables the teams to investigate and optimise every component before physically building a vehicle, drastically reducing time to market.

'Dymola is not a competitor to Matlab and Simulink. It's more of a complement to them,' says Chris Denly, Sales and Marketing Manager at Claytex. 'Matlab and Simulink are ubiquitous, but they model things in a discreet lower-level kind of way. It is possible to interface Dymola and Simulink in both directions. It manages to refine the equations of the system is into their lowest and most cogent form, it's more of a supporting tool to systems like Simulink. Dymola can be used to tweak systems that have been previously modelled in Matlab and Simulink and take into account multi-physics and multi-domain modelling.'

THE MODELICA LANGUAGE

Modelica is an object-oriented, multi-domain modelling language for component-oriented modelling of complex systems, e.g., systems containing mechanical, electrical, electronic, hydraulic, thermal, control, electric power or process-oriented sub-components. The free Modelica language is developed by the non-profit making Modelica Association. The Modelica Association also develops the free Modelica Standard Library, that contains about 1280 model components and 910 functions.

"Modelica is specifically designed for modelling physical systems"

Modelica is specifically designed for modelling physical systems. It allows individuals and groups using disparate modelling systems to work together efficiently on large-scale projects, constructing reusable custom components and libraries.

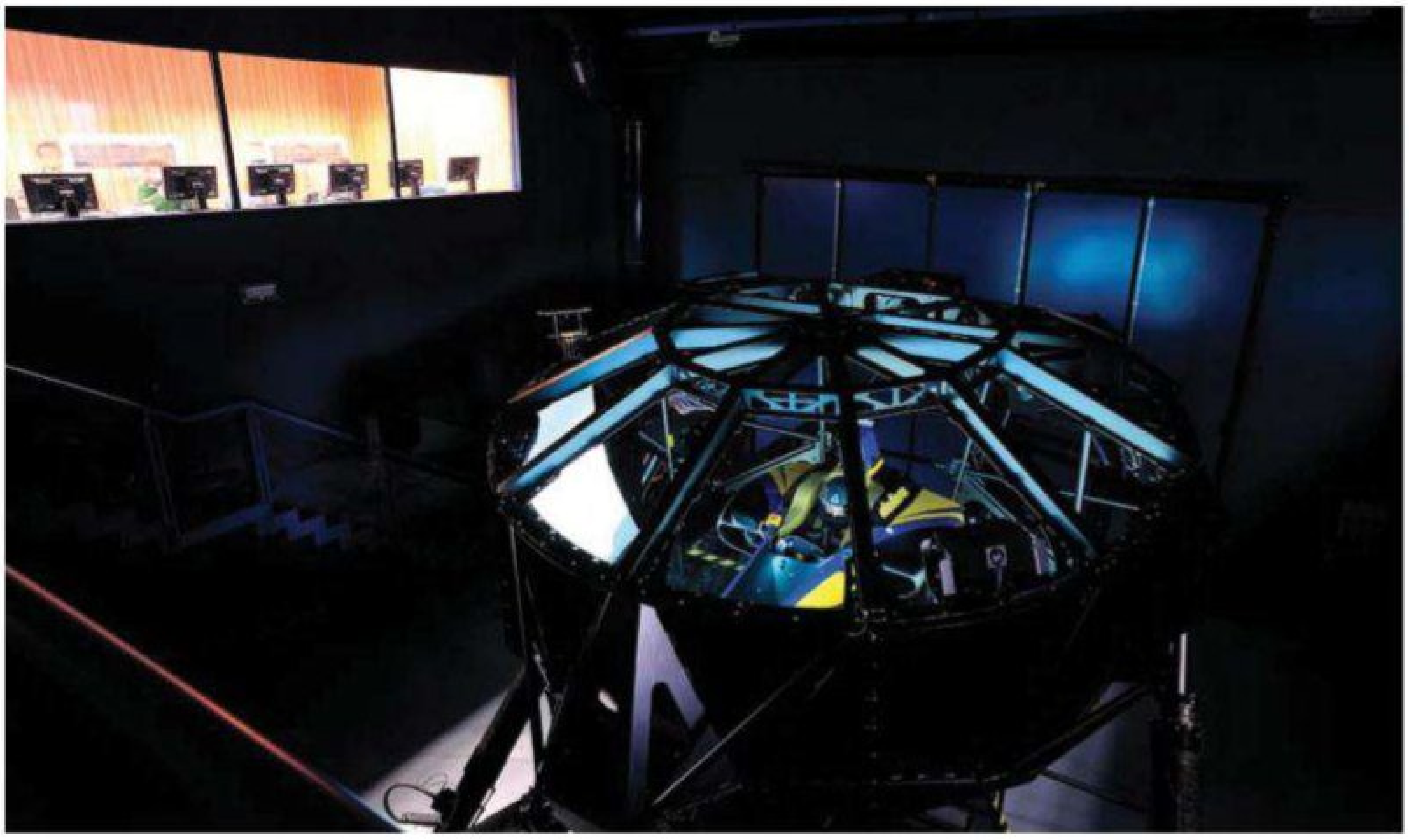
Whilst Modelica resembles object-oriented programming languages, such as C++ or Java, it differs in two important respects. Firstly, Modelica is a modelling language rather than a conventional programming language. Modelica classes are not necessarily compiled in the usual sense, but are translated into objects, which can then be exercised by a simulation engine. The simulation engine is not specified by the language, although certain required capabilities are outlined. The Modelica code can also be translated into C code which is then compiled as, with Dymola.

Secondly, although classes may contain algorithmic components similar to statements or blocks in imperative programming languages, their primary content is a set of equations. In contrast to a typical programming language assignment statement, where the left-hand side of the statement is assigned a value calculated from the expression on the right-hand side, in Modelica an equation may have expressions on both its right- and left-hand sides.

Equations do not describe assignment but equality. In Modelica terms, equations have no pre-defined causality. The simulation engine may (and usually must) manipulate the equations symbolically to determine their order of execution and which components in the equation are inputs and which are outputs.

Dymola implements the Modelica language, which takes advantage of the strengths of component-based modelling, where the flow in individual components is modelled. This presents significant advantages compared to block-based modelling. In addition it is acausal which means that the flow can be studied in both directions.

'This means that it's a quitebit more flexible and it makes it quicker and easier to develop simulations,' says Denly.


One of the key factors of a simulator is to immerse the driver in a virtual world that accurately reflects reality

time-consuming exercise, but ultimately it placed us in a very good position,' says Wirth. 'We managed to create some very sophisticated thermal tyre models which have been of great benefit to our customers who are involved in racing at the highest levels.

'If a customer asks us to develop a very accurate mechanical / thermal tyre model, we have procedures for doing that, which involves a lot of track data and a lot of flat track machine testing to gather data. Abaqus, and other non-linear FE codes, are part of the tyre model development.

'Our basic tyre model is commercially available in a product called Murityre (for multiple rib thermal tyre model). This is not just used exclusively on our simulator it is a is generally available to anybody who wants it.'

The drive to establish an efficient and comprehensive simulation package is worth the cost. 'It is a massive saving whichever way you look at it,' says Wirth. 'It's environmentally friendly, you don't destroy tyres, you don't use fuel - it's definitely the right way to go. But equally there is no point doing it if the models are wrong. You just end up getting frustrated and wasting everybody's time. You don't want to educate drivers to react to car behaviour that's non-existent, because they'll just end up performing more poorly at the track.'

MONEY TALKS

So, as in most branches of motorsport engineering, you pay your money and you take your choice. Simulators are very much part of the motorsport landscape, and because of the restrictions on both track and tunnel testing, they are fast becoming the design verification tool of choice for most 'Formula' teams. Because of the link to the physics of the real car, working with simulators is teaching a new generation of motorsport engineers much more about systems engineering and tyre technology than they're learning about the cars. Some Formula 1 teams shroud their simulator technology in a veil of secrecy, which is a shame as only a handful of engineers could gain anything by looking at them.

You can buy a serious entry level sim for about $25,000, and, as in all motorsport, the sky's the limit, with the stratospheric hexapod entry point coming in at about $2.5m. Most professional drivers are used to simulators and you can rent a hexapod for about €2,000 for a half day at Toyota in cologne, with UK-based facilities costing about twice as much. But one things for sure: Team GB is leading the way again.

SIMXPERIENCE

One of Simcraft's key competitors is SimXperience, a premier motion simulator manufacturer with expertise in electronics, engineering, manufacturing and software development. Their products are used world-wide in driver training facilities, homes, simulation centres and race driver development programs.

The SimXperience motion engine software, Sim Commander 3, is simple enough for home use, yet powerful enough for the professional. Their Stage 5 full motion simulator includes the SimXperience exclusive SimVibe physics based tactile feedback technology in addition to 3 degrees of freedom motion.

The Stage 5 simulator provides 250 motion updates per second to ensure that you feel every detail of the vehicle suspension and track. SimXperience is the only simulator in its class to simulate rear traction loss and rear wheel hop accurately, allowing the driver to drive by the seat of his pants in the same way that he does on the track. The Stage 5 simulator provides a wide variety of training capabilities including laser mapped tracks and advanced analytical tools.

'The SimXperience simulator is able to produce details as small as 0.02mm and the tracks are laser mapped to 2mm,' says Berney Villers Jr., owner, President of SimXperience. 'It's good for 15 inches or 400 mm a second and it can reproduce the very high frequency details.'

SimXperience simulators create the ultimate immersion by employing a variety of techniques. First and foremost they manipulate your inner ear / sense of balance to create a sense of motion. They combine this with minute body pressure cues by creating just enough roll and pitch to utilise your body weight to create these pressures. Finally, they combine the body pressure and sense of balance manipulation with kinesthesia (skeletal and muscle pressure manipulation) and proprioception (the sense of the relative position of neighbouring parts of the body and strength of effort being employed in movement).

'Our simulator pivots from the front so rear traction loss is very noticeable,' says Villers. 'It simulates the event better than the central rotation simulators and you can recover better.'

The SimXperience objective is to enable the driver with personal immersion. Expensive simulators have a team of engineers making adjustments to ensure the fidelity of the experience. In a SimXperience simulator the driver does it.

The software also has multi-level tuneability. What's inside the motion profile is listed, and you can adjust it to have more, or less, of the various attributes so that it begins to feel more like your own car. You can even control the speed and the rate of the accuators.

'In a simulator what you don't notice is what's realistic,' says Villers. 'What you do notice are the things that are out of tune with reality. In our simulators professional drivers are running to within a hundredths of a second of their track times'

The SimXperience Stage 5 Simulator ships to your door for $17,500(in Continental USA).

The same, but different

Nissan announced in February that it was joining Australia's V8 Supercar series, and produced an engine in double quick time

BY STEFAN BARTHOLOMAEUS

Nissan's media invitation to the recent launch of its V8 Supercar engine was about as cheeky as it gets in the often sanitised world of automotive PR. Arriving in the post was a valve from a V8 Supercar motor, with an attached tag reading: 'You're used to seeing 16 of these in action. Now come and see what 32 looks like.'

The introduction of the Nissan and Mercedes-Benz brands into the traditionally Ford and Holden-only championship under the Car of the Future (COTF) regulations next year signals a significant change for the class both conceptually and technically.

While Mercedes-Benz Australia will play no role in a privately funded programme that utilises the AMG Customer Sports department in Germany, Nissan Australia has committed heavily to its campaign, engaging the currently privateer Holden squad Kelly Racing to design, develop and race its Altima-bodied contender. The Melbourne-based Kelly outfit is co-owned by brothers Rick and Todd Kelly, who both won the Bathurst 1000 as part of the factory Holden team before eventually taking on the ambitious task of setting up their own four-car squad in 2009.

Utilising the same control chassis as all other COTF entries, the team's Altima cars will be powered by a bespoke version of Nissan's all-aluminium, quad-cam, VK56DE engine. Conveniently for the manufacturer, the basis of the motor will also enter local showrooms next year in its latest Patrol SUV, giving Nissan another marketing trump card against the racing-only engines currently used in the category by Ford and Holden. The fact that no Altimas will be available in rear-wheel-drive or V8 form is, according to Nissan Australia managing director and CEO William F Peffer Jr, beside the point.

'If you look at the NASCAR series in the US, those engines are all V8s and in platforms that don't necessarily carry V8 power trains as standard equipment,' he says. 'That's not an issue for us. The key is that we produce this engine and it will go into our Patrol in 2013. Racing a production engine is an association our competitors don't have in this market, and it's something that we're very excited about.'

Although initial plans for the COTF had included the possibility of new manufacturers simply 'dropping in' already developed racing engines from other classes (such as the GT1 version of the VK56DE), V8 Supercars' desire to maintain parity with the current Ford and Holden motors saw the new rules follow a different path.

A significant departure from the cast-iron, push-rod, engines of the incumbents, the V8 Supercar VK56DE shares the same bore, stroke, compression ratio and rev limit of the existing units, alleviating early fears over the need to juggle items such as air restrictors and gear ratios if working with fundamentally different engines.

'Outside NASCAR style racing in the USA, we've probably got the closest category in the world as far as horsepower spread across the whole field at the moment,' notes Todd Kelly. 'We (the category) could have wrecked all that in one fell swoop by not making the right decision with these new regulations.'

A HEAD START

Groundwork for the Nissan V8 Supercar motor was undertaken midway through 2011, when Kelly Racing was still in the early stages of its negotiations with the car maker.

"We pulled it apart, put the heads on the flow bench and did a bit of porting"

A member of V8 Supercars' Commission panel, charged with overseeing the basics of the sport's technical package, Todd was keen to find out whether developing a production-based, double overhead cam engine around the existing V8 Supercar rules was a realistic goal.

'There had been a lot of discussion on the commission as to how we would, as a category, implement a new manufacturer and their engine,' recalls Kelly of the situation. 'There were a couple of ways of going about that, and with us (Kelly Racing) being partway through our negotiations with Nissan, we thought it'd be a really good investment to get an engine down and start learning first hand what it was capable of, and what we'd need to do to get it to match the horsepower produced by the current engines.'

What followed was three months of development undertaken at the Kelly brothers' personal workshop, located several suburbs away from the team's racing headquarters. In order to keep their still unfolding Nissan negotiations under wraps, team staff called in to work on the Nissan engine were told that it was being built to power one of the Kelly's own ski-racing boats housed within the facility.

'We were so convincing with our story that a few of the guys in the engine department started to get a bit annoyed with how much effort was being put into a boat engine,' laughs Kelly.

The team adapted the exhaust and inlet manifolds from its existing Holdens for initial testing of the wet-sumped VK56DE unit,


8
6
4
2
POWERED BY
NISSAN

before a more serious second phase of evaluation began. 'We pulled it apart, put the heads on the flow bench and did a bit of porting,' says Kelly. 'There was no CAD design or CNC time put into it, just hand-designed detailing. After we'd done some camshaft work we got it to the point where it made over 600bhp. We then shut the process down, happy with what we'd found.'

With the Nissan deal officially done in the new year, Kelly joined his team's engine department head Ryan Webb and chassis engineer Brendon Hogan for a two-day trip to NISMO's headquarters in Tokyo, Japan. It was during that visit, made in the days leading up to Nissan's February 9 announcement that it would be joining V8 Supercars, that the choice of block and head was officially locked in.

'Once the basics were confirmed we sat down with ten or so of the guys at NISMO (Nissan's racing arm) and went through a lot of the bits and pieces that they'd developed from the standard block, cylinder head and running gear that they'd uprated and modified for their race engine,' says Kelly. 'That's really been a huge saving for our own R&D. Tapping into the valve train and timing development that they'd done probably saved us a year or more of work.'

HEAVY WORKLOAD

Despite the time savings brought through NISMO, Nissan's declaration at the launch in February that it would need to have its first car on track for a mooted group test of the new COTF vehicles in early August proved wildly optimistic. The engine itself would not be fired into life for the first time until late September, with a maiden track run still expected to be another month away. Delays in the finalisation of various category-wide rules, it should be noted, saw just one team hit the track on the initial test date.

'I reckon it's a world record to have had an engine running on the dyno in late September with how much work there was to do,' counters Kelly of suggestions that the programme has run slower than hoped.

'Everything you can think of with this engine we've either had to work with a supplier to come up with a new design, or design it in-house. You can't go and buy a head gasket for this engine, for example. The port spacings and the bore diameter is nothing like any other VK engine, so we've had to get custom head gaskets made, custom head studs... just everything that you can think of.'

At the launch NISMO openly showed off a range of engine components

The engine's crankshaft (Pankl), pistons (Mahle), conrods (Carrillo) and valves (Del West) have all been developed through the team's existing suppliers. The crankshaft alone required a 30-week time frame between initial design discussions and first delivery, while much effort has also gone into the new English made Piper camshafts.

The amount of design and production work done on the engine at Kelly Racing's own headquarters, meanwhile, is a point that Kelly stresses with some pride. 'All of the sump and the covers, the timing chain tensioners, the inlet manifold, the throttle bodies, the carbon fibre trumpets and airbox base, all of that has been made here at our shops,' he notes. 'Even with the blocks themselves, they are machined and sleeved externally, but they go into our CNC machines for all of the detailing work. We've designed and machined all of the cylinder head porting here too, so it's been non-stop for all of our guys.'

Planning to have a pool of 14 engines in place by the 2013 season opener next March, the team's initial build programme consists of two engines. The first will undergo a short period of dyno testing before being installed in a chassis ready for track running, while the second will be extensively dyno-tested by the team before being sent to V8 Supercars to conduct its own evaluations.

'We'll get the engine to where it's as good as we can get it within the specifications, and then V8 Supercars will check it to make sure that we've hit the right performance targets without having fudged anything,' says Kelly. 'They'll run it and try to tune it to its limit to make sure it won't make any more horsepower than the level we've submitted it at. Once they've done that it'll be stripped down, with every last nut and bolt homologated.'

Matching the fuel economy between the different engines is set to be a big part of the parity programme, with the results of many of the category's modern day races heavily influenced by fuel windows. Economy and performance characteristics will both be closely monitored by V8 Supercars throughout the racing season in case any changes need to be made to the specifications after the homologation.

The nailing down of the Nissan package will set the parameters for any other manufacturer that wants to enter with a double-overhead cam engine, including the Mercedes. Only announced in late September, the German effort sees AMG honing the M159 motor it uses in its SLS GT3s back from 6.2 litres to 5.0 litres. The AMG engines will be designed and built by the company in Germany, as well as being sent back to their homeland for major servicing and development.

"It'll be stripped down, with every last nut and bolt homologated"

There has been a suggestion that Ford and Holden are also looking at updating their engine packages, but the changeover cost may prove prohibitive at a time when the evolution of the local car market and a trend for downsizing has forced both manufacturers to significantly roll back and control their level of racing expenditure.

Regardless, the arrival of two highly respected brands, in the shape of Nissan and Mercedes-Benz, sets the scene for a refreshingly new look Australian V8 Supercars Championship next season.

TECH SPEC

Specification overview

Block: Nissan VK56 - Cast Aluminium 90 degree V8

Heads: Nissan VK56 - Quad Cam, four valve per cylinder

Bore: 102.69mm

Stroke: 75.31 mm

Capacity: 4990cc

Induction: Naturally aspirated

Fuel: E85

Liners: Dry Cast Iron

Valve Train: Chain driven quad cam with direct acting DLC coated bucket followers

Ignition: Direct fire coil on plug

Injection: Sequential

Compression Ratio: 10.0:1 Maximum RPM: 7500

Crankshaft: Pankl

Bearings: ACL

Camshafts: Piper Cams Timing

Drive Components: Nissan/NISMO/ Albins

Pistons: Mahle

Rings: Total Seal

Conrods: Carrillo

Valves: Del West Valve

Springs: Performance Springs International

Plugs: NGK

Engine Management: MoTeC

Oil Pump: Dailey Inlet

Exhaust: Nissan Motorsport

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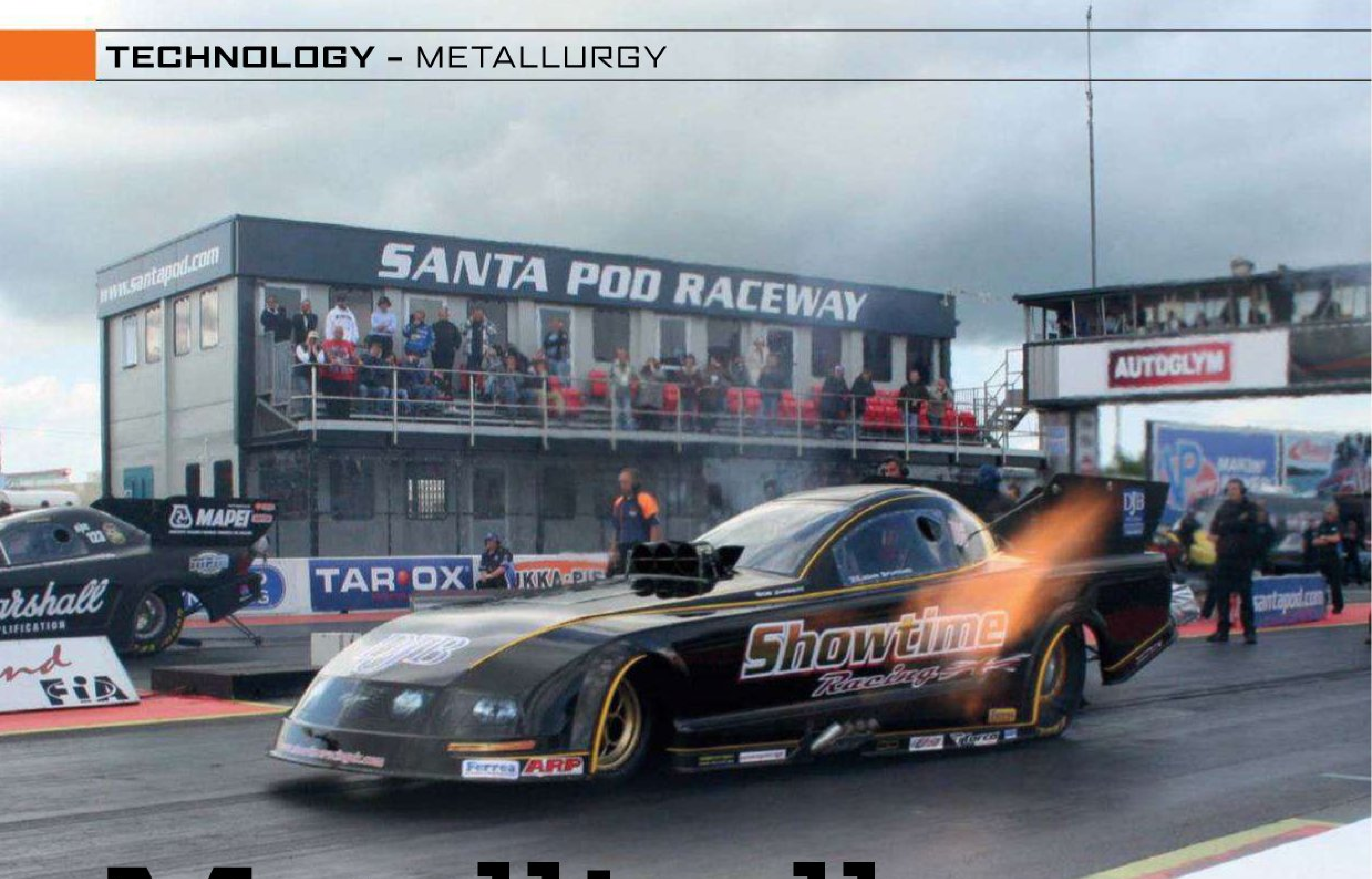

Metallically speaking…

Under extreme temperature and external forces, the battle rages to provide metallic materials that are up to the ever increasing tasks

BY GEMMA HATTON

In the world of motorsport, performance equals success. Achieving the desired performance relies on a complex network of factors and variables, all of which make 'success' an enormous challenge.

As motorsport becomes more competitive, teams pump their resources into exploring a potential performance gain, and developing robust, lightweight metals is critical.

Metallurgy is defined as the material science that studies the physical and chemical behaviour of metallic elements, their intermetallic compounds and their alloys, and covers the way in which science is applied to their practical use, as well as understanding the production, processing and testing of relevant metals and alloys.

TITANIUM

Titanium alloys have a wide variety of applications in motorsport, and have been used since the mid-1960s in 'bike and racecar engineering.

Nigel Hoskison, Motor Sport Technical sales engineer at All Metals, explains; 'It is important to remember that titanium is not a singular material, but is in fact a family of alloys in the same way as the range of steels. Generally, titanium is stronger than aluminium, but slightly heavier and has similar strength to many steels, but for only 60% of the weight.'

Titanium alloys are divided into three groups with widely different mechanical properties and attributes. Firstly, there are Alpha Alloys, which are known as commercially pure titanium. They have relatively low strength and are used in motorsport for motorcycle exhaust systems due to their lightness.

The Alpha/Beta Alloys have moderate strength up to 1000 MPa, and are heat treatable. Grades 6Al or 4V are the most widely used in applications such as impact structures, wishbones, hubs, flywheel, gearbox casing, clutch baskets and pressure plates, hydraulic cylinders, engine valves, fuel and hydraulic lines. Beta alloys are the third group and have the highest strength but apart from hubs and torsion bars, they have relatively limited applications, even in Formula 1.

'Titanium's strength to weight ratio is not the only factor that makes it so popular within motorsport; it is also a known material because it has been used for so many years and is

Table of common metals used in motorsport

Material	Grade	Properties	Application
	Aluminium Lithium, Aluminium Lithium Silver	Advanced aluminium alloys that usually contain around 2-3% lithium along with copper and magnesium alloying elements. Key advantage is lower density combined with improved elastic modulus, also resistance to fatigue cracking, improved corrosion resistance and greater toughness	Used on aircraft builds for the A350/A380
	2014, 7068	All lightweight, good weldeability and high fatigue levels. Different grades have different strength levels	
	2618		Used for pistons in general motorsport applications
	6082		Brake Calipers
	7075		
Steel	BS S155 (300M)	Very High strength with excellent fatigue	Used for driveshafts and gears
	4130 tube		Used extensively in chassis construction
	13-8 Mo	Precipitation hardenable stainless. It has medium to high strength which is achieved through appropriate ageing treatments, very good resistance to stress corrosion	Used for fastners
	MP 35N	35% Cobalt alloy	Con rod bolts
	15CDV6		Very popular for a variety of applications
	S132	Tensile Strength of 1320-1470MPa. Excellent hardenability for high core strength and develops hard wear resistance case after surface treatment	
	Maraging steels	Very high strength material, especially after heat treatment, has very good toughness with excellent transverse properties	Torsion bars
Nickel based alloys	625, 718	High strength, excellent fabricability and very good corrosion resistance	Engine valves and exhaust systems in F1, Le Mans, Indycar and NASCAR
	MP53N	Nickel Cobalt Chromium Molybdenum alloy that has very high tensile strength, good ductility, toughness and extremely good corrosion resistance	Fastners, Springs, Valve stems and Pump Shafts
Magnesium	WE43/WE54	A high strength magnesium alloy with excellent corrosion resistance and weldability. Usually heat treated.	Gearbox components, pistons and casings
Titanium	6 Al 4V		Drivetrain Components
	6246	An alpha-beta titanium alloy offering higher strength than 6-2-4-2 and good retention up to 4500C . Heat treatable and deep hardenable with good corrosion resistance but limited weldability.	
	6AL4V	Alpha beta type that is heat treatable to achieve increases in strength. Lightweight, high strength, formability and corrosion resistant.	

therefore understood by material technologists, designers and stress engineers. Furthermore, it is readily available (apart from the more specialist/proprietary beta alloys).'

All Metals don't just supply Titanium as Hoskison explains. 'We have over 30 years of experience supplying aluminium, steels, titanium and nickel alloys, primarily to the aerospace and defence industries. We have in excess of 15,000 tons of material within our five UK sites and four overseas locations, uniquely, all linked through the company computer system. As an owner managed business we have unparalleled decision making capability. Within the UK we operate a fleet of vehicles enabling us to offer next day delivery nationwide.'

A slightly unusual, but equally interesting, example that the company is working on is a 'Top Fuel Funnycar' that will be demonstrating its abilities at the world famous Volkswagen festival next July. It is a new car, said to be the fastest outside the US, and is expected to cover the quarter mile in 5.05 seconds, 309mph. The figure shows what materials are used and where, giving an idea of the suitable applications for specific alloys.

A Formula 1 car has been described as a "low flying aircraft" and as such employs many of the materials and technologies from the aerospace sector. Supplying materials to recognised aerospace specifications and standards has almost become a requirement in motorsport.

STEEL

Ovako has a steel production capacity of 1.3 million tonnes per year, with OvaX high performance steels supplying the motorsport sector. By combining cleanliness with durability, they are formulated for high performance motorsport engine and gearbox components including crankshafts, camshafts, gears, shafts and bearings.

The cleanliness of steel has become a major factor. Cleanliness is defined by the composition, size and distribution of inclusions, which are non-metallic particles contained within a metal. These inclusions have a major impact on the mechanical properties of the metal, as they disrupt the homogeneity of the structure, and during deformation, non-metallic inclusions can cause cracks, significantly effecting particular properties such as tensile strength, ductility and toughness. The amount of inclusions in a metal is no more than 0.1%, but the number is high as they are finely dispersed.

Connecting rods are a huge challenge for materials specialists, in a Formula 1 engine they can stretch and compress 3mm between BDC and TDC

Most of these non-metallic inclusions come from the actual steel making process. Inclusions that are formed in liquid and solidified due to chemical reactions (such as deoxidation) between the elements within the steel are called indigenous (or natural) and include oxides, sulphides and nitrides.

Also found in the metal are exogenous (foreign) inclusions which are a result of external sources such as parts of the casting mould material. However the amount of these inclusions is small and therefore have a relatively insignificant effect on the steel's properties.

The influence of these inclusions depend on their size, shape and chemical characteristics, which are defined by the chemical composition of the steel, the method of smelting and the steel grade. These properties can change within wide limits even within the same mode of production.

There are three stages to the formation of inclusions. Firstly, there is nucleation, which is where the nuclei of the new phase are formed by supersaturation (containing more of the dissolved material than can be dissolved) of the solution (liquid or solid steel) with the solutes (eg. Al and O) due to the dissolving of the additives (deoxidation reagents) or the cooling of the metal. This process is determined by surface tension on the boundary between the inclusion and the liquid steel. Essentially the lower the tension, the lower the supersaturation required for the formation of the new phase nuclei.

The second stage is growth of these inclusions, which continues until the chemical equilibrium (the chemical reaction and it's reverse progress at equal rates) is achieved. The growth in solid steels is particularly slow and thus, a level of non-equilibrium supersaturation can be reached.

The third and final stage is called coalescence and agglomeration. Here, thermal convection and stirring of the molten metal causes the inclusions to collide, which lead to merging of liquid inclusions (coalescence) or solid inclusions (agglomeration). Inclusions that have more energy on the surface will undoubtedly have more chance to merge when colliding.

The large inclusions float to the top faster, and are absorbed by the slag. This floating process can be intensified by stirring. Gas bubbles moving up through the molten steel also promote the inclusions floating and absorption by the slag.

OvaX alloy steel minimises the number of macro inclusions by refining the ingot casting process which allows for greater homogenisation (uniform composition throughout the material) and modifies the inclusion morphology within the material ensuring a lower number of sulphides, an extremely low sulphur content and the reduction in size and distribution of oxides. Another method to increase the quality is by reducing micro-segregation which is where the impurities and the alloying elements separate in different regions of a solidified alloy. By increasing the soaking time and top cropping Mirco-segregation can be avoided.

As a result, the finished material has an excellent isotropic profile, demonstrating toughness and fatigue strength with identical properties in both longitudinal and transverse directions. The quality of this material is so high it can often be used to replace re-melted steels, reducing delivery times.

Another factor that makes these high performance alloy steels so suitable for motorsport applications is that they are ideal for case hardening, nitriding or

"A Formula 1 car has been described as a low flying aircraft and uses aerospace materials"

TITANIUM ARIEL ATOM GETS GREEN LIGHT

British company Caged Laser Engineering has secured funding from the Niche Vehicle Programme to develop a titanium chassis Ariel Atom, which the company hopes will be finished in time to run up the hill at Goodwood in 2013.

Titanium itself is not difficult to work with, but the fabrication is not as the metal is combustible and cannot be welded with oxygen in the air. CLE aims to build the largest oxygen free chamber in the world in order to create the chassis, but it is a risk – oxygen equivalent to one thimble full of Ribena fruit juice in an Olympic size swimming pool would be enough to burn the metal under construction.

However, the advantages are that the metal is not susceptible to corrosion and has the highest strength to weight ratio of any metal. If a Formula Ford was to be built from titanium, it would be 40 per cent lighter than it is currently, including a lightweight chassis and suspension.

The already lightweight Atom, which boasts a power to weight ratio of 400bhp/tonne, would see that increase to more than 650bhp/tonne with a titanium built chassis.

TITANIUM EXHAUSTS

For a considerable amount of time one metal alloy has dominated the world of exhaust design, Inconel. But now a German company believes that it has an alternative and arguably superior titanium based alloy to take its place. S&D Spezialstahl (Speciality Metals) has developed KSTI-1,2 ASN in collaboration with Kobe Steel of Japan and Alconix GmbH of Düsseldorf, Germany. The alloy is targeted directly at high performance car and motorcycle exhaust systems.

The new alloy is basically based on commercially pure titanium, so the formability of it is similar. Due to its very good ductility the material can be used for more extreme cold bending applications, as well as some deep drawing processes. Some exhaust manufacturers thought to be in Japan are already employing the new alloy as it has a high temperature oxidation resistance up to 800degC and excellent fatigue properties. A good oxidation resistance helps exhaust manufacturers create lighter manifolds, because the use of thinner tube walls is possible.

As is the case with commercially pure titanium welding of the new alloy requires shielding in Argon gas, as it is reactive and can become contaminated with atmospheric gasses. If this happens the colour of the weld and surrounding area appears blue. This is caused by Oxygen and Nitrogen absorption.

Titanium has to be properly prepared and be clean of oil or grease before it is welded orthe joint could become porus.

The new alloy is supplied in cold rolled coils from 0.5mm up to 3mm thickness in either annealed pickled or vacuum annealed condition. The standard width is 1250mm.

Typical analysis

	H_2 (ppm)	O(%)	N_2(%)	Fe(%)	C(%)	Si(%)	Al(%)	Nb(%)	Ti
Min						0.3	0.3	0.1	
Max	13	0.15	0.05	0.2	0.08	0.60	0.7	0.3	bal

quenching and tempering. In particular, the advanced, clean nitriding grades are specifically developed for plasma, gas or nitro carburising. Supplied in an air quenched and self-tempered condition with a martensitic (solid solution of iron and up to 1% of carbon) structure, they can be machined with standard coated carbide cutting tools. The nitriding process produces a surface hardness on the material of approximately 850 HB with core hardness levels between 350-400 HB.

The micro structural quality of the metal is key to delivering a successful material. But another major factor when supplying motorsport companies, is meeting their specific requirements as Martin Tomlinson from Dynamic Metals explains 'generally, motorsport companies always require the material to a specification – it may be that our stock material will already meet this specification but if not we will heat treat and carry out testing to prove the material meets requirements.'

Furthermore, we can offer non-standard products by producing them ourselves using established and new production techniques from materials held in stock or sourced externally. We use subcontract facilities such as open and closed die forges (closed die is used to produce fairly complex shapes close to the finished size), rolling mills, heat treatment, machining, grinding, cold drawing, mechanical and ultrasonic testing. After hot working or heat treating we carry out independent testing and these results are supplied to the customer – we are also selective on where we purchase our materials so ensuring we start with the best quality.'

Smiths High Performance are a multi metal stockholder, holding a circa of £20 million stock at any time. They supply a wide variety of metals suitable for motorsport applications. Rob Kitchen, Smiths HP Manager explains; 'on all our materials we are pushing the boundaries with specifications, individually ultrasonic testing on bars not batches is becoming more standard for us, and dual certifying materials to British and American Aircraft standards where possible.'

"The micro structural quality of the metal is key to delivering a successful material"

Ultrasonic Testing (UT) uses high frequency sound energy to detect flaws and defects within a material. The main advantage of this method is that the depth of penetration for flaw detection is much better than other methods. It is also highly accurate in estimating the size and shape and the electronic equipment provides instantaneous results.

QuesTek Innovations LLC of the USA is a leader in the new field of computationally designing new materials, and their four new premium Ferrium steels (produced and sold by Latrobe Specialty Metals Co., a subsidiary of Carpenter Technology Corp.) are being applied to motorsport gears, shafts and other components for greater fatigue life / durability, hardness / pitting resistance, or temperature resistance. QuesTek is also developing new titanium, aluminum and other alloys.

There is no right or wrong answer; the only guide is either by following the trend of the competition, or developing a new technology/method. With the use of metals. The advantage of alloys is their degree of adaptability to suit teams' specific requirements, which may well be just enough to achieve that desired performance.

TECH SPEC

The Funny Car

Body: Carbon fibre/kevlar with lexan windows

Chassis: Chrome moly tube

Injector: Carbon fibre

Supercharger case: Magnesium

Rotors: Magnesium

Supercharger restraint: Kevlar ballistic material

Inlet manifold: Magnesium

Valve covers: Magnesium with titanium over covers

Heads: Aluminium Billet T6065

Intake valve: Titanium

Exhaust valve: Inconel

Block: Forged aluminium

Engine studs/nuts: Titanium where possible or 87 40

Pistons: Forged & coated aluminium

Pins: Tool steel

Rods: Deep cycle billet aluminium T6065

Cam shaft: Steel billet

Sleeves: Austenetic iron

Bearings: King dual metal babbitt

Crankshaft: Steel billet full counterweight

Motor plate: Chrome moly or titanium

Bell housing: Titanium

Flywheel: Titanium

Clutch cover: Titanium

Clutch plates: Steel sintered iron friction face

Clutch floaters: Steel

Reverser case: Magnesium

Drive shaft: Maraging steel gun drilled

Rear axle: Aluminium with carbon fibre top cover

Rear brake discs: Carbon fibre

Wheels: Aluminium

Fuel pump: Aluminium with steel rotors


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Validating simulation

If you want to be successful in the industry, simulation is vital

The A1 GP car should have been easy to set up as it was based on a Lola F3000 chassis that had 12 years of development. However, it turned out to be unique

BY DANNY NOWLAN

For almost five years now, I've written for *Racecar Engineering* on a number of different aspects of vehicle dynamics. These articles have covered vehicle modelling, the mechanics of running racecar simulation, and various useful tools for determining setups and reviewing data. I have gone into a lot of detail about how these things are done.

However, what I haven't touched upon is *why*. So I'm going to discuss why I do what I do, give a brief outline of where simulation comes from and then touch upon why it's so necessary. Some of the motivation for this article is the entrenched behaviour seen in the industry. Other motivations have been some of the writing I've seen recently questioning the validity of simulation.

However, the real motivation for this is that as an industry, we're still to really comprehend exactly what simulation is, and precisely why we need it.

THE LEARNING PROCESS

To kick things off, if you're serious about being good at something, you have to know the fundamentals. This is something you can consider to be cast in stone, and if you don't want to accept this, other professions and activities beckon. During my professional and personal life, I've worked with some of the very best in their professions. These have spanned people who have worked in Formula 1, Indycar / Champ Car, touring car, aviation and sporting activities. This is what all of these individuals had in common:

1. **They knew their basics inside out.**
2. **They were obsessed with what they did.**
3. **They had a very high level of professionalism.**
4. **They have a determination to see things as they are, not as they would like them to be.**
5. **They possess a well developed intellect, hunting for the next advantage.**

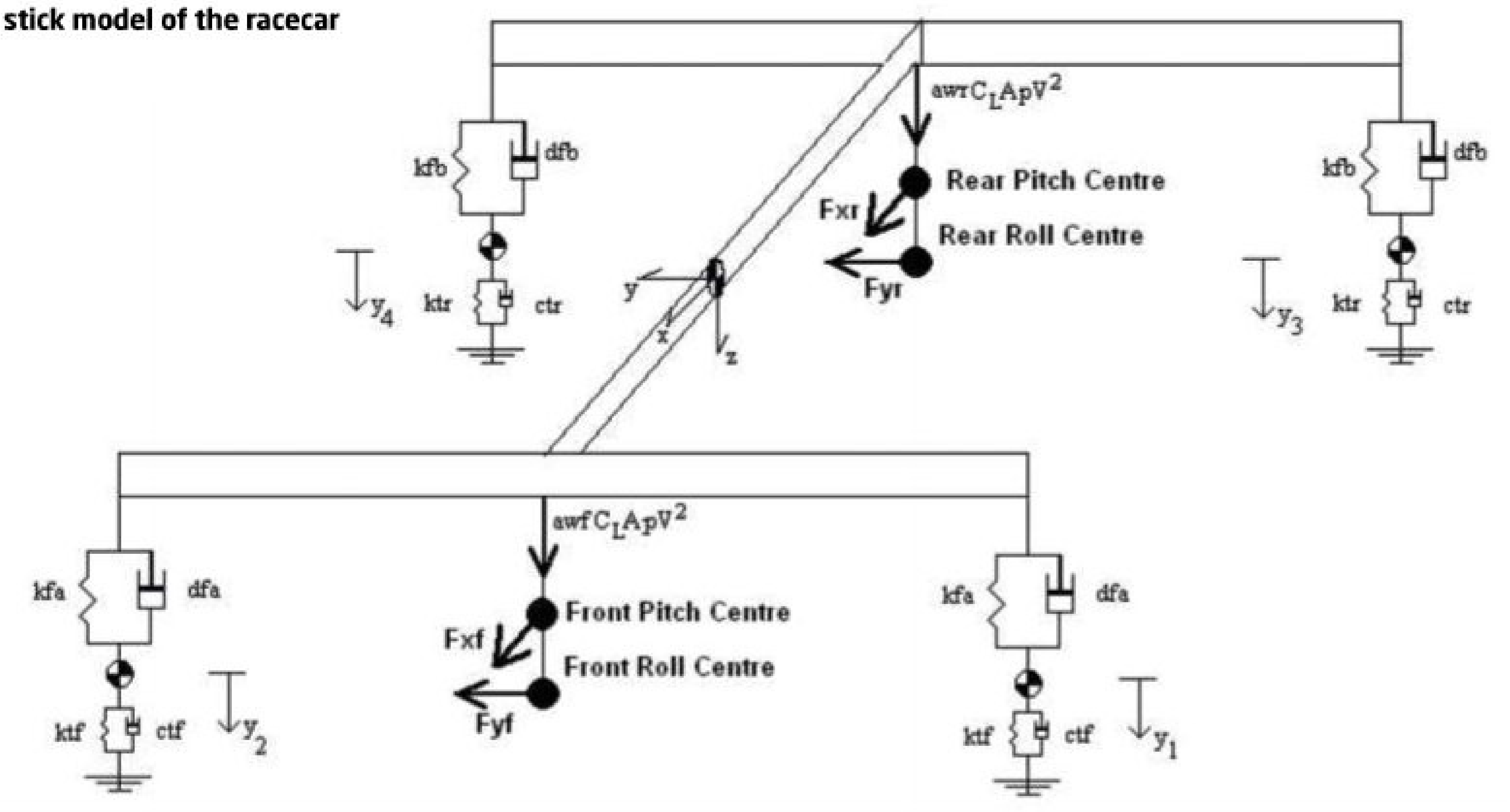
"Properly using all the tools at your disposal is an attitude that helps to separate championship teams from the rest of the pack"

6 **If they don't know something, they'll go out of their way to find out everything about it.**

This is what you'll see in any athlete worth their salt, whether we're talking about Ayrton Senna or Michael Jordan. Which brings me to what is the greatest underbelly in motorsport – the 'silver bullet syndrome'.

It's magic. If we can get this magic damper, or the magic blowoff valve, or dare I say the magic simulator, and then just hit a few buttons we'll go two seconds a lap quicker. It's a nice idea, but it doesn't work. When you see these kind of improvements, it's taken an awful lot of hard work to get there. The Williams reactive / active suspension in F1 is an excellent case in point. This kind of one-fix-sorts-all thinking is a crutch and if you're at all serious about this business, let it go now.

Figure 1: Beam pogo stick model of the racecar



UNDERSTANDING SETUP

Simulation is one of the most powerful tools you can use to really understand what your car is doing. If you truly want to understand how your racecar really works and how to set-up under a variety of circumstances, simulation is the perfect product for you. Obviously there is a lot of work involved in setting it up, but once that's done and you're in a situation to employ it properly, it will be huge asset.

This way of thinking is commonplace in aerospace, but the motorsport industry has also embraced it – especially in F1 – with hours run on team simulators, by test and race drivers. Over Grand Prix weekends, data is sent back to the factory, and the team simulator will often run through the night to allow teams to adapt their cars next morning. When you make this kind of leap, you'll never look back.

CAN YOU FEEL THE FORCE?

The first aspect to talk about is the ChassisSim fully transient multi-body vehicle model, that I like to term the beam pogo stick model. This model is illustrated in **figure 1**.

EQUATIONS

$$\alpha_f - \alpha_r = \delta_{steer} - \delta_{N.S} \qquad (1)$$

$$\Delta\delta = \left|\delta_{steer} - \delta_{N.S}\right|$$

For understeer

$$m_t \cdot a_y = fn(\alpha_f)(F_{y1} + F_{y2}) + fn(\alpha_r - \Delta\delta)(F_{y3} + F_{y4})$$

For neutral steer

$$m_t \cdot a_y = fn(\alpha_f)(F_{y1} + F_{y2}) + fn(\alpha_r)(F_{y3} + F_{y4})$$

For oversteer **(2)**

$$m_t \cdot a_y = fn(\alpha_f - \Delta\delta)(F_{y1} + F_{y2}) + fn(\alpha_r)(F_{y3} + F_{y4})$$

Our goal here is to build up a picture of Lateral force vs load. Effectively our goal is to populate this function

$$F_{yi} = fn(L_i) \qquad (3)$$

Where Fyi is the relevant lateral tyre load and Li is the tyre load. By comparing the mid-corner data using equations 1-2 you can start to populate the equation

For full clarity, third springs or roll bars aren't illustrated in this model, but it's simple enough to add them in. Every single major interaction with the car is illustrated in one fell swoop. We can see what the springs are doing, how the roll and pitch centres interact, and where the downforce comes into play. What you see in **figure 1** is the beating heart of any reputable multi-body vehicle model.

Do a free body diagram and prove it to yourself. (A handy hint: university engineering undergraduates, junior data engineers – this means you).

THE FORMULA

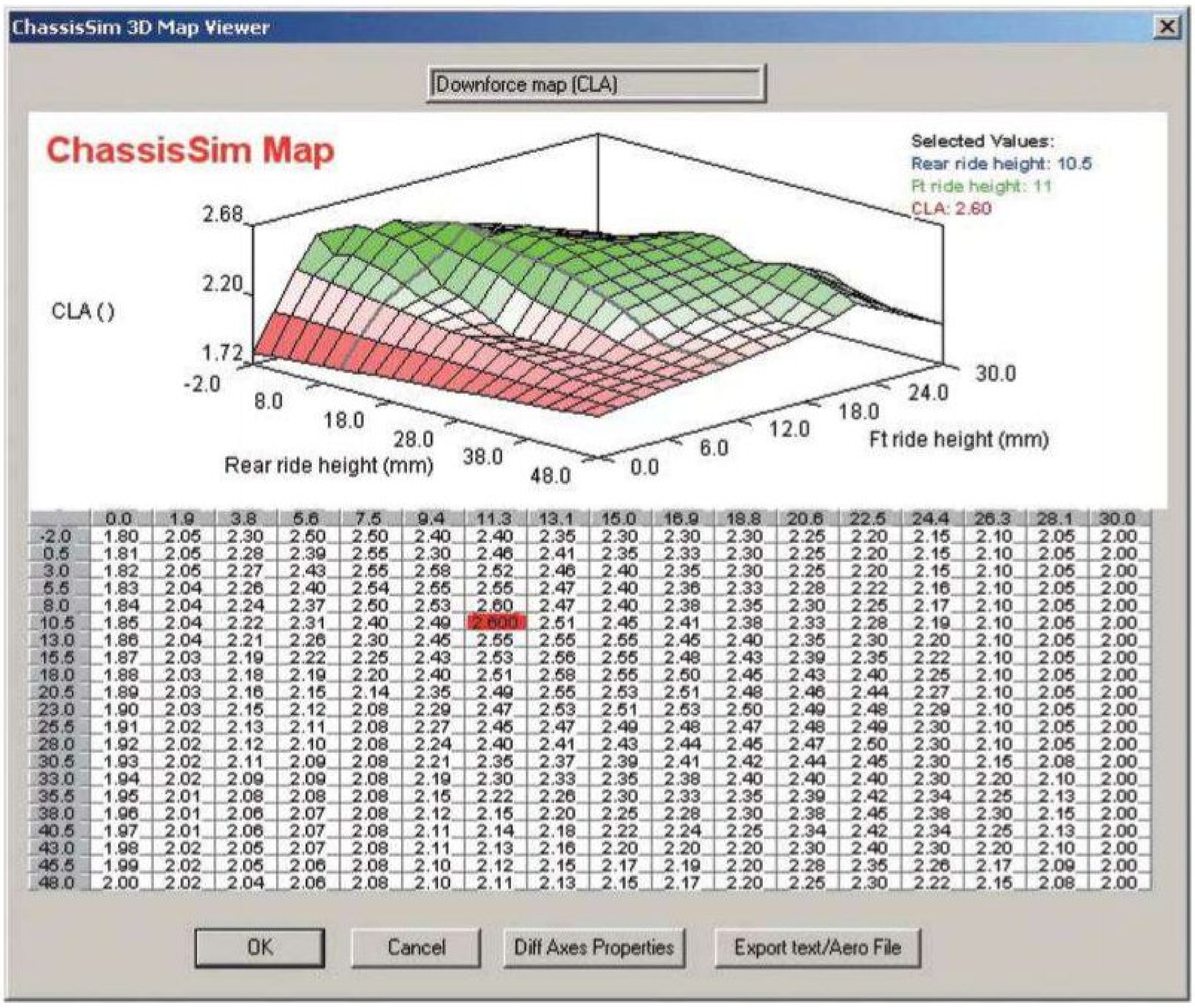
The second aspect to talk about is where the tyre models come from. Recently there have been some that have asserted that coming up with a usable racecar tyre model is impossible. Well, having done it for years in fields as diverse as open-wheelers, sportscars and touring cars, I can say with confidence that this is an outmoded belief that has no place in the modern motorsport engineering world. If you have data, it's actually a lot easier than you think. The first trick is to look at your mid-corner data properly. Compare actual steer to neutral steer and from that you can determine the appropriate details. I outlined this in detail in one of my earlier articles for *Racecar Engineering*, but the highlights are as follows:

The equations to the left form the basis of tyre force modelling that is used in ChassisSim, as well as other specialist simulators. In reality it's a bit more complicated in equations 1-3 because it factors in tyre temperature, camber sensitivity, slip angles and slip ratios as well as load incorporated. It also uses the tyre loads derived from the beam pogo stick model using actual data to get the most accurate possible picture of what the tyre is doing. This includes both transient and static behaviour. However what's described in equations 1-3 is the concept behind it.

SIMPLICITY

The moral of the tale is that while this seems highly advanced, in reality all we've done is gone back to the basics of what makes a racecar work – it's just a matter of connecting the dots. However, what we've wound up with is a very powerful tool that has derived tyre models in fields as diverse as V8 Supercars, GP2, Formula 3, and sportscars with no rig data. This is what happens when you do your homework properly.

The ultimate proof that this is in the pudding was rammed home with the first generation A1GP car. On paper this car



	0.0	1.9	3.8	5.6	7.5	9.4	11.3	13.1	15.0	16.9	18.8	20.6	22.5	24.4	26.3	28.1	30.0
-2.0	1.80	2.05	2.30	2.50	2.50	2.40	2.40	2.35	2.30	2.30	2.30	2.25	2.20	2.15	2.10	2.05	2.00
0.5	1.81	2.05	2.28	2.39	2.55	2.30	2.46	2.41	2.35	2.33	2.30	2.25	2.20	2.15	2.10	2.05	2.00
3.0	1.82	2.05	2.27	2.43	2.55	2.58	2.52	2.46	2.40	2.35	2.30	2.25	2.20	2.15	2.10	2.05	2.00
5.5	1.83	2.04	2.26	2.40	2.54	2.55	2.55	2.47	2.40	2.36	2.33	2.28	2.22	2.16	2.10	2.05	2.00
8.0	1.84	2.04	2.24	2.37	2.50	2.53	2.60	2.47	2.40	2.38	2.35	2.30	2.25	2.17	2.10	2.05	2.00
10.5	1.85	2.04	2.22	2.31	2.40	2.49	2.600	2.51	2.45	2.41	2.38	2.33	2.28	2.19	2.10	2.05	2.00
13.0	1.86	2.04	2.21	2.26	2.30	2.45	2.55	2.55	2.55	2.45	2.40	2.35	2.30	2.20	2.10	2.05	2.00
15.5	1.87	2.03	2.19	2.22	2.25	2.43	2.53	2.56	2.55	2.48	2.43	2.39	2.35	2.22	2.10	2.05	2.00
18.0	1.88	2.03	2.18	2.19	2.20	2.40	2.51	2.58	2.55	2.50	2.45	2.43	2.40	2.25	2.10	2.05	2.00
20.5	1.89	2.03	2.16	2.15	2.14	2.35	2.49	2.55	2.53	2.51	2.48	2.46	2.44	2.27	2.10	2.05	2.00
23.0	1.90	2.03	2.15	2.12	2.08	2.29	2.47	2.53	2.51	2.53	2.50	2.49	2.48	2.29	2.10	2.05	2.00
25.5	1.91	2.02	2.13	2.11	2.08	2.27	2.45	2.47	2.49	2.48	2.47	2.48	2.49	2.30	2.10	2.05	2.00
28.0	1.92	2.02	2.12	2.10	2.08	2.24	2.40	2.41	2.43	2.44	2.45	2.47	2.50	2.30	2.10	2.05	2.00
30.5	1.93	2.02	2.11	2.09	2.08	2.21	2.35	2.37	2.39	2.41	2.42	2.44	2.45	2.30	2.15	2.08	2.00
33.0	1.94	2.02	2.09	2.09	2.08	2.19	2.30	2.33	2.35	2.38	2.40	2.40	2.40	2.30	2.20	2.10	2.00
35.5	1.95	2.01	2.08	2.08	2.08	2.15	2.22	2.26	2.30	2.33	2.35	2.39	2.42	2.34	2.25	2.13	2.00
38.0	1.96	2.01	2.06	2.07	2.08	2.12	2.15	2.20	2.25	2.28	2.30	2.38	2.45	2.38	2.30	2.15	2.00
40.5	1.97	2.01	2.06	2.07	2.08	2.11	2.14	2.18	2.22	2.24	2.25	2.34	2.42	2.34	2.25	2.13	2.00
43.0	1.98	2.02	2.05	2.07	2.08	2.11	2.13	2.16	2.20	2.20	2.20	2.30	2.40	2.30	2.20	2.10	2.00
45.5	1.99	2.02	2.05	2.06	2.08	2.10	2.12	2.15	2.17	2.19	2.20	2.28	2.35	2.26	2.17	2.09	2.00
48.0	2.00	2.02	2.04	2.06	2.08	2.10	2.11	2.13	2.15	2.17	2.20	2.25	2.30	2.22	2.15	2.08	2.00

Figure 2: Ride height map for the downforce of the A1GP car

should have been the easiest thing in the world to setup. It was based on the Lola F3000 chassis that had over 12 years of development. The teams running it knew these cars inside out. However, there where a couple of things that spoiled the party.

1. **The series organiser's insisted on bodywork that gave the car some rather unique aesthetics, to say the least.**
2. **It ran tyres that were unlike anything that had ever been seen on an open-wheeler.**

Consequently, all the setups for the F3000 car went flying out the window. To say that this car was unique was a huge understatement.

The first challenge with this car was constructing an aeromap. Unfortunately the aeromap supplied by the racecar manufacturer didn't provide the complete picture due to time constraints. This is where the ChassisSim aero toolbox proved to be invaluable. This was a brilliant case study of why it's so important to review your data scientifically. Fortunately, the engineer I was working with had tried so many different setups we had just enough information to construct the aeromap. This is illustrated in **figure 2**.

This map was absolute gold because it showed you that there was a definable sweet spot in the aeromap. One of the idiosyncrasies of this car was that there was a very fine ride height range in which the aero of this car properly functioned.

Using the ChassisSim aero toolbox we where able to define it, and quantify it.

Consequently we could then use simulation to dictate at what ride heights the car should be run at which was critical to getting the car to work. This just shows you how critical it is not to take anything for granted and why it is so crucial to do the modelling yourself.

The next crucial step was the tyre modelling and this is where the tyre force modelling toolbox and comparing simulated to actual data proved to be invaluable. By making use of these, the following was found:

"One of the scariest things I've seen in recent times has been the emergence of ready-made racecar simulation"

1. **The slip angles were much greater than standard racing numbers.**
2. **The rear tyres were highly camber sensitive.**
3. **The shape of the traction circle radius vs load characteristic was determined.**

What all this demonstrated was that here was an open-wheeler that was running on tyres that behaved like those found on touring cars. To say that this knowledge was used to good effect would be a huge understatement.

The other thing to gain from all this is just how important it is to do the car modelling yourself. The reason that this is so vital is that you're forced to really think about what your car is doing. The modelling of the A1GP car is a massive case in point.

WORD OF WARNING

One of the scariest things I've seen in recent times has been the rapid emergence of ready-made racecar simulation. The reason that this is such a disturbing trend is that it makes you almost completely dependent on what the racecar manufacturer tells you. This is all well and good if they've done their job well, but unfortunately I've seen too many cases where this work has been less than adequate.

(Also, there's the not insignificant matter that they're not necessarily going to tell you if they've messed up.)

What's a lot more disturbing, however, is how this kind of approach tends of pander to the lowest common denominator. If you're serious about doing well and you have a tool that can help you, an enormous part of your job is to learn that tool inside out, to help you get the most out of it. This is one of the key attitudes that separates the championship teams from the rest of the pack.

To get ahead in motorsport, you have to know the fundamentals and you need to know how and why things happen. Racecar simulation is indispensible in that regard, which is why it's such a powerful tool. This power comes from the fact that any simulator worth its salt is based on analytical tools, such as and tyre models that can be readily derived from track data.

As a successful businessman friend of mine says: 'If you're not learning, somebody else will. And when the two of your meet, they'll win.'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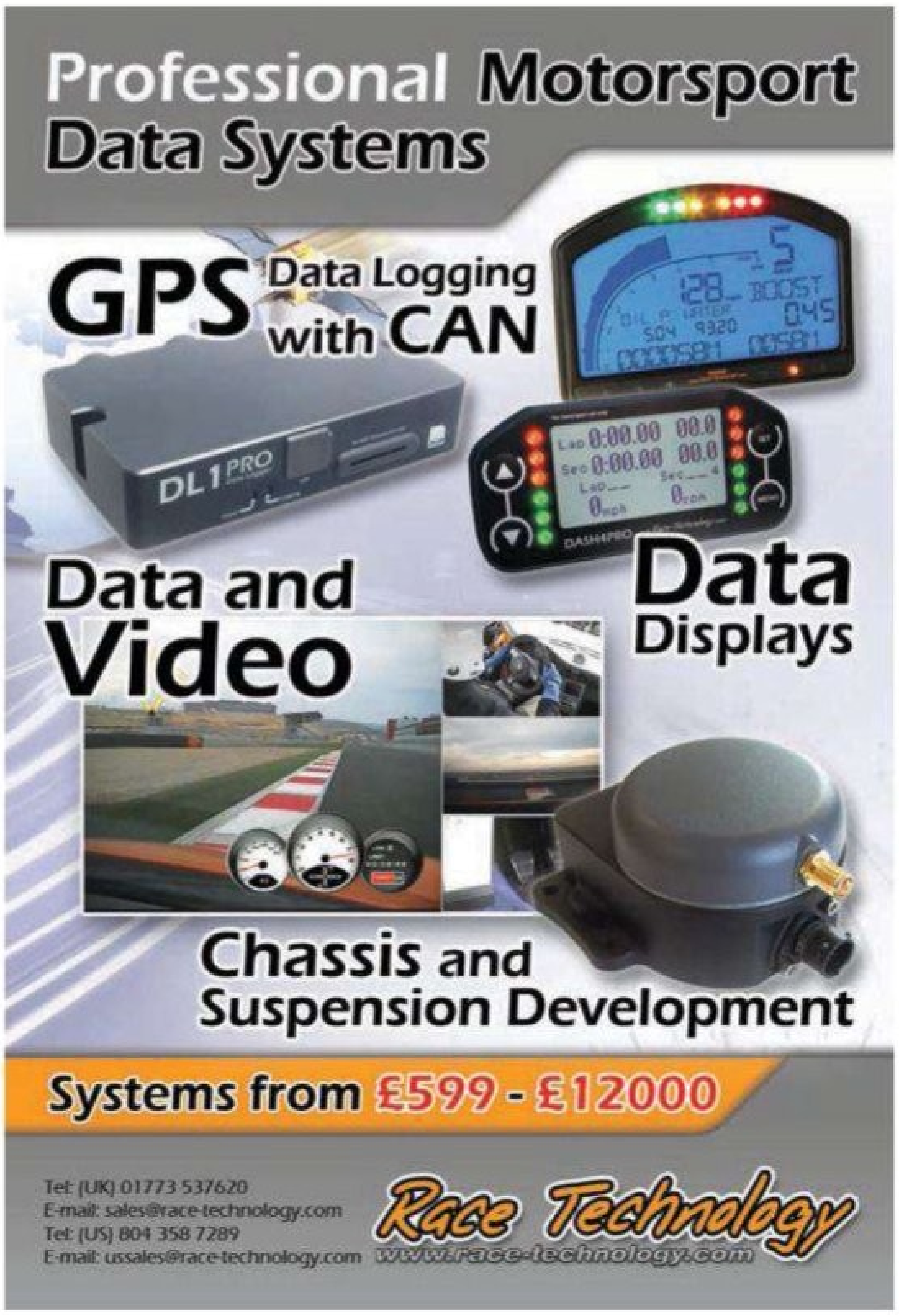
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FROM THE ARCHIVES

Junkyard blues

Back in 1996, the digital revolution had yet to really get going. Traditional scrapyards were not cursed by health and safety rules, and our columnist Paul Van Valkenburgh thought that there were things to be learned from video tapes you could order through the post. His thoughts are even more relevant today with the rise of video on demand sites like YouTube.

There was a time in my adolescence when knowing the right girls, the right fraternities and the right wine was a lot less important than knowing the right junkyards. These were the days when I considered myself a connoisseur of rare old pieces. A youth spent scrounging through every yard within a day's drive produced such treasures as a genuine '32 Ford grille shell at a time when you could not find a replica of every stamped steel part Ford ever made. Now, it's exciting just to find replicas in the junkyard.

Oh yes, I knew those yards deeply, slogging through a mud composed of a thousand spilled crankcases and six thousand empty beer cans (part of the reason some of those cars were there), my less than white shoes, going smuck, smuck, smuck through the mire. Or else sluffing through inches of talcum powder fine brown silt in those river bed yards where the hulk overflow was used for erosion control. You brought your own wrenches and risked your life crawling through a stack of carcasses balanced on three upended rims.

A long time ago in a Midwest far, far away, the junkyards and their owners had characters. Now they have specialisms and its not the same thing. There are GM-only yards, import-only yards and Ford-only yards. There are inner city yards populated mostly by trashed and abandoned old relics whose last known address was kerbside shelter for the homeless. Then there are the theft-recovery yards, with neatly ordered rows of stripped and burned Porsches with address numbers on the hood. It reminds you of an automotive ghost town rather than an automotive graveyard. But the most memorable are the highway yards, where lie the remains of those who never made it gracefully into retirement. Instead of dying of old age, these are the ones which met a sudden, tragic end. The young soldiers final resting place.

These were the places that intrigued me, and made the most lasting impression. It wasn't a morbid preoccupation with death and mutilation. It was a fascination with method of mash or collapse of these man made

Computer simulations can predict the way that a car dissipates the energy, but not everything can be accurately simulated

Viewing the remnants of a crashed racing car could be considered in poor taste. However, as an engineer, much can be learned from such events

structures. Long before NHTSA (or Euro N-Cap) was created to mandate impact integrity, I found myself doing mental re-creations of these crashes from an analytical viewpoint. I did not think "why did this have to happen?" My thinking was that humans make mistakes and these are the consequences, but how did it happen and how can those consequences be minimized.

Even today, 38 long years later, I can still see the remains of the final car of a highly regarded high school classmate. I recall standing there and studying the perfect cylindrical imprint of a two foot diameter concrete overpass pillar which stopped at the windshield header, the V8 engine pushed back in the rear seat. Never before had I been in such awe of the forces which move in this universe and stop our fragile lives.

Experience is critically important in predicting what is most likely to fail, or how structures may collapse into the passenger space, the non linear deformation that is so difficult to simulate on a computer. Its another kind of 'street smarts'.

All too many times I've looked at a new design, and been very nervous about its strength. I tactfully ask the designer, 'are you sure that is strong enough', and the standard reply is, 'Of course! Do you want to see the computer output?'

No I don't.

"Too many times I've looked at a new design, and been nervous about its strength"

I want to see a real structural test, that does not rely on simplifications, assumptions and possible input errors.

However there still are not many racecar impact or crush test standards, and no junkyards for crashed racecars. The remains are rapidly covered and disposed of, for obvious public relations and legal liability reasons. Even the results of GM Motorsports' widely used onboard crash recorders (Racecar V3N4) are not identified with specific teams. Personally I wish that the sanctioning bodies could impound all crashed cars and keep a collection of non salvageable chassis for future design reference.

Today, for better or for worse, the TV racing audience is exposed to close up action shots of every professional race impact. In fact it is overkill. I once watched 23 replays of an accident as a filler while they cleaned up the mess. But these are just a fraction of the racing impacts that occur around the world.

If you are not aware of it, there are video tape production companies that specialise in racing crash footage. On the surface it seems like cheap sensationalism, the worst of racing, a preoccupation with violence. These are not rigged stunts, but real pain, suffering, and death, involving highly paid live crash test dummies. There are whole series, not only from pro road racing, but specialising in off-road, drags, boats and motorcycle accidents.

I once rented one of these tapes with the intent of chastising the producers and came away realising that, as an engineer, I had learned more from these tapes than from any race coverage I had ever viewed. Among scores of incidents, I saw an off road truck leap over a crest, nose down, and do a series of 'endos', unlike the expected landing. I saw a GTP car strike a guardrail, do a 360deg spin five feet in the air and then dissipate its kinetic energy by shedding parts down the track. I would not have believed it, much less predicted it, if I hadn't seen it.

What we have is the modern day electronic equivalent of the educational experience of the junkyard.

States sportscar scene to benefit from merger

The merger of Grand-Am and the American Le Mans Series (ALMS) is set to provide US sportscar racing with impressive marketing opportunities, claim executives from both parties.

Although billed as a merger, the deal, which is believed to be worth around US$10m (£6.1m), effectively sees Grand-Am buying Panoz Motor Sports Group, the operator of the ALMS.

The combination brings together the two big crowd-pullers in American endurance racing, the Daytona 24 hours and the Sebring 12 hours, along with some of the best races from both series. From a business point of view, both parties believe they will now be in a much stronger position to market their events, particularly by joint promotion of these two early-season US sportscar classics.

Jim France, Grand-Am founder and NASCAR vice president, said: 'Going from Daytona to Sebring, another great internationally recognised event, it is possible for teams to come over with a budget to compete in both events from overseas and bring their fans with them. There's a tremendous opportunity in front of all of us.'

Technical regulations have yet to be finalised for the ALMS / Grand Am merger

ALMS boss, Scott Atherton, who has now moved to the board of the new organisation, commented: 'When you think about a collaborative effort between Daytona and Sebring to kick off the racing year with a 24 hour and a 12 hour event that can be co-promoted and co-produced, the possibilities here are amazing.'

Atherton also said there were other elements to the deal – which includes the acquisition of Road Atlanta and of a lease on Sebring – that would help generate more business. 'One of the under-reported aspects of this is that the assets of Panoz Motorsports Group have been merged into a new entity that will include Road Atlanta, Sebring, American Le Mans Series, IMSA, and Grand-Am.'

The two series will become one in 2014, but final details have yet to be hammered out, including the name and the tecnical regulations that will govern the new series. As yet, there is no news on the class structure, but ALMS owner Don Panoz, who is expected to become vice chairman of the new organisation, hinted that there would be no place for LMP1 on the new-look US sportscar scene, leaving the class to the World Endurance Championship.

'LMP1 cars and their technology...that is beyond what the ALMS was capable of and Grand-Am was capable of,' said Panoz at the announcement. 'That's really the manufacturers' playpen, maybe tens of millions of dollars in development.

'We are American-based. What we are putting together is the American Sports Car Series. We have to take care of our own business, our own market, addressing our sponsors, our fans, our teams, and that is exactly what we are going to do.'

It is thought that the series will feature Daytona Prototypes and LMP2s, but Atherton has made it known that GTE – known as GT in ALMS – will feature in the new series, though how it merges with the Grand-Am's GT category has yet to be established.

Rio to kick off Formula E in 2014

Formula E looks set to kick off its inaugural championship on the streets of Rio de Janeiro, Brazil.

The FIA recently announced that it had reached an agreement to license the commercial rights of its electric car-racing championship to a consortium of international investors, who will operate under the Formula E Holdings Ltd (FEH) banner.

Among the investors is Alejandro Agag, a former MEP and the boss of GP2 team Addax. He announced that the first race will be in Brazil in 2014. Speaking on respected business outlet Bloomberg TV, he said: 'The first race is for 2014, and we have Rio de Janeiro for our first city. We met with the mayor, and as soon as he understood the project he said, immediately, that he wanted it in his city.' Agag added that the consortium is now looking for other cities, and that it would, 'love to have a race in New York'.

FEH is headed by Enrique Banuelos, a Spanish real estate developer who was badly hit by the property crash of 2007, and is now active in Brazil. Others associated with the project are Lord Drayson, managing director of Drayson Racing Technologies, and Eric Barbaroux, chairman of electric car company Electric Formula.

While the series will be open to any cars sanctioned as Formula E by the FIA, the consortium will ensure that a Formula E Car, based on the Formulec EF 01 prototype already in operation, is available for those teams willing to race with it. Agag said that the consortium hopes that battery companies, and other technology providers, will see the series as an ideal shop window to display their wares.

Demonstration runs for the series will start next year, and the objective is that 10 two-car teams will participate in a championship of races taking place in major cities across the world. Agag has confirmed that the series will 'only race in cities'.

Jean Todt, president of the FIA, told reporters: 'I would like to thank all the parties involved. This new competition at the heart of major cities is certain to attract a new audience. We are pleased with the agreement with Formula E Holdings as they bring a very strong experience in motorsport.

'This spectacular series will offer both entertainment and a new opportunity to share the FIA values and objectives of clean energy, mobility and sustainability with a wider and younger audience.'

Formula 4 not a threat, says Formula Ford

Motorsport Vision's (MSV) all-new entry-level UK single-seater championship, due to come on stream next year, is not a threat, according to Formula Ford, which says that the series is aimed at a different customer base.

MSV's new Formula 4 series has been launched in conjunction with the British Racing Drivers' Club (BRDC), and will use a spec chassis designed by Ralph Firman Racing. The cars will not be run centrally, as is the case with MSV's Formula 2 series, and the aim is to offer them to a mix of teams and private entrants.

The headline specifications for the car, which will be known as the MSV F4-013, include a spaceframe chassis which will meet the latest 2012 FIA safety standards. It will be powered by a 2-litre 175bhp Ford Duratec engine and the gearbox will be a 6-speed Sadev transmission incorporating paddle shift. The cars will run on slicks and wets provided by Yokohama.

With a 2-litre Duratec engine and 6-speed Sadev transmission, the MSV F4-013 is a 'very controlled car'

Budgets will be between £35,000 (US$57,000) to £70,000 (US$114,000), dependand upon whether the driver races as a private entrant or with a team, and this compares well with current top-level Formula Ford budgets, which can be as much as £150,000 (US$243,000).

The announcement came as UK single-seater racing is going through a lean time, with the Formula Renault championship cancelled and very thin grids for the new Ecoboost Formula Ford.

However, Sam Roach, championship manager for the British Formula Ford championship, says that he does not think the new series will necessarily hit the Ford formula: 'I don't know if this will affect Formula Ford; it will certainly make for a more crowded scene,' he said.

'But it's a very different offering. It's a very controlled car, which is completely against the engineering ethos of Formula Ford, and it's at a distinctly lower level in terms of the engineering on the car. It's a much lower level – a club-level championship.'

Roach also hinted that Formula Ford will reinvent itself as a higher spec formula sometime soon, and while he would not confirm the news, it seems highly likely that it will race with wings, and on a European stage, in 2013.

MSV boss Jonathan Palmer insisted that the time was right for Formula 4. 'We are in an era of relative austerity, which looks like continuing for some years, and it is essential we provide young single-seater drivers with an affordable path to learn and prove themselves.

'With F4, we have focused on four key areas: providing the lowest season running costs, the lowest car purchase price, the highest levels of car equality and highest safety standards.'

Three of the top five motor giants to compete in WRC by 2014

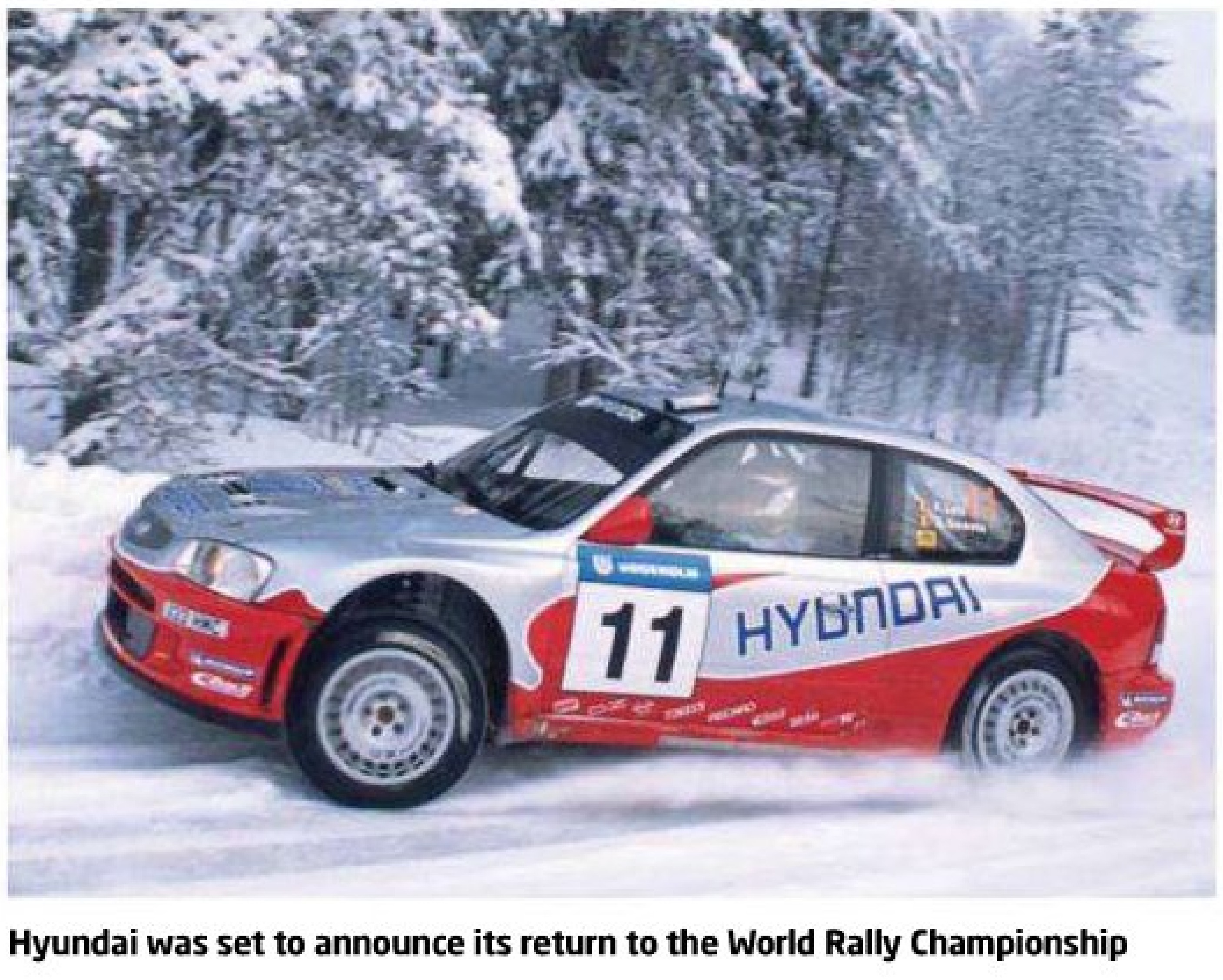
The World Rally Championship is set to play host to no fewer than three of the world's top five car producers, with the expectation that Hyundai will return to the competition in 2014.

Hyundai, which last competed in the WRC nine years ago, was set to announce its return to top level rallying as *Racecar Engineering* went to press. It will join Ford and Volkswagen, which will begin its programme next year, at the pinnacle of rallying. And if anticipated plans by Toyota to compete with its Yaris come to fruition, the number of manufacturers taking part could even swell to four.

Hyundai is currently the world's fifth biggest car producer in terms of units sold, with only Toyota, GM, Volkswagen and Ford ahead of it. The South Korean manufacturer has been flying high in recent months, posting its 13th straight quarter of rising profits this summer. April to June quarterly sales topped 1.11 million vehicles, while net profits rose to US$2.22bn, (£1.36bn) marking a rise of 10 per cent on the same period in 2011.

It is believed that Hyundai will use its current i20 as the base for its WRC return, and sources say that this is now being developed in Korea, and at the company's German base in Offenbach.

Hyundai last saw WRC action in 2003, with its Accent WRC and before that the company campaigned its 2wd Coupe model. Hyundai would not comment on its plans as *Racecar* went to press.



Hyundai was set to announce its return to the World Rally Championship

BRIEFLY

Le Mans date change

Next year's Le Mans 24 Hours will take place one week later than originally planned. The weekend of 22-23 June is now favoured over 15-16 June, the date originally announced by the organising body behind the classic race, the Automobile Club de l'Ouest. The change of date was requested by the FIA, the ACO explained, saying in a statement that the move had been made, 'in order to harmonise the world calendar of motor racing events'.
The Le Mans test day has also been moved and will now take place on 9 June.

Rallycross world

The FIA has signed a deal with a new promoter for its European rallycross championship that will see it drop its European tag and eventually become a World Championship.

Formula 1 payout helps Williams revenues to rocket

A one-off sweetener to keep Williams in F1 until 2020 is part of the reason for an impressive financial first half of 2012 for the group, it has emerged.

The strong half-year financial report also shows that the company is beginning to reap the reward for its diversification, while it reveals its share price has performed well and has not been affected by a volatile year on the race track.

The Williams Group reported a rise in revenues of £27m (US$43.8m) in the six months to June 30, from £47.3m (US$76.7m) to £74.3m (US$120.5m), with pre-tax profits up from £1.9m (US$3.1m) to £6.3m (US$10.2m). A large part of the revenue increase is down to a payment from Bernie Ecclestone, for signing a commercial agreement back in April. The actual amount of this payment has not been disclosed.

All the leading teams, other than Mercedes, signed the agreement, committing them to the sport until 2020. In return, they have been offered a bigger slice of the profits generated by Formula 1. In the financial report Williams says it 'received an initial payment, payment immediately on signature of the agreement,' and goes on to say this has been treated as part of the revenue for the period covered.

Williams' drive to diversify has also been cited as a reason for its strong performance over the first six months of 2012, particularly its use of F1 technology in the wider world. The Group's chief executive, Alex Burns, said: 'These results also validate our long-term business plan of adapting technology and know-how developed in Formula 1 for commercial application in energy efficiency, safety and education.'

The share price for the Williams Group has also been doing well, with earnings per share rising from 19.31p on the same period last year to 68.55p this year. The company floated on the Frankfurt exchange in 2011 and after an initial dip its price has fluctuated in line with the DAX, the benchmark index for the German exchange.

Williams has told *Racecar Engineering* that its share price has largely been unaffected by the team's performance on track, which has been patchy this year, though has included a win at the Spanish Grand Prix. 'Our investors tend to be funds who are focussed on long term financial returns,' said James Francis, a communications executive at the company. 'While on track performance is important to this, individual race results don't directly impact share price. There is little correlation between share price activity and on track performance though we are aware that very tiny numbers of shares (fewer than 50) are occasionally traded immediately after races, which suggests there are a few private investors buying or selling on this indicator.'

Francis said that even the Spanish victory did little to affect the share performance: 'The share price actually dropped marginally from €22.50 to €22.15 after the win.'

Williams shares were at €22.90 at the time of writing. It was launched at €24.21 and initially plummeted, hitting a low of €12.50 when the market crashed in August 2011.

Office Depot withdraws sponsorship with SHR

NASCAR operation Stewart Haas Racing has lost its second major backer, with the news that Office Depot will not be signing up as a primary sponsor for 2013.

Office Depot's announcement came just two months after SHR lost another primary sponsor, the US Army, but while that was largely down to political pressures, Office Depot's decision has to be looked at in the light of a very disappointing financial performance for the business products retailer.

In the most recent financial report from Office Depot, from August this year, the company reported a loss of US$22m (£13.6m) in the second quarter of 2012, compared to a loss of US$11m (£7m) in the second quarter of 2011. Meanwhile, sales were reported to be down seven per cent.

Mindy Kramer, senior director of communications for Office Depot, said: 'The decision to significantly curtail our relationship with Stewart-Haas Racing was very difficult, and one that we did not take lightly. However, the changing business landscape warrants a realignment of priorities and resources.'

The company will still be involved with the team. Kramer added: 'Tony Stewart has been an exceptional ambassador for our brand, and he has gone above and beyond in everything that he has done for our company. Being a part of his legendary 2011 championship run was a moment of tremendous pride for everyone at Office Depot.' The company's departure leaves Mobil 1 car's largest sponsor next year.

Office Depot's departure also comes as SHR is searching for a sponsor to keep Ryan Newman in the No. 39 car for 2013. Danica Patrick is expected to move from JR Motorsports Nationwide to race in the Cup fulltime with SHR next season, bringing her long-term sponsor GoDaddy.com with her.

SEEN: AUTOGP 2013

Images of the 2013 AutoGP car have been released. The car is an update of the current chassis, the original A1GP racer built by Lola. AutoGP had approached Lola about building a new car but this plan was scuppered when the manufacturer went into administration in May.

In what is described as 'major technical update', the new version of the car should be, on average, 1.5 seconds a lap quicker than the current car, says AutoGP.

Series boss Enzo Coloni said of the 2013 car: 'We want to give our drivers an even better tool to prepare themselves for the leap to Formula 1. The talents taking part in our series are already facing many of the challenges they'll find in F1: we have pit-stops, three different tyre compounds, an overboost system that can get them used to KERS, and this performance upgrade will bring their driving style even closer to the one they'll have to adopt in an F1 car. What we are unveiling today is a first preview that shows the major changes that have already been given the green light, but our technical staff is still working on the tiniest details, and on some other interesting solutions.'

The definitive car should be testing in November, says Coloni, with the first full test for all the teams scheduled for early December. The 2013 season will also see the championship expand, with a calendar of 16 races and four days of official testing.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PEELING BACK THE STICKERS. NO.7: 3M

The name Minnesota Mining and Manufacturing Company' brings to mind all manner of crunching, grinding rock-eating machinery. Yet the product those three 'm's are actually most famous for is *Post-it* notes. But the company, now known as 3M, does still have some involvement with earth shaking machinery, through its sponsorship deal with NASCAR outfit Roush Fenway Racing.

The involvement of 3M with NASCAR began in 1998 and the Roush Fenway relationship started in 2005. In 2010, the company signed up for more of the same, a deal which will see the sponsorship go on through 2014. But where this sponsorship differs from others is in the way different organisations within the huge 3M empire are able to get a slice of the cake. 'We have 22 operating divisions utilising our NASCAR programme,' Randy Taylor, programme manager motorsports, 3M Corp marketing and public affairs, told *Racecar Engineering*.

This means that on some weekends the Greg Biffle Ford will be decked out in the colours of 3M itself, while at others it might run with Bondo or Post-it liveries. This is a vital part of the company's marketing strategy, says Taylor: 'It is extremely important as it provides an avenue for us to show all the 3M products and technology that touches your life every day. It always amazes consumers to find out how many products we have.'

In fact, 3M manufacturers a staggering 55,000 different products, including: car care products (such as sun films, polish, wax, car shampoo, treatment for the exterior, interior and the under chassis rust protection), adhesives, abrasives, laminates, passive fire protection, dental products, electronic materials, medical products, electronic circuits and optical films. This remarkably wide range of products also sells quite well, too, for 3M posted revenues of around US$30bn (£18.5bn) for 2011 with a profit of just over US$6bn, (£3.7bn).

But what brings a worldwide organisation like 3M – it employs 84,000 people in 60 countries – to NASCAR? 'NASCAR is the sport for business. The fans are extremely loyal to the brands in the sport and they support those brands. We feel fortunate to be a part of it,' Taylor says. Research in the US certainly backs this up, with 40 per cent of the sport's fans said to be willing to switch brands just to buy NASCAR-associated products.

NASCAR also has some telling advantages over other sports in the US. For example, the season is ten months long – which means the sponsor spends more time in the public eye – while it is also said to have some 75 million fans, about a third of the population of the US, and it is watched by both men and women, with a 60 per cent male, 40 per cent female split – a stat' that is very unusual in sport, and very attractive to sponsors.

And how much does 3M's involvement cost? Taylor isn't saying, but the average cost of a primary sponsorship deal in the NASCAR Sprint Cup – which gets you the most prominent parts of the car plus its colour scheme – is widely believed to be in the region of US$10m (£6.2m) to US$20m (£12.5m), depending on team. Oh, and that'll be in dollar notes, not Post-it notes.

CAUGHT

NASCAR Sprint Cup crew chief Richard 'Slugger' Labbe has been fined a whopping US$100,000 (£61,7000), suspended from NASCAR until early October, and placed on probation until the end of the year. The Richard Childress Racing No.27 Chevrolet he tends to was found to be equipped with illegal frame rails. A statement from NASCAR said the penalty was for 'intentionally modifying frame rails for the purpose of deceiving NASCAR's inspection gauges.' The irregularity was found during an inspection at the sanctioning body's Research and Development centre in Concord, North Carolina. On top of the fine, the car's owner, Richard Childress, and the driver, Paul Menard, have each been docked 25 points in their championships, while car chief Craig Smokstad and a crew member, Grant Hutchens, have also been suspended until October and placed on probation until the end of the year.

FINE: US$100,000 (£61,700)
PENALTY: 25 points

Dave Rogers, the crew chief for the No.18 Joe Gibbs Racing Toyota in the NASCAR Sprint Cup, has been fined US$25,000 for racing with an improperly attached weight. The infraction came to light at the Michigan International Speedway round of the series.

FINE: US$25,000 (£15,400)

Mercedes V8 to Australia

Mercedes will be on the Australian V8 Supercars grid next year with three non-works Car of the Future-based cars. One of the series' longest serving teams, Stone Brothers Racing, has ended its relationship with Ford amicably, and will next year merge with Erebus Motorsport to run the AMG E Class V8s in 2013.

The agreement, which has been almost a year in the making, is now a reality, with the newly formed team operating under a Customer Sports Program of AMG. The announcement was made in Melbourne by Stone Brothers Racing owner Ross Stone, Erebus Motorsport owner Betty Klimenko, Erebus Motorsport CEO Ryan Maddison and V8 Supercar Chairman Tony Cochrane.

Erebus has been dominant in the Australian GT category with Mercedes-AMG's SLS AMG GT3 racecar. Stone Brothers Racing found success with Ford since it formed in1998, and won three Championships with Marcos Ambrose and Russell Ingall.

'Since SBR's inception in 1998, Ford has backed the team and together we have enjoyed many successes including three Championship wins,' said Stone. 'Leaving Ford was not an easy thing to do, but as car markets change here in Australia I felt the time was right for a new challenge.


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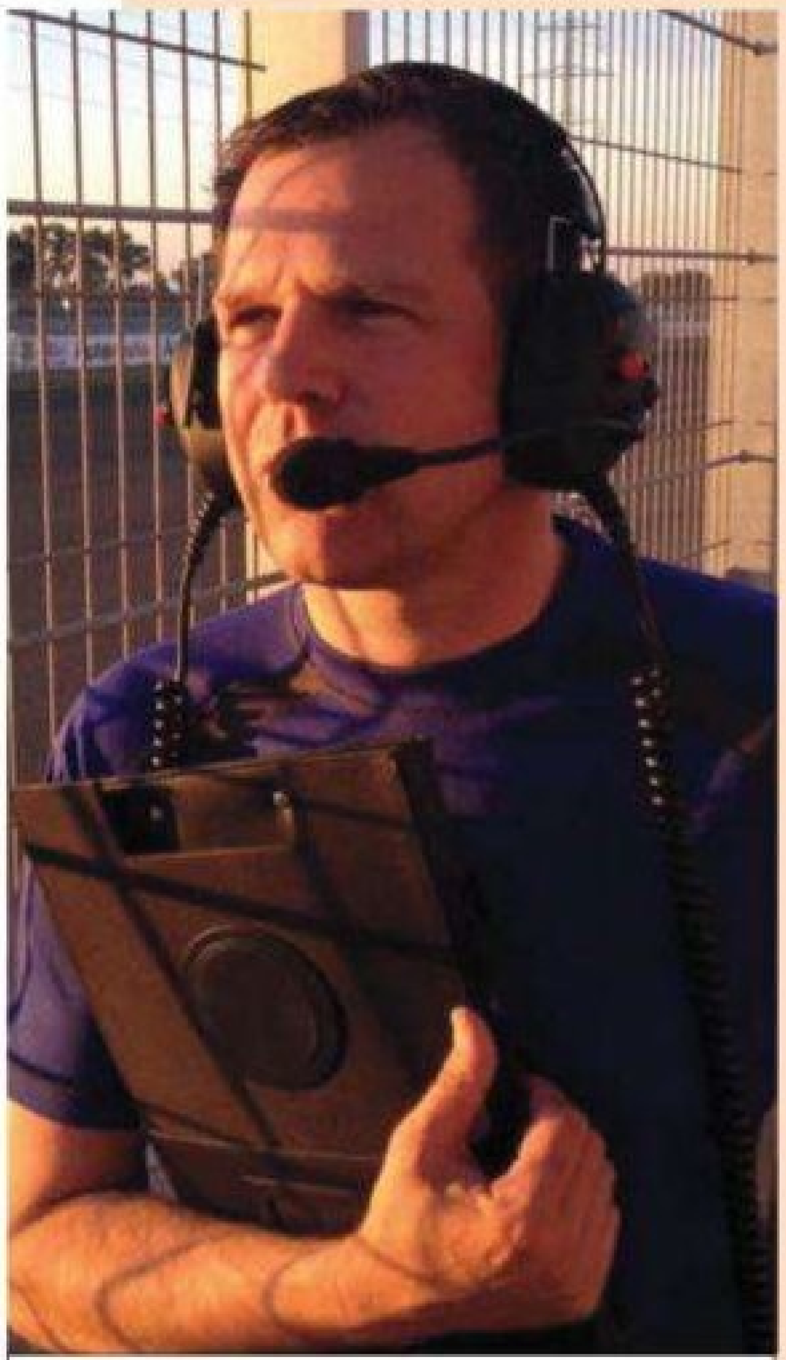
INTERVIEW: TIM SUGDEN



Tim Sugden is the team manager at JMW Motorsport, where he also fills the role of race engineer on the team's GTE Pro-class Ferrari 458. This year the team won its class in the shortened European Le Mans Series, as well as taking a strong second in the Silverstone World Endurance Championship round.

But Sugden is probably better known for his exploits behind the wheel in the British Touring Cars Championships, GTs and more. He also manages seven drivers and is driver coach at P1 Motorsport, who campaign in Formula Renault 3.5.

Q. How did you end up as race engineer of the JMW Ferrari?
It was completely by accident. We had a new engineer, and he would have done a very good job I'm sure, but just a week or so before the first race his father was taken ill. So he couldn't make that first race, then it looked as though his father would probably be poorly for quite some time, so he had to bow out.

It was all perfectly amicable, but we didn't really have anybody else. I thought that I'd engineered enough cars over my time – my own cars – so I'd see how I got on, and it turned out well; we won first time out.

Q. How are you finding life as a race engineer?
I enjoy it. I've been doing GT racing and touring cars now for 20 years, so it's all stuff that I've worked on with an engineer over the years, and you do manage to pick up quite a lot. I'm also very lucky in that we've got an exceptionally good young data engineer who is able to give me a lot of information, certainly for things like fuel strategies. He's very good with the telemetry and being able to keep on top of things during the race.

I think it would be very wrong for me to take a great deal of credit for the results we've had because actually, it's very much a team effort.

Q. What can a driver bring to the role of race engineer?
A perfect example was at Silverstone, with James Walker driving. We very nearly got pole and we still qualified second. It was fantastic, we out-qualified the factory Ferraris, and that was really down to tyre choice. James did a fantastic job driving, but we also picked the right tyre. I think that was purely because I've raced at Silverstone so many times in the past, I could see what the weather was doing and I knew that it was definitely not time for wets, but I was also 90 per cent sure it wasn't yet time for a full slick. So we fitted some cut slicks, and to me that was definitely the right tyre.

Another way it helps is in being able to know which bits of the driver's input to disregard, to an extent. As they're giving you feedback on what the car's doing and what the track's doing, as a driver with experience you're able to filter out what you know is actually extraneous information.

The JMW Ferrari has enjoyed huge successes

New tech director for Toro Rosso team

James Key, the recently appointed technical director at the Toro Rosso Formula 1 team, has said he will not only focus on improving the car but also the team's technical structure.

Commenting on the announcement of his new position, Key, who replaces Giorgio Ascanelli in the post, said: 'We will be studying the team's working practices, throughout all the departments, while looking to see which areas need strengthening further.'

But Key also says he was happy with what he's found at the team so far: 'It's a great opportunity for me to join a team that strikes me as extremely ambitious with a workforce that is very motivated. Even after just a few days, I have sensed, from everyone I have dealt with, an enthusiasm to move the team forward. There are clear opportunities coming up through regulation changes and we intend to look not only at the long term, but the short term too.'

Key has been in F1 since 1998, when he started as a data engineer at Jordan. He has been technical director at Spyker, Force India and Sauber, leaving the Swiss team earlier this year.

Franz Tost, team principal at Toro Rosso, believes the arrival of Key marks the start of a new era for the Italian outfit. 'With James Key in the role of technical director, we start a new chapter in the history of Toro Rosso and I hope it's an interesting one. James comes to us with a strong reputation and has proved he can help smaller teams punch above their weight.'

The announcement of Key's appointment coincided with the long-awaited confirmation that Giorgio Ascanelli has left Toro Rosso. Although no reason was given for the Italian's departure it's believed he was unhappy with the technical direction in which the team was going.

Franz Tost paid tribute to Ascanelli's time at the team: 'Over a period of almost five years, Giorgio has contributed positively to the development of our team. Especially in the difficult transition period from a simple racing team to a fully-fledged constructor, he made an important contribution and his undoubted experience was very valuable to us. We would like to thank him for his efforts and wish him all the best fortunes for the future.'

The classic one is track condition in the first free practice session. All drivers will complain that the car's understeering, but it always does because the track's still green at that point.

Q. What would you say is the secret to engineering a GT car?
What we've found is that you have to have a good base set up. I think that really is key, because if the car is right then generally you don't deviate much from that base set up.

We've raced the Ferrari for quite a while and the standard Michelotto set up for that car is very good. So while you never run the standard set up as such, it is a great starting point to develop the car from.

Q. Your primary programme for this year was to be the ELMS, so how did you feel when the last two rounds were cancelled?
We've all been in this sport a long time and I think everybody understands that we're in a very difficult time, financially. But the reality is that it's caused all sorts of problems. We have contracts with sponsors, we have contracts with drivers, we have all sorts of undertakings. One of our sponsors was taking a lot of guests to the Portimão race in Portugal [which was cancelled], and that causes a lot of problems and a lot of embarrassment.

Q. You race a Brisca Formula 2 stock car as a hobby. How does engineering a stock car differ from engineering a circuit car?
I can give you a good example. Coming from a circuit background, I thought I'd go testing for a day to sort the car out, and I took a really good race engineer with me. This is somebody I've worked with many times over the years who I really value and who I imagined would get the most out of a car like that – a non-aero car that moves around quite a lot, with a very simple treaded tyre with quite a soft sidewall, very similar to a Formula Ford.

We spent a day fiddling about, changing things, trying things, working with the lads who usually look after my car. But we couldn't get it to come off the corner how I wanted it to come off the corner, which is the hardest bit. Then, right at the end of the day, the lad who'd been patiently making the changes said 'Can I try something?'. He did, and I went out and immediately went a tenth and half faster than we'd done all day – which over a 14-second lap is a lot! All he'd done was put cross-weight in the car – which is something which we just don't do in circuit racing – by jacking up the spring platforms. They do a huge amount of the tuning with cross-weight, and also by playing about with the track of the car, so it's slightly narrower at one side than the other.

RACE MOVES

NASCAR Nationwide outfit JR Motorsports has parted company with longtime crew chief and competition director **Tony Eury Sr.** The 58-year-old uncle of team driver **Dale Earnhardt Jr** and father of JRM co-owner and crew chief **Tony Eury Jr,** had been with the team since 2007, spending the past five years as competition director.

Ryan Pemberton has been hired by NASCAR Nationwide outfit JR Motorsports. Pemberton has served as a crew chief for several organisations since 1997, most recently at Tommy Baldwin Racing, and has been a winning crew chief twice in the Sprint Cup Series. He is the younger brother of **Robin Pemberton**, NASCAR's vice president of competition.

Scott Reombke, the chief operating officer at IndyCar team Rahal Letterman Lanigan Racing, has died after a long illness. Roembke began his career in professional motorsport in 1986 with Patrick Racing, as the logistics manager, before becoming assistant team manager. In 1991 he joined Rahal-Hogan Racing, as it was then known, as general manager. He was promoted to COO in 2000.

IndyCar team owner **Bobby Rahal** is now the chairman of the US Bobsled and Skeleton Federation. The former race driver's role will be to assist with fundraising and with the development of the sport in the run-up to the 2014 Winter Olympics, to be held at Sochi in Russia. The tie-up came about as a result of a meeting arranged by BMW, which sponsors both the USABSF and Rahal Letterman Lanigan Racing.

Richard Petty Motorsports has swapped around the crews of its Marcos Ambrose- and Aric Almirola-driven NASCAR Sprint Cup cars. The crew chief of the Ambrose car will now be **Mike Ford**, while the Almirola car will be tended by **Todd Parrot.** Both Ford and Parrott are veteran crew chiefs. Parrott has one Cup championship, a Daytona 500 and 31 Cup wins to his credit. Ford has 25 Cup wins.

Gil Martin has replaced Shane Wilson as crew chief on the Richard Childress Racing NASCAR Sprint Cup car of **Kevin Harvick**. The move was something of a reunion, as Martin was previously crew chief for Harvick in 2010 and 2011, during which time he won seven races.

URT Group has recruited **Bob Simpson** from McLaren Racing to fill the newly created role of innovations manager at the Bognor Regis-based composites company. Simpson will lead research and development into new and improved composites production and manufacturing methods, as well as helping to develop URT's in-house apprenticeship and training schemes. At McLaren Simpson was in charge of the team responsible for the manufacture of models for wind tunnel testing.

Phoenix buys Lake Connect

Motorsport electronics company, Lake Interconnection Services, has been bought by Phoenix Dynamics, a specialist provider of electrical cable assemblies.

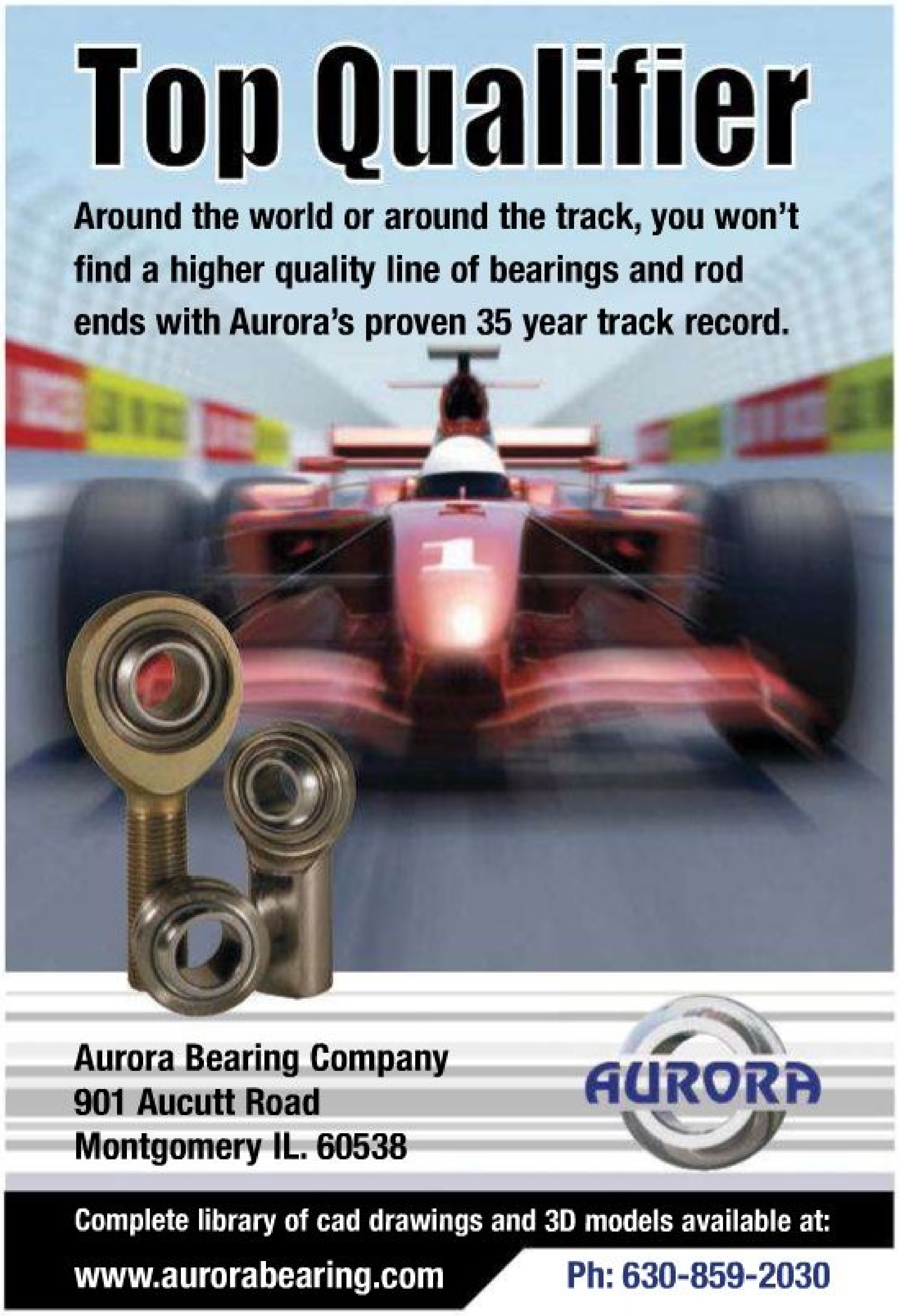
The move will see the businesses being run side by side, with Lake Interconnection Systems continuing manufacture of its high-performance wiring harness assemblies and related products from its existing facilities in Swindon.

Phoenix Dynamics' managing director Graeme Boull welcomed the move, saying: 'We are viewing this acquisition as a horizontal integration of the two businesses, which will create a highly agile business well positioned to respond to customers across the combined customer bases. The combining of the two businesses marks the beginning of a group business that will have a strong technology presence in the interconnect and wiring harness sector'.

Phoenix Dynamics has expertise in the military vehicle, battlefield weapons, and renewable energy markets, while Lake Interconnection Systems has knowledge of motorsport (including F1), security, military communications and aerospace.

'We see this acquisition as an extremely positive move for both businesses,' says Kevin Twigg of Lake Interconnection Systems.

'Immediate benefits to customers will be the additional design engineering resource and a quadrupling of manufacturing capacity.'



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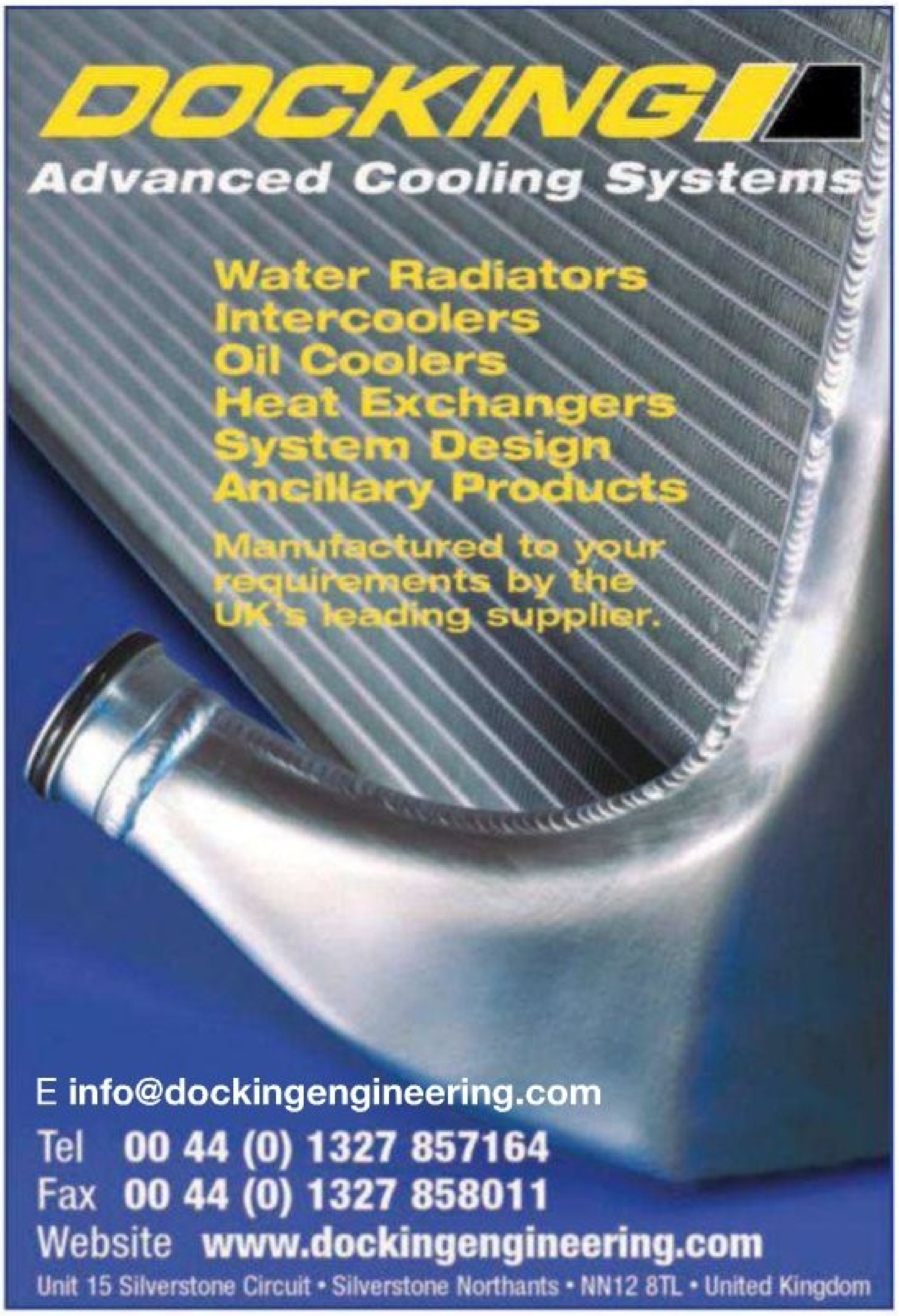

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SPONSORSHIP

The Caterham F1 team has scooped a blue chip sponsor in the shape of aerospace and defence group EADS. The group comprises commercial and military aircraft maker Airbus, the European leader in space programmes Astrium, defence and security systems provider Cassidian, and helicopter maker Eurocopter. In 2011 it employed a workforce of more than 133,000.

Production Resource Group (PRG), the largest company in the audio-visual services industry worldwide, has reached an agreement with the HRT Formula 1 Team to become its official supplier of audio-visual technology for the rest of this year.

One of NASCAR's most recognisable sponsors, automotive parts supplier NAPA, has signed a new three-year sponsorship extension with Michael Waltrip Racing and its driver Martin Truex Jr in the Sprint Cup. NAPA, which stands for the National Automotive Parts Association, is a retailers' cooperative that distributes components to car parts stores.

British Touring Car Championship team Rob Austin Racing has been trying out a novel form of sponsorship: charging fans of the team £35 (US$57) in return for the privilege of having a 10cm by 5cm (4in by 2in) photograph of themselves on the roof of the team's Audi A4 NGTC car.

BRIEFLY

F3 engines

Formula 3 is to run to a dual engine formula next year with the new-for-2013 engines running alongside the existing units. The move has come about after there were concerns that there would not be enough engines built to the new formula on the market. F3 teams have been notified by the FIA and it's now expected that the new engines will be forced to run with a smaller-diameter air restrictor to peg back power – the new F3 engine is set to have 30bhp more power than the current unit. The dual engine formula will run for just the one season and at the time of writing it was awaiting final ratification from the FIA World Motorsport Council.

Formula 1 seeks to save costs in 2013 schedule

Next year's Formula 1 World Championship will include an unprecedented eight back-to-back weekends as the Grand Prix community attempts to save travel costs.

Although still in deep water financially, the Nürburgring is included in its alternate year with Hockenheim, which is understood to be ready to stand in if required. The German Grand Prix is listed as being subject to contract, as are the races in South Korea and Singapore.

As expected, the list does not include the new Russian Grand Prix near the city of Sochi, which is now expected in 2014.

Provisional 2013 calendar

March 17	Australia
March 24	Malaysia
April 14	China
April 21	Bahrain
May 12	Spain
May 26	Monaco
June 09	Canada
June 16	America
June 30	Britain
July 21	Germany
July 28	Hungary
Sept 01	Belgium
Sept 08	Italy
Sept 22	Singapore
Oct 06	Japan
Oct 13	Korea
Oct 27	India
Nov 03	Abu Dhabi
Nov 17	USA
Nov 24	Brazil

RACE MOVES

Motorsport electrical systems company DCE has appointed **Jack Hastings** to the post of general manager of its US facility in Mooresville, North Carolina. Hastings previously worked for Goodridge, joining in 2000 and working his way up from facility manager to general manager, and he is a well-known figure within the American motorsport industry.

The crews for the Turner Motorsports NASCAR Nationwide cars have been swapped, with **Trent Owens** taking over the No38 team previously tended by **Mike Hillman Jr,** while Hillman is to crew chief the No.30 car formerly overseen by Owens. The changes are said to be part of an ongoing process by Turner Motorsports to gauge performance and ensure that the right people are in the right place to achieve race wins and championships.

Dany Bahar has issued court proceedings against Group Lotus and its parent company DRB-Hicom for wrongful dismissal. Bahar, who was removed from the Group Lotus CEO post in June, is seeking £6.7m (US$10.9m) in damages from the sportscar maker. DRB-Hicom has said it will 'vigorously oppose and / or defend the claim by Bahar, including filing counter-claims against Bahar.'

Ryan Hess, a crew member in the NASCAR Nationwide Series, has been indefinitely suspended from NASCAR for violating the governing body's substance abuse policy.

The president of the company behind next year's Grand Prix of America has resigned from his post. **Tom Cotter,** who was only taken on to head the New Jersey event at the start of this year, plans to return to work at his sports marketing company. His duties have been taken over by **Dennis Robinson,** the chief operations engineer, and **Richard Goldschmidt,** who is also the special assistant to the grand prix's promoter, **Leo Hindery.**

Lorene King is the new executive director of the NASCAR Foundation, a charitable organisation that raises funds and provides support to communities across the US. King was previously senior director of corporate alliances at St Jude Children's Research Hospital in Memphis, Tennessee.

Mike Elliot is now head of aerodynamics at the Mercedes F1 team, reporting directly to technical director **Geoff Willis.** Elliot, who formerly worked for Lotus, replaces Loic Bigois in the role. Bigois was sacked from Mercedes in June and at the time of writing was expected to take up a new position as head of aerodynamics at Ferrari.

Tony Cochrane has quit his post as chairman of the Australian Super V8 series. Cochrane came in as co-founder of the marketing company Sports Entertainment Limited in 1996 and took the commercial rights to the championship, as well as 25 per cent ownership. Mid-2011, SEL's share was bought out by private equity firm Archer Capital. Cochrane left SEL to stay with the V8s. His successor has yet to be announced.

IndyCar driver **EJ Viso** is considering setting up his own team to race in the premier US single-seater series. The Venezuelan national believes that becoming an owner-driver could give him more control over his career, but says the project largely depends on whether he can get the right people in place.

Eric Neve, Chevrolet's European motorsport manager, is to leave his position with the US motor giant, which announced that it will withdraw from the World Touring Car Championship earlier this year. Neve is to take up another, as yet unknown, position in the motorsport industry.

The Sports Partnership, a company set up by **Jenson Button** and his management team of **Richard Goddard** and **James Williamson,** is now managing Formula 1 driver Paul di Resta. The company stepped into the breach after the Scot parted ways with former manager **Anthony Hamilton,** father of Lewis.

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

highest levels of customer service. Many of these customers are still being served.

'Another significant event in 2011 was the decision by HMRC not to pay outstanding Research and Development claims and to compound this decision by asking for a rebate on earlier claims. Given Lola's involvement in high tech business it seems astounding that the dispute ended up being focused on Lola's status as an SME [small or medium sized enterprise] as a result of my personal involvement in other completely different businesses. At a time when the Government is supposed to be helping SMEs it seems ironic that their agency was intent on hammering a nail into our coffin. The amount in question was not insignificant. It was in the order of £1.4m.'

The Lola brand is now owned by Lola Group Holdings, which is not in administration, but it is not clear what is for sale.

'The two main trading companies, Lola Cars International Limited and Lola Composites Limited are both trading currently in administration,' says Birrane. 'The administrator is looking at an asset sale for Lola Cars, which involves selling the substantial stock in that company. A purchaser is being sought for Lola Composites who will buy the business as a going concern continuing with existing contracts and bringing in new business. This business can continue using its previous name, Composite Tooling & Structures Limited, and has its own self-contained 50,000 sqft facility in Huntingdon separate from Lola House.

'Through one of my companies I own Lola House, which is an 85,000sqft office and factory facility fully equipped for composite manufacture, design, engineering and car builds. On the same site and also in my ownership in a different company, is the wind tunnel, 7-post rig and technical facility. These assets, together with the name 'Lola' and the IPR in all the Lola Cars designs, is still under my ownership and control. In conjunction with the administrator we could sell the entirety in the previous operation to a buyer or I could sell any combination of the elements still in my ownership.

STAFF ASSETS

'Of course it was true that one of Lola's greatest assets was its staff and to that extent, unfortunately most of the engineers were laid off. However, I know from keeping in touch with them that many remain in the area and would love to return to Lola and continue to be part of the next chapter of Lola's great history. In the short term we have made some key appointments to keep the facilities operational and where we do not employ people directly we are using sub-contractors to meet our customers' needs.

'My hope is that an F1 team, current or future, will want the facilities we have. Another possibility is that one of the three manufacturers that I know are seriously looking at doing a Le Mans programme will appoint Lola Group Holdings or a representative to do the programme. Our capability to do this was proven with the MG Lola 675 Le Mans programme and the MG Touring Car project. However, when we have spoken to manufacturers in the past, it has always been for a turn-key product made by us, such as the aforementioned work we did for MG. At present we are open to all discussions with manufacturers or teams and what they want to achieve with these facilities, engineering know-how and technical capabilities that we can still provide.'

One of Lola's main revenue streams was sports car racing, but the introduction of new regulations for LMP2, under cost cap regulations, and the prospect of overall new regulations in 2014, damaged the business case of the company.

'The Americans have a good old saying which states, "if it ain't broke, don't fix it,"' says Birrane. 'Unfortunately not everyone in the Automobile Club de l'Ouest (ACO) agreed with this sentiment. Over my 15 years at Lola I worked closely with my good friend and then President of the ACO, Jean-Claude Plassart, in my capacity as a director and shareholder of LMS. We both felt there needed to be continuity and certainty of rules and regulations for teams and competitors. In 2008/2009 there were senior personnel changes at the ACO, which led to changes to the regulations in the hope of attracting manufacturers. At that time, Lola had over 30 enquiries for our P1 and P2 coupes

The Lola Formula 3 car challenged the otherwise dominant Dallara before being developed into the World Junior Formula car, of which a significant number were sold to a race school in Sonoma

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although the season ended with the sale of only five, due to the uncertainty created. Key people within the ACO introduced confusion by promoting open cars when in 2009 the decision had been taken on safety grounds to end open-cockpit prototypes. A later decision to cost cap the P2 car was completely unnecessary. After much internal debate the ACO mandated that the price cap, originally mooted at around €500,000 ($645,600) to respect the R&D and production cost of the coupe, be reduced to €355,000 ($458,400) in the full knowledge that this price could effectively exclude any coupe, but in particular, the Lola coupe which was the only customer car in manufacture.

I feel that some people within the ACO were assisting other manufacturers with whom some ACO affiliates had an interest. The uncertainty that influenced 2009 has continued to destabilise the series in subsequent seasons. A look at the entry lists and calendars of 2011 and 2012 for the European and American Le Mans series [ELMS and ALMS] tells the story. Who knows what 2013/2014 and onwards are going to bring?

'During my ownership of Lola we produced 69 prototypes starting with the SR1 cars, the B98/10, the B2K10 and the SR2 cars including the B2K40. In 2001 we made the MG Lola 675, the forerunner to a number of LMP1, LMP2 cars and the P1 and P2 open and coupe cars. All were designed and manufactured for customers, and all bar one won multiple races or championships.'

Top: Lola's 85,000 square foot office facility in Huntingdon
Above: Paul Drayson's rolling test bed, the Lola B08/60, at Goodwood

Lola was one of the companies that looked to enter Formula 1 under the cost cap regulations in 2009. Previous forays into the category almost brought Lola to its knees, before Birrane stepped in, and it seems plausible that this failed bid brought on the demise for a second time. Birrane, however, denies this.

'Lola's Formula 1 bid was a positive project for Lola Cars International,' he said. 'I personally funded the whole of the Formula 1 programme through Lola F1 Team Limited and we were ahead of all the competition having assembled the key personnel and provided the engineering services, materials and wind tunnel facilities to proceed. We had a wind tunnel model with the basic external shape defined and we completed over 90 data runs in the tunnel. History shows that of the three teams chosen, two were uncompetitive, and have since been sold, and one never appeared. I very much regret that we were not awarded a licence because I know with absolute certainty that had we been awarded a licence the funding was available and I believe we would have produced a very competitive car.'

Part of Lola's rich history was in American single-seat racing, where in the 1990s it supplied parts to Champ Car and Indy Lights, as well as F3000, Formula Nippon and Formula 3. It moved into sports car racing with MG to tackle Le Mans in the then LMP675 category, moving away from single seaters.

'I believe the rebirth of Le Mans prototypes in 1999/2000, improving as it did through the mid 2000s, was one factor as it attracted drivers and resources from a very difficult economic situation brought about by 9/11,' says Birrane. 'It is not just a shift away from single seaters but the fact that those single-seater championships that remain have shifted to being one-make series. By being one-make it was the organisers' intention to reduce costs. What happened is that most one-make single-seater series are now supplied by Dallara whose business model is completely different from Lola, and I understand they may benefit from Government support in Italy.

"My hope is that an F1 team, current or future, will want the facilities we have"

WINNING WAYS

'Lola thrived in competitive championships as demonstrated by our return to dominance in Champ Car and Le Mans prototype racing. We came back into F3 in 2005 and despite having only having three cars running in the highly competitive British F3 series, we won three races against a whole grid of our competitors' cars. In Germany in 2007 Lola won 75 per cent of the pole positions and 75 per cent of the races being represented by only two teams amongst a field of Dallaras.

Unfortunately Dallara had a stranglehold on the British teams and unless we were prepared to give our cars away, the British teams could not afford to change because any deal we offered was bettered by Dallara to retain their dominance in the series. Lola's last single-make series was the A1GP car from 2006. The car was highly regarded by teams, drivers and organisers and it's unfortunate that the financial model the series was built on was unable to continue beyond the first three years.'

Composite world

On England's west coast, one of a series of technical centres has opened, with the aim of sharing knowledge from different high-tech manufacturing sectors

Technical innovation in the UK was as likely to come from a man in a shed at the end of his garden as it was from a major corporation. Now, with more complex materials and a greater need for return, the emphasis has switched slightly, and the British Government has invested £350 million of government and public money in seven High Value Manufacturing Catapult Centres around the UK to encourage companies to talk to each other.

At the National Composites Centre (NCC) near Bath, housed in an 8,500m² building with a clean room, autoclaves, thermoplastic, dry-forming and liquid resin cells, a composite machining centre and a materials laboratory, sitting under office space and meeting rooms, there is already a plan to double the size of the building thanks to its immediate success.

Already the likes of Rolls Royce, Airbus, Agusta Westland, Dassault Systems and the Surrey Satellite Technology have found a home in the centre, which is looking for racing teams to join its membership and help to maintain the year-on-year funding to keep the facilities up to date.

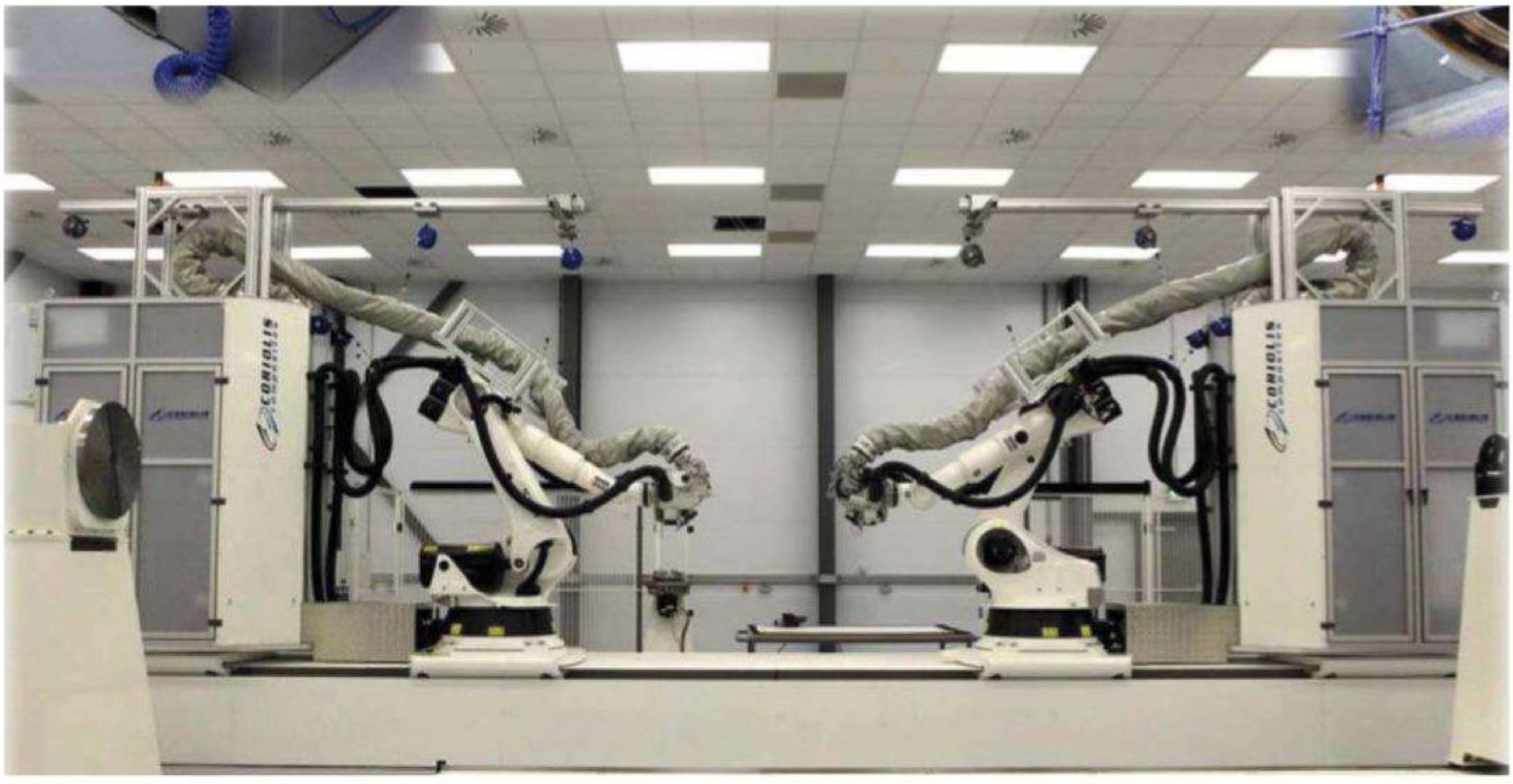
The idea is to encourage different technology-based companies to talk, leading to more business opportunities in new market areas, and the link to Bristol University is intended to give students access to world-class facilities and train up a new workforce.

The HVM Catapult Centre will receive grant funding of £25m per annum, securing sustainable leading-edge technology. Alongside the composites centre, there are six others covering printable electronics, chemical processing and biotechnology; billet forging; fabrication of nuclear components; machining, automation and tooling; and lightweight product system optimisation and energy storage management.

'Good ideas tend to be killed off without proper investigation

'Peter Mandelson's assessment was that for UK plc to thrive, UK plc had to be really good at things,' said Tom Hitchings, Business Development Director at the NCC. 'The UK composites industry was very compartmentalised. Automotive was doing what it wanted, aerospace the same, and so was wind energy. If you look at their technology road maps, there were huge overlaps, and bits that one sector took for granted was a new area for another.' The centre is designed to work with industry and universities, in what Hitchings describes as 'the valley of death', where good ideas tend to be killed off without proper investigation.

'TRL1 is a good idea at the 'sitting in the bath' stage,' said Hitchings, explaining the jargon used to describe a project's stage. 'TRL 9 is good enough to go into space. The NCC is designed to sit in the areas between TRL 4 and 6, smack in the middle of the valley of death. So we take university ideas at TRL 2 or 3, and see whether or not they can work. We are led by industry, fed back down the scale. Industry has thrown composite wing span into the valley of death and asked 'would this work in carbon fibre, or thermoplastics?' We are feeding back to universities what the industry is looking for.'



The very latest technology is available to those who use the centre. Membership structures dictate what level of access companies have

Understanding aerodynamics

As part of our technical excellence feature ahead of the Autosport Engineering Show in association with *Racecar Engineering*, Mercedes technical director Ross Brawn considers his nomination for the greatest advance in motorsport technology

It is almost comical, given today's understanding of basic aerodynamics, that in the late 1970s and early 1980s such huge gains in performance were being made as experimental wings began to filter into modern racecar design.

Young drivers across the world are learning their trade around the concept of aero balance, and almost every racecar is now designed from an aerodynamic perspective. As the next generation will have a better understanding of electronics and KERS systems, aerodynamic efficiency will continue to be an important area of performance.

'For me, the biggest advance was the understanding of the effect of aerodynamics on racing cars, and I was lucky to be involved in that period,' says Brawn.

'The late 70s and early 80s, when ground effect first came in, we suddenly realised the huge forces that could be generated even within the confines of a Formula 1 car. It opened up a whole new world for us, and every Formula 1 car designed now is sensitive to aerodynamics.

'Until then, people were dabbling and putting wings on cars, but they didn't really understand the full implications of what they were doing. In the late 1970s, when I was at Williams, we were going to wind tunnels one week in every month. Before then, people would go in, design a car, go to the wind tunnel to check it, and then wouldn't go back until it was time to design a new car. This was a game changer, designing a car around the aerodynamics as required.

'People didn't have the tools to realise what was going on. They didn't have CFD, they didn't have regular programmes in the wind tunnels. They were building a quarter-scale model and testing it in the wind tunnel, which was a big step forward for Formula 1 at the time, and it spread to other formulae.

'There are arguments that it was detrimental to the nature of the cars that we design, but not to the performance of Formula 1 cars. I was involved in the early stages where you were making half and one second differences from one week to the next, so it was a very exciting period.'

Cars are now routinely designed around aerodynamics, but Ross Brawn was in right at the start

Zircotec to launch two new coatings at Autosport International

At Autosport Engineering 2013, coatings specialist Zircotec will launch two brand new products that combine ceramic thermal insulation with the radiant heat reflection ability of a gold coating.

Offering this feature for both its ThermoHold coatings for composites and its lightweight heatshield ZircoFlex®, Zircotec believes it can provide engineers with a solution to a range of heat issues through products that are both simpler to apply and require less package space.

Both coatings can be applied to areas of a racecar where it is key to reflect heat away from sensitive components, such as a car's fuel tank or driver's area, through the reflective nature of gold.

One example application will be in and around the cockpit area of cars, particularly in endurance racing. The reduction in heat transfer caused by the combination of ceramic and gold coatings could lower the need for air conditioning during races, increasing efficiency.

Developed over a 12-month period, the products have been tested extensively internally at Zircotec, including research into the optimal amount of gold coating that should be applied to ceramics.

'Gold has long been used for reflecting heat,' says Zircotec managing director Terry Graham. 'For the first time, we are offering this effect in parallel with our trusted ceramic coating benefits. We expect this to be of particular interest to F1, WEC, GT and Touring Car categories.'

Zircotec has a fine tradition in motorsport, first entering the sector in 1994 when the company applied thermal barrier coating to Subaru rally cars. Since then, Zircotec has worked in many forms of motorsport, ranging from F1 to classic car racing, to increase reliability and performance.

A long-time Autosport International exhibitor, Zircotec will be exhibiting both products at Stand E962 in Hall 9.

- The show continues to attract exhibitors from across the globe, with 12 nationalities now represented in the Engineering hall alone. Among these is new exhibitor MFactory, Autosport International's first ever exhibitor from Hong Kong, which specialises in gears and differentials. Other international exhibitors already signed up for Autosport International 2013 include Greece's ZRP Racing Parts and Belgium's Simtech, another new exhibitor for 2013.

- Engineering services provider Development Engineering & Enterprise Ltd will be launching its new 3.5-litre Toyota V6 engine engineering package at Autosport International 2013.

- Racing electronics supplier Ole Buhl Racing has recently launched the new generation of its EFI Engine Management Engine Control Units, which will be on show at Autosport International 2013. Containing PowerPC microchips the new systems enjoy increased processing power.

- The MIA will once again be hosting 'Business Workshops' at several exhibitors' stands during the show in January (details to be confirmed).

Motorsport Business Week Schedule

7-8 January	*Race Tech* World Motorsport Symposium
9 January	MIA International 'Low Carbon' Racing Conference
10 January	MIA Business Awards Dinner
10-11 January	Autosport Engineering in association with *Racecar Engineering*
10-11 January	UKTI International Business Exchange (IBEX)
11 January	Motorsport Safety Fund 'Watkins Lecture'
10-13 January	Autosport International

"We've had everyone from those working within Formula 1 all the way through to Formula Student showing interest. The mix has been excellent and we've had discussions with people from Australia, South Africa, Eastern Europe and the USA. There's been a great vibe and a lot of enthusiasm."
Paul Webb Autosport sales & marketing manager, Deutsch UK

ELECTRIC HARDWARE

DEI plug boots

Design Engineering, Inc
DEI, who produce a range of heat control products, has released a new version of their popular Protect-A-Boot spark plug protectors. The new Protect-A-Boot Sleeves provide thermal protection for highly-angled, oversized and rigid spark plug boots. Excessive heat generated from an engine block, exhaust system or turbo can easily affect a vehicle's ignition system. Spark plug leads and boots can harden, burn or crack, leading to arcing, engine misfire or even complete ignition system failure. The new sleeves are pliable to enable them to be fitted to plug boots with a sharp or 90-degree angle, to fit over rigid boots or onto the ends of ceramic or silicone ignition leads. Their flexible construction also makes them suitable for many coil-on-plug applications where the connector is stepped or otherwise varies in diameter. The boots are made from a tightly woven, high temperature resistant glass fibre material, resistant to direct and continuous heat – up to 650degC - enabling them to protect against heat emitted by turbocharged engines.
To find out more check out www.designgengineering.com

HARDWARE

A new articulated hose

Viper performance has recently released a new articulated silicone hose, designed specifically for areas of heavy vibration or where there's a high level of lateral and compression movement within the engine. Such movement could cause other hoses to stress and split quickly. The bellows-type hose features a convoluted centre section to offer excellent flexibility and vibration absorption. The hose is reinforced with five steel rings to prevent the hose from 'ballooning' under boost or pressure, making the hose ideal for connecting a charge coolers. It's constructed with Nomex reinforcement and has a high temperature rating for use up to 250degC. The hose is supplied as a 300mm (1ft) length, with straight sections either side of the bellows which can be cut down to suit a variety of applications.
For more information see www.viperperformance.co.uk

HARDWARE

Cosworth Duratec dry sump

The Ford Duratec engine can be found in a plethora of racecars from single seaters to saloon racers. Engine specialists Cosworth have been deeply involved with developing tuning products for the Ford Duratec HE I4 engine, and now have a complete dry sump conversion for race versions of this engine. The kit is suitable for use on both longitudinal and transverse engine installations. The dry sump itself is cast in a high strength aluminium alloy and features a two-stage internally mounted scavenge pump. The pump is driven by an internal drive chain. This arrangement reduces the amount of plumbing associated with an external pump.
For more information visit www.cosworth.com

MATERIALS

Aurora heavy duty rod ends

The US-based Aurora Bearing Company has developed a new series of large bore rod ends, optimised specifically for the rigorous demands of off-road racing. The bearing portion features a heat-treated race for maximum impact resistance, and Aurora's exclusive AT 3200 liner, approved to AS81820. These features are combined with a torque fit developed to give long life and smooth operation, ensuring that the parts are strong and durable. The new bearings are available in sizes from 0.75in to 1½in.
Find more details at www.aurorabearing.com

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The International Journal of Motorsport Technology

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It's all about the engines

Much of the talk at the Italian Grand Prix in September was about maintaining low cost, popularity, and parity of performance in Formula 1, and the catalyst for this was the introduction of new engine regulations in 2014.

Since the Japanese Grand Prix in 2006, the fundamental engine regulations have been frozen, allowing the field to bunch up as the units achieve something close to parity. This freeze has also led to a reduction in running costs as the engines have had peak rpm capped, and teams now have to run no more than eight units over the 20-race season.

This has lulled Formula 1 into a false sense of economic security. Engine costs have reduced dramatically year-on-year, in line with Max Mosley's plan to achieve just that, albeit in a slightly different way to how he envisaged. However, 2014 is the time for change. With new engines, and larger KERS systems, teams and manufacturers have no other option than to spend. The only saving they can make is the running costs, and the number of units that can be supplied.

'It is clear that this new powertrain in 2014 will increase costs,' says Toro Rosso Team Principal Franz Tost. 'At the moment a lot of details are unclear on the technical side and also the price. We've also very clearly said that we don't want to go down to those times many years ago where engines were so horrendously expensive. Now costs have gone down a lot and we don't want to take three steps back again.'

Ferrari president Luca di Montezemolo says that Ferrari can supply customer engines, customer cars even, and young drivers to the smaller teams to help them. Italian newspaper *Gazetta dello Sport* reportedly quoted FIA President Jean Todt as saying that he would like to see Audi, Toyota and Porsche building drive trains for Formula 1. Currently, only Mercedes, Ferrari and Renault have signed up to develop new engines. Cosworth is evaluating the costs, and has yet to reach a decision.

Formula 1 is also worrying about competition. The parity of engine performance, coupled with fast-degrading tyres, has produced some spirited racing this season. Essentially, teams are all in the same boat. The usual suspects are at the helm, and others are paddling furiously with the oars, but no one yet owns a speedboat. The worry among teams is that suddenly, someone will take a risk on engine reliability, and could eke out a huge advantage.

Far from being catastrophic, this is how Formula 1 always was. Look at Ross Brawn's comments regarding the understanding of aerodynamics in the late 1970s and early 1980s. With no wind tunnel programmes and only limited understanding of what wings could do, gains of up to a second a lap were being made.

Formula 1 has become so close, and so unpredictable, that some laud it as a golden age of the sport. Not because of the feted drivers, as has been the case before, and not for the technology either. No, this is a golden age because the racing has been good. It has been cost effective, and the challenge is really to introduce new technology at the right price.

"Crowds want to hear the different sounds, and if manufacturers are to spend their money, they need to have relevance"

In my opinion, Formula 1 should inspire, whether through technical innovation. I would love to see the engine regulations relaxed, allowing V12s if anyone wanted to run one, V10s, V6s. Each would be limited by fuel allowance, and by the lifing of the engine anyway. Crowds want to hear the different sounds, and if manufacturers are to spend so much money developing new engines, they need the engines to have relevance.

Montezemolo wants the technology to be more road relevant. This way the money can be soaked up in other areas, as well as increasing the speed of development. The Ferrari president wants people to consider things differently, but Formula 1 has to protect what it has. Sadly, it cannot afford to venture too far from a formula that currently works.

EDITOR
Andrew Cotton

PAGID RS

Brake control from green light to chequered flag.

Top podium finish
for the Ferrari factory team and
PAGID RS technical partner
AF Corse at the 80th 24 hours race in Le Mans 2012.
Giancarlo Fisichella, Gianmaria Bruni and Toni Vilander drove their Ferrari 458 Italia GT2 equipped with PAGID RS yellow endurance brake pads to victory at the world's most important endurance race.

That was already the 3rd great success for PAGID RS in 2012, after winning overall at the Rolex 24 in Daytona and the World Endurance Championship (WEC) win at the Sebring 12 hours race.

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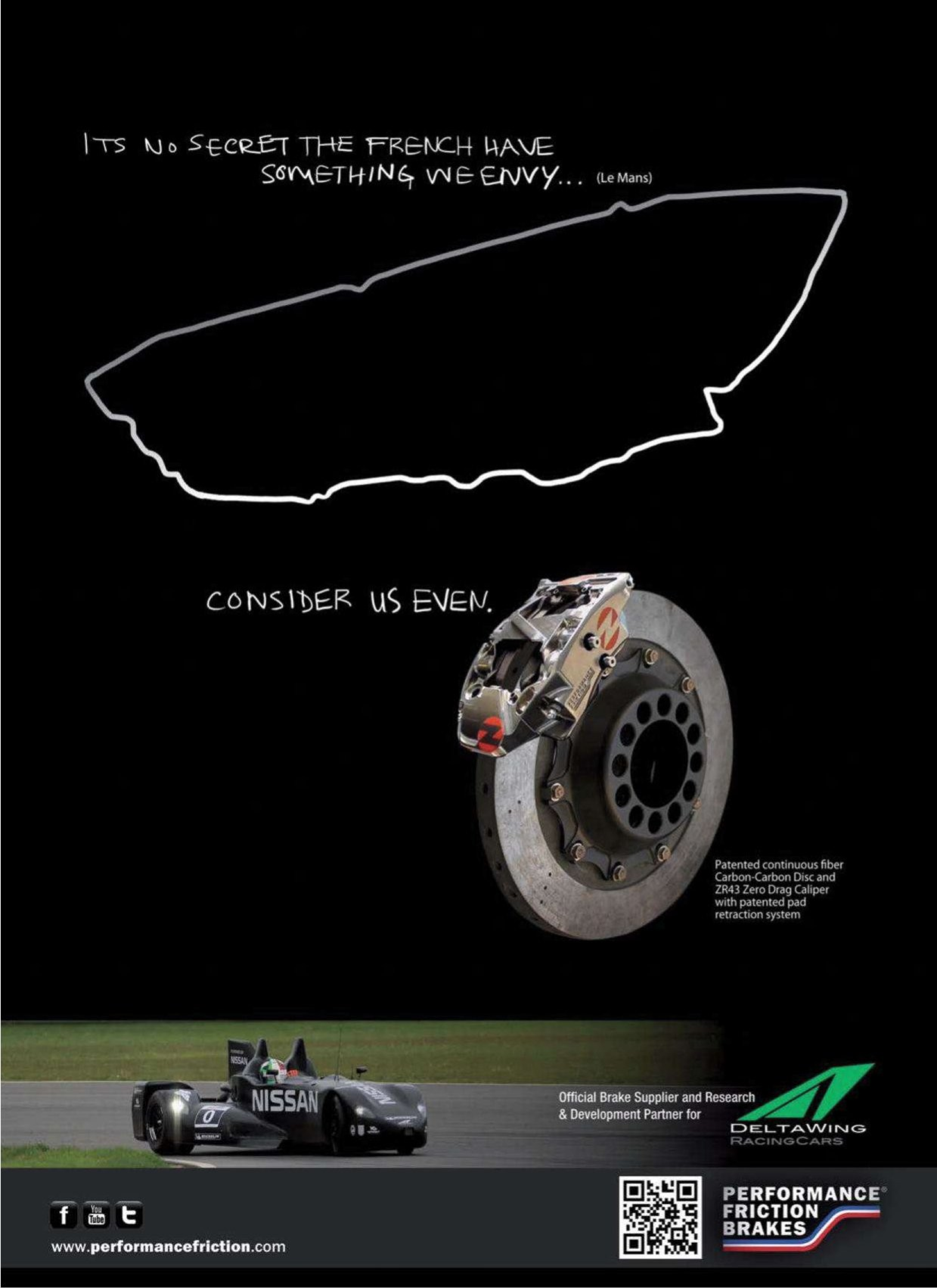
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