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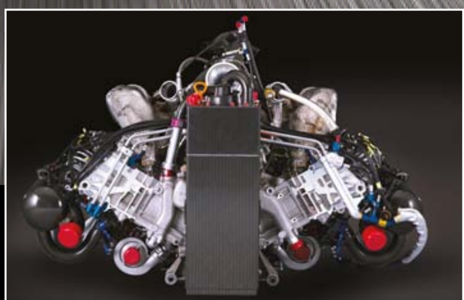

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Seeking inspiration

In a world of uniformity and tweaks, you can't beat a bit of genuine ingenuity

Two projects I was lucky enough to be involved in last year spanned the extremes. One was an LMP killer weighing 417kg with 300bhp, 300Nm of torque and a Cd of .31, with a minimal frontal area, the epitome of fuel and tyre efficiency, one single front tyre/wheel combo weighing 7kg and packed full of innovative concepts.

The other weighed five tons, has 1400bhp and the aerodynamic characteristics of a brick, plus the biggest frontal area you can envisage on a track, beam axles front and rear, with a wheel/tyre combo that weighed 117kgs each.

The LMP killer was the Nissan Deltawing, a paradigm changer employing thinking outside the box to produce a new concept of going fast, in tune with the times. The other project was a Formula Truck, a wretched excess shock and awe transformation of a heavy goods workhorse whipped into a frenzy.

Yet the basics of racing them were the same – the same use of engineering precepts to go faster, the same looming deadlines, and technical problems to be solved in tight timetables, albeit with a different twist.

The Nissan years I had were a exercise in diversity. Designing, building, testing and racing Dakar prototypes, four-wheel drive, 1300kg, 350mm suspension, travel armour-plated all-terrain monsters, sliding into single-seater Formula Nippons through Japanese GT500, BTCC Supertourers, LMP prototypes and finishing off with the Andros trophy four-wheel drive, four-wheel steer 450bhp mid-engined spike-tyred ice racers, with slight detours into class B rally cars in the UK and doing private work on a South American land speed record car, which seems to be the only frontier unexplored so far.

Previous to that I designed single seaters, from Formula Vs to F1s, and racing vehicles in most categories that have four wheels. Different rules, different epochs, different materials, different finance, different technical environments, different countries and continents.

As these cars were running all around the globe, it involved around 35 trips a year to Japan and other shores, which meant sleeping in planes for two months of the year on long hauls, fending off the ever-circling wolves of disrupted circadian rhythm.

Being a lover of mechanical porn, I had regaled myself with the history of cars, aeroplanes, locomotives and ships, details of textile looms, printing machines, bridges and hubristically thought I had seen most solutions to design problems. Upon setting my eyes on the regulations for the truck formula I was supposed to start designing for, in the list of design parameters first pencilled out,

Formula Truck is not dainty, and safety cell design requires different thinking

Jetlag takes on a different meaning on that scale. It takes you out of the everyday, legally, with no effort required over and above being crammed in a small cramped chair, ingesting bad food and looking at a minute screen showing bad movies. Watch existence in a funhouse mirror: it may not be enjoyable, but epiphanies are not often sparked by the pleasant and the everyday. Accept the red pill from Morpheus, not the blue one that masks reality.

It's no accident that Hermes, the Greek god who transported the deceased souls from the earth to Hades, also serves as the god of luck, fraud and ambiguity. Quoting William Gibson: 'It is that flat and spectral non-hour, awash in limbic tides, brainstem stirring fitfully, flashing inappropriate reptilian demands for sex, food, sedation, all of the above, and none really an option now.'

the sheer mass of the truck – five tons – started to give me a headache to design a survival cell that could take care of the energy potentially unleashed in an accident. A Formula Truck at 200kph has 3.8 times the kinetic energy of an F1 at 300kph.

Fortunately I had the opportunity to see an extant truck that was participating in the championship, only to find the solution counter-intuitive. The rollcage on the double rail chassis was designed to shear off the main mass of the truck through frangible (I love that word) connections. Simple, efficacious and track-proven. The shock of recognising true lateral thinking shook me from preconception syndrome.

All my previous work had rather fossilised my concepts, diverse though they were, by a common thread of lightness and scale quite different from this one. When you think you know it all, it's a sure sign you don't, or as I say: 'I'm old enough to know practically everything, but cannot remember any of it any more.'

The shock of recognising true lateral thinking shook one from preconception syndrome

Working with diverse formulae is an excellent way to get away from knee-jerk automatic pilot designing. Once a category has been running for some time, the major problems have been sorted out and all that remains is incremental refining of the basic car, at the most jolted now and then by rule changes, most of them banning any forward steps or creative thinking when it appears, in the name of equivalence or parsimony.

All the rest ends up being anally compulsive gains in performance, and in F1 in particular by endless iterations on small gains by an army of designers, a true 'brute force' approach to design, not pattern recognition as mentioned in a previous column.

Many hedgehogs, few foxes. Adrian Newey has taken bold steps in layout to optimise the airflow, going with a pullrod rear rather than the tried and true pushrod, plus McLaren's brilliant F-duct. But distancing oneself from the forest and seeing the trees, ultimately the concept steps have been in optimising the same ideas, mainly in aerodynamics, the rest have been frozen.

Where are this century's inertia dampers, rear wheel steering and double chassis? The new fields to be ploughed will probably be in drivetrain and energy providers, alternate fuels and electronically guided or assisted systems – as most of the rest will be incremental improvements of the already known. You can be sure that one will recognise it as soon as it appears, for if it looks like a duck, quacks like a duck and shits like a duck, one can be forgiven for getting the old 12-bore out.

I can easily echo the last words of Lady Mary Wortley Montagu (who died in 1762): 'It has all been very interesting.'

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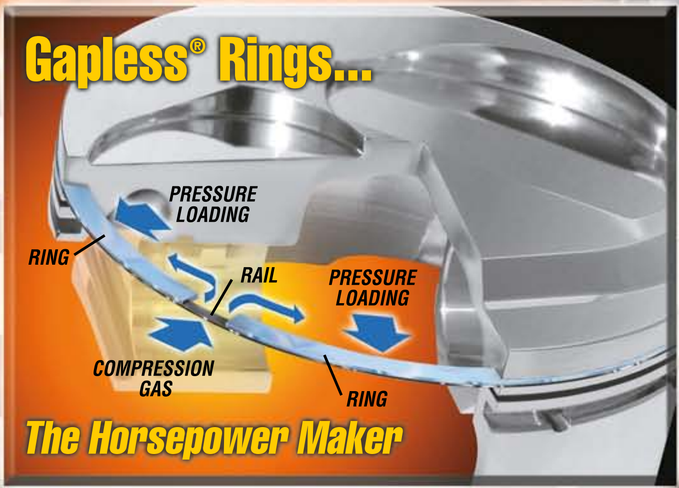

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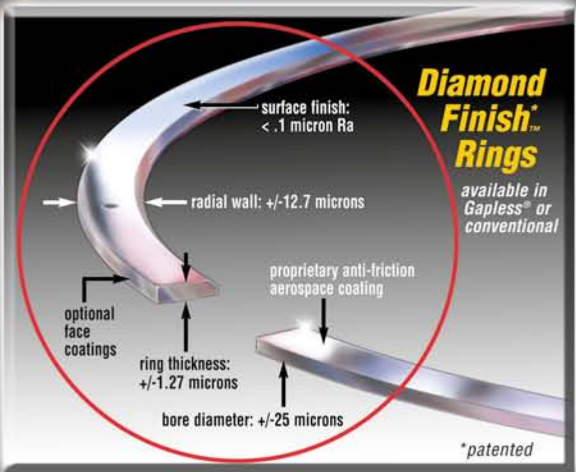

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The secret test?

A slip of the tongue sparks a major political debate in Monaco

When Hilary Clinton 'misspoke' some years ago it was really just a politician's way of saying she made it up. At the Monaco Grand Prix, one of the Mercedes drivers really did mis-speak; he mistakenly spoke when he should have stayed tight lipped. Shortly after the end of the first day of running at the Monaco Grand Prix, the Grand Prix Drivers Association sat down for one of their regular meetings. Exactly what, or how, it happened is unclear, but one of the Mercedes drivers apparently let slip that his team had conducted a secret tyre test on behalf of Pirelli. The single car test had taken place at the Circuit de Catalunya in the days following the Spanish Grand Prix, and roughly 1000km of running was completed.

The problem is that in-season testing is strictly banned in Formula 1. The FIA's 2013 Sporting regulations state quite clearly that the only in-season running a team can conduct is restricted to a limited number of straight-line and constant radius aerodynamic tests (typically conducted at airfields), and an official young driver test held late in the season. Filming days are also permitted at circuits, but the teams have to use a specific 'demo' tyre supplied by Pirelli and rival teams are invited to send observers. A single day of additional running is also allowed if a team wants to run an inexperienced driver.

Mercedes did not comply with any of these criteria, but Pirelli has a clause in its contract which allows it to request for a team to do 1000km of running for tyre development, despite the fact that this is specifically prohibited in the regulations.

News of the secret test broke late in the evening before the Grand Prix, when most people had left the paddock, and a full 48 hours after the Mercedes driver let the proverbial cat out of the bag. When word finally reached the team principals they were outraged, although it does leave you wondering why the drivers didn't think to mention it earlier. The team managers of McLaren, Ferrari and Red Bull met, and the latter pair lodged formal protests.

'Whats wrong is that a team, in an underhand way, knowingly tested tyres that are designed for this years championship,' Red Bull's Christian Horner told the press at Monaco. 'The testing rules are very clear. When you enter the championship at the start of the year, you sign up to those regulations. In our opinion, Mercedes, by doing that test, have not complied. We put in a protest because we want clarity. We talk about saving costs and we spent three hours on Friday talking about in season testing and trying to find a solution, and it turns out that one team has already done a huge amount of it.'

Indeed, for Mercedes to conduct such a test raises a number of additional issues. The number of engines used by a team in testing and in racing is tightly restricted. The question of what engine the team used has also been asked as it seems unlikely that it used any from the tight allocation.

'Of course they have used engines and gearboxes outside of the allocation,' said Horner. 'I can't believe they have used those from the 2013 allocation, so of course its just additional mileage. They are so far beyond the regulations that by the time you start looking at engines and gearboxes it becomes irrelevant.'

A team, in an underhand way, knowingly tested tyres for this year's championship

Mercedes, however, contests that it asked the FIA for permission to run the test and that it only had the request from Pirelli to test eight or nine days notice ahead of the Spanish Grand Prix. The team claims that it did not test any new parts as it did not have time to prepare any.

'Pirelli has been asking teams to help them out for 12 months, and people haven't been supporting them, so there are lots of communications between Pirelli and teams asking them to do 1000km for them,' argued Ross Brawn.

In addition, Pirelli contests that the test was run fairly, and asserts that Mercedes was unaware of the exact purpose of the test. But there is strong speculation that the test was to evaluate new compounds and constructions for introduction after the Canadian Grand Prix

'We've done it before with another team, and we've asked another team to do some work as well,' stated Pirelli Motorsport Director Paul Hembery. 'In reality we were looking at next year's solutions and trying a variety of different things. Mercedes haven't got a clue what on earth we were testing in reality. It was 90 per cent for next year. We only changed at the last minute. The bottom line is we've been trying to find a way to test.'

The protesting teams feel that, even if there were no new parts, and that tyre data was not shared with the team by Pirelli, Mercedes gained an advantage.

'Whenever you run these cars you are learning. You are learning about reliability, you are learning about the mechanical side of the car, you are learning about how these tyres behave. The drivers are learning as well,' says Horner. 'For Mercedes to claim that they did not benefit from that test would be difficult to believe.'

The Monaco race stewards, unable to make a ruling on a situation that really had little to do with the event in Monte Carlo, referred the protest to the FIA. That, those present thought, was that. The FIA had apparently approved their test and there was no way Mercedes would be hit with a big penalty.

Just as everyone was packing up and heading to the airport the FIA handed out a note detailing its position. It revealed that in early May, Pirelli asked the FIA if it was possible to run a tyre test with a team using a current car, as their contract allows. Pirelli and Mercedes were advised that the test could go ahead if it was carried out by Pirelli rather than Mercedes, which would supply the car and driver. In addition, all the teams would have to be given the opportunity to test in order to ensure 'full sporting equity'.

After that initial request, the note revealed that the FIA had heard no more about it. Crucially it did not receive any confirmation that all teams had been given the opportunity to take part.

It seems to my mind that Pirelli or Mercedes, or both, misunderstood the criteria set by the FIA, which wanted all teams to be given the chance to run in that specific post Barcelona test. Pirelli perhaps thought it had already done that by sending all of the teams very general requests for tyre testing over the last year or so. It also raises the question; what was to gain from keeping the test a secret? If Pirelli had made tyres to run at the test, why could they not have been run in Free Practice where cars are often parked for much of the session due to the tyre allocation?

It seems almost certain that the case will now be heard at the FIA's International Tribunal in Paris, and it could issue severe penalties including race bans, points deductions and hefty fines.

Porsche takes the next step

Neatly coinciding with the 50th anniversary of the French marque's 911, here comes its latest Le Mans challenger, the 991

BY ANDREW COTTON

Porsche's most eagerly anticipated race programme is the 2014 LMP1 project, that is due to hit the track testing in mid-2013. The facilities and number of staff at the Weissach plant have been considerably upgraded as the programme steps into top gear, but before then, Porsche's latest 911, type 991, was unveiled at the Porsche motorsport party in Decmber. Porsche took the covers off the 991 Cup car, and in winter testing in Florida, the company tested its latest 991 GTE contender, a car that is being developed with factory backing and run by the Manthey team in Europe, ahead of a planned full customer programme in 2014.

For many, GTE ticks all of the boxes. It is a category that is supported by manufacturers, with no fewer than five entered at Le Mans. Over the winter, the class has seen the introduction of a new Dodge Viper, and upgrades for Aston Martin and Ferrari, as well as the new BMW Z4 in the American Le Mans Series only, and now, the Porsche 991.

THE COST OF COMPETITION

Porsche is one of the most prolific racing car manufacturers in the world, producing cars for the Supercup series that follows Formula 1 in Europe, Carrera Cup series around the world, GTE and GT3. With this in mind, the cost of development – quite aside from the running costs – are factors that are perhaps more important to the engineers at Weissach than anywhere else.

As such, you might expect the manufacturer to support Balance of Performance measures that are designed to reduce development costs, preferring penalties of air restrictors, weight, fuel tank size or aerodynamics to compensate for any advantages or disadvantages. You would also expect Porsche to be firm supporters of the GT3 category, with running costs roughly half that of a GTE car. You would be wrong on both counts. 'It is a fairytale that could become a nightmare,' says Porsche's head of motorsport Hartmut Kristen of the proposed amalgamation of the GTE and GT3 categories. There are other ways of saving money that would far better help the customers compete in the national and international series if the regulations were framed better.

'It is so easy when you come up with telemetry. With a two-car team you need to have somebody at the racetrack, and not somebody who is reasonably paid, but someone who is quite well paid, to read the data,' says Kristen. 'If you have a highly sophisticated DI engine, you have another guy. This is what is expensive. We still have a life cycle of 30 hours on the engine or more in GT3, so that is not the big change, but the cost of the car has gone up because of the cost of development, and the car is more sophisticated.'

'Waivers are allowed to reduce the cost of development, but you can reduce the number of evolutions for each car – that saves a lot of money. You can reduce the aero level that you want to achieve. With the changes that happen due to waivers and BoP, and the money that is spent to achieve competitive aerodynamics, the costs have gone up. The manufacturers, the FIA and the ACO, have to find a way of dealing with that in the future. It has been impacted by what happened in GT3. When you look at the cars in GT3 and GTE, most of the cars are at the end of their life cycle.

'If something did not happen in the next two years, everyone would spend more money to get up to the level. I say you have to make the change now, in time for the next life cycle of the cars, because then you have a chance to save money up front.

'We calculate the running costs based on hours. If you take depreciation of 25 per cent of the car, and then you go with engine cycles, and have no big accidents, it is about €2000 an hour for an RSR, and there is no real difference between the old car and the new one.

'When you're asked to compare the running costs of the RSR and the current one, the new one might be more expensive, but some components might be more rigid because they are not so closely related to the streetcar. We know that we got to the end of what can be achieved with some of these parts. We took racing parts that are a little more expensive, but they last longer. With our experience from the RS Spyder, we know that the suspension didn't have a three-year life cycle – it lasts forever. It doesn't make sense to go to the limit on each and every

Porsche had struggled with the rear-engine, short wheelbase 997 against the new Ferrari 458, the new Aston Martin Vantage and the Corvette Z06, and so it was with some sense of relief that the company introduced the 991 this season. This was a car that, despite the lack of a direct injection engine, would be able to take the challenge to Ferrari ahead of regulation changes that are scheduled for 2016.

The Balance of Performance is the biggest bone of contention of the category, with all manufacturers having a gripe about the others, while to the media it seems that all are keeping their powder dry ahead of the Le Mans 24 Hours in June, and none have showed their true potential in the first two races.

For the 991, the FIA allowed Porsche to retain similar BoP criteria as the outgoing car, running 35kg under the base weight of 1245kg, with an air restrictor up from 28.6mm to 29.3mm, but with a lower rear wing than its predecessor, down 100mm to the horizontal line taken from the roof.

Porsche requested several waivers before it was able to homologate the car. The first was to run with a lower floor due to the streetcar homologation. Porsche would otherwise have to raise the ride-height of the car by up to 6mm and then spend a lot of money on aero development.

The front suspension is a double wishbone arrangement, in keeping with the other updated or new GTE cars. While the system is more expensive to buy, it is cheaper to maintain and the mechanics working on the car may be more used to working with this system than the MacPherson strut.

The big waiver granted for the manufacturer is the engine, however, as Porsche was unable to use a unit that exists in the 991 streetcar. The lack of direct injection, a system that delivers better fuel economy, is a handicap, but at Silverstone, the car used just 357 litres of fuel to complete the six-hour race, although it finished just off the podium. This compares favourably with the Ferrari (390 litres) and the Aston Martin (405 litres). At Spa, the picture was different, with the

part. Performance will go up. Look at tyres and aero – lateral forces have gone up compared to even three years ago.

The GTE and Cup cars are similar up to a point, with the bodies in white being almost identical to each other but, Kristen says, the philosophies are different when it comes to costing out the final specification for customer purchase. 'The transmission, besides the ratio, is the same, and the basic concept of the roll cage is similar, they were designed together,' says Kristen. 'The doors are the same. The windows, the dashboard and the interior is very close. The Cup car might be less sophisticated. On the RSR it is independent from cost saving. With the cup car, it is a different point of view.

'I prefer to look at total cost of spending, and there you have to be a little more conservative because the clientele and purpose is different. In the RSR you have to look at competitiveness. Developing racecars in the last five or six years has not become less expensive. The streetcar technology has changed and customer expectations have changed. If you look at the new Cup car and compare to the 996 or 997, it is more mature, and you have to be very careful. Customer expectations are one thing, and on the other hand you have to take into consideration that they are not willing to spend significantly more money. You have to do a lot of detail work.'

The 991 Cup car was launched in Germany in December, and is built to different criteria to the GTE

Strakes behind the rear wheel are not significant, says Porsche's motorsport director Hartmut Kristen. They just look good. The roofline and rear deck are slightly higher than on the 997

Ferrari using 19 litres less than the Porsche as the 991 picked up race speed, and the Ferrari overcame two penalties mid-race to claim victory. BoP, anyone?

Yet there have been problems in the early races. The drivers have reported issues surrounding oversteer at the opening two rounds of the World Endurance Championship at Silverstone and Spa, and a solution is clearly not presenting itself, suggesting either a deep seated issue with the car, or a low-downforce setup ahead of the Le Mans 24 Hours. At Spa, the 991 was able to match the leading times, although there were still set up problems that meant lost time in the opening stint on Marc Lieb's car where the Michelins didn't work as well as hoped.

DI LAMENTS

After Ferrari's introduction of direct injection in the 458, it seemed obvious that a manufacturer bringing out a new road car with direct injection should be able to install this piece of equipment.

From early on in the schedule it was obvious that Porsche would continue with the 4-litre flat six engine used in the 997 in 2012. With Porsche's reserves concentrating on the 2014 LMP1 contender, there was no spare money or resource to build a new engine, and there was an homologation issue too. 'The GT3 street car that will get a direct injection engine was not available for homologation,' says Porsche's motorsport director, Hartmut Kristen. 'On top of that, there are some discussions of where GTE will be in the future performance-wise, so we didn't want to spend a lot of money to develop an engine that will be obsolete in two years.

PFC has been announced as the partner brake manufacturer for Porsche's 991 programme. It is the first time that the two companies have entered a technical partnership. PFC has produced a bespoke lightweight, stiff brake

'The GT3 will become available on the market later this year, in summer or autumn, so the car was not available as a homologation platform. That is why the new RSR is not called the GT3 RSR. Bodywise and chassis it is based on the Carrera 4.'

One of the main handling problems with the 997, apart from the obvious location of the engine, slung out beyond the rear wheels, is the short wheelbase. Around the fast, tight turns such as Turn 17 at Sebring, the inside wheel of the 997 was clawing at thin air as the car turned into a tricycle.

The 991 has a longer wheelbase, extended by 100mm, 30mm at the front and 70mm at the rear. A new gearbox has been designed, lighter than the previous one by up to 5kg, but with driveshaft location points located optimally for the car.

> **"We didn't want to spend a lot of money to develop an engine that will be obsolete in two years"**

'We moved the engine because of the wheelbase,' says Kristen. 'If you open the rear deck lid you think that we have a lowered engine, but that is because the body is a bit higher compared to the 997. Compared to the centre of the wheels, it may be 5 or 10mm that the engine moved, but this is because of the wheelbase extension.

'The rear bumper is slightly higher, so the roofline has been moved up with the 991 – and this is with the streetcar already. There is some ground clearance that you have to achieve. The 991 is lower than the 997.'

In an effort to reduce the weight of the 997, Porsche raided the 997 GT3 Hybrid for dashboard parts and doors in an effort to be able to play with ballast. The 991 has addressed that, with greatly improved weight distribution and the ability to move ballast around, a handy weapon in the armoury as the Balance of Performance was not finalised until February, 2013.

'We never got close to having a reasonable weight balance with the 997,' says Kristen. 'To a certain degree what helps is the wheelbase. We worked to save weight in the rear and put as much in the front staying within the limit of the 1245kg that the regulations require. We have designed certain components to get to the goal that we wanted. We had to design the car lighter and that was the point where we had to be careful because we didn't know the final weight. That was gambling. If the car was heavier we could have put more weight in the front.

'That is why we don't like Balance of Performance, because you never know where you end up. If you have a car that has some kind of natural weight balance that is close to 50-50 it is easy. Aero balance has to be close to your weight balance. If you are 32 per cent or 36 per cent, it is already significant. The less weight you have in the front the less downforce you can create at the front. If you have


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too much downforce at the rear you have the typical situation that we had in the past that you put a lot of stress on the rear tyres, and it is difficult to make the front tyres work properly. The BoP was set in February so we have to now rethink the position that we have and see what changes we can make within the homologation.'

AERO GAINS

One of the common sights in endurance racing after a frontal impact was a Porsche driving around with water pouring from the radiators. In the 991, the system has been changed and the car now runs a single-mounted radiator in the centre of the front bumper. Those to the sides have been removed.

'Whenever you hit something it didn't make sense [to have the corner-mounted radiators], and we can improve the overall efficiency of the car and use that to create the downforce,' says Kristen. 'We always had the centre radiator, but with the regulations in the past you had to keep the number and the position of the radiators, so the GT3 street car has three radiators so we always had to use the outer ones and the centre, which was not as favourable.

'Overall we gained efficiency, and what we now have to see is that we get the car to respond properly to the setup and make the tyres work, and then we see what we can keep over the season.'

At the rear, dive planes are located behind the rear wheel. By regulation they are not allowed to be adjustable, and Kristen suggested that there was nothing to them other than the fact that they look good. 'With the rear mounted engine you have some disadvantages,' he said. 'Behind the wheels you have the turbulence, so it is a compromise to have a diffuser that you can have with a rear-mounted engine.'

The call for a mid-engined 911 continues, but Porsche has made an interesting step with this latest edition of the 911.

"The BoP was set in February, so we have to see what changes we can make within the homologation"

TECH SPEC

PORSCHE 911 RSR

Body
Self-supporting body in steel aluminium hybrid design (base 911 Carrera 4, type 991)
Welded-in safety cage
Removable roof hatch
Body widened and aerodynamically optimised with carbon parts
Front underbody, aerodynamically optimised
PC side and rear windows
Adjustable rear wing
Steering wheel with shift paddles
Six point safety belt
Racing buckle seat
FT3-safety tank with fast-filling function air jack
Fire extinguisher

Engine
Six-cylinder aluminium boxer engine in the rear
Bore: 102.7mm
Stroke: 80.4 mm
Capacity: 3996cm^3
Power output: approx 338kW (460hp) with restrictor
Four valve technology
Water cooling, dry sump lubrication, multi-point fuel injection
Weight optimised modular race exhaust system, twin-branched muffler with centred exhaust pipes

Transmission
Porsche six-speed sequential dog-type gearbox with pneumatic shift mechanism
Oil/water heat exchanger
Hydraulic disengagement lever
Single mass flywheel
Three-plate carbon clutch

Suspension:
Front axle: Fully adjustable double wishbone
Four-way gas pressure shock absorber
Double coil springs (main and helper)
Adjustable blade-type anti-roll bar
Power steering
Rear axle: Multi-link axle with rigidly mounted cross member, adjustable ride height, camber and track
Four-way gas pressure shock absorber
Double coil springs (main and helper)
Adjustable blade-type anti-roll bar

Brake system
Brake system with balance bar control and optimised cooling air ducting
Front: Monobloc six-piston aluminium fixed calipers
Steel brake discs internally-vented, 380mm diameter
Racing brake pads
Rear: Monobloc four-piston aluminium fixed callipers
Steel brake discs internally-vented, 355mm diameter
Racing brake pads

Rims and tyres
Front axle: 12.5J x 18, central bolt, Michelin racing 30/68-18
Rear axle: 13J x 18, central bolt Michelin racing 31/71-18

Electrics
Cosworth colour display with integrated data recording and gear shift point display
Cosworth electrical system control
Battery 12V, 70Ah
140A alternator

Weight
1245kg (minimum weight in compliance with regulations)


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Stuck in neutral

The innovative Swiss team has fallen back into the middle of the pack in 2013, but its relentless quest for the next tweak forward goes on

BY SAM COLLINS

With more than a quarter of the 2013 F1 season completed, the Sauber C32 has not lived up to expectations. Its predecessor, the C31, had fought for race wins by this point a season ago, but the 2013 car had mustered just five points after six races. While some in the paddock blame the shortfall on a weaker driver lineup than in previous years, Sauber's chief designer Matt Morris believes the reason for underperforming is technical.

'We wanted to build on the strengths of last year's car and to improve its weaknesses,' he explains. 'Last year we had very good high-speed aero performance, but from driver feedback and from other comparisons we realised that we were losing out at low speeds – so that was a big area of focus.' Morris and his team made something of a breakthrough in terms of exhaust design with the C31, taking many teams by surprise. Indeed, many on the grid eventually copied Sauber.

'Last year, especially in the first half, we had an advantage with our exhaust layout. That made the difference in the high-speed corners,' says Morris. 'I think what has happened is that a lot of others have caught up in that area, so we have lost a lot of that edge. I think our system is still pretty good, but the advantage has gone, and now we are still struggling with our low-speed performance. That can make a big difference in terms of lap time.'

Indeed, the low-speed deficit is hurting the C32. Although it is marginally faster than the C31 at tracks like Barcelona, it proved slower at Bahrain. In fact, while the field on average is around a second a lap quicker, Sauber has only improved by a few tenths. This has seen it fall down the field somewhat. 'Compared to the rest of the field we have not moved on as much as we wanted to,' admits Morris. 'There is no point in hiding – you have to face up to it and try to work out why we are struggling. We are getting there, though, and we have lot in the pipeline, providing we can get that performance where we need it. We are not miles off – if we can find five tenths, we would be fighting for podiums again.'

Most of the development is coming from the team's aerodynamic department. 'These days the main thrust is there,' says Morris. 'It's easy to sit back and just say "put some more downforce on" for the low speed stuff, but to actually do it is quite difficult. You have to trade off in other areas.'

DISTINCTIVE NOSE

The C32 features a number of interesting aerodynamic features, starting with its nose. While most teams on the grid have opted to use a full 'vanity panel' to cover up the regulatory step in the nose, the Sauber features a bit of both. Ridges run down the outer edges of the nose's upper surface with the step in the middle, forming a kind of H shape when viewed from above.

Sauber has smoothed out the nose of the C32 with a vanity panel but it is the view from above that shows the distinctive H-shape

'The nose is definitely quite different to the rest,' Morris smiles. 'We are bound by the regulations in terms of the main height of the structure, but it's no secret that we have the little duct that connects the top and the bottom which creates some aerodynamic efficiency gains. It is a nice part of the car and the design of the top of the nose helps that – it interacts with it and gives a bit of performance. Noses, however, do not tend to make big differences to the performance of the car, even though you can make them look quite different. The most powerful part is the distance between the front wing and the underside of the nose and how that all interacts. That's critical.'

In that area, Sauber has been experimenting with the position of the mandatory pair of TV camera housings, moving them from between the wing supports to the tip of the nose and back again. 'There is a little gain from moving the cameras around,' says Morris. 'Rather than giving raw performance, they can slightly adjust the aero balance. So, on circuits where you want a more forward aero balance, you will relocate the cameras.'

While the nose of the C32 is distinctive, the element on the car many have focused on are the sidepods, which are much narrower than those of other cars.

Tyre wear was traditionally a strong point of the C32, but the new 2013 construction means they cannot make fewer stops than their opposition

'It was a difficult challenge,' confesses Morris. 'The aero department came and said they wanted to create a narrow sidepod. But I had to work through it with the other departments. It was not easy as, for example, the guy in charge of cooling had his targets, and then is told that his more efficient radiators have to fit into a much tighter space. The structures guy has to save weight and put the impact structures in, and his job gets much harder. If you are just doing a rear wing it's easy, but it's much harder when it goes across departments. The key is to have regular meetings where things can be discussed openly – and quite ferociously sometimes!

'If there were points for packaging sidepods, we would be doing really well, but unfortunately that is not how we get judged – it's raw performance. The sidepods are great, but the car is not where we want it to be. It's a shame that we have not got a fast car where people start copying us. Instead, because we have fallen back a bit people blame the sidepods.'

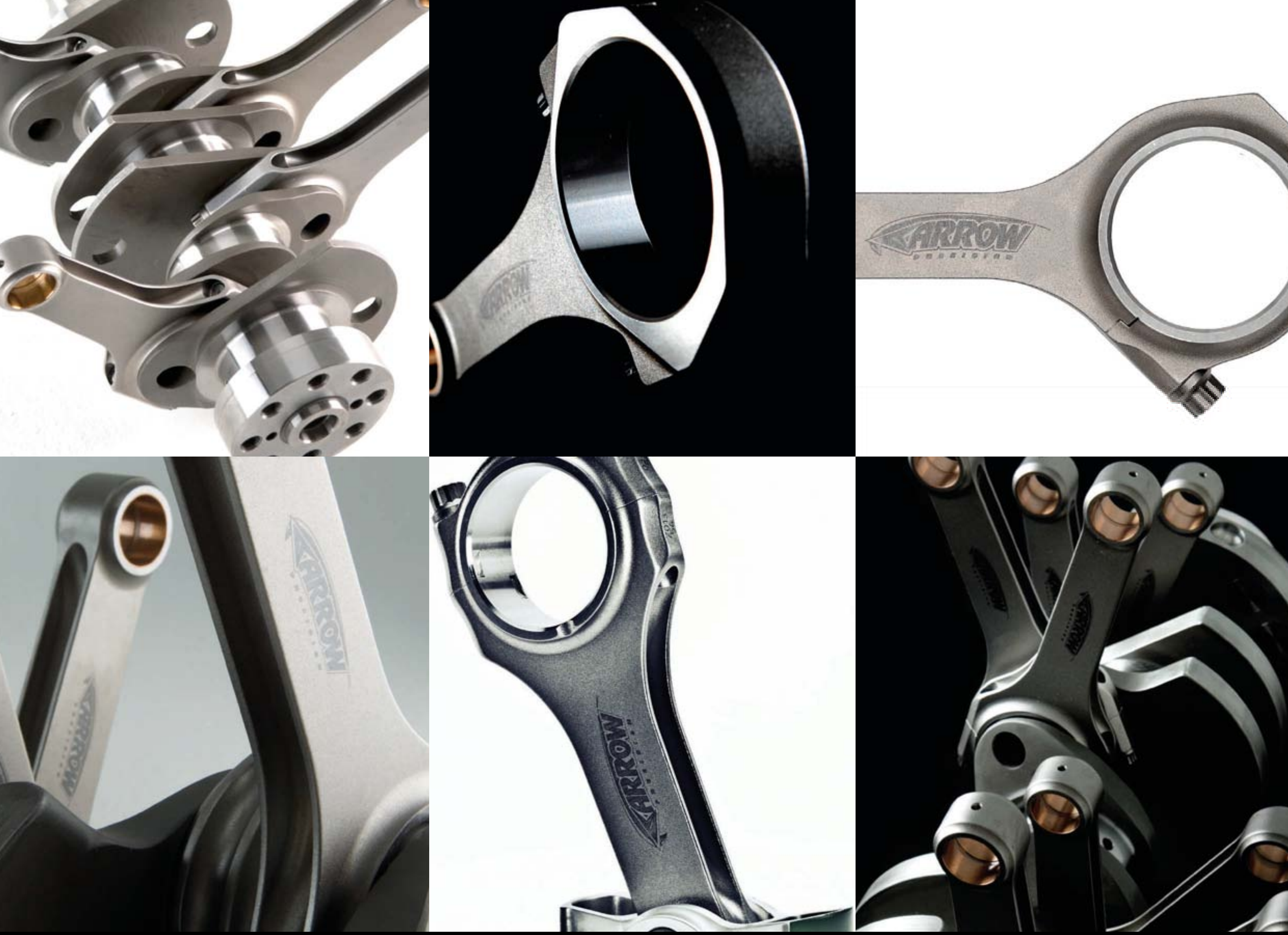
"We are not miles off – if we can find five tenths we would be fighting for podiums again"

SWISS EFFICIENCY

Despite the small size of the sidepods, Morris claims that the C32 has made steps forward in terms of efficiency over the C31. 'We did a lot of work last year measuring temperatures and working out how close we could get things,' he says. 'The actual size of the coolers is very similar to last year, it's just a matter of how we have laid them out. If anything, we have made a cooling efficiency gain. What that allows us to do is to keep the bodywork more closed and to have less air going through. It's a good lesson for next year when there are some pretty big cooling challenges. What have learnt with the C32 will put us in good stead for C33.'

While tyres are a huge topic of discussion for many teams, especially in the wake of the Spanish Grand Prix, Morris is not often heard being critical of them. However, he does point out that the 2013 compounds and construction have appeared to rob Sauber of another of its advantages, seen in both the C30 and C31. 'We certainly don't have an advantage on tyres any more,' he says. 'I don't think we are any worse off than anyone else, but we are clearly not able to do one stop less than others teams. The last couple of years that has been one of the feathers in our cap – it allowed us to get better race results than the car's raw speed would suggest that we could.

'One of the things with these tyres is that it does not really matter what you do with them –they are simply going to wear out after a certain number of laps. That's a shame, because the only way to make them last is to drive slower, and as an engineer I just don't like it. We are here to build the fastest cars we can. We are having to manage the tyres through the driver rather than being clever with the suspension, or getting more downforce as engineers. Those things still count, but the general construction of the tyre is so far the other way that you make a change, and it doesn't make enough of a difference. That's a bit frustrating, because we have been good at that in the past. I don't think there is anything inherently wrong with our car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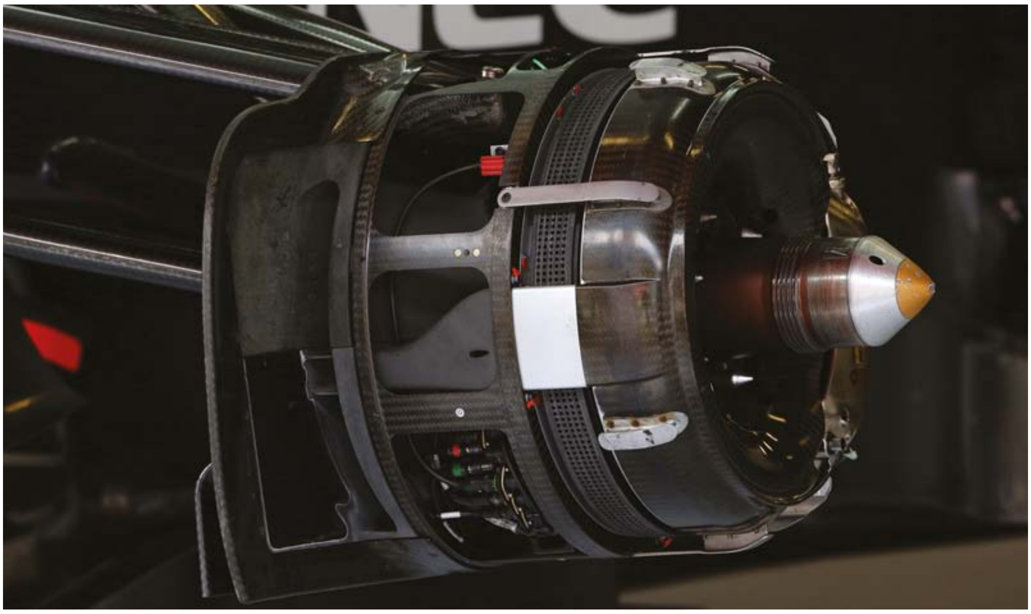


Wake from the front wheel is critical to aerodynamic efficiency. Sauber's wind tunnel is one of the most versatile

this year that has made our tyre wear worse, it's just the way the tyres are.'

The tyres are even having an impact on the car's aerodynamic performance, as the team is reliant on the scale model tyres supplied by Pirelli for use in the wind tunnel.

'It is nigh-on impossible to make a model tyre behave the same as a real tyre, because the stiffness changes and the shape slightly changes,' adds Morris. 'Some of these changes are pretty small, but you scale them up and they can become quite big. So if you develop your car around one shape and it changes, it can have pretty big consequences on your performance. I would not say this year is any worse than before, but we always want them to be closer. Pirelli has recently given us a new tyre which is more representative, so that is good.'

FOLLOW THE WIND

Sauber is especially sensitive to model tyre accuracy due to the capabilities of its widely respected wind tunnel in Hinwil, Switzerland. 'It depends on the type of wind tunnel you have,' says Morris. 'We have a very good one that allows us to play around a lot with the loading on the tyre. It makes us desire a much closer

correlation, as we can do more. Some of the other tunnels can't do that so those teams place less emphasis on it. It's interesting, because you could argue that our approach is only good if the tyre is perfect, but if we really optimise around a tyre that isn't then it's not the right thing to do.'

Some have suggested that with the C32 performing poorly in the early races, Sauber would be better off concentrating its resources on 2014. But Morris disagrees with this approach and says that there is much to be learned from this year's car. 'There is no point in throwing out this year's car for 2014,' he says. 'We need to learn the lessons of this car, otherwise you just end up designing all of its problems into next year's car. Before we get too far into next year's car, we need to really understand this one.'

Although Morris is unhappy with the performance of the car, he is not downbeat. He wants to see his designs at the front of the pack again as soon as possible.

'It's always a bit frustrating when you make bold changes and they don't work, but that's the way I work,' he says. 'There is always the risk that something doesn't come off, but I think being bold is the only way to move forwards in this game. Unless you find that next grey area to exploit for performance, you will always just be midfield and that's not good enough for me. I want to be winning races.'

"There is no point in throwing out this year's car for 2014, otherwise you just end up carrying over all of your current problems"

TECH SPEC

Sauber C32

Chassis: carbon-fibre monocoque

Front suspension: upper and lower wishbones, inboard springs and dampers activated by pushrods (Sachs Race Engineering and Penske)
Rear suspension: upper and lower wishbones, inboard springs and dampers actuated by pullrods (Sachs Race Engineering and Penske)

Brakes: six-piston brake callipers (Brembo), carbon-fibre pads and discs (Brembo)

Transmission: Ferrari 7-speed quick-shift carbon gearbox, longitudinally mounted, carbon-fibre clutch

Chassis electronics: MES

KERS: Ferrari

Steering wheel: Sauber F1 Team

Tyres: Pirelli

Wheels: OZ

Dimensions:
length: 5.240 mm
width: 1.800 mm
height: 1.000 mm
track width;
front: 1.495 mm
rear: 1.410 mm

Weight: 642 kg (incl. driver, tank empty)

Ferrari 056 engine
Type: naturally aspirated 8-cylinder, 90° cylinder angle

Engine block: sand-cast aluminium

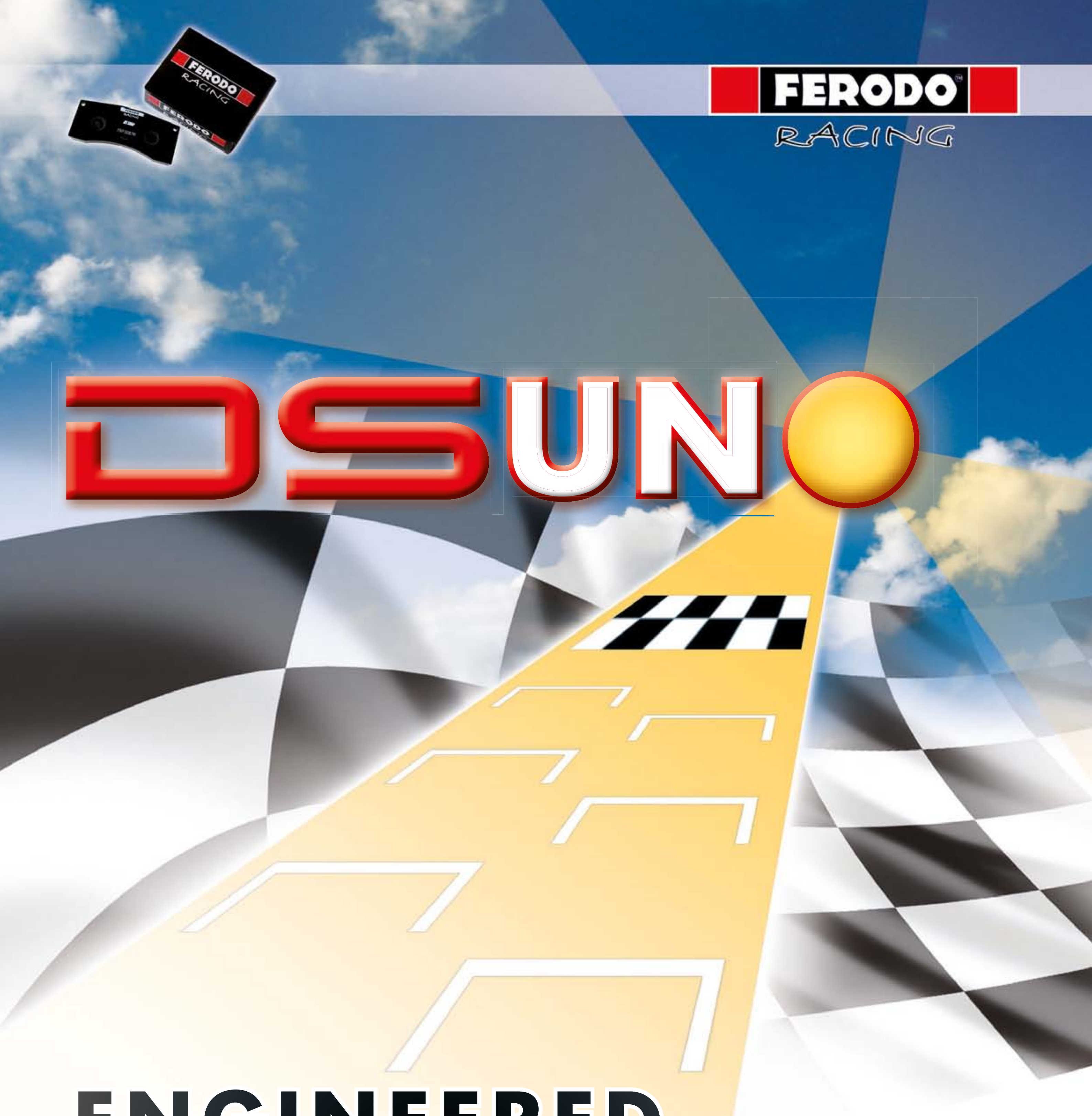
Valves / valve train: 32 / pneumatic

Displacement: 2.398 ccm

Bore: 98 mm

Weight: > 95 kg

Electronic injection and ignition



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Compound fracture

With vocal criticism about its tyres, and no contract in place for 2014, Pirelli's future participation in F1 is shrouded in uncertainty

BY SAMUEL COLLINS

The 2013 Spanish Grand Prix was – like most of the 2013 season – defined by the performance of the Pirelli tyres. But with Fernando Alonso's winning Ferrari making four pit stops, many claimed that the tyres are spoiling Formula 1.

Red Bull owner Dietrich Mateschitz was highly critical of the tyre-maker. 'We can neither get the best out of our car nor our drivers,' he complained. 'This is a competition in tyre management. Real racing looks different. There is no more real qualifying and fighting for the pole, as everyone is just saving tyres for the race. If we were to make the best of our car we would have to stop eight or 10 times during a race, depending on the track.'

With teams complaining so loudly that the tyres should be changed, it seemed that Pirelli was listening. 'Our aim is to have between two and three stops at every race, so it's clear that four is too many,' said Pirelli motorsport director Paul Hembery. 'In fact, it's only happened once before, in Turkey during our first year in the sport. We'll be looking to make some changes, in time for Silverstone, to make sure that we maintain our target and solve any issues rapidly.'

But in the days to follow there was what can only be described as a U-turn, with Pirelli now only changing the rear tyres to fix a delamination problem.

The rapid degradation of the Pirelli tyres is not so much a failing of the tyre, but actually a design feature engineered in at the behest of both the teams and FOM boss Bernie Ecclestone, who wanted to spice up the racing. 'I asked Pirelli to make tyres that would not complete 50 per cent of a race – meaning we need pit stops,' said Ecclestone. 'That's what they did. It is very, very difficult to predict and say these tyres will last 15 or 20 per cent of the race, because each circuit is different. We are facing very different temperatures, the cars are different, and last but not least, each driver has a different driving style. In the times when Niki Lauda was racing, his biggest concern was looking after the gearbox and the brakes – not the tyres. Then we got away from that and the drivers didn't have to think about anything. Now they have to use their brains and start thinking about how to win races.'

A delamination problem with the rear tyres became very apparent in recent races, with a number of cars throwing their treads at high speed. This issue is something that Pirelli now wants to rectify. 'Visually, from a tyre-makers perspective, the failures are not great, and so we have to make a change,' Hembery explains. 'After Barcelona we had internal discussions and we did a lot of testing internally. Through drum testing we were able to replicate the issue and we found a solution that meant that we could minimise the changes. We have found that the delamination was caused by debris hitting the tyre, which creates a weak spot and overheating in a small area. We believe the solution we have will completely resolve that.'

The 2013 F1 tyres feature a belt made of high tensile steel, which means that the tyres can delaminate, but not deflate, a clear safety benefit, but it seems that this belt creates an issue when the tyre is damaged by debris. 'It's an interesting technology,' says Hembery. 'The tyres use a very fine steel band which weighs about 150g. If we had unlimited testing, we could develop it more and stay with it, but we don't have that luxury.

'So, we are looking at replacing the steel belt with a Kevlar belt. You would still have the same vertical stiffness and we are not changing the carcass or the rigidity, so the shape of the tyre will not change. We are not expecting to have to make new wind tunnel tyres or anything like that. But it will change cornering force and we will lose a little bit of lateral force, so the lap times will probably increase by two or three tenths, but there will still be a thermal challenge.

'We believe that as a result of this change, the working window of the tyres will be about 5-10degC lower, so that could have a small impact, but a lot of the cars are front limited. It may have a small impact on the number of laps you can get out of the tyre. People talk as though we need to make big changes, but

"There is no more real qualifying and fighting for pole – everyone is just saving tyres for the race"

Pirelli says that it needs to test before it can finalise tyre sizes for 2014, but that testing with 2013 cars is not an option due to the difference in downforce and delivery of power

two to three laps on a set of tyres changes your strategy from four stops to three. A lot of teams in Barcelona switched from three to four stops after the first stint.'

DIFFERENCE OF OPINION

The changes to these tyres could move the performance window for some cars and change the order of the pack somewhat, but Hembery downplays this possibility. Nonetheless, all of the teams in the grid have to agree for the changes to be made – and not all of them are playing ball.

'We have to get the teams to agree because it could change the shape and deformation of the tyre. You can imagine that there are a number of teams that have been extremely vocal about wanting dramatic changes and there are some equally vocal teams who want no changes, so we are stuck in the middle of that. We have to find a solution that is equitable, which means making as few changes as possible because everyone had the same information and data at the start of the season and it would be unfair if the teams that are doing well at the moment are penalised by a change that is too dramatic.'

If all of the teams agree, a revised rear tyre will be introduced at either the Canadian or British Grand Prix. Hembery feels that if Pirelli was able to test its tyres on a representative car, the problems could have been avoided altogether. 'It is quite clear that the sport has to change its ways,' he says. 'Not just with tyres, but the way we go testing and how information is shared. We need to find a better way of testing. I don't think that means going back to full test teams, but there needs to be a better way or an ability to allow us sometimes to change.'

Currently Pirelli performs tests using a 2011 Renault, but it does not feel that the car gives realistic feedback. Despite this, there are those that claim that the team that built and helps run the car has an advantage and Lotus (nee Renault) has run strongly since its car was used. The team deny this.

The problem is worsened for 2014 when Formula 1 introduces its new rulebook. Without adequate testing, Hembery fears that there could be major problems. 'If you assume we have a contract for next year, we have some simulation data of how the new engines will be,' he says. 'But the reality is that it may prove to be even more severe than expected. 'Even if we say we are going to be very cautious, we would still like to be able to test a new solution during the early part of the season. We don't want to test on a 2013 car because it would be pointless, as the new cars will be so different. Maybe the engine manufacturers have a similar point of view. If they start running in January, they may discover something that they did not expect and would not be able to go testing themselves.

'If we could stay on to test with a couple of teams, rotating them each race, then we'd be in a much better situation. That would be the dream, but I don't think it will ever happen.'

The tyres for the 2014 cars will be very different to those used in 2013, simply to make sure that the teams do not have too much on their plate in the first year of a new engine formula. 'It's not quite guesswork – we know that the power delivery will be very different and that the aero loads will be dramatically different, but there is a big question about the tyre size.' says Hembery. 'With less downforce maybe you need wider tyres, and there is also a risk of excessive wheelspin. So if we do it, we will take a conservative approach and go back to a single pit stop or even none at all. You need to take into account that the change is so dramatic that if you ask the teams what the cars will be like next year you will have 11 different answers.'

OUT OF CONTRACT

Crucially, Pirelli does not have a contract for the 2014 season. It has made it clear that it wants one, but progress seems to have halted, with the tyre company now considering its options – which include quitting Formula 1 altogether. 'On the 1st of September we are supposed to tell the teams everything they need to know, but it's almost halfway through the year, so you can imagine how ludicrous that is when we have not got a contract in place,' Hembery complained. 'So maybe we will not be in F1 in 2014. At a certain point someone has to make a decision and the chances of that have grown. I have always said that I will not reveal the internal deadline, but things really are getting too late. As far as we can see, things are getting extremely serious because the changes next year are so substantial. The sport has to make a rapid decision because we have resources we need and we have to do the technical job of actually making the tyres. It will not be a case of putting a harder compound on to this year's tyre, we need to do a thorough re-engineering of the tyre and that takes time. The point will come soon when it will become impossible, and we will say that we do not have the time to do the job any more.'

If Pirelli does decide to quit Formula 1, it creates an unclear future. It seems unlikely that a tyre war will be permitted with multiple tyre companies taking part. Korean firm Hankook has openly stated its desire to take over from Pirelli, and it claims that it was approached to become the single tyre supplier after Bridgestone left the sport at the end of 2010. It felt that eight months was not enough time to develop a new racing tyre to meet the demands of Formula 1, however, and opted to supply the less challenging DTM series and some Formula 3 classes instead.

In a period of huge upheaval for the sport in preparation for 2014, the tyre dilemma provides yet another unwelcome variable for teams to overcome.

"The point will come soon when it will become impossible and we will say that we do not have the time to do the job any more"

Record Rapide

Aston Martin's Rapide S became the first car to complete a qualifying lap of the Nürburgring Nordschleife on hydrogen power alone. And it didn't stop there...

Aston Martin's Rapide S model set a landmark at the Nürburgring 24 hours when company CEO Ulrich Bez completed the first lap in the competition running on hydrogen power alone.

Driving a Rapide that has been converted with renewable experts Alset Global to run on hydrogen, gasoline, or a blend of the two, Bez completed a qualifying lap on the fuel, and went on to complete 40km before reverting to gasoline power to return to the pits. The car went on to compete in the 24 hours in the E1-XP2 category for experimental technology.

Formed in 2005, Alset Global is a technology and engineering company working on clean mobility solutions based on hydrogen. With European engineering headquarters in Graz, Austria, Alset Global has developed a patented Hybrid Hydrogen system to run on pure gasoline, pure hydrogen or a blend of both, which is designed to offer car manufacturers, vehicle fleets and cities a clean mobility solution in time for new European emission standards in 2020 without disrupting the industry.

The hydrogen, produced at the Linde plant in Germany, is manufactured from raw glycerol, a byproduct of biodiesel manufacturing. Advanced to industrial scale, this production path has the potential to reduce greenhouse gas emissions by between 50-80 per cent compared to conventional hydrogen production processes.

Hydrogen has a wide ignition range, which allows very lean combustion. It burns six times faster than gasoline which – together with mature injection and combustion control technology – means that hydrogen combustion can be up to 30 per cent more efficient than the gasoline equivalent.

"Hydrogen combustion can be up to 30 per cent more efficient than the gasoline equivalent"

Alset believes that this could be the future of production car technology, allowing cars to be classified as zero emission under current regulations, and which can be run for between 100km-200km between fills, substantially further than the Porsche 918 or the Toyota Prius.

'If you add 100km or 200km, rather than looking for 400-500km before you switch back to gasoline, you are not looking for a large tank size,' says Alset's vice president of operations, Markus Schneider. The Rapide S ran at the Nürburgring with four hydrogen fuel tanks placed next to the driver and in the boot of the car, although in production the system will be more refined. Already the system, which can be fitted to existing cars, has attracted manufacturer interest, with a Chinese delegation of VIPs shown around the car at the Nürburgring. 'The system will add around 10 per cent to the car's price, which is nothing when you look at the amount some people spend on their satellite navigation systems today.'

Having been the first to run the technology in competition, Alset plans to produce the system for road cars, making use of the fuel stations in major cities. 'If you want to drive your car in a city on zero emissions, you can,' says Schneider. 'If you want to drive

to Italy, you don't need a second car. You can do it on the regular gasoline fuel, which is a big bonus.'

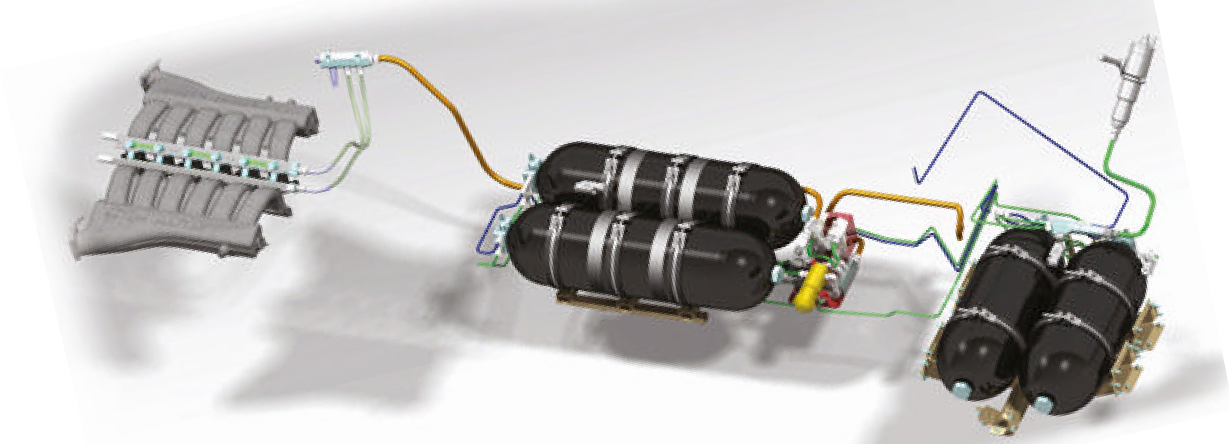
ENGINE UPGRADES

Hydrogen burns faster and at a higher temperature than normal gasoline, which means that changes had to be made to the V12 engine. The first step was to fit twin turbochargers to the 6-litre V12 engine before fitting the four Magna Steyr-built carbon tanks.

The two exhaust-driven turbochargers are used when the car is burning hydrogen to improve the mixture heating value of the charge, forcing more air/fuel mixture into the combustion chamber. 'The gas takes up a lot of volume,' says Schneider. 'The fuel air mixture in the manifold doesn't have the same density as a liquid, so you are losing power. To get that back, we had to turbocharge the engine.'

The Rapide S uses a Pectel engine management system from Cosworth as the project required a bespoke unit. The hydrogen injectors, supplied by AFS, are similar in design to natural gas injectors found in OEM CNG applications. There are small differences needed for the different requirements, including high durability seals and materials. In the case of the Aston Martin Rapide, those injectors are fitted to the intake manifold, upstream of the regular gasoline injectors. The hydrogen is delivered to the fuel rail in a constant flow at between 4 and 5 bar. The mixture formation system was redesigned and a hydrogen rail, injectors and a turbocharger unit were integrated, considering the specific thermodynamic properties of the hydrogen combustion process. Since the modification effort of the base engine is low, it is feasible to retrofit virtually any engine, including direct injection engines.

In gasoline-only form, the engine produces 400kW of power,



A 3D rendering of the complete Rapide S Hybrid Hydrogen fuelling system

the hydrogen 20 per cent less, at 320kW in hydrogen mode only. The gasoline is mixed with the hydrogen, adding around 10 per cent, meaning that the car can produce around 90 per cent of the overall power while reducing emissions.

A new exhaust manifold was fitted, as well as new pistons and new cylinder head gaskets, while the higher temperatures mean that, as a fail-safe, the exhaust valves were replaced with ones made from Inconel, although Alset admits that the production valves probably would be able to cope.

The Alset system was developed in just eight months, 10 months faster than the original schedule, but one that brought it out in time for the race, held in Aston Martin's centenary year. As such, it may not be the prettiest system in the Rapide S, and Alset believes that the system can be optimised. 'Some of the machining was a one-hit, which worked,' said Schneider. 'I think that we can improve on the 320kW of power with a bit of development, and expect a minimum improvement of around 10 per cent, which means the hydrogen would run at 90 per cent of the power compared to gasoline.'

MASS STORAGE

The four carbon-fibre storage tanks hold a total of 3.2kg of hydrogen, equivalent to 12 litres of gasoline. In the race version of the car, the hydrogen is stored at a pressure of 350 bar for simple and quick refuelling.

The hydrogen system adds around 100kg to the weight of the Rapide S, around 70 per cent of which is added by the fuel tanks and plumbing

During the race, the car had two stops to refuel, the first for the hydrogen only at the start of the pit lane from a 35 tonne, 14-metre long TrailH$_2$-gas mobile hydrogen refuelling truck which stores two separate high pressure couplings for gaseous hydrogen, and stores the gas at 300 and 450 bar in cylinder packs. The second was a regular service, for gasoline and – if necessary – driver and tyre changes. In a production version of the vehicle, however, 700 bar pressure storage is possible and allows for smaller packaging or for higher amounts of fuel to be stored. The Rapide S race car is equipped with a 100-litre motorsport-specified gasoline tank in its regular position, providing a total combined range of nine laps on the Nordschleife and resulting in no range disadvantage during the race.

The hydrogen system, together with assorted engine enhancements, adds around 100kg to the weight of the car, around 70 per cent of which is added by the fuel tanks and the plumbing system, which includes holding brackets for the front and rear, tubes and a pressure regulator unit.

The 350 bar hydrogen tanks are fully wrapped composite cylinders with an aluminium liner with a 15mm thickness. The cylinders, developed together with Magna Steyr, are denominated Type III. The packaging was specially designed to meet all safety regulations and to avoid any sort of damage during the race.

An ECU, developed together with partner Gigatronik, monitors and manages the Hybrid Hydrogen safety and tank system on the car. A safety concept has been developed that considers the specific properties of hydrogen as a fuel and ensures maximum safety in all racing conditions. The ECU is connected to four hydrogen sensors, which continuously monitor the gas system, as well as crash sensors. In the event of one of the sensors detecting a trace of hydrogen, or if there is a crash, the hydrogen supply will immediately shut off. A valve between the tank and the pressure regulator closes and all the hydrogen, beside the amount left in the pipes, is retained within the extremely robust carbon fibre composite storage cylinders.

Crash safety has been ensured by carrying out crash tests of the conventional Rapide S as a part of the standard homologation process. Relevant modifications of the conventional vehicle were developed according to the results of crash simulations.

'Hydrogen is as safe, if not safer, than normal gasoline engines,' says Schneider. 'It has different properties, but the burning process means that, if you had an accident and were able to rupture a tank, which is difficult, you would not have toxic fumes and a high heat transfer that you have with a gasoline fire. You would have a rapid release of gas, so no build up, and if you were unconscious you would not be inhaling the fumes.'

The car finished in 115th position overall at the Nürburgring, but given the interest that the system has already generated, this technology could have a long-term future.

"We can expect a minimum improvement of around 10 per cent, meaning that we could run on hydrogen at 90 per cent of the power of gasoline"

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Gazoo debuts Lexus LFA

The Japanese manufacturer contested the Nürburgring 24 with an all-new LFA, a car that bears a striking resemblance to TMG's stillborn GTE challenger...

BY ANDREW COTTON

The Gazoo Racing team returned to the Nürburgring 24 Hours with an all-new LFA that had more than a passing impression of Toyota's GTE car that was built in Cologne but which never saw the light of day.

Lexus has contested the Nürburgring 24 Hours every year since 2007, first with the Altezza RS200 before switching to the carbon tubbed, 4.8-litre V10-powered Lexus LFA in 2008. The aim of the programme was to 'create a good spirit' of the car, and improve the image of Toyota, moving away from the boring label with which it had become associated.

There were a few improvements for the 2009 season, but for the 2010 event, the car featured revised aero parts, underbody, brakes, tyres and longer wheelbase as well as a reduction in weight. The car won its class, a feat that it repeated in 2012, although second in class was the best it could manage in the rain-affected 2013 event.

For years it was rumoured that the LFA was being developed as a GTE car ready for competition at the Le Mans 24 hours, and indeed there was a plan to run the car alongside the TS030 LMP1 in 2012 (see sidebar), but Toyota elected to concentrate on its return to Le Mans in the LMP1 category, seeking overall victory.

With the GTE specification car built and sitting at TMG in Cologne, gathering dust, a request was made to return the car to Japan, along with two sets of bodywork.

What came back to Europe for the Nürburgring 24 hours in Maywas an all-new car, based on the production version of the LFA, of which 500 have been built and sold. 'It is a separate product, a separate car,' says team manager Nobuaki Kanamori. 'In order to race at the 24 hours, the car was developed and improved at the Nürburgring. This is better than in the past.'

Development of the 2013 Nürburgring LFA began last October, with the design of the car sent to TOMs which undertook the build programme. The plastics in the production car were replaced with carbon bodywork, while the carbon tub was retained. The engine is similarly production car-based, retaining the 4.8-litre V10 layout, although strangely the engine is designed to run with air restrictors despite the Balance of Performance not requiring these devices.

The team says that the engine mapping was designed to run with restrictors and that it was easier to keep them, even though it slowed the car for the Nürburgring race. 'We would have had to change the software to cope without the restrictors,' says Kanamori. Maximum power is 367kW (500PS), produced at 8000rpm.

The engine in the new LFA is based on the production supercar, retaining the 4.8-litre V10 layout. Maximum power is 367kW, produced at 8000rpm

The radiator has moved from the back of the car to the front, a move that helps with weight distribution and reduces weight, not needing to feed the fluids through the length of the car. The car weighs 1390kg in Nürburgring trim, with a beefed-up suspension that has added approximately 30kg to the base weight of the original car.

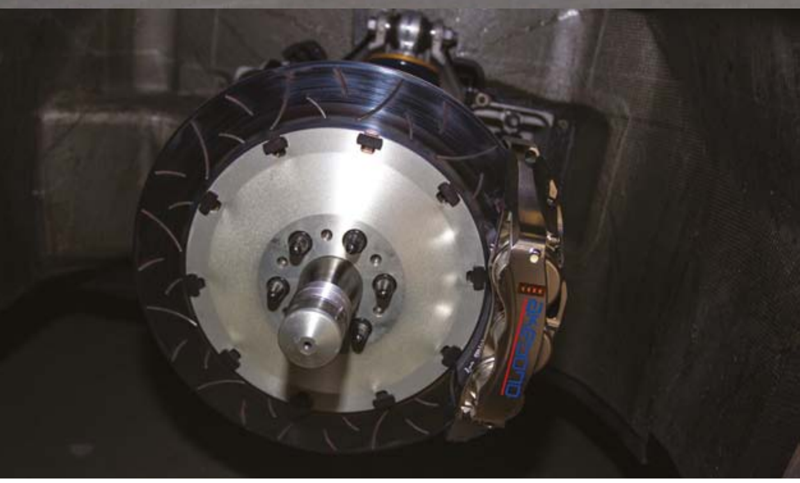
As with the production car, the transaxle transmission is at the rear, with an aluminium gearbox casing. The gearshift is a six-speed, paddle-shift system mounted on the steering wheel. A production car exhaust is also changed to improve the sound and the power.

The car runs with traction control, and on Bridgestone 18-inch tyres, the same size as the Japanese Super GT tyre but - due to the high weight of the car - on a bespoke compound and construction. Aerodynamically, the team has fitted a front splitter, diveplanes and louvres over the front wheels.

With the company's immediate future lying in hybrid technologies, showcased at Le Mans with the TS030, it is something of a surprise that the LFA didn't run with the same system. In 2010 the team attempted to enter a hybrid car, but it didn't meet regulations and was refused entry to the race. Given the LMP1 programme, will there be an opportunity to bring a hybrid in future? 'Maybe,' says Kanamori with a smile...

The engine mapping was designed to run with restrictors. The team says it was easier to keep them even though it slowed the car

Gazoo Racing's LFA, driven by the team of Toyota president and CEO Akio Toyoda, Masahiko Kageyama, Hiroaki Ishiura and Kazuya Oshima. The car finished second in the SP8 class of the 24 Hours of Nürburgring, and 37th overall

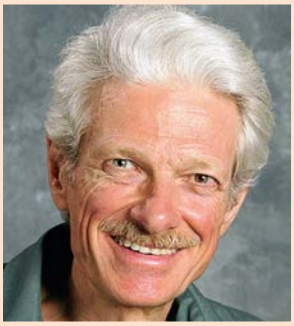


TOYOTA'S SECRET GTE CONTENDER

Toyota was all set to join the GTE category with a version of the Lexus LFA in 2012. The plan was to have the LMP testing in 2012, but Peugeot's withdrawal from LMP1 caused Toyota to step up to a full race programme.

The GTE plan was scrapped due to the logistics of running the two programmes simultaneously on the company's return to Le Mans for the first time since 1999. The LFA was tested in May 2011 at Valencia, following a full wind tunnel test programme. There was an alternative plan to run the car for customer teams in the VLN series and at the Nürburgring 24 hours, so various setups were produced for the car, and there was also a setup for sprint racing in the FIA GT Championship, demonstrating a clear intent to sell customer cars.

The engine was a 72 degree V10, running with two 29.4mm air restrictors. Power was 475PS/560Nm of torque at 9000rpm. It had a six-speed gearbox, with an aluminium casing and was geared to 300km/h.



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Revisiting the thrust roll effect

Explaining unsymmetrical suspension forces while cornering

Q I have always been curious about power on/off steer during cornering. I am familiar with the usual suspects, such as weight transfer affecting slip angles, but I have driven cars where I feel that the amount is too great to be explained by this.

I have investigated this and I find that certain suspension configurations cause the body to roll when the suspension is unsymmetrical, as in cornering. The thrust loads fed into the body by the suspension attachment points can or cannot cause roll angle change depending on the geometry.

If the car has roll steer, then of course the change in roll angle will cause steer. But the really interesting thing occurred to me when I realised that when roll change is not caused by a side force, the roll centres are taken out of the equation and only the elastic roll resistance applies. So if a car has no roll steer but has unequal elastic roll resistance front and rear, it will still steer during power on/off during roll due to tyre loading. Like perfectly balanced car with elastic roll plus geometry roll resistance, but unbalanced when power on/off is applied.

I would like to know your views on this. Maybe this has something to do with the difference in oversteer/understeer difference between tight corners and sweepers as the power requirement is different.

This is a real effect that I have touched on previously. We might call it thrust roll: roll due to unequal anti-squat/pro-squat or anti-lift/pro-lift (in the case of powered front wheels) on a driven wheel pair.

As the questioner correctly notes, only some cars exhibit this effect. Therefore, thrust roll doesn't explain why nearly all cars, unless they're aero-tight, are looser in sweepers than in tight turns, but it does relate to differences between one car and another.

There are analogous effects in braking, as well, and even some due to drag forces on free-rolling wheels when the tyres run at a slip angle in cornering.

Thrust roll is roll due to unequal anti-squat/pro-squat or anti-lift/pro lift on a driven wheel pair

Any difference in jacking forces between the right and left wheels of a front or rear pair creates a roll moment. This is true whether the jacking forces result from longitudinal ground plane forces or lateral ones.

In the case of propulsion forces in rear-drive road or road racing cars with independent rear suspension, the existence of a thrust roll moment under power depends on curvature of the motion path described in side view by the wheel centre as the suspension moves. Usually, this trace is either straight, or concave forward. It is possible to make it concave rearward, but this is uncommon.

If the trace is straight, but inclined identically on both sides of the car, the car has some rear anti-squat or pro-squat, but this doesn't vary from side to side as the suspension displaces in roll. If the trace is concave forward, anti-squat increases on the inside wheel and decreases on the outside wheel due to roll.

In that condition, equal forward thrust at the rear contact patches will roll the car out of the turn. It will create a change in diagonal percentage. It will add load to the inside rear tyre and the outside front, and take load off of the outside rear and inside front. In other words, it will wedge the car. It will make rear tyre loading more equal, and make front tyre loading less equal, which will add understeer.

If the traces are straight but inclined rearward at the top, there is anti-squat, but it stays the same on both sides as the car rolls. There is then no thrust roll or thrust wedge.

If the traces are concave rearward, the effect is the reverse: thrust de-roll and de-wedge, adding oversteer.

Note that all of this assumes equal longitudinal ground plane forces at the rear wheels, as with an open differential and zero tyre stagger. That generally is a good approximation for road cars, and some racecars as well. However, when we consider racecars with spools (locked axles), lockers, or limited-slip differentials, we often have thrust forces that are unequal, and in some cases even in opposite directions.

The biggest effect of unequal thrust forces is that they directly produce yaw moments that reduce or increase understeer. However, in addition they affect thrust roll.

With systems other than open diff, the thrust forces not only are unequal, but vary as the car approaches the limit of adhesion. As this happens, both yaw moments and torque roll are affected.

Taking the case of a spool – or locked axle – in a road racing car, when the car is cornering and the tyres are well short of the limit of adhesion, the inside rear tyre drives and the outside one drags. The outside tyre is not propelling the car at all. Its x-axis force is rearward. The inside wheel exerts a larger forward force. The difference between these forces is the resultant that propels the car.

If both wheels have some identical amount of anti-squat geometry, the induced jacking forces will try to compress the outside suspension and extend the inside suspension, rolling the car out of the turn and adding wedge.

Now suppose we have a car in this state, and we slowly roll on more power until the rear wheels approach the limit of adhesion. The amount of slip on the inside wheel will increase. The forward force at the inside wheel will increase. The rearward force on the outer wheel will decrease, and its per cent slip, which is negative, will decrease negative.

At some point, the slip on the outside wheel will reach zero, then pass zero and become positive. At this point the car is driving with both rear wheels. As the tyres approach saturation, the propulsion force from the outer one will generally exceed that from the inner one, since both are now grip-limited and the outside one has more normal force. The inside tyre may also be at a per cent slip that is past its peak for longitudinal force, at the lateral force it's generating.

Interestingly, if there were a linear relationship between per cent slip and longitudinal force, and if the hub motion paths are also linear, then as this process progressed, the overall upward jacking force from the anti-squat would increase, but there would be no change in thrust roll. However, the relationship

Any difference in jacking forces between the right and left wheels of a pair creates a roll moment

between per cent slip and longitudinal force is highly non-linear. It is also different when the tyre is making lateral force at the same time than when we are using the tyre's full capability longitudinally.

The rate of change of longitudinal force with respect to slip is greatest near zero slip, and diminishes with increasing slip, eventually reaching zero, then becoming negative. That zero point is the point of tyre saturation: the point where the tyre's longitudinal force peaks, and it is at impending wheelspin breakaway. When we are not cornering, on dry pavement, a typical per cent slip at peak longitudinal force might be around 10 per cent. If we are cornering, this number decreases.

Because the relationship between slip and longitudinal force is non-linear, and because there is more normal force at the outside tyre, in the case we are examining we get a decrease in thrust roll and thrust wedge as we add power. This will intensify the transition from power understeer to power oversteer. If the car has pro-squat geometry instead, and that geometry produces side-view hub motion paths that are linear and slope forward at the top, we get the opposite effect: the jacking force at the outside wheel again increases faster than at the inside wheel. But this time it's downward, or pro-compression. This makes thrust roll and thrust wedge increase as we add power, making the transition from power understeer to power oversteer less in magnitude and abruptness.

Now let's consider the same situation as above, but with a locker. A locker drives whichever wheel rotates slower, and lets the faster one – the outside one in a road racing car – overrun. To release and overrun, the faster wheel has to exert enough torque to overcome a spring load in the mechanism. Consequently, there is a slight drag from the outside wheel, but it's much smaller than with a spool. If neither wheel tries to overrun sufficiently to unlock, the device drives both wheels at identical RPM.

At moderate power application, the inside rear wheel drives and the outside one coasts, with just a little drag. If the suspension has symmetrical anti-squat, this produces some thrust roll and wedge.

If we roll on more power, the inside rear will produce more thrust, while the outside rear continues to coast. Thrust roll likewise increases. Inside rear slip percentage will also increase.

As we continue to roll on more power, inside rear slip will increase enough to equalise shaft speeds. Then the locker will lock, and drive both rear wheels at identical RPM. At this point there is an abrupt increase in thrust at the outside rear, which adds oversteer and produces the characteristic known as 'locker twitch'. With symmetrical anti-squat, there is also an abrupt decrease in thrust roll and wedge. This will tend to intensify the twitch.

As with the spool, symmetrical pro-squat will have an opposite effect, and moderate the transition.

Gear-type and clutch pack limited slip differentials have behaviour somewhere between spools and open diffs, depending on the amount of locking torque. The amount of locking torque depends on the amount of power applied, the preload in the unit, the size and number of frictional elements, the ramp or gear tooth angles, and the type and condition of the lubricant. This makes modelling the unit's behaviour, or generalising about it, rather difficult. We can say, however, that the closer the unit is to being locked, the more it acts like a spool, and the less the locking torque is, the more it acts like an open diff, with respect to thrust roll as well as otherwise.

The questioner notes that the front/rear distribution of elastic roll resistance affects the amount of wedge or diagonal percentage change that we get from thrust roll, and that geometric roll resistance doesn't matter for this. That is quite true.

However, it is not true that there will be no diagonal percentage change if the front and rear elastic roll resistances are identical. Rather, the rear suspension has to have all the elastic roll resistance for this to be so. In other words, either the front elastic roll resistance has to be zero, or the rear suspension has to be completely rigid in roll. Short of this point, having less front elastic roll resistance, and more rear, will reduce the magnitude of wheel load changes from thrust roll. This is also true for diagonal percentage changes from driveshaft torque roll in live axle rear suspensions.

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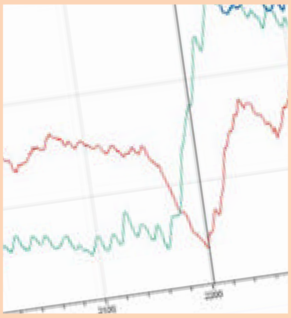

Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

Early warning system essentials

When pressures are high and fatigue is setting in, clear error detection and speedy troubleshooting is a must

When analysing data it is important to be able to spot whether sensor values make sense or not. It is crucial, not only for vehicle performance, but also – and arguably more importantly – for reliability. Around the time of the biggest challenge of the sportscar season at Le Mans, teams prepare their cars for a gruelling 24 hour battle of endurance and speed.

The specific challenges that Le Mans presents mean that it is important to try to make as much of the error detection automatic as possible. When the night falls and fatigue settles in, it's all too easy to miss a broken sensor here or an unusual behaviour there. Luckily for us there are many ways to detect errors in sensor values and methods to trigger an automatic warning when a channel goes out of the normal operating range.

The most common of those is of course the dashboard alarm telling the driver what is going on with the car. There are, however, many other parameters that engineers need to be aware of. They may be less important for the driver, as when driving a sportscar at speed for multiple stints it is important not to be distracted more than is absolutely necessary. This is where live telemetry from the racecar comes into play, allowing the team to carry out on-the-fly analysis of all the car systems.

Starting with the sensor end of things, in most cases it is possible to choose a sensor that has a working range that has small margins either side of the ultimate range. For example, a 0-5v sensor could have a

MATHS CHANNEL 1
Choose ([Input 5 Voltage] < 0.5 + [Input 5 Voltage] < 4.5 , 1, 0)

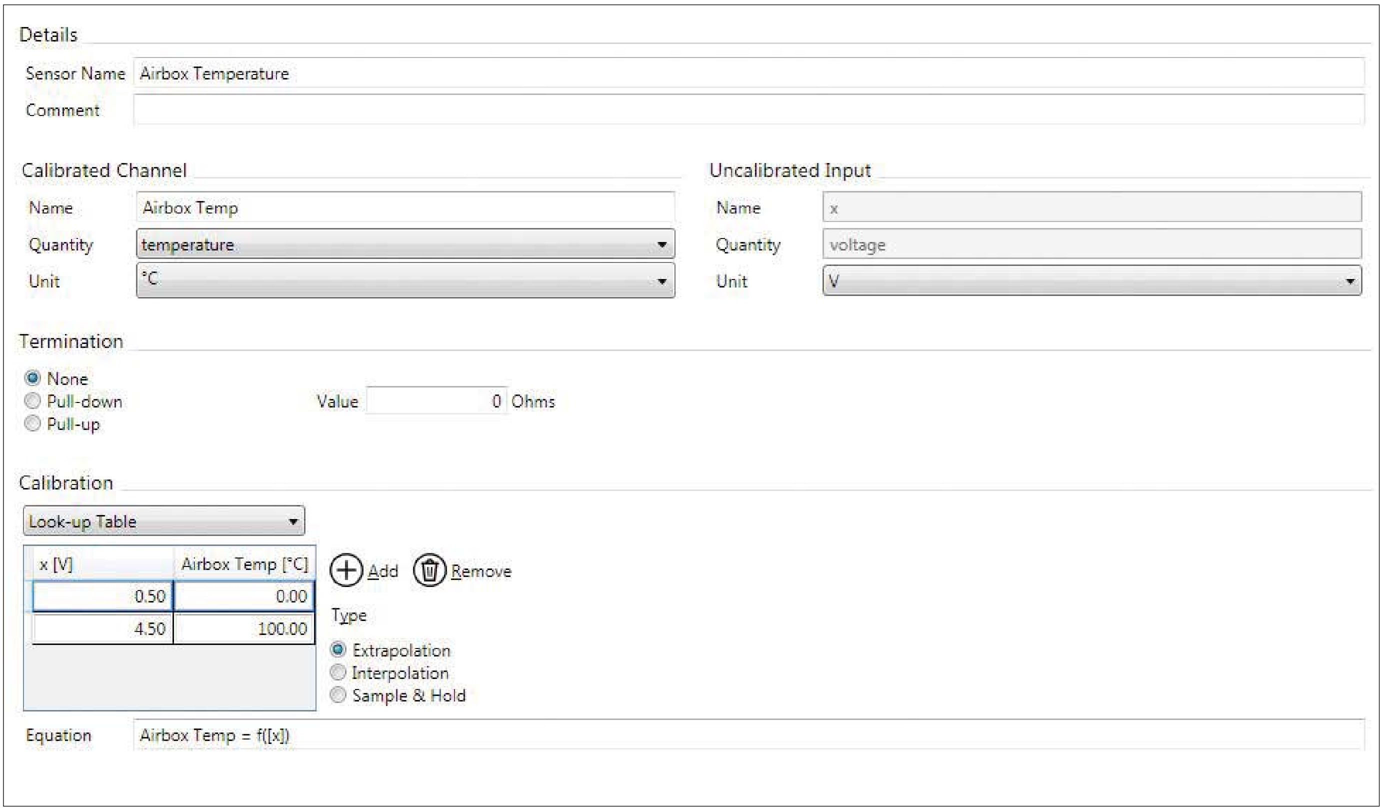

Figure 1: an example of a sensor incorporating the potential for fault detection

```
MATHS CHANNEL 2
Choose ( [ Airbox Temperature ] >= 100 + [ Airbox Temperature ] < 0, 1, 0 )
```

```
MATHS CHANNEL 3
register @a0;
register @a1;

@a1 = choose ( [TPMS CAN Tx Counter] != @a0, 0, 1);

@a0 = [ TPMS CAN Tx Counter ] ;

@a1
```

```
MATHS CHANNEL 4
register @a1;

@a1 = ( choose ( @a1 == 0, @a1+1, @a1-1) ) ;

@a1
```

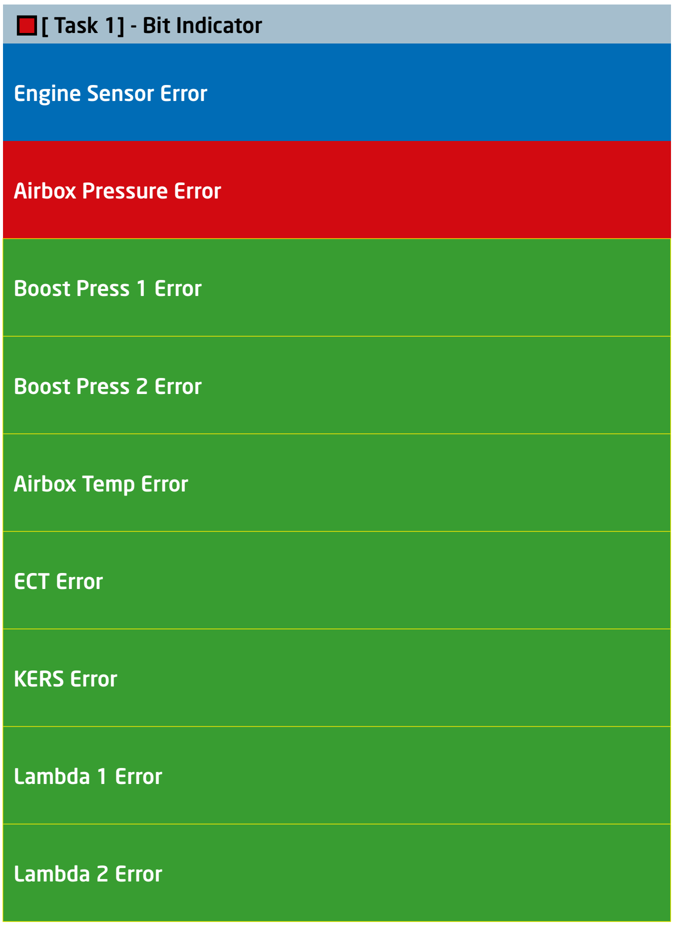

Figure 2: this engine sensor error bit field makes for easy sensor status checks

calibrated range between 0.5 and 4.5 volts. This means that it is possible to detect failures in this sensor by triggering an alarm for when the raw voltage goes out of the calibrated range.

For the sensor in **Figure 1,** it is possible to generate a maths channel that flags any errors in the sensor, whether they are open circuit or short circuit. See **Maths Channel 1** for an example of this. Here the channel looks at the raw voltage value of a sensor and goes to 1 if the voltage is either below 0.5 or above 4.5.

It is also possible to create similar error detection channels for sensors that do not have the same type of calibration, simply by defining their normal operating range. **Maths Channel 2** is a sample of a fault detection channel for an RTD temperature sensor.

Here the normal range of the sensor is defined as being from 0-100 degrees and any other value will be flagged as a

```
MATHS CHANNEL 5
([Airbox Pressure Error] ) +
([Boost Press 1 Error] << 1) +
([Boost Press 2 Error] << 2) +
([Airbox Temp Error] << 3) +
([ECT Error] << 4) +
([KERS Error] << 5) +
([Lambda 1 Error] << 6) +
([Lambda 2 Error] << 7)
```

potential fault. When channels like these are used for fault detection, it is still imperative that any flag is evaluated by looking at the data and verifying the fault.

As racecar systems tend to comprise of many different components and they tend to communicate via CAN, it can be useful to have a channel that makes sure all the devices are transmitting information. In many instances it is possible to get a counter channel transmitting from a device, and when this is not moving the device has a problem. Using this channel it is possible to create a similar fault state maths channel – see **Maths Channel 3**.

This maths channel goes to zero if the value of the channel TPMS CAN Rx Counter doesn't change, thereby indicating that there might be a CAN bus issue. A further implementation of the CAN fault check is to generate a heartbeat. This can be done by multiplying the result of the above channel with a flasher similar to the one shown. **See Maths Channel 4**.

Now as some of you may have noticed, we have just generated some channels that show either one or zero, on or off and that on its own is not all that useful. The really clever bit comes next.

Once the sensors and CAN devices and whatever else we can think of has a fault channel, it is possible to start collating all this information into bit fields. By doing this it is possible to have a single visual indication of whether the whole CAN bus is OK or whether all the chassis sensors are OK. A single red in sea of green is a pretty easy to spot even at four in the morning at Le Mans. **Maths Channel 5** is used to generate a single U8 bit field channel for evaluating several sensors.

Once displayed in a telemetry view as a bit-field it could look like **Figure 2**, making any error very obvious.

When channels are used for fault detection, it is still imperative that any flag is evaluated by looking at the data and verifying the fault

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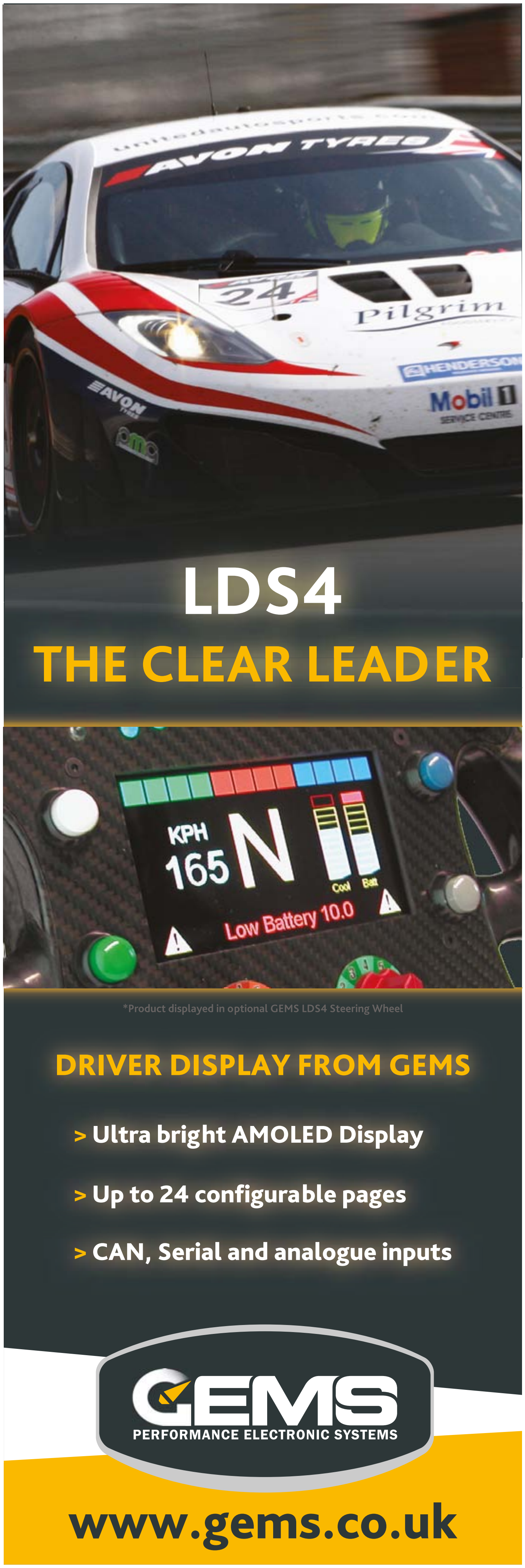
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Balance in Attack

Continuing our look at two different examples from the essentially uninhibited world of Time Attack aerodynamics

Time Attack is still relatively free of aerodynamic constraints, especially in the 'pro' class, and with often very high power outputs, the successful approach seems to be to aim for high downforce without worrying unduly about drag. *Racecar* has been taking a closer look at the aerodynamics of these enthralling machines with two very different UK Time Attack cars, one already a front runner and one that assuredly will be, in a session in the MIRA full-scale wind tunnel.

The first of the cars in question was Jamie Willson's 2012 UK Time Attack Club Pro class championship-winning Lotus Exige, a car successfully developed on the archetypal shoestring budget with much DIY graft and help from a team of friends. The Exige has recently undergone engine and aerodynamic development and will compete in the Pro class in 2013. In contrast, the second car was the much-anticipated latest creation from Roger Clark Motorsport – Gobstopper II – a sophisticated Subaru Impreza hatchback bristling with technology. The car's predecessor, Gobstopper, won the UK Pro class in 2008 and 2009, and RCM are clearly aiming for similar success. So these two cars will be in direct competition!

We saw in last month's issue that both cars had rear biased downforce balances, and although the Exige needed more front bias, the Impreza's aerodynamic balance was actually in the range that the team was hoping for after some relatively small changes. Let's have a look at some of the changes that shifted aerodynamic balance on both cars.

LOTUS POSITION

The Exige featured end plates on its front splitter, but there were gaps between the rear edge of the end plates and the main bodywork. These were taped over and **Table 1** shows the coefficients before and after this adjustment. The delta values, or changes as a result of the adjustment, are also given in 'counts', where 1 count is a coefficient change of 0.001.

So there was a little more drag, slightly less total downforce and slightly reduced efficiency (-L/D) but there was a useful forwards balance shift from this simple alteration. The effect was akin to that sometimes achieved by steep dive planes, and it's not hard to visualise why that might be, although the exact mechanisms involved would be rather different.

Another common method for shifting aerodynamic balance forwards is to increase a car's rake angle, so the rear ride height of the Exige was raised in two 10mm increments using shim plates beneath the rear tyres. The delta values relative to the preceding configuration are shown in **Table 2**.

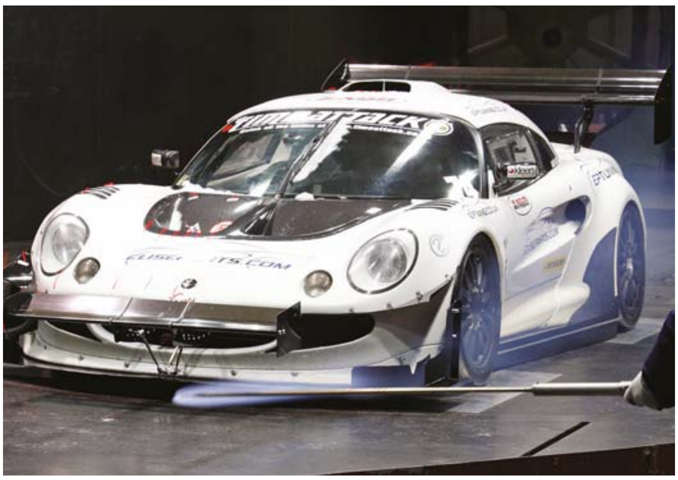
The car's response here was obviously very non-linear, and although a useful forwards balance shift was achieved overall, not much of that balance shift had occurred with the first 10mm rear ride height increase. The non-linearity was most probably down to the side skirts being lifted high enough, with the second ride height increase, to compromise underbody flow.

Over to the RCM Impreza, and the very last change that was squeezed into our half-day session was to add 20mm rear ride height using tyre shims (we had run out of time to do two 10mm increments). The results are given in **Table 3**.

So, we can see that the Impreza was more sensitive to this coarse ride height adjustment than the Exige, with over 8 per cent of the total downforce shifting to the front. This was

Table 1: the effects of sealing the gap at the rear of the Willson Exige's splitter end plates

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Gaps open	0.518	-0.917	-0.222	-0.695	24.2	1.770
Gaps closed	0.522	-0.912	-0.236	-0.677	25.9	1.747
Change, counts	+4	-5	+14	-18	+1.7%	-23



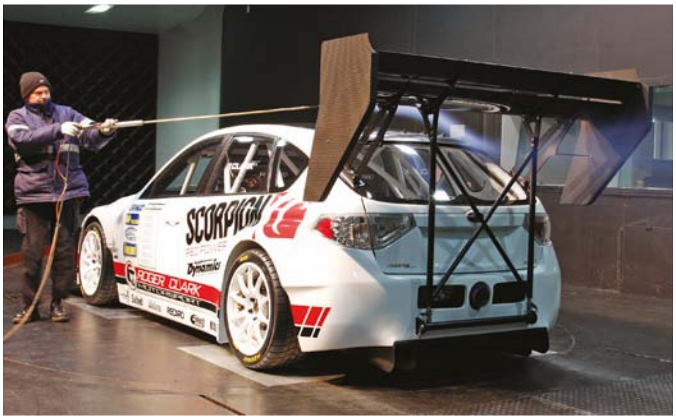
The Jamie Willson Lotus Exige Time Attack car featured splitter end fences that partially constrained the airflow

Table 2: showing the effects of rear ride height increases on the Willson Exige

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
RRH up 10mm	+26	+79	+25	+52	+0.4%	+61
RRH up 20mm	-1	+4	+26	-22	+2.5%	+11
Total change	+25	+83	+51	+30	+2.9%	+72

Race tape helped the splitter end plates to deliver more front downforce

Adding rake to the Impreza certainly shifted the aerodynamic balance



The airflow not only turned down the rear screen unexpectedly well…

… but the wing's own induced downwash also turned the upstream flow downwards, as shown by the smoke plume outboard of the car's body

Table 3: showing the effects of rear ride height increase on the RCM Impreza

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
RRH up 20mm	+22	+24	+62	-38	+8.1%	-8

Table 4: showing the effects of adjusting rear wing angle on the RCM Impreza (in counts)

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
-2 deg O/A	-30	+27	+2	+26	-0.5	+109
-5.5 deg O/A	-22	+3	+7	-5	+1.0%	+57
Total change	-52	+30	+9	+21	+0.5%	+166

by virtue of an increase in front downforce and a decrease in rear downforce, whereas overall the Exige exhibited downforce increases at both ends but with proportionately more front increase. There will be a number of reasons why the responses of the two cars were different, and with 'moving ground' the differences may be even more marked. But the comparison here serves to illustrate the usefulness of actually being able to measure the extent of these effects.

The 8 per cent balance shift on the Impreza took its %front value to 29 per cent, the highest achieved on the car during this session. Ordinarily, on a car with roughly 43-44 per cent of its static weight on the front, this might be thought of as heading in the right direction, but not yet balanced for steady state cornering – even allowing for more downforce on the front end over moving ground as opposed to the wind tunnel's fixed floor. However, the team's chassis dynamics analysis showed that the car would mechanically oversteer under power, and to combat that the target for %front was actually in the range of 20-25 per cent. At least it was now known that raising the rear ride height to increase rake angle was a useful balancing aid, and that changes of less than 20mm would probably attain noticeable balance shifts.

Rounding off for this month, adjustments to the Impreza's rear wing overall angle produced some interesting numbers, as **Table 4** shows.

That first 2 degree increment of wing angle reduction demonstrated that initially the wing was actually past its peak operating angle in this location on this car, with drag reducing but rear downforce increasing. However, the next angle reduction saw rear downforce decrease slightly, along with another drag reduction, suggesting that the wing was now just below its peak downforce angle. This was interesting, because on many cars the original wing angle would not be over the peak setting, and the different behaviour here was probably down to the hatchback configuration of the Impreza. The smoke plume showed that the airflow turned down the steep rear screen and, probably aided by the line of vortex generators ahead of the roof/tailgate transition, the flow was remaining unexpectedly well attached to the rear screen. However, combined with the wing's induced downwash, this also meant that the wing was running at a steeper effective angle than anticipated, hence it started to stall at a lower installation angle than expected.

Next month: we'll take a final look at more configuration changes on both these cars.

Racecar Engineering's thanks to Jamie Willson and team, and to Roger Clark Motorsport

Future fuels

Could Audi's investment in drop-in fuel technology prove to be the game-changing next leap forward for transport worldwide?

BY PETER WRIGHT

For those not involved or enthusiastic about motorsport, it may appear to be wasteful, polluting and irresponsible. The apparent excessive consumption of limited fossil fuels and the emission of CO2 into the atmosphere in the pursuit of speed, pleasure, entertainment and profit render motorsport vulnerable to criticism from environmentalists and indeed from vote-seeking governments.

The same criticisms are aimed at motorists, though to a lesser extent, as even environmentalists have a need to get about. While governments are attempting to address the problems of potential fossil fuel shortages and climate change, by putting pressure on automobile manufacturers and at the same time encouraging alternatives to the petrol and diesel engine, they are losing the battle as developing nations crave for, and achieve, personal mobility. Mainstream motorsport has tried to stay relevant by introducing KERS to Formula 1, hybrids to Le Mans, and – from 2014 – putting the emphasis on fuel efficiency in both categories. The FIA, encouraged by governments in Europe, is introducing city racing with all-electric vehicles in Formula E, though how the electrical energy for these will be generated remains to be determined.

Now, however, a technical solution with potential is at hand. And it's a solution not just offering potential for carbon-neutral, guilt-free motorsport, but also carbon-neutral, guilt-free motoring, and indeed all forms of transport. Courtesy of Audi and their synthetic biology engineering partners, Joule Fuels, this is not merely a scientist's dream, demonstrated at the molecular level on the laboratory bench. Already it is way beyond that, with pilot production under way in the desert of New Mexico, with a predicted commercial production of drop-in, carbon-neutral fuels in the second half of this decade.

As is well known, all fossil fuels, including oil, are the product of sunlight, CO2 and water, converted by a variety of biological organisms, heat and pressure into

This is potentially the most significant automotive, aviation and shipping technology since piston and turbine IC engines

hydrocarbon fuels over a period of several million years. Fossil fuels are the energy of the sun captured in chemical form: as a solid in the form of coal, as a liquid in the form of oil, and as a gas in the form of methane or natural gas. Since mankind discovered the value of readily available energy deposits over 250 years ago, and unravelled the science behind their formation, it has been clear that using new biological processes to shortcut the production of fuels would be highly desirable. The last 30 years have seen ever more rapid progress in the development of the techniques required to do this and the evolution of the science of synthetic biology: the design and construction of biological devices and systems for useful purposes. Flagship VentureLabs has been at the forefront of this initiative since 2000, providing finance for the conception, launch and realisation of novel technologies and processes outside of typical constraints, resulting in the formation of companies several years before more mainstream investors spotted that an emerging market opportunity is likely to become compelling.

The majority of the effort to produce renewable fuels has been based on two main approaches:

- **The sun's energy and CO2 are captured by plants, which are harvested to produce sugars. Fermentation or other bio-processes are used to turn these sugars into fuels, or something that can be turned into fuel – eg ethanol, and more recently diesel.**
- **Algal biofuels also capture the sun's energy and CO2 and accumulate lipids in their cells. After harvesting and processing, the lipids are converted into biodiesel or kerosene (jet fuel).**

To be successful, the products of these processes must not only be relevant to society's needs, but must be producible below market prices for competing oil-based products. Many of these processes have so far proved to be uneconomical on the basis of their competition with food, energy return on energy invested, and the costs of post-processing and scaling up.

In 2009, a new approach emerged, pioneered by Joule Biotechnologies – now Joule Unlimited. The company was founded by Noubar Afeyan and David Berry, partners in Flagship VentureLabs, and funded privately so that the control of information could be maintained. Joule has developed a range of patented bio-organisms that streamline the process of capturing the sun's energy and CO2 and that directly synthesise and secrete specifically designed hydrocarbon end products. No sugars or biomass are needed in the process. While algal biofuels attempt to do this, they required batch processing and suffer from efficiency limitations due to the accumulation of the desired product in the organism and the associated separation and post-processing costs. Joule's process shortcuts the synthesis of hydrocarbons into a single, continuous, biological step. One way of looking at it is that Joule is making dairy cows, rather than bulls for the beef market – they're milking the organism, rather than slaughtering it.

Joule Unlimited set out to develop this one-step process with specific objectives:

- **It must not deplete or compete with agricultural land.**
- **It must not require fresh water, nor compete with human and agricultural demands for water.**
- **It must produce 'drop-in' products that are compatible with existing infrastructures.**
- **It must have a cost structure that would, without subsidies but including capital costs, be lower than fossil-based equivalents.**

Joule's drop-in fuel doesn't require agricultural land, and won't be competing for space with food – instead they use the desert

The old oil pumps of New Mexico (above) could be replaced by cyanobacteria (pictured centre), which could soon be producing renewable fuels on a large scale

In 2009, Joule announced that they would produce Sunflow-E (ethanol) at a price of $1.28/US gallon, and Sunflow-D (diesel) at a price equivalent of $50/barrel. More recently they announced Sunflow-G (gasoline) and Sunflow-J (kerosene or jet fuel).

Joule uses genetically modified cyanobacteria, the organism which accounts for 20-30 per cent of Earth's photosynthetic productivity and converts solar energy into biomass-stored chemical energy. To emulate nature in the conversion of CO_2 and water into hydrocarbons, an appropriate reactor is required as well as modified organisms. Joule has skilfully combined biology and engineering to optimise culture density, gas-liquid transfer and temperature and light exposure to maximise photosynthetic efficiency. Joule's SolarConverter is a modular system, central to reducing the risks inherent in scaling up production processes. Once a modular system is validated on a small scale – a few units – identical modules can be produced to predictably scale up to suit any plant size.

Three key technologies underpin Joule's process. Firstly, natural photosynthetic organisms use sunlight, CO_2 and water to grow and reproduce by cell division. Joule has reorganised their cyanobacterias' metabolic systems so that after one week of growth and reproduction to the required culture density, an internal biological switch is triggered to stop growth and hence reproduction. From then on, for a further eight weeks, all the solar energy is deployed in product synthesis, which is secreted as 'waste' from the cells, and none is wasted on growth and reproduction. At the end of these eight weeks, the organisms are collected and burned, with the heat generated being used within the overall process, and a new culture initiated.

Secondly, the cells are engineered to produce specific products, selected to be interchangeable with industrially used, oil-based products. Products are either volatile or organic, and the range of hydrocarbons Joule states that it will be able to make reads like a fuel formulator's chemistry set. Indeed, Joule has reported making a wide variety of hydrocarbons, with carbon chains from 2 to 34 carbon atoms in length. Volatile products such as ethanol are passively released from the cells, and are collected as a vapour using the sun's energy. Aqueous products, such as diesel, require the bio-engineering of a transporter for secretion and are then captured by centrifugal separation.

Finally, the engineering of their SolarConverter – using low-cost materials with proven, long outdoor lifespans and capable of passive thermal management – is a key technology. The 'soup' – water, cyanobacteria and gaseous CO_2 – is kept below 50degC, but not allowed to drop to too low a temperature at night to ensure that the organisms function as desired.

Audi's plan is that for every litre of fuel a customer puts into the tank, they'll put a litre of e-fuel into the network

They do not require sunlight continuously, so must be circulated appropriately. Joule has not revealed exactly what the organisms require, but have demonstrated them at their SunSprings plant in Hobbs, New Mexico.

So Joule would appear to have developed a process that ticks all the boxes for renewable, carbon-neutral, drop-in fuels:

- **They do not require biomass and agricultural land, and are not competing with food. They use desert.**
- **The primary energy input is sunlight, the most plentiful energy source on Earth.**
- **Waste CO_2 from power, steel and cement plants is used as the source of carbon.**
- **The water used in the process can be brackish and non-potable, so there is no competition with human or agricultural needs.**
- **There are virtually no waste products.**
- **The fuels produced are cost-competitive with existing, oil-based fuels.**

The numbers quoted by Joule similarly indicate that there are no limitations on production. They claim that to produce all the transport fuels used by the USA would require just 5 per cent of the desert land area in the USA.

- **Joule are currently producing Sunflow-E at 75,000l/ha**
- **The target for Sunflow-E is 230,000l/ha**
- **The target for Sunflow-D is 140,000l/ha**
- **Algae yield diesel at 20,000l/ha**
- **Corn based ethanol yields 4,000l/ha**

Audi's first demonstration facility for e-fuels in the New Mexico desert. They've also partnered SolarFuel to build an e-gas pilot plant in Germany

Joule claim that just 5 per cent of desert land in the USA would be needed to meet all the transport fuel needs of the entire country

They further claim that to produce all the world's transport fuel requirements would require the CO2 from just the existing steel and cement plants. It is massively unlikely that mankind will cease to use steel and cement. Similarly, there are massive, brackish water aquifers, not currently usable. Perhaps most pertinently however, at current and foreseeable oil prices, the products are cost-competitive without subsidies.

Too good to be true? Audi does not think so.

Some years ago, Audi recognised that the eventual electrification of cars would require massive R&D, production facilities and infrastructure investment. Whether EVs would be powered by on-board battery storage or hydrogen fuel cells, Audi's investment in the internal combustion (IC) engine and their superb range of gasoline and diesel engines would become obsolete. Audi foresees this starting to happen from as early as 2020, and decided that it needed to act. Their head of sustainable product development, Reiner Mangold, provided some insight into the company's vision.

When the company realised that it had to do something to maintain its investment in IC engines, he explained that it set out to analyse the life-cycle carbon emissions of current and future cars. Audi believes that EVs will be needed for transport in cities, and plug-in hybrids will have a place as dual-role cars for city and general use, but they will still require IC engines. 80 per cent of the life-cycle carbon emitted by a car comes from the fuel consumed, the rest comes from making the car and the fuel. Their analysis showed that the carbon emitted during the life of a renewable-electric powered EV could be bettered if a conventional IC-engined car used a carbon-neutral, synthetic fuel.

The added advantage of this solution is that the technology, production plants and infrastructure required already exists, provided the synthetic fuels truly are drop-in. Once Audi's engineers had made this analysis, they knew exactly what they were looking for. Scouring the world for carbon-neutral substitutes for fossil fuels, they identified two potentially viable technologies, and have bet on – and invested in – both.

The first is e-gas. The process technology, developed by Stuttgart-based SolarFuel, converts surplus wind power electricity – of which there is plenty in northern Germany – into hydrogen by electrolysis. Methanation further converts the hydrogen into gas by combining it with waste CO2 from biogas plants, which are also plentiful in Germany. The gas is fed into the existing network, effectively providing an energy storage system for the excess wind power – a very politically popular development. Audi and SolarFuels have built a pilot plant in north-east Germany.

The second is e-ethanol and e-diesel, as Audi has named Joule Unlimited's synthetic biofuels. In 2011, Audi together with Joule Unlimited, formed Joule Fuels, and the relationship means that while Joule has secured its technology with patents, Audi has exclusive automotive rights to these and future automotive fuels. These fuels are sulphur-free, and the diesel has a high

(Top) The bacteria and their output are analysed in the Hobbs laboratories. (Above) Paul Snaith from Joule shows Reiner Mangold, Audi's head of sustainable product development, the first cultures

cetane number, indicating good burning properties. Audi brings technical support to the fuel development process, in the form of know-how and hardware in the field of fuel and engine testing. Gaining exclusivity may appear a surprising achievement, but Audi says that when it approached Joule in 2011, there was no sign of interest from the US automotive industry. Audi is very conservative with the figures it uses for production economics, upon which its business plan for these fuels is based, and it is the business plan that is one of the most intriguing aspects of Audi's vision.

Audi do not want to become fuel manufacturers or distributors, but they do want to encourage the production of e-fuels at an economic price, and to see them added to the fuel distribution networks around the world. They also want Audi customers to continue to be able to buy IC-engined cars that have the lowest life-cycle carbon emissions, at least equal to an EV's. To achieve this, they plan to provide purchasers with an agreement that for each litre of fuel put in the tank, Audi will put a litre of e-fuel into the network, so that they effectively run solely on carbon-neutral fuel. This model is the same as for purchasers of renewable electricity: they do not need a new set of (green) wires connected to their house, attached to a wind turbine, they simply sign a contract with a renewable electricity supplier. Indeed, any EV owner who wishes to be truly carbon-neutral must do just this for all sources of electricity they use to recharge their car. Audi offer this for its range of natural gas engines using Audi e-gas, and initially for its diesels and eventually gasoline-powered cars, whatever the fuel mix of gasoline and ethanol. The key marketing feature is that this form of certified, guilt-free motoring will be exclusive to Audi owners, as per their exclusive automotive rights contract with Joule Fuels.

Not many silver bullets actually work, but if Joule and Audi's vision comes to fruition – and it is the economics of production relative to oil-based fuels that will determine this – and synthetic fuel production reaches significant scales, this technology is a true game-changer. It's potentially the most significant automotive, aviation and shipping technology since piston and turbine IC engines were invented. It is applicable not only to new vehicles and aircraft, but also to all existing ones, solving the transport industry's CO2 problem at a stroke. No new engine technology is needed, though improvements to efficiency, providing they are cost-effective, will always be required, and there would be no call for new infrastructure. Automobile manufacturers' full range of cars, large and small, will meet the EU CO2 emission standards by a mile, and Audi will be the first to be able to claim this, therefore avoiding the EU's fines. Energy supplies will no longer be subject to the geopolitics that drive so much of the conflict in the world. There will be no need to exploit potentially environmentally risky and costly sources of oil such as deep-water, the Arctic, Canadian tar sands and shale. These unconventional sources of oil are mostly uneconomic at an oil price below $70-90/barrel. Indeed, one can anticipate the biggest problem for synthetic fuel will be resistance by Big Oil...

Audi says that when it first approached Joule Unlimited in 2011, there was no interest from the US automotive industry

This may all be a long way off, but Joule and Audi are demonstrating that producing carbon-neutral transport fuel is possible. Now they must demonstrate that the extremely favourable-looking economics work. With such a promising start, there appears to be a very high chance that synthetic biology will succeed in solving the transport industry's CO2 problem, and ease the pressure on oil supply. The impact on all forms of mobility could be far, far reaching.

The CO2 emitted by racecars on the track is a small percentage of the total CO2 emitted by motorsport. By far the majority comes from the transport, particularly flying, of equipment, personnel and fans around the world. In the latter case, motorsport is no different from football, the Olympics, and rock concerts. However, environmental discussions tend to veer towards the emotional, and the sight and sound of 20-30 cars, each with more power than most people will experience in a lifetime, going round and round at full power is how motorsport's environmental credentials tend to be judged. It will take several years before the transport emissions can possibly become carbon-neutral, but there is a real, near-term opportunity to not only achieve carbon neutrality on-track, but also to pave the way for public acceptance of synthetic fuels and to encourage car buyers to take up what Audi plans to offer its customers: guilt-free motoring.

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The making of Audi's mini marvel

When 5.5-litre engines were outlawed ahead of Le Mans 2011, the German marque set off on an alternative route to glory.

BY SAM COLLINS

When design work began, with no rulebook fixed, engineers were left to take a gamble

Downsizing was the buzzword when Audi Sport was developing its new engine for the 2011 Le Mans 24 Hours. The ACO had outlawed the big 5.5-litre engines used previously and forced the manufacturers to think small. For diesel engines, the upper displacement limit was set at 3.7 litres and the maximum number of cylinders set to eight, while petrol engines were restricted to normally aspirated 3.4 litres and 2-litre turbo.

The reasons for this reduction on the maximum capacity for diesel engines were primarily those of safety and equivalency. Concerns were being raised about the speed of the works LMP1 cars as Peugeot and Audi were locked in a development war. This led to a dramatic reduction of the lap times in qualifying, but also increasingly during the race to within striking distance of the 'eternal' record of 3m 14.8s from 1985 where maximum speeds of more than 400km/h were recorded on the famous Hunaudières straight.

Audi first took the decision to develop a new Le Mans Prototype engine for 2011 back around the time of Le Mans in 2009. The successful R10 V12 and R15 V10 predecessors supplied a starting point which allowed the German engineers to develop the new unit in just 20 months. For the new design, it was imperative to assess whether the chosen concept, which explored previously unknown technical territory in many aspects, could also be successfully developed in the short development time.

Usually the engine regulations and rulebook for the car are fixed before design work begins on a new project but in this case only 'guidelines' for engine power and maximum displacement had been issued, which left the engineers to take a gamble.

At the start of the project the Audi Sport engineers considered using a high efficiency spark ignition engine, but again opted for a diesel after early evaluation of the concepts.

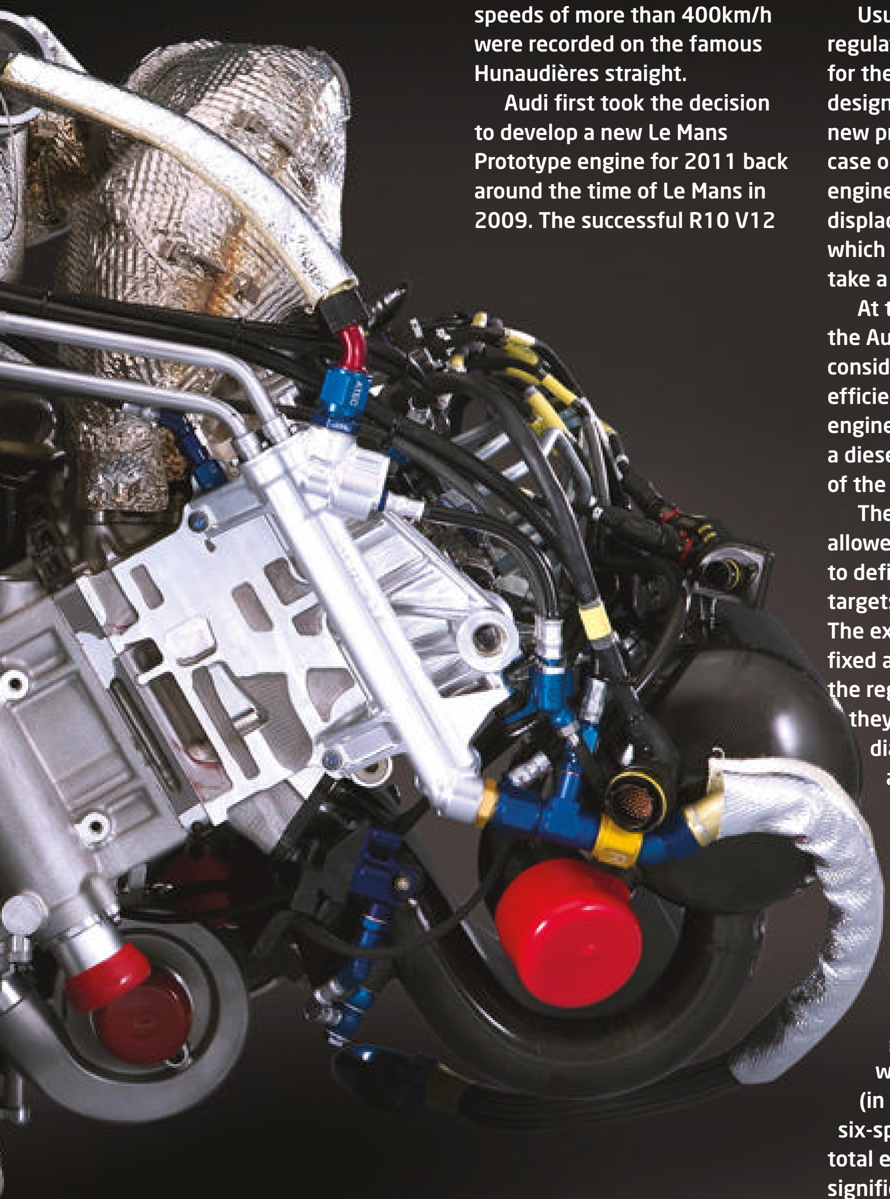
The 'guidelines' issued allowed the Audi engineers to define some performance targets for the new engines. The expected power was fixed as a broad premise in the regulations - such as they were. The restrictor diameter was also defined accordingly in the same rules, and the operating range along with the maximum boost pressure were effectively predefined. So, the targets set were: power exceeding 520PS (382kW), torque greater than 900Nm in a wide, useable RPM range (in order to be able to use a six-speed gearbox efficiently); total engine weight significantly less than 200kg, and stiffness when installed in-car as a fully stressed design, with supporting elements. The restrictor diameters and boost pressures were reduced still further for 2011. This resulted in a power and torque reduction and a slight shift of the power point in the rev range.

The next question was; what size and shape would this engine be? The definition of the number of cylinders was also on the agenda at the beginning of the concept stage. An eight-cylinder engine would have had the advantage of being able to transfer the enormous amount of experience gained from the area of the 12-cylinder R10 engine. However, Audi was convinced that a six-cylinder block had greater potential with regard to frictional losses, weight and compact dimensions. The targets for the new engine resulted from the demands to reduce engine dimensions and to be able to change the car's weight distribution. The overall dimensions of a 3.7-litre V6TDI engine showed the advantage of its shorter length, but a V8 engine could be fitted lower in the car achieving lower height and width dimensions.

The regulations also permit engines with a capacity of less than 3.7 litres. With the weight and size of the engine crucial to overall car performance, a smaller capacity was also considered but - as was the case with the R15 engine - the choice of a 3.7-litre displacement was made with the underlying intention of keeping the specific load as low as possible. With increasing displacement, the engine's effective mean pressure sinks for the same attainable power (air mass).

The next step was to design a block. It would have to be as compact as possible and lightweight. Its design is also heavily influenced by many other factors. In order to reach the weight target, the majority of the engine had to be manufactured from light metal alloys and - at the same time - be able to withstand combustion pressures permanently above 200 bar.

The R18 V6 cylinder block is manufactured from hypoeutectic alloy

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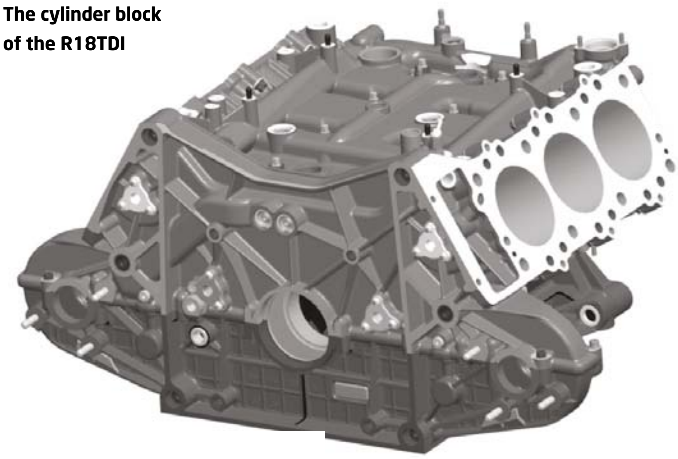
SWEPT VOLUMES FROM V12 TO THE V6TDI					
Displacement	5500	5500	5500	3700	3700
Cylinders	12	10	8	8	6
Swept volume	458.3	550	687.5	462.5	616,6667
Increase		20%	50%	0.92%	34.56%

SIZE COMPARISON BETWEEN THE V6TDI AND V8	
When V6 TDI 3.7 = 100	**V8 3.7-litre in comparison**
Engine length	18%
Engine width	-2%
Engine height	-7%

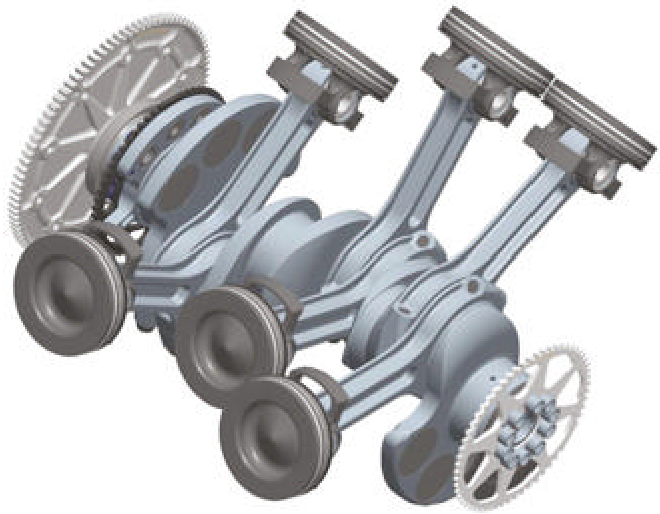


The cylinder block of the R18TDI

using the low-pressure sand casting method. The cylinders themselves are Nikasil coated. Completely new engine block architecture was required due to the large cylinder bank angle. The cast water channels, with a fork to the heat exchanger, have only a joint to the water cooler in an otherwise closed system. The relevant oil galleries are integrated in the block for piston cooling. The crankcase below the main bearing centre line – the so-called bedplate – is manufactured as complex, heavy-duty cast component. The precision casting blank has equally high strength (RM 35 MPa) and ductility owing to the directional solidification. The minimum wall thickness is less than 2mm.

The final block design featured a slightly long stroke as a result of piston loads, engine size/installed height and combustion chamber thermodynamics. The installation height of the engine is influenced substantially by the stroke. The stroke increased by five per cent when compared to the V10 and is accounted for by the increase in the crankshaft centre-line from the bottom plate. The 120-degree cylinder bank angle led to the Audi engine achieving a very low mounting position and therefore a low centre of gravity.

It was also designed specifically to suit the steel piston's lower compression height. Due to the larger bore of the V6TDI, the piston area loading is increased by approximately five per cent for the same ignition pressure. Meanwhile, the 120-degree cylinder bank angle is a result of the following points: lowering of the centre of gravity, layout and drive of ancillary components, firing interval and the mono-turbo exhaust layout. With this cylinder bank angle, the bedplate can still be connected extremely well to the crankcase. The cylinder spacing was adjusted to suit the increased bore so that the land width could be retained. As a result, the closed-deck engine block achieves the required stability.



The obliquely divided steel connecting rod is manufactured with an optimised profile and further refined with regard to stiffness, optimum dynamic bearing stability and minimum weight by FEM calculation

KEY ENGINE ELEMENTS

At the heart of the engine is the cranktrain, topped with some innovative steel pistons, which are one of the key elements of this engine. Due to the high piston loads generated in a race engine, the maximum load limit for the aluminium piston with a fibre-reinforced bowl rim was achieved during development of the V12TDI. Steel pistons were fitted to the R15 V10TDI from the very beginning. The larger bore and increased loads on the R18 V6TDI piston necessitated extensive analysis of the thermal management of the piston and piston rings.

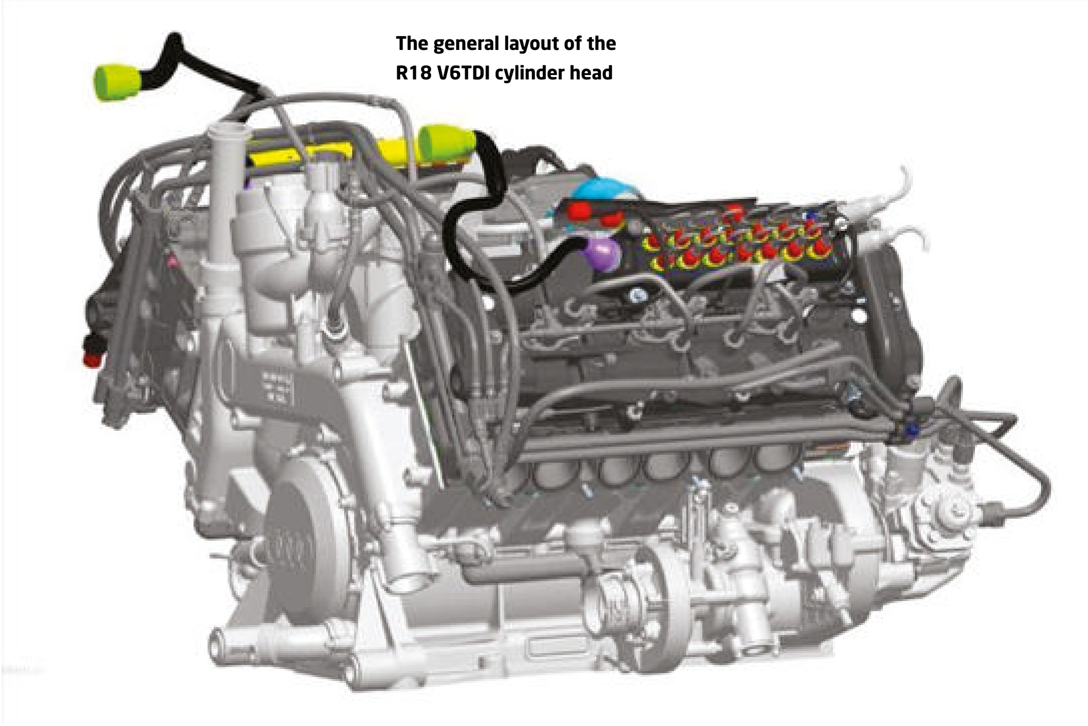
The piston is manufactured from heat-treatable steel. This material combines the properties of high temperature resistance and good thermal conductivity with excellent machining properties. In addition to the higher temperature resistance, the steel piston has the advantage that the top-land is smaller than that of an aluminium piston. Owing to the greater transferable force in the pin bore, the gudgeon pin fitted to the steel piston can be considerably shorter, which in turn allows a weight reduction. As a result, a weight saving is even achievable when compared to the aluminium piston. The steel piston, made by Mahle, has a combustion bowl developed specifically for this application. The high thermal loads made the use of two piston spray nozzles necessary – one for the piston base and the other for the cooling channel.

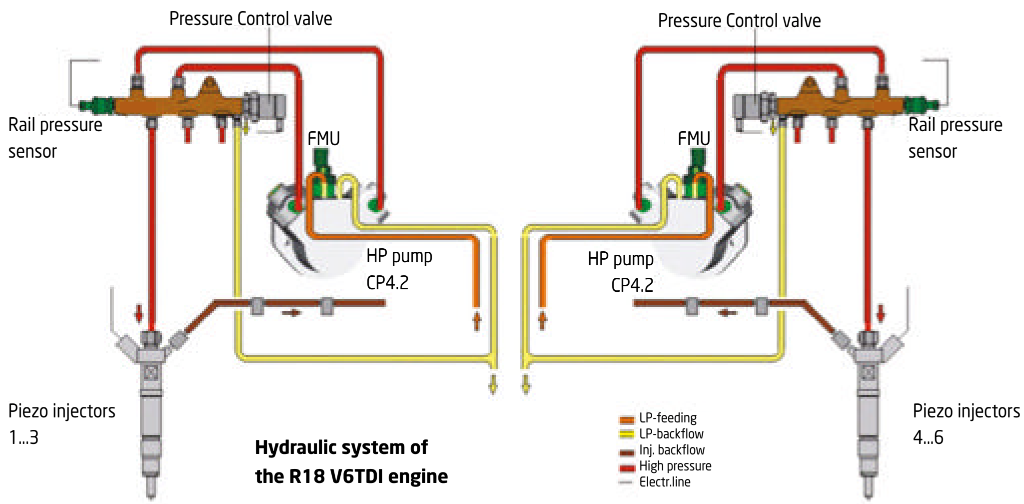
The reduction in displacement and number of cylinders led to a direct increase in the litre and/or cylinder power and therefore – inevitably – to higher piston loads. In conjunction with the extremely short development time of the engine, the reliability of the piston had to be proved by calculation at an early stage of the design.

The design of the piston bowl, the lowest possible compression height as well as minimum weight are actually contrary to achieving the stiffest possible and operationally reliable design of the piston, which is subdivided into different disciplines. In addition to the actual stress analysis for the piston and liner (also from the tribological viewpoint), a perfectly functioning ring package is also required.

The crankshaft was designed around several key areas: the bearing load through the RPM range and load spectrum (ignition pressure and inertial forces); torsional and bending stiffness; free moments of the first and second order; vibration sensitivity and lightweightness.

Its essential dimensions were determined using bearing load and hydrodynamic lubrication gap calculations in conjunction with FEM. In this way, the diameter and width of the main and connecting rod bearings were defined according to operational demands, and


The general layout of the R18 V6TDI cylinder head



Hydraulic system of the R18 V6TDI engine

the crankshaft webs made for greater stiffness of the journal connection.

Because of the engine's design, the free moments of the first order acting outwards can only be minimised by balance masses on the crankshaft.

The weight target for the entire engine did not, however, allow complete balancing of the free moments, but the resulting vibrations caused by the imbalance are acceptable for a race engine. An additional weight on the front end of the crankshaft and an extra web ahead of the gear drive facilitate efficient compensation due to the large centre-to-centre distance. The crankshaft's stiffness is so high that a vibration damper could be omitted.

On the drive-side, a light steel flywheel transmits the torque to the clutch. Teeth with straight-sided serrations replaced the flywheel flange previously used. In this way a conventional, high-strength crankshaft gear could be used.

An incremental toothed gear positioned alongside the crankshaft drive gear supplies the impulse for the Bosch Motronic rotational speed signal. Another incremental toothed gear at the front end of the crankshaft gives a redundancy of the rotational speed recognition.

At the top of the engine the design owes a lot to its predecessors, especially the R15 V10 engine. In the first development stage, the cast aluminium cylinder head design was tested in a single cylinder engine. The basic single cylinder unit used in the development of the V10 was modified rather than a new unit built. Some of the components were created quickly using the rapid prototyping process to increase the speed of development. The single cylinder engine was used for the main tasks in the combustion process development, but was also used for endurance tests.

But it is not the case that the V10 heads were carried over to the V6, not least as they had two cylinders too many. Many areas had to be re-dimensioned due to the increased loads caused by the larger bore. The included valve angle was optimised and the valve enlarged so that the bore diameter could be used to its maximum.

Further development of the ports and port positions were verified together with the definition of the included valve angle on the single-cylinder cylinder head using flow boxes and simulation. The basis for this was the previous engine on which the systematic for the swirl flow optimisation was carried out.

VALVE TALKING

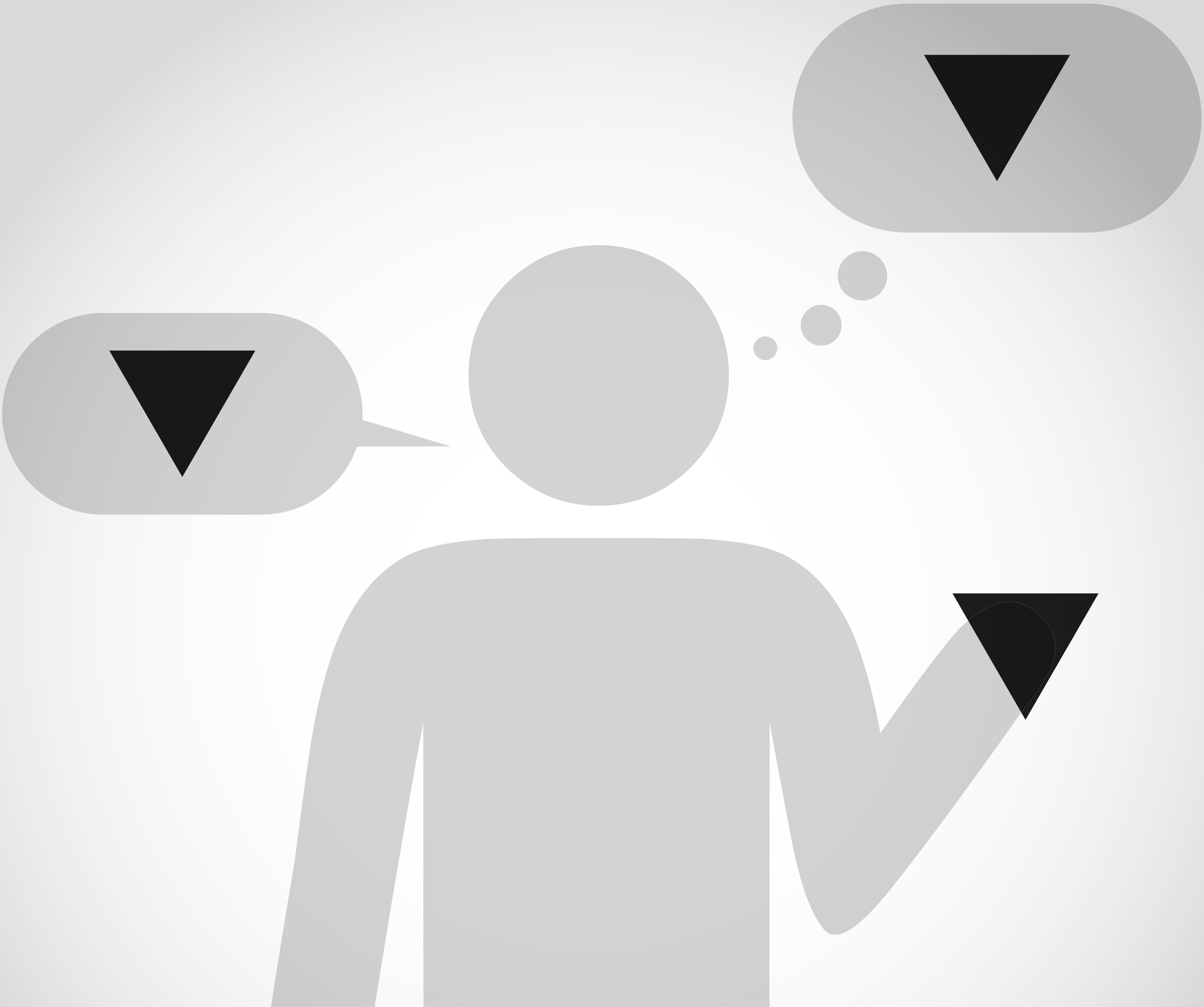
Two inlet valves and two exhaust valves are aligned parallel to the cylinder axis. The valve seat rings are manufactured from sinter alloys that were specially designed for the high loads. The valve guides are produced from copper-beryllium alloy. The valve gear consists of natrium-filled steel valves, conical valve springs and finger followers. The injector duct positioned centrally at the cylinder head middle is well supported by ribs in the oil chamber and therefore ensures a stable combustion chamber plate.

The cylinder head cover with the engine mounting points is machined from solid billet for strength reasons. Thanks to the integration of the camshaft bearings in the cylinder head cover, the cylinder head has a particularly high stiffness level in the upper area. This allows the introduction of suspension forces via the monocoque and/or the gearbox.

Through optimisation measures, it was possible to omit a mounting point between the cylinder head and the monocoque. In the area of the gear wheel housing, a part of the cover and the housing was replaced by a carbon-fibre part to reduce weight.

The camshafts are steel and are hollow drilled for weight reasons. The cam lobe profile was modified when compared to the R15 V10TDI. Greater cam lift and modified valve timing were required to optimise the new combustion process.

Because of the engine's short length, it was not possible to position the high-pressure injection pumps alongside the engine on the timing gear



housing. A radical change to the camshaft and pump drive was the result.

The gear drive was repositioned on the engine's power output face and the CP4 hydraulic pumps are located towards the rear.

The twin pump arrangement balanced the peak torque produced by the hydraulic pumps – but for increased weight when compared to the single pump design.

The layout of the gear drive on the clutch side of the engine ensures that the gear drive runs relatively smoothly, and that only low alternating torque occurs.

In addition to the camshafts, gears also drive the oil and water pumps and the high-pressure fuel pumps. The needle roller bearing steel gears are supported in the housing using floating axles. One floating axle per cylinder bank simultaneously assumes the function of compensating for tolerances and height differences in the cylinder head. The synchronously injecting hydraulic pumps are integrated into the gear drive with a ratio of 0.75. By reducing the drive speed, a high-load layout was possible for the highest injection pressures.

The piezo injectors are tailored to suit the engine. The nozzles were designed for the required output and tailored for the selected combustion process parameters through elevation angle, number of holes/type and nozzle protrusion. The low and high-pressure fuel systems are modified to suit the engine installation. Quick-release couplings in the feed and return circuits form the interface to the car. The fuel tank system with electric low-pressure supply pumps (lift pumps) was newly developed for the R18.

The inlet manifold length assumes a part of the charge exchange work, and is therefore a part of the engine calibration. In 2011, a relatively short inlet manifold equipped with a small plenum volume was used. The cross-sections are tuned to the inlet port area of the cylinder head. For 2012 the setup was reworked and a significantly larger induction manifold length used. The boost pressure monitoring system/sensors supplied by the organisers ACO/FIA are located on the inlet manifold. The inlet manifolds and the plenum chambers are manufactured from carbon-fibre for weight reasons.

HOT SIDE INSIDE

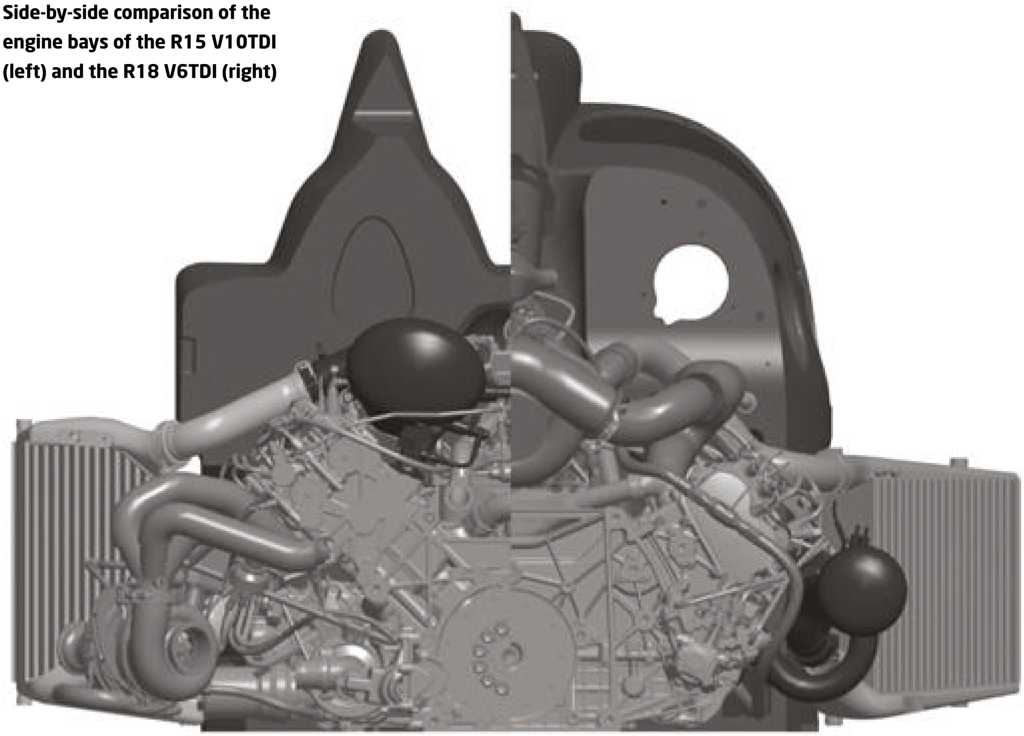
With the ban of 'snorkel like' air intakes – ie air inlets protruding above bodywork parts – a central air intake was the only efficient solution for an LMP1 coupe. Two closed monocoque Le Mans Prototype racecars had previously been designed and built by companies within the VW group – the Audi R8C from 1999 and the Bentley prototypes between 2000 and 2003. The difficulties of achieving good airflow with low resistance for a twin turbo system installed on the side of the engine were known from the Bentley project. Therefore, in order to fully exploit the dynamic air pressure, great value was attached to achieving a very short, fully streamlined route for the intake air.

The following considerations were obvious to the Audi engineers: a central turbo layout, exhaust channels mounted in the engine's V, a wide V angle to make space for the turbocharger and a large cylinder bank angle.

Several concepts were developed for the inner V area – especially the exhaust system within the narrow constraints of the aerodynamic outer bodywork. A fundamental question was whether a single turbocharger can generate the same or even better initial response than a twin turbo system.

The calculations made by Honeywell Turbo Technologies indicated that the mono turbo with VTG was the superior concept. On top of this came the significantly lower air mass due to the reduced restrictor size, when compared to preceding engines, which made a mono turbocharger possible.

A consequence of 'hot side inside' is an externally mounted intake system with very short charge-air piping, which is advantageous for improved response characteristics. The unfiltered-air side of the engine induction



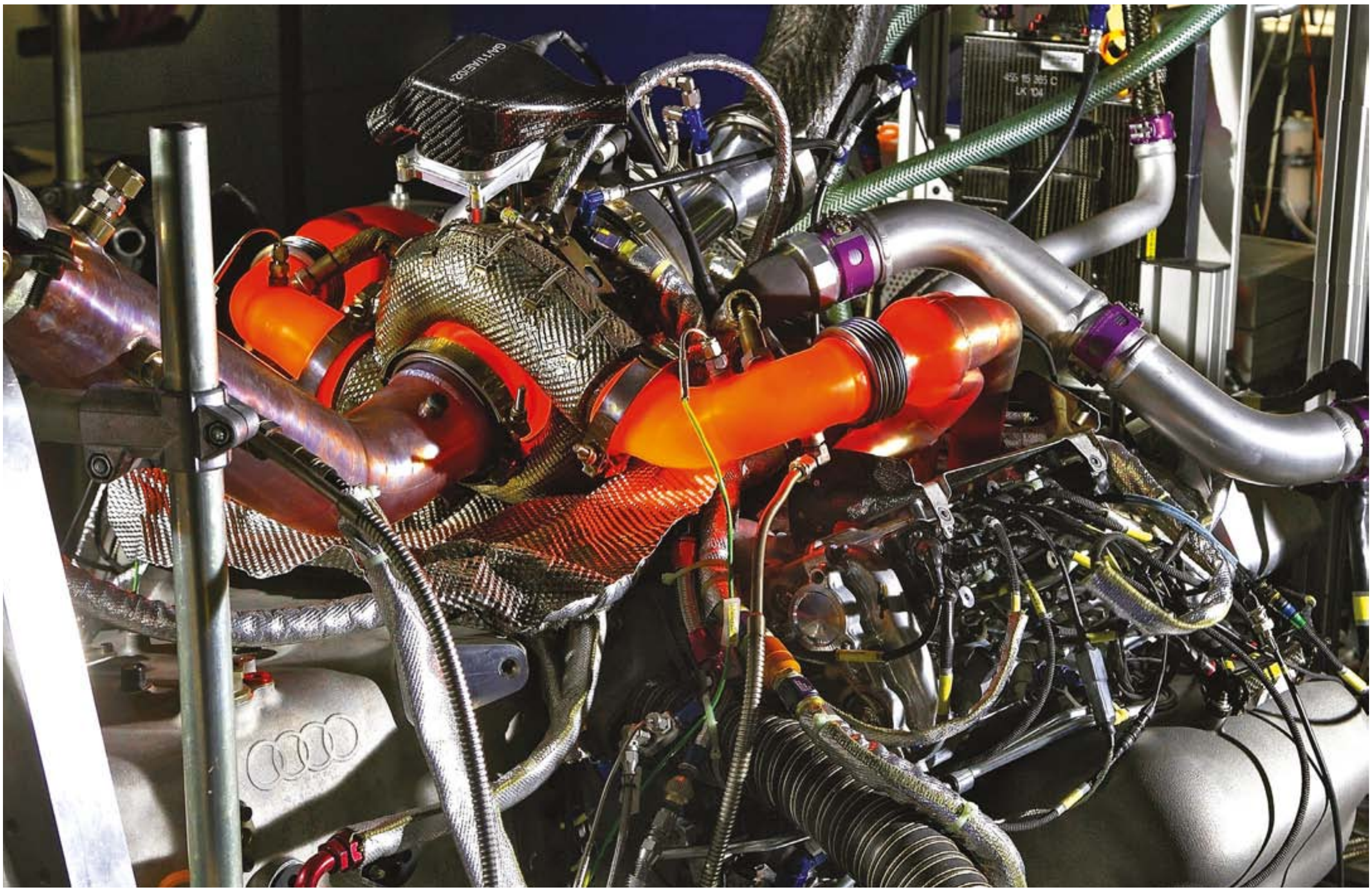
Side-by-side comparison of the engine bays of the R15 V10TDI (left) and the R18 V6TDI (right)

ELECTRONICS

For the R10 V12TDI in 2006, a new, dedicated, motorsport ECU – the MS14.x for diesel mode – was designed in co-operation with Bosch. Many details of the ECU were developed over the following years.

However, for use in the R18 e-tron quattro, a completely new ECU (MS24.x) had to be developed in order to be able to represent the hybrid and engine operation in a single control device. The software for the hybrid operation – as well as for the entire operating strategy – was developed, programmed and created independently by Audi. The software for this and for other in-house developed functions was written to a dedicated partition, separate from the basic engine functions, in the MS24.x ECU.

In order to fully exploit the dynamic air pressure, great value was attached to achieving a very short, fully streamlined route for the intake air



The Audi R18 engine under peak power condition, here shown without exhaust manifold insulation

system is made along the car's roof. The ducting incorporates a low pressure loss air filter and airflow to the restrictor is optimised. Exploiting the dynamic pressure at high vehicle speeds generates a marginal increase in mass flow rate. The air is compressed to the permitted boost pressure in the compressor and enters the intercooler at temperatures of up to 200degC. After cooling, it reaches the induction system through a short carbon-fibre connecting pipe.

Another aim of the externally mounted intake system was to achieve the lowest possible blockage of the radiator exhaust air. A result of the centrally mounted turbocharger was that a very simple and light exhaust system layout was possible with the DPF at the back of the car. This was changed for the 2013 season to allow the development of a 'blown diffuser' (see *RCE V22N6*).

To develop a diesel engine as a thoroughbred race engine is a great challenge from the very beginning. The task is further complicated by the necessity to integrate the engine perfectly in the very small overall package of a sports prototype. As with the R15, the engine and car were designed as a harmonic unit without weak points. To obtain the ideal suspension setup, all the car's stressed components must have an equally high stiffness, which is why the engine is mounted rigidly as a fully stressed member between the monocoque rear bulkhead and gearbox. The stiffness could be further increased by the use of very light backstays between the monocoque and gearbox casing. The installation of a turbo engine is significantly more complex than that of a normally aspirated engine due to the air ducting. The intercoolers and water coolers are located on both sides of the monocoque in close proximity to the engine – the result is low-loss flow for low duct volumes. The car side cooling-air ducts were optimised in the wind tunnel and ensure very efficient cooling of the charge air and water.

The R18 has been an imposing presence in sportscar racing since its introduction. While both the Peugeot 908 and Toyota TS030 have taken it on and beaten it in short distance races such as those that make up the bulk of the WEC, the R18 has so far proven unbeatable at Le Mans.

REVS AND LOADS

Because of the use of the mono turbocharger, it was necessary to increase the cylinder bank angle from the 90 degrees seen on the R10 and R15 to 120 degrees for the R18. This proved to be a very good compromise for the overall package concerning the centre of gravity position and sufficient stiffness for the fully-stressed engine as part of the whole car.

The number of main bearings reduced from six to four because of the number of cylinders. At the same time, the bore was increased by 3.5 per cent and, in addition, the maximum combustion pressure increased, which actually would have had to lead to higher bearing loads. However, by exploiting intelligent lightweight design for the entire crank mechanism, as well as clever mass distribution, it was possible to maintain the bearing loads level from the R15 in the R18.

With increasing revs, the maximum bearing loads reduce due to the ever-increasing inertia forces, while the mean bearing loads increase. The change of the cylinder bank angle, however, leads to an increase in bearing forces in the lateral direction. Particular effort was necessary from the design side to prevent sliding in the joint.

For lower revs, this effect is even more apparent due to the dominating gas forces, in the upper rev range the effect reduces because of the revolving inertia forces.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Injecting performance

Honda's new direct injection P2 engine may be a dead ringer for the 2012 model, but this year there's a lot more going on inside

BY MARSHALL PRUETT

The ACO's move towards cost-capped, production-based P2 engines in 2011 was met with a particularly hearty response by Honda, Nissan and Judd, and after dominating both the WEC and the ALMS last season, Honda decided to turn up the heat on the competition even further for 2013.

Produced at the Honda Performance Development base in southern California, Honda's 2.8-litre twin-turbo V6 engine was rarely accused of having the most power during Starworks Motorsports' run to the WEC P2 title, nor did Level 5 Motorsports enjoy a top speed advantage on the way to another ALMS P2 crown.

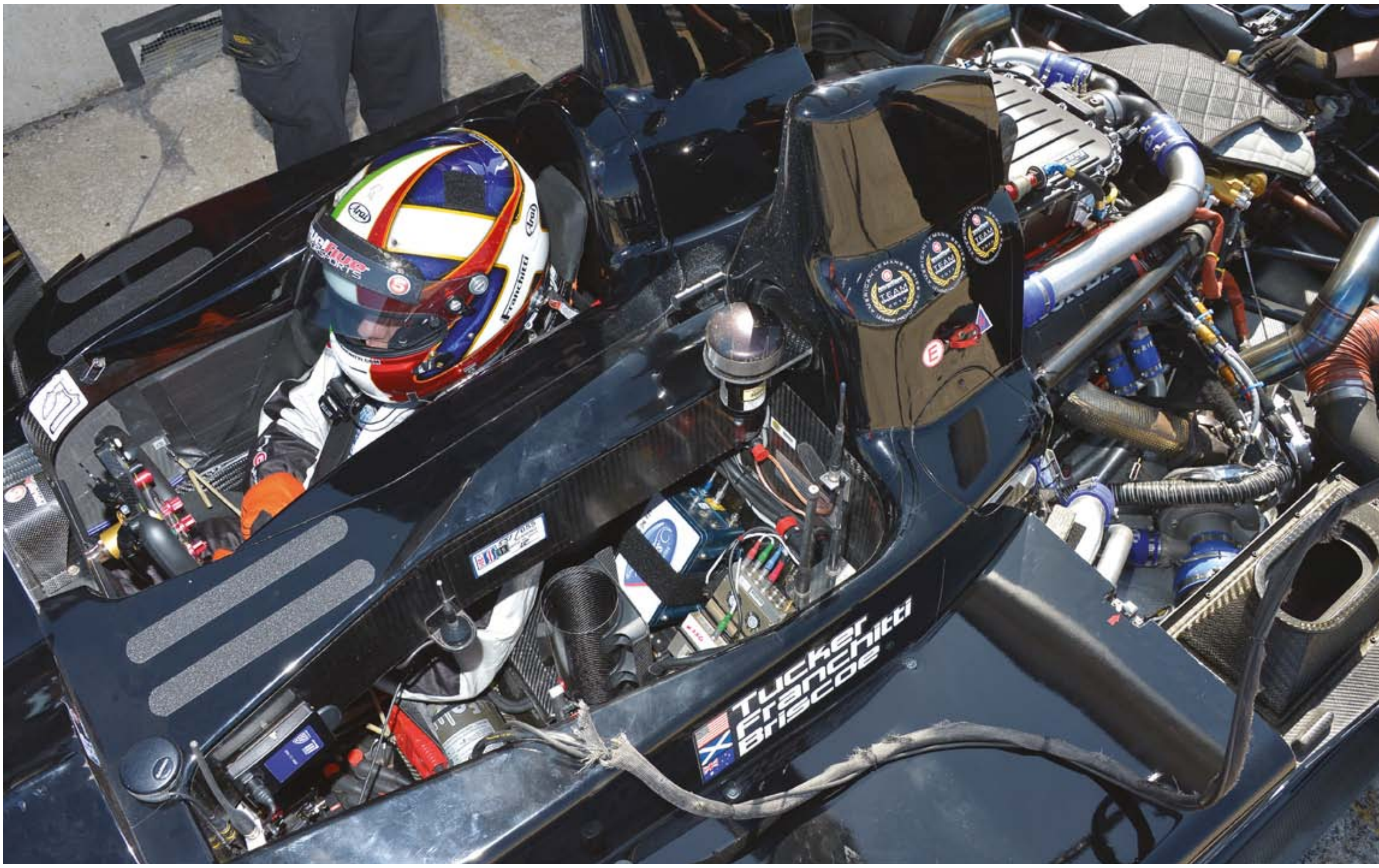
Balance of Performance restrictions made sure the lone turbo P2 powerplant was unable to stretch its legs against the naturally-aspirated engines, leaving HPD to search for performance gains elsewhere.

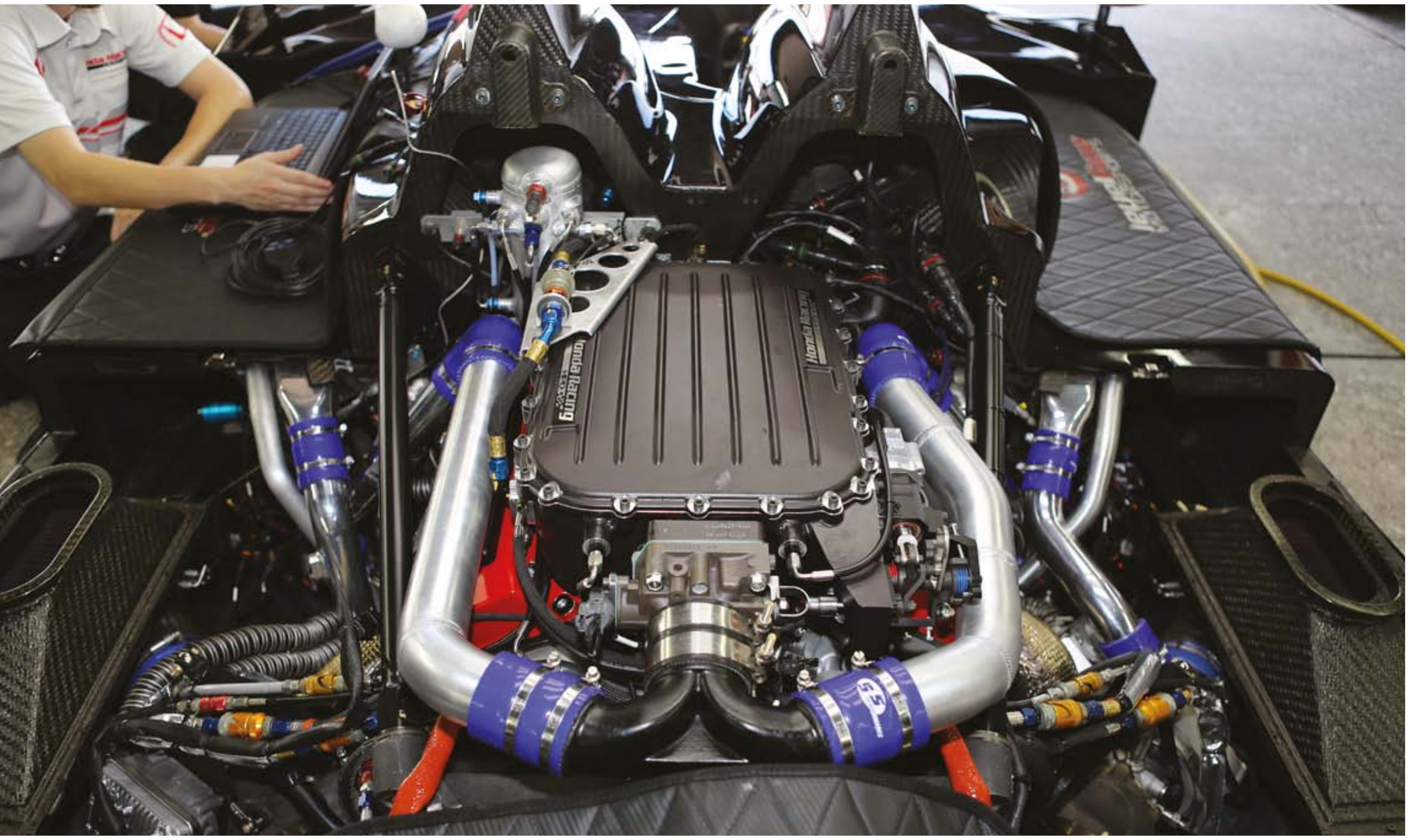
The result was most notable in the HR28TT's fuel economy, and with a chance to move the bar even higher this season, HPD leapt at the chance to homologate a brand-new direct-injection (DI) system derived from models found in Honda's upper echelon Acura brand.

'The DI P2 engine is taken from the one that's going in the 2013 Acura MDX and the 2013 RL,' said HPD technical director Roger Griffiths. 'Acura has already produced 3,000-4,000 engines, so we've met the minimum quantity for ACO compliance.'

Switching to DI was also a marketing-driven decision, which only strengthens the ties between what a manufacturer like Honda sells for the road and promotes through sportscar competition.

'The push came from the road car people, too,' continued Griffiths. 'They said it would be really nice if we could have the new DI engine, which will debut in 2013, in your race programme. So we looked at it. And it actually works great. We use a lot of the production components – it's production pumps, production injectors, those kinds of things. It's worked out really, really well.'





Dimensionally, the direct injection version of the P2 engine has been tailored to bolt into the HPD ARX-03b chassis with minimal modifications required

Except for the lower, flatter turbo intake plenum, the new-for-2013 DI engine is a dead ringer for the port-injected motor it replaces. Dimensionally, the DI version of Honda's long-lasting P2 engine was tailored to bolt into the HPD ARX-03b chassis with no modifications required to the firewall or bellhousing.

'While the head and the block are all fundamentally the same, there's all these detailed changes that the production guys are doing all the time,' Griffiths explained. 'So we did absolutely everything we could to ensure that the engine was close to being a direct replacement. You can take this one out, bolt the new one in and although we ended up having to change a couple of intercooler pipes and a couple of water pipes, there's otherwise no change. It's really been a marked and driven exercise by the production people to have the same technology in the race engines as the road car.

'The project really got going pretty late, probably around October. We've got all that castings done for the engine etc, so while the interface to the chassis is very similar, the front and rear plates that actually mount to the gearbox and then mount to the chassis were all new and had to be recast, as did the top plenum. All of that is normally 20-plus weeks lead time.

'We managed to compress it dramatically. The engine ran on the dyno for the first time really in early January. By the middle of February we were track testing. We've done a fair bit of verification of performance and now we're in the midst of durability testing. So it's all going to plan. The engine is designed to go 5000 miles. That's the target.'

For all of the advancements found with the 2013 engine, Griffiths was less than pleased about one wasteful expenditure that was lobbied for retention by another P2 engine provider and ultimately approved by the ACO.

'We had hoped to be able to do away with the $7000 throttle blipper that we had to run on the side of the engine,' he said. 'But one of our competitors put a spanner in those works so we've had to keep up with them. We submitted a proposal to the ACO and said it was crazy. We removed a perfectly good drive-by-wire throttle body, and now we have to replace it with a mechanical throttle body and a $7000 throttle blip. We could have left the original production car part on there and life would've been a lot simpler. Unfortunately, that's not the decision they took.'

The benefits of DI, despite coming mostly through fuel economy, also include a slight power increase. And with more off-season development work, Honda has found additional performance gains with the new P2 engine.

But with the ACO holding the reins rather tightly over the pace of development in the class, Griffiths knows that showing up for the WEC season opener at Silverstone with gobs of extra torque and top speed would be met with harsh restrictions for round two and beyond.

Implementing HPD's own pre-emptive performance balancing, as it were, was the smartest option to take.

'We understand that if we turn up and produce considerably more engine power the ACO will just run us back in,' admitted Griffiths. 'We understand that the focus of this has not been about getting more performance. So we're obviously aware that the performance of some of the competitor engines is potentially stronger than ours. But what the ACO looks at, unlike some of the other sanctioning bodies, they don't take the engines, put them on a dyno, run all the engines and compare the performance – they look at the performance of the package.

'At Le Mans it's over an average number of laps – how does your lap time compare to

"It really would be a crying shame if teams were to get penalised for actually producing a more fuel-efficient engine"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The Level 5 Motorsports HPD ARX-03b running in ALMS at Laguna Seca in May

LAT

your competitor? And then they'll balance based on that. So if we were to come with another 20hp, for example, we know we would just get pulled back. So that hasn't been the focus of what we tried to do.'

Like the incremental reduction in fuel capacity for diesel P1 cars to balance the mileage disparity encountered by petrol-powered competitors, a similar BoP of sorts could be in the works for the fuel cells of DI-engined cars.

'Everybody will say that the direct-injection engine is potentially more economical from a fuel perspective,' said Griffiths. 'There's already been some discussion within the ACO that what they're looking at in the GT category is that those DI engines could get a smaller fuel cell. That's something we have to be prepared for.'

Like most aspects of ACO-based races, politics will surely decide whether the merits of DI are neutralised by smaller fuel tanks.

'It was interesting in one of the meetings when this came up with the GT people, those with direct-injection engines said it was probably only worth one or two per cent increase and those without direct injection engines said it was eight to 10 per cent! I'm sure the truth is somewhere in-between. But the Le Mans category has traditionally been about efficiency. It would be a crying shame if you were to get penalised for actually producing a more fuel-efficient engine.'

One improvement that will likely go without sanction is the durability of the new-era P2 engines.'I think the key thing is that we were able to achieve the performance that we did, but we also meet the ACO's goals for reliability,' Griffiths said. 'Some of the engines out there produce more power, yet they are unable to achieve the ACO's goals for reliability. So maybe performance and reliability are directly linked – perhaps that should be looked at.'

After completing successful tests at Sebring, HPD dispatched the DI engines – now branded as Hondas – to its teams in North America and Europe.

'The shakedown of this engine was full systems check, evolution of calibrations, evolutions of strategies, getting ready to go to the Sebring 12-hours, which went ahead in March,' said HPD principal engineer and large project leader Allen Miller. 'We were flat out building engines ahead of the season. We needed to ensure that the control strategies and the calibrations behind it are ready to go. There's roughly 15 to 17 engines in the pool we're completing.'

Griffiths and his HPD counterparts will soon know whether all of the work on its DI P2 engine was enough to win the 24 Hours of Le Mans, but it is clear he's expecting the HR28TT to meet all of its marketing goals.

More than the victories and championships that may come, look for Honda to tout the real world performance attributes its road car-turned-racecar engine provides.

'Of course we are here to win everything we can – every single race,' said Griffiths. 'Butwe also need to demonstrate the longevity that has been achieved while pursuing those victories. We should be able to do the ALMS championship on three engines and we expect to achieve the same for the WEC.

'We've got one car running in Europe, and that is supposed to do the whole season on one engine.

'The more things we can deliver to our marketing department to promote, the stronger the case is for everything we do in motor racing. That's vitally important as well, and this P2 engine goes an incredibly long way to establish this case.'

"We removed a perfectly good drive-by-wire throttle body, and now we have to replace it with a mechanical throttle body and a $7000 throttle blip"

TECH SPEC

2013 Honda HR28TT V6 Engine

Engine type: aluminium alloy, twin turbocharged, fuel injected V6

Displacement: 2.8 litres

Valve train: single overhead camshaft, four valves per cylinder

Crankshaft: alloy steel

Pistons: forged aluminum, low-friction coatings

Connecting rods: machined alloy steel

Engine management: HPD/Continental

Ignition system: digital inductive

Lubrication: dry sump system

Cooling: single mechanical water pump

Transmission: HPD-Hewland six-speed sequential, paddle-operated

Fuel: E10 100-101 octane gasoline, 10 per cent ethanol


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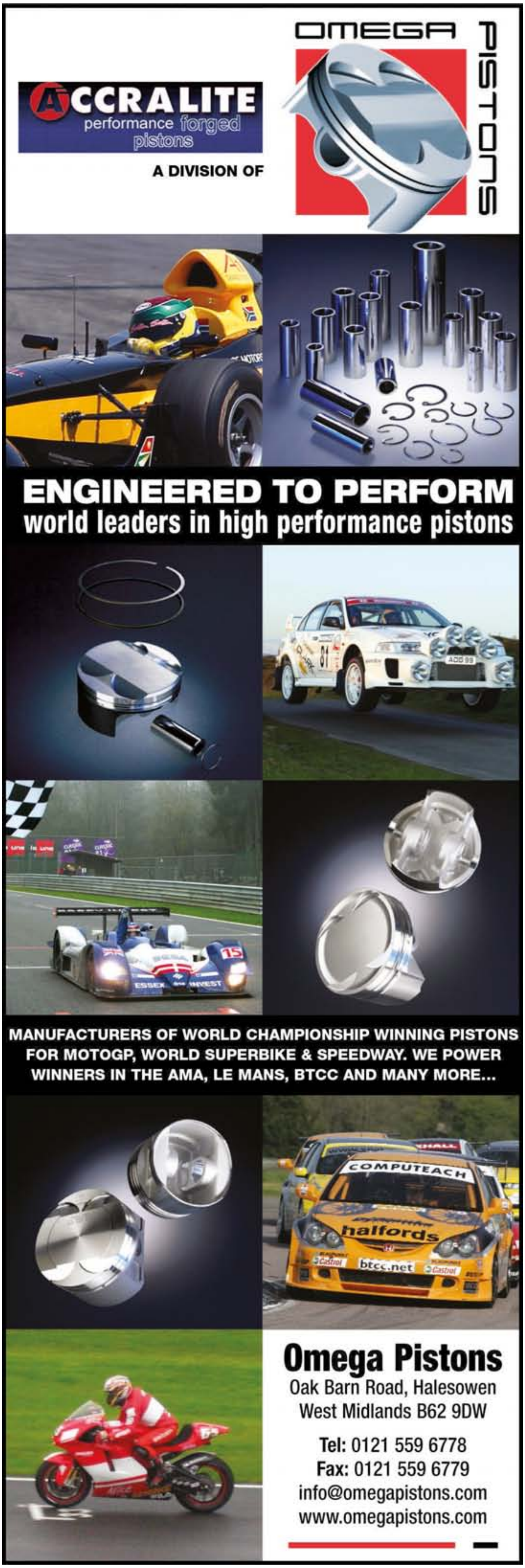
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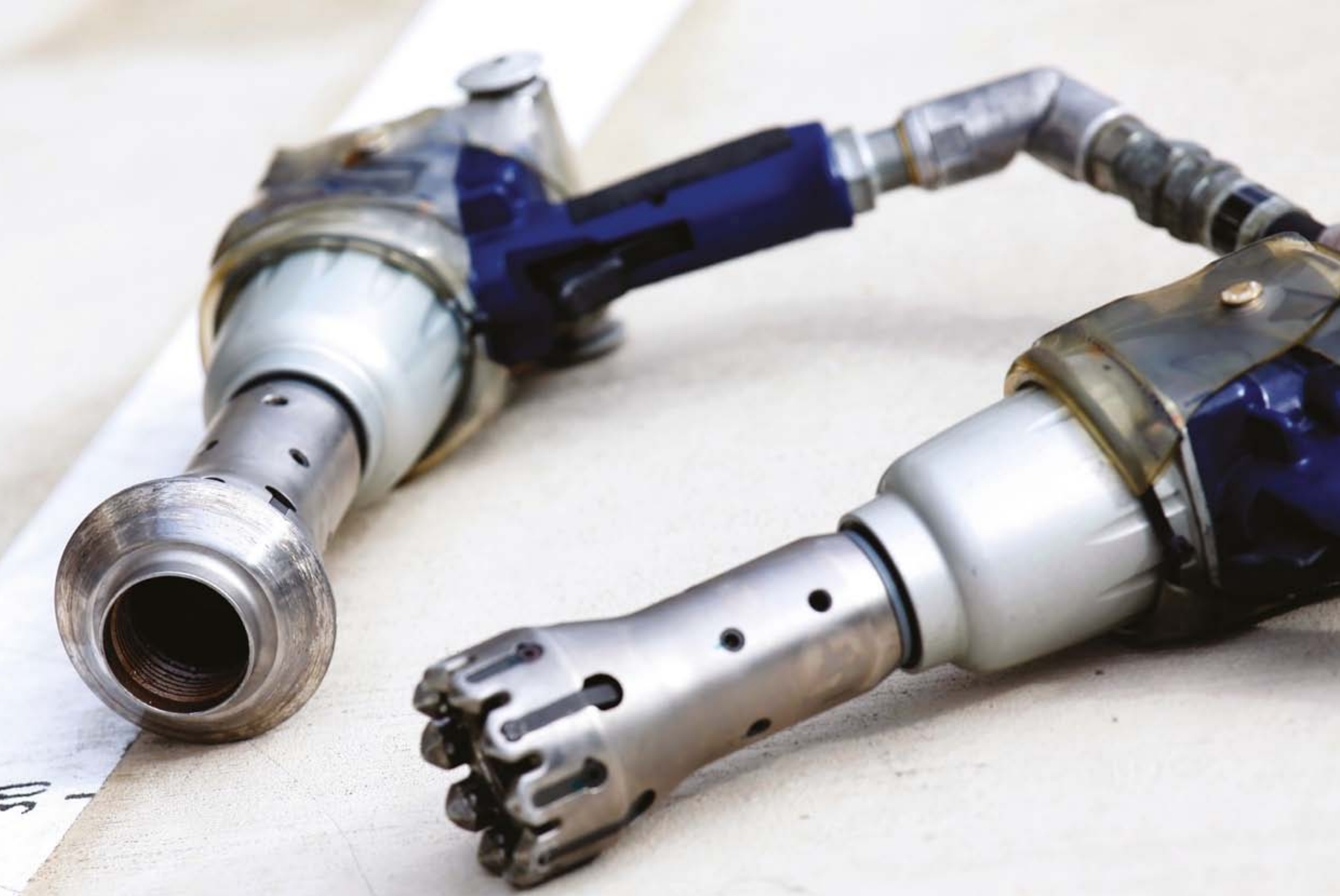

The pick of the new pit kit

You need to be quick, and you want to stay safe. Thankfully, pit technology – from wheel guns to booms, and ADR to EDS – is keeping pace with the sport

We have all witnessed the astounding speed of modern day pit stops. This year in Malaysia, Infiniti Red Bull Racing set a new record, clocking in at 2.05 seconds. Of course, the humans involved in this slick operation spend days practising until it becomes a series of robotic sequences. However, machines are not quite so reliable, which is why Progressive Motorsport have designed wheel guns that not only do the job safely and accurately – but also quickly.

BY GEMMA HATTON

'The WGS Mega-Line Wheel gun system is something that was developed for a specific customer,' says Progressive's managing director Dave Ward. 'The system has many attributes and can be altered to suit different championships. For example, some don't allow electronic assistance for the gun operator, such as an indicator light or an electronic pressure shut off valve. Other championships and systems may need to cater for a traffic light system that is viewed by the lollipop operator. These lights are automatically triggered by logic that is created by the four wheel guns.'

Whichever WGS system is chosen, there are three common parts: the ECU, wheel gun and control valve. 'The ECU and corresponding 15-inch TFT display is housed in the pit garage and records the state of all four wheels during a pit stop, including a range of variables such as trigger time, calculated wheel nut torque and airline pressure,' says Ward. 'These variables can then be analysed during a race to build a quick and efficient wheel change pit stop.' The ECU is also equipped with a back-up battery which will power the entire system in case of a power cut.

The wheel guns supply the ECU with all the necessary data via a CAN bus connection. Each gun is fitted with an LED display to give the gun operator an indication of the torque status and the system can be setup to any number of guns up to a maximum of four.

It is estimated that a wheel gun can generate up to 2,200 pound feet of torque, so to avoid over-running the gun, a control valve is integrated into the design. It is located between the gun and the air line and is also electronically connected to the ECU. When the valve is inactive, the gun is supplied with air. However, when the ECU detects that the desired torque has been reached, the valve is activated and cuts off the air supply. This happens in parallel with the optical feedback to the gun operator, illuminating a green LED.

Another recent development is the 'nut in wheel' design which prevents the nuts from flying out of the gun when removing the wheels, which could be a major safety hazard. Now, the nut floats within the rim itself, saving time for the mechanics as there is one less job to do. However, if the nut is not aligned perfectly, then the nut crosses threads and it cannot simply be removed and replaced with a spare. This is because it's part of the wheel, so the entire wheel would have to be changed. And as it's illegal to use a wheel from a different tyre allocation, all four wheels would therefore need to be changed.

Greaves Motorsport has developed a 360 degree pit lane boom that saves time in endurance racing where the number of wheel guns is strictly limited

'The overall safety of a pit stop procedure, in any championship, can only be achieved by a logical approach to the pit stop practice sessions,' says Ward. 'No matter what electronic or pneumatic gadgetry you have in place, there still needs to be a military operation when it comes to safety. The condition of the equipment, the air pressures, the operation of the jacks all need to be monitored and looked after and the WGS can help with this process, but only to a certain degree. I'm sure the tyre stops in F1 are now so fast that the failsafes and safety nets you could put in place have almost been discarded as the human interaction is effectively muscle memory. There is no time for a gun operator to react to any issue. The stop either works at sub-four seconds, or it doesn't. So, analysis on pit stop training is essential and the WGS is a good tool to help this process.'

PIT LANE BOOM

Another innovation aimed to aid a 'fast and furious' pit stop was unveiled at the Silverstone 6 hours. It came in the form of the new 360-degree pit lane boom for Aston Martin Racing, produced by Greaves 3D Engineering. Its management of air lines and cables can cut seconds out of pit stops in comparison to a conventional fixed boom.

The design consists of high-grade aluminium, 316 stainless steel parts, and a hollow carbon fibre arm, making the boom lightweight and strong. It also offers options for data cables, vent pipes and lighting solutions.

"No matter what electrical or pneumatic gadgetry you have in place, there still needs to be a military operation when it comes to safety"

Alongside the boom, Greaves also offers a motorsport fuel rig, which has a $2m^2$ floor plan. The outer shell is constructed of aluminium and honeycomb, which makes it incredibly light. The unit's strength comes from a rigid internal powdered coated steel chassis. Three large compressed air bottles can be easily stored, with added space for fuel hoses and tools and a 2.6m max tank height.

Launched in November 2012, Greaves 3D Engineering is the sister company to the Le Mans-winning Greaves Motorsport, which competes in a wide range of endurance racing series including ELMS, ALMS, Le Mans and the FIA WEC in the LMP2 class. The two companies recently moved into a new 15,000 square foot facility near Peterborough in the UK. As well as pit lane equipment, Greaves 3D also utilises the use of four new CNC machines, including a five axis milling machine with a large CNC turning capacity and live tooling. Along with inspection and metrology facilities, such as CMM machines and 3D measuring arms, the setup means the company is will placed to cater for any number of engineering projects.

ACCIDENT DATA RECORDER

Over the last few decades, the FIA have pushed the boundaries for the number of safety regulations and ensured that they are enforced effectively. For this reason, occurrences like a lack of the number of fire extinguishers surrounding a pit stop – as a team in the Blancpain Endurance Series in Monza were criticised for this year – or of unsafe pit stop releases will get punished.

A clever piece of data-logging kit is the accident data recorder (ADR), which helps to understand the behaviour of the car minutes before a crash. Therefore, it not only helps to improve the safety systems before and during a crash, but it also helps engineers to analyse and understand the causing issues, to avoid it happening again.

The ADR is positioned under the seat and is composed of a 'rolling' data logger and connections to two accelerometers that are mounted on the centreline of the survival cell. During an accident, the logger stops recording and secures the data for the two minutes preceding the crash for analysis. The data is downloaded by the FIA and then passed on to the team.

The ADR is also connected to a medical warning LED light which flashes blue when set parameters are met to give marshals an instant indication of the severity of the accident.

This system was primarily used if F1 and WRC for decades, but in 2008 it was expanded into WTCC and the Australian V8 Supercars and, in 2010, into endurance racing with the GT1, GT2 and GT3 categories. All the accident data is fed into an FIA database in Geneva, and because of this, teams don't need staff to monitor the programme, making this safety system available for teams and championships where money is harder to come by.

Progressive Motorsports' Electronic Drink System features screw caps, plus bottle tops which utilise a quick release dry-break coupling

Progressve's EDS bottles are constructed from carbon fibre and ABS plastic. Like the pump and fittings, they've been tested to withstand racing G forces

EDS Ultra bottles are available in three different sizes to suit the race: 0.6-litre, 1-litre and 1.5-litre

ELECTRONIC DRINK SYSTEM

Another popular Progressive Motorsports product is the Electronic Drink System – or EDS – used for drivers with top teams. The bottle itself, the dry break fittings and the pump, have all been tested and developed to withstand high G-forces. Not only is it lightweight, consisting of non-return valves to prevent leakage under high G loads, but the system is proven to be extremely durable, as demonstrated by successfully completing the 24 Hours of Le Mans for several teams.

Progressive supply many of their products to Team Joest GmbH Racing, which benefits both parties. 'We are able to guarantee a level of engineering to Joest Racing and keep the IP in-house,' says Dave Ward. 'Having an engineering group allows for better communication away from the track, and also creates an engineering platform to work from. This equates to everything from the pre-race engineering briefings to the post event reports. We can employ young engineers at Progressive and then train them up over a period of time to a required level. These employees are then part of our own pool of engineers ready to step over to the Joest contract if and when required.

'The sort of pit equipment we produce is always changing alongside championship regulations, both sporting and technical. We will always be here to support the needs of our customers, old and new, to ensure they have what they need. Just like a racecar, there is always a need for lighter, smaller and more efficient equipment as well as changing the aesthetics to suit the current pit garage setups and sponsors.'

Greaves' new 360-degree pit lane boom offers efficient management of air lines and cables, cutting crucial seconds from pit stops


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Autotel's NX9200 race system, including digital radios for two cars, two engineers and full pit crew

Crystal-clear comms

With increasing competition for the raceday airwaves, and interference building up all the time, radio systems are evolving to meet the challenge

BY GEMMA HATTON

'Multi 21', 'Fernando is faster than you', 'Webber, maintain the gap', 'box, box, box' – heart-stopping phrases that no driver wants to hear over their radios. The importance of effective communication from the pit wall to the driver during a race is unquestionable and can separate the winners from the losers.

It is easy to forget that before the mid-80s, the only way teams could communicate with their driver was with a pit board displaying a few numbers signalling laps to go, position and when to pit. The only way a driver could communicate with the team was with hand signals, for example in NASCAR where the driver would reach around the A-pillar and tap the hood to signal the need for a pit stop, or by banging the door panel to indicate a problem with the suspension.

Today, the amount of information that a driver receives is much more than that one second per lap of speed reading. However, pit boards are still vital in relaying information effectively, rather than cluttering up the driver's other senses via the radio, and it is also a useful back-up if radio communications fail.

In 2006 it was estimated that 40 frequencies were used per team in F1, leading to a minimum of 700 radios on the air on raceday, including media and security, plus mobile phone traffic. Yet, this was with only 11 teams on track, so double that and you'll be close to the figures reached today.

Most of this communication is between the various pit crews rather than the driver and the race engineer, as only high-priority communication is transmitted to the driver throughout the race. In 2011, only three minutes of radio chatter per race, across all the teams, was exposed to 60 million viewers by FOM. Of course, this is mainly for entertainment purposes for the audience and obviously not the total amount of messages between the team and the driver. However, it is a good indication that although the transmissions may not be frequent, when a message is sent, it is vital that it is received clearly.

There are many technical challenges engineers are faced with to establish a clear radio link between the pits and a racecar travelling at over 200mph. For the driver's microphones, the main concern is unwanted engine noise which is dealt using noise-cancelling microphones. This technology works by having two faces, or ports. The front port is oriented towards the desired noise such as the voice of a driver, and the opposite (rear) port receives the background noise. Although the desired and background noises reach both ports at approximately the same time, because the desired noise is closer to the front port than the rear, it creates a larger pressure gradient and therefore generates greater movement of the diaphragm that is placed between the two ports. The microphone's proximity effect (an increase in bass or low frequency response when a sound source is close to a microphone) is adjusted to ensure that flat frequency response is achieved for the closest sound sources, therefore effectively comparing and killing off the unwanted background noise.

Another type of noise concern within the car is electrical, which interferes with the radio. The generator and voltage regulator are the main sources of this and as they continue to get smaller, they continue to become noisier. So, once background/engine noise is cut from the driver's microphones, the electrical interference noise also needs to be cut. Beyond that, there is also the mechanical noise from vibrations within the car to be dealt with.

Once all the types of background noise are counteracted, there are further issues. On race day, the radio frequency spectrum is completely full, which results in two types of problematic phenomena. Firstly, interference, and secondly an intermodulation effect. The latter can cause major problems, for instance, when a broadcaster passes through a garage it can destroy the network even though they are on a different frequency. This is because intermodulation distortion (IMD) is where two or more signals from different frequencies mix together to form undesired addition signals at non-harmonic frequencies.

The effect of IMD varies between circuits due to the geographical location. Spa, Monza and Hockenheim make things tricky as they are surrounded by forests that absorb the waves. Alternatively, Monaco, Monza and Brazil are in the centre of cities where there is a wide range of many frequencies. However, Melbourne is one of the worst as there are big TV and radio broadcasters on-site that generate a lot of IMD.

David Julier from Ideas To Reality – which supplies racing radio equipment to many types of motorsport and motorcycle series – explains how a typical radio package works. 'Firstly, the driver has an in-helmet headset featuring a noise-cancelling boom microphone that positions directly in front of their mouth,'

Autotel's NX920 digital engineer or crew radio, featuring digital, analogue and mixed modes

he says. 'The headset can use either conventional speakers, or a socket into which they can plug a set of moulded in-ear monitor speakers. These are preferable for racing as they protect the driver from hearing damage and also feed the audio from the pit crew directly into their ears for clarity. The driver has a "press to transmit" button on the steering wheel spoke and a radio located within the vehicle. One-pin jack plugs allow the driver to connect into the system quickly and securely. The pit crew member or engineer then wears a full headset with padded "muffs" and an aviation-quality microphone. The mics are also noise-cancelling and the muffs help to insulate the wearer to eliminate external sounds, so they get both protection and clear communication.'

EVOLVING AFFORDABILITY

As with most things in motorsport, radio communications has continually evolved, as Shawn Sampson from Sampson Racing explains. 'Digital radios, radio size and battery life have made major improvements over the last 20 years,' he says. 'The radios are now much smaller and lighter and offer a five watt output in a handheld unit.'

Julier highlights that cost has also helped to drive development. 'The EU have released a set of license-free channels available to anyone (PMR446),' he says. 'And Ofcom – who regulate radio communications in the UK – have made obtaining a set of licensed channels far simpler, with online application starting at only £75 for a three-year license covering the whole team's radios. Pit-crew headsets and in-car comms kit used to cost several hundred, even thousands of pounds each, with most teams having to hire radios and headsets.

'The internet and global trade means that smaller companies are now able to access manufacturers from all over the world and become extremely competitive, whereas 10-20 years ago this type of communication was only offered by the main corporations. It's no longer the domain of "rich" teams – a full driver-to-engineer kit can come in at well under £400.'

Improvements in battery life has meant that radios can deal with every type of motorsport, from a 16-lap BTCC race to a 24-hour race at Le Mans. 'The duration of the race is generally less of an issue than in years gone by, as battery power has recently improved dramatically,' says Julier. 'For 24-hour endurance racing, we can power radios directly from the vehicle instead of relying on batteries. The main difference is with open or closed cockpit, because with a metallic roof the radio signal cannot be transmitted, so an external antenna has to be fitted to the body.' Sampson agrees. 'The nuts and bolts of the systems are all the same,' he says. 'What it comes down to is the in-car radio battery life. If you don't want to change a radio battery at the 10-hour mark of an endurance race, then having the in-car setup with a mobile – which draws its power from the in-car 12v system – is the best way to go.'

'Digital radios will eventually come down in price and offer greater clarity and improve performance'

AN ALL-DIGITAL FUTURE?

On Motorsport radios will be going digital in the future, claims Sampson. 'With analogue you can have static-filled conversations at different points on the track, but this is never the case with digital,' he says. 'With systems such as the Vertex EVX-531, we can also adjust the voice quality and the ability of the microphone to pick up more or less background noise. They are very light, small and waterproof and once fully charged you can expect up to 14-16 hours of talk time before adding a new battery. An invaluable advantage is that they are private, so other teams cannot scan your conversation.' Julier agrees, although highlights that this won't be happening in the near future, 'Digital radios will eventually come down in price and offer greater clarity and improve performance, but this is still some time away. Currently analogue radio does, and will continue to dominate almost all racing.'

Meanwhile, Sampson thinks that Bluetooth could be making a comeback, 'We are working with Bluetooth communications and have had really positive results. There are some limitations, but for the most part we are very happy with the quality and ease of use. It can also be used for crew systems, so crew members can have full duplex conversations and still talk to the driver via two-way radio when they need to – it's going to be a game-changer.'

The beautiful simplicity of FRIC

Examining the theory behind Mercedes' ingenious new innovation

BY DANNY NOWLAN

One of the most interesting developments to come out of this current F1 season has been the Mercedes GP FRIC (Front and Rear Inter-Connected) system. It's a hydraulic system that connects the front to the rear to aid the pitch and heave response of the car. I find this particularly interesting because some of my clients are starting to play around with similar ideas. In this article we'll discuss the theoretical background of FRIC and then we'll put some numbers to it with simulation.

On a personal note it is just so refreshing to hear something coming out of Formula 1 that isn't about the floor deflecting 12mm instead of 11mm. One of the main attractions of F1 is its potential to be a hotbed for new ideas, and we in motorsport are losing this at our great peril. Remember: motorsport brought us innovations such as disc brakes and the paddle shift system for semi-automatic transmissions, and those regulating the sport should never lose sight of this. Without this tradition, we in motorsport run the great risk of dooming ourselves into irrelevancy and I fear this is well under way. Which is why FRIC is so exciting – it's a genuine innovation. However, I'm saddened to hear that it might be banned because as I'll explain – it actually isn't that hard.

The primary motivation for FRIC is to control the outrageous amounts of downforce that an F1 car generates. In order to understand this better, let's consider the bicycle model of the racecar (see **Figure 1**).

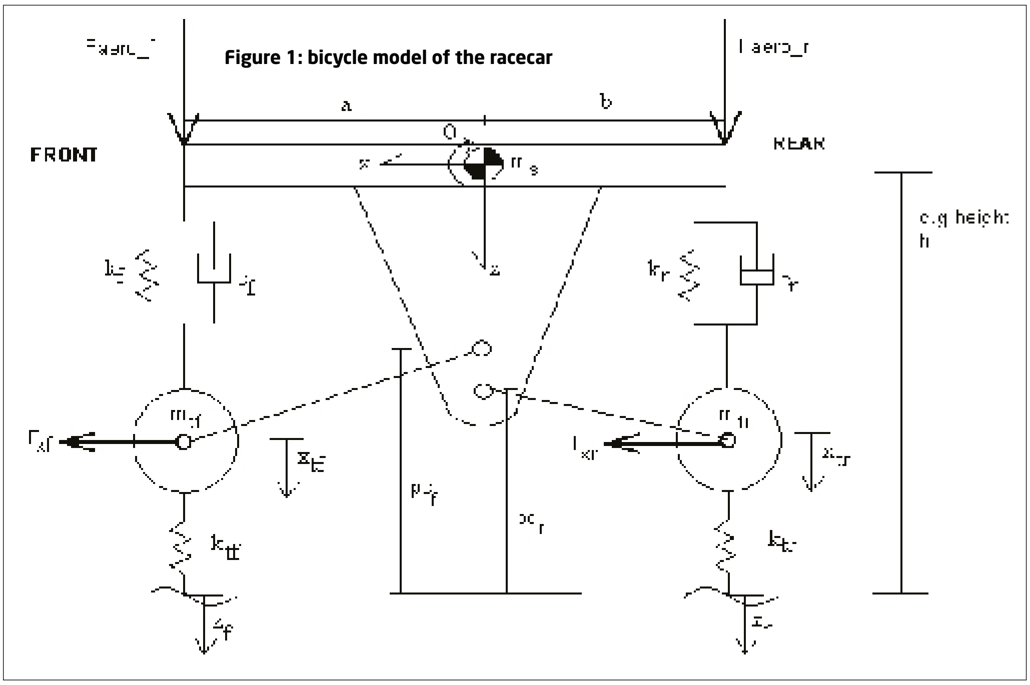

Figure 1: bicycle model of the racecar

Equation 1

$$m_s \cdot \ddot{z} = F_{aerof} + F_{aeror} + m \cdot g - k_f(z - a\cdot\theta - x_{tf}) - c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) - k_r(z + b\cdot\theta - x_{tr}) - c_f(\dot{z} + b\cdot\dot{\theta} - \dot{x}_{tr})$$

$$I_y \cdot \ddot{\theta} = a\cdot\left(k_f(z - a\cdot\theta - x_{tf}) + c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) - F_{aerof}\right) - b\cdot\left(k_r(z + b\cdot\theta - x_{tr}) + c_f(\dot{z} + b\cdot\dot{\theta} - \dot{x}_{tr}) - F_{aeror}\right) + \left(h - pc_f\right)\cdot F_{xf} + \left(h - pc_r\right)\cdot F_{xr}$$

$$m_{tf}\cdot\ddot{x}_{tf} = k_f(z - a\cdot\theta - x_{tf}) + c_f(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) + m_{tf}g - k_{tf}(x_{tf} - z_{bf}) - \frac{F_{xf}\cdot pc_f}{a}$$

$$m_{tf}\cdot\ddot{x}_{tr} = k_r(z - a\cdot\theta - x_{tf}) + c_r(\dot{z} - a\cdot\dot{\theta} - \dot{x}_{tf}) + m_{tr}g - k_{tr}(x_{tr} - z_{br}) + \frac{F_{xr}\cdot pc_r}{b}$$

The terms for this equation are:

z	= movement of the chassis down (m)	I_y	= sprung weight inertia along the y axis (kgm2)
θ	= pitch angle of the chassis (radians)	m_{tf}	= front tyre mass (kg)
x_{tf}	= front tyre displacement (m)	m_{tr}	= rear tyre mass (kg)
x_{tr}	= rear tyre displacement (m)	a	= distance from front axle to cg (m)
k_f	= front spring rate (Nm)	b	= distance from the rear axle to the cg (m)
c_f	= front damper rate (Nm/s)	F_{aerof}	= front aero force (N)
k_{tf}	= front tyre spring rate (Nm)	F_{aeror}	= rear aero force (N)
k_r	= rear spring rate (Nm)	pc_f	= front pitch centre location (m)
c_r	= rear damper rate (Nm/s)	pc_r	= rear pitch centre location (m)
k_{tr}	= rear tyre spring rate (Nm)	F_{xf}	= total longitudinal forces at the front
m	= sprung weight mass (kg)	F_{xr}	= total longitudinal forces at the rear

Concentrating on the sprung and unsprung masses, the equations of motion can be seen in **Equation 1** on the previous page.

While this may seem perfectly obvious, it goes without saying that the spring rates are going to be double what you see on a setup sheet. To better understand the impact that FRIC is going to have, we need to simplify **Equation 1** a little bit. So, see **Equations 2 and 3** below. Then, re-writing **Equation 1,** we arrive at **Equation 4**.

All that is happening in the FRIC system is that we are adding an extra spring by combining the front and rear damper movements. It's as simple as that. Putting the effect of FRIC into **Equation 4**, we get to **Equation 5**.

For simplicity, I haven't included damping or inertance terms, but it would be very simple to incorporate these. As we can see, there is no magic trick that needed a team of 5000 engineers to come up with this. All we are actually doing is adding an extra spring rate to give us some flexibility in tuning the characteristics of the racecar. That's really all there is to it, and any undergraduate engineer or junior data engineer worth their salt should be able to do some basic hand calculations on this.

The principal advantage that FRIC brings to the party is that it's effectively a third spring on steroids. Current third springs simply use the combined displacement of either the front or rear springs for pitch control. By combining the front and rear displacements we are actually addressing what is going on when we start developing large amounts of downforce and large amounts of aero-generated pitch sensitivity.

To explore this in further detail, let's add **Equations 2** and **3** to see their effect on vehicle behaviour. Doing this, we arrive at **Equation 6**. Then, substituting this back into **Equation 5** yields **Equation 7**. For simplicity I have just shown the heave equation, but as you can see we have effectively added extra terms for both the heave and pitch terms of our differential equations. What this means is that we have given ourselves a very effective tuning tool to adjust heave and pitch characteristics. This is due to the fact that the heave - or z term - effectively doubles the effectiveness of the FRIC springs.

The concept of FRIC is not a new one, particular to open wheelers. Hydraulically interconnected suspension has been attempted intermittently in rallying. I've also worked directly on cars with suspension components that were linked hydraulically. One of my first jobs was working on an Australian F3000 car that had a Penske third spring arrangement that was connected to the main springs hydraulically. It was consistent and it performed as advertised and it was particularly appropriate given that the chassis was a Reynard 95D with a flat bottom that generated very high levels of downforce. The front and rear were not connected, but it shows that there is no black magic here.

But enough of the theory – let's put this into practice. What I'm going to show is a GP2 simulation of Eastern Creek showing the

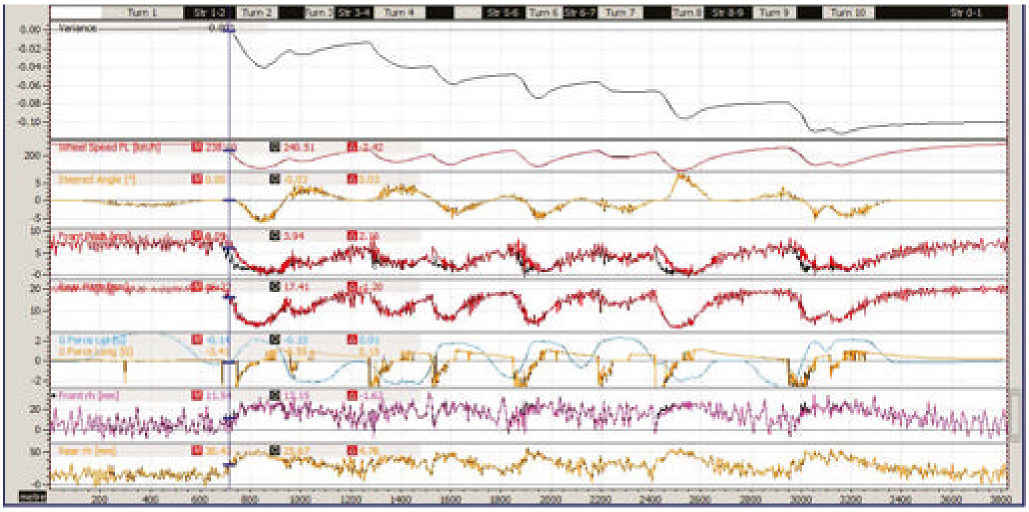

Figure 2: overlay of FRIC vs baseline GP2 car

EQUATIONS

Equation 2 $$ma = z - a \cdot \theta - x_{tf}$$

Equation 3 $$mc = z + b \cdot \theta - x_{tr}$$

Equation 4
$$m_s \cdot \ddot{z} = F_{aerof} + F_{aeror} + m \cdot g - k_f(ma) - c_f(ma') - k_r(mc) - c_f(mc')$$
$$I_y \cdot \ddot{\theta} = a \cdot \left(k_f(ma) + c_f(ma') - F_{aerof}\right) - b \cdot \left(k_r(mc) + c_f(mc') - F_{aeror}\right) + \left(h - pc_f\right) \cdot F_{xf} + \left(h - pc_r\right) \cdot F_{xr}$$

Equation 5
$$m_s \cdot \ddot{z} = F_{aerof} + F_{aeror} + m \cdot g - k_f(ma) - c_f(ma') - k_r(mc) - c_f(mc') - k_{FRIC\_F} \cdot (ma + mc) - k_{FRIC\_R} \cdot (ma + mc)$$
$$I_y \cdot \ddot{\theta} = a \cdot \left(k_f(ma) + c_f(ma') + k_{FRIC\_F} \cdot (ma + mc) - F_{aerof}\right) - b \cdot \left(k_r(mc) + c_f(mc') + k_{FRIC\_R} \cdot (ma + mc) - F_{aeror}\right) + \left(h - pc_f\right) \cdot F_{xf} + \left(h - pc_r\right) \cdot F_{xr}$$

Where:

k_{FRIC_F} = Front FRIC spring rate (Nm)

k_{FRIC_R} = Rear FRIC spring rate (Nm)

Equation 6
$$ma + mc = 2 \cdot z + (b - a) \cdot \theta - x_{tf} - x_{tr}$$

Equation 7
$$m_s \cdot \ddot{z} = F_{aerof} + F_{aeror} + m \cdot g - k_f(ma) - c_f(ma') - k_r(mc) - c_f(mc') - k_{FRIC\_F} \cdot \left(2 \cdot z + (b - a) \cdot \theta - x_{tf} - x_{tr}\right) - k_{FRIC\_R} \cdot \left(2 \cdot z + (b - a) \cdot \theta - x_{tf} - x_{tr}\right)$$

effects of a standard car and with a FRIC equivalent arrangement. Due to confidentiality I need to be guarded about my methodology but what you are seeing can be taken as a FRIC equivalent. The results are presented in **Table 1**.

As we can see, there is a small but very distinct advantage to using FRIC. Where we gain the time is, not surprisingly, under braking. A general overlay of the baseline to the FRIC car is shown in **Figure 2**.

The first trace is variance, the second trace is speed, the third trace is steering, the fourth and fifth trace is front and rear pitch, the sixth trace is accelerations and the last traces are front and rear ride heights. The coloured trace is standard and the black is the FRIC setup. The variance trace show decisively that we are making the time under brakes. This is also consistent everywhere which shows this is a change that will work.

The reason this worked is because of the better control of the front ride height. This is illustrated in **Figure 3**.

Again, the simulated lap is black and the standard lap is coloured. As we can see at the selected cursor point the front ride height of the FRIC car is 17.05mm vs 13.91mm for the standard car. This yields an increase in corner entry of over 3km/h. I should also add that I biased the FRIC effects totally at the front.

As can be seen from this simple simulation FRIC definitely helps, but it's not a magic tweak to the car. The change is consistent everywhere, which means this is definitely worth pursuing. However, it is still up to the race engineer and driver to deduce the best direction to go in. Consequently this is not active suspension via stealth and to pretend otherwise would be an act of breathtaking foolishness.

Also, given what we have discussed it is also very foolhardy to pretend that teams need to spend a fortune on this. Yes there is a lot of detailed engineering in something like this, but it actually isn't that hard to figure out and refine. The principles behind it are pretty simple and you can refine it with simulated work and track testing.

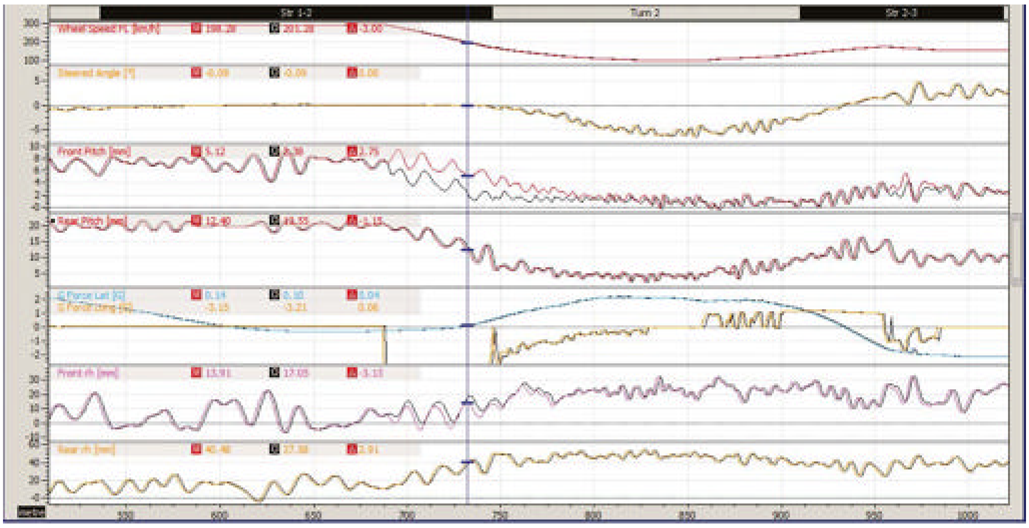

Figure 3: overlay of FRIC v baseline GP2 car for Turn 2

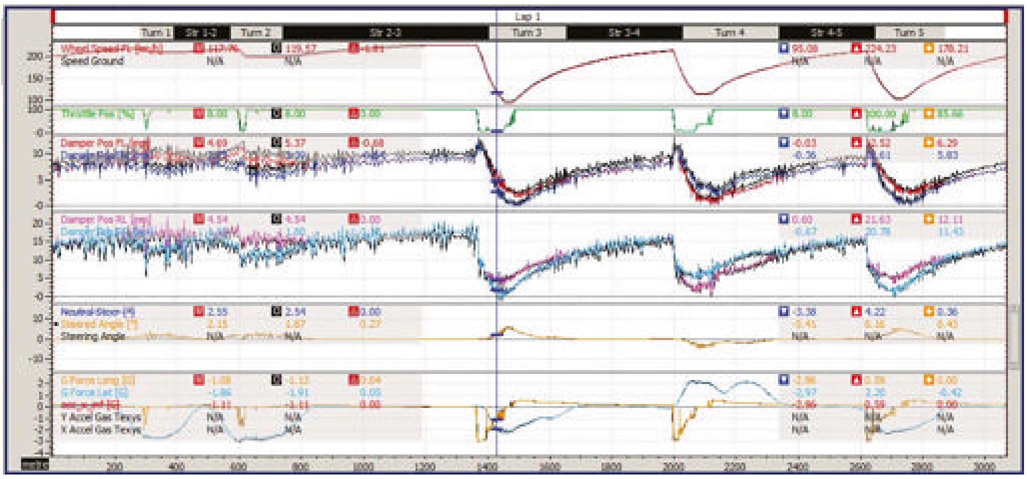

Figure 4: standard v optimised setup

Table 1: standard v FRIC setup

Setup	Lap time
Standard	71.60s
FRIC equivalent	71.48s

Reading between the lines, I think there are a few in the F1 paddock that are kicking themselves that they didn't think of it first.

In closing, FRIC is a fundamentally sound idea that is obviously enjoying the success that it deserves. The principles behind it are very straightforward because it's effectively enhancing the heave mode response of the car when we need it, and it can be readily incorporated into existing simulation techniques. The simulation results also indicate that it's an open and shut case. However, it is a tweak and not a magic bullet, and everyone – including officialdom – should keep this in mind. The last word on this should come from a friend of mine who used to be a senior F1 race engineer in the early-2000s – 'It shouldn't be about us trying to regulate what Ferrari is doing, it is up to us to catch up.'

INTERPRETING SIMULATED DATA

You'll notice in **Figure 2** and **Figure 3** that I had two different simulated plots and the differences between them where noticeable, but were quite small in magnitude. What you saw there is a classic case in how simulated data looks and how to interpret it.

The key with simulated data is changes that are small but are consistent throughout the lap. This arises for two key reasons:

- **The simulated driver always knows where the grip is.**
- **It knows no fear.**

For these two key reasons, the simulated driver will always be much more consistent than a real driver. Consequently, this is why you are always looking for small and consistent trends. The last thing you want is huge spikes in the compare time plot.

The other thing you'll notice when looking at simulated data is that you may not see big changes in throttle and steering, but you will see changes in speed. What is happening here is the simulator is driving to the grip of the car. It doesn't necessarily mean the driver is giving you bad feedback, but the simulator will always be more subtle about what it does. A really good case in point is the comparison between a standard and optimised setup in **Figure 4**.

As we can see here, the standard setup is coloured and the optimised setup is black. Looking at the speed trace there is no massive increase in speed – there are just a lot of little differences that have added up to a lot. This is exactly what you are after for a simulated change.

GP2's big tyre change

While the car itself remains static, new Pirellis aim to provide an F1-style feel

BY SAM COLLINS

Every year since its inception, Formula 1's official feeder series has updated its cars, simply to keep the teams on their feet. Every three years a totally new car is introduced, and in the intervening seasons there are changes to the package. Sometimes new bodywork or engine upgrades are included, and other times the changes are more subtle, but they are always there. Except, that is, in 2013.

'This year we have done nothing to the GP2 car – its the first time this has happened,' rues Didier Perrin, technical director of GP2. 'Money is driving the series for the moment and it's a very difficult period of time, so we have been very careful. So, no technical changes to the car.'

However, the teams cannot rest easy and use last year's setup data this season, as although there have been no changes to the car itself, the rubber it sits on is drastically changed.

'We asked Pirelli to change the tyres,' says Perrin. 'We wanted a more extreme difference between the prime tyre and the option tyre. We have made it much harder, similar to Formula 1. Any driver arriving in F1 will tell you that they struggle to get the best out of the tyres. It's not an easy thing for them to learn, but it is a key part of F1 at the moment, so it has to be a key part of GP2 as well. The teams have to think about their setup very differently, so maybe it is a more important change than any we could have done mechanically.'

The idea was that the tyres in GP2 would teach the drivers how to cope with the rubber in Formula 1, something that even former world champions seem to struggle with. Nonetheless, Pirelli's engineers in Milan were given a set of targets by Perrin and his team.

'We had several test sessions last year in order to develop a tyre with higher performance, as the old tyre was quite conservative,' explains Pirelli racing manager Mario Isola. 'We have used new materials and new compounds, but they are different to F1 as in GP2 they do not use tyre warmers so we need tyres that can warm up faster from cold to the optimal working temperature. Another target was to have two compounds at each track with a gap between them of 0.5 and 0.7 seconds a lap. We then limit the tyre allocation so the drivers have to manage qualifying and the two races with two sets of each compound. In total there are four compounds and we select different pairs for each track, the same as we do in F1.'

The tyres are behaving pretty much as ordered and are clearly giving some of the drivers a bit of a head-scratching time, but the Pirelli engineers also have to deal with some tough track conditions too. 'The tyres will degrade in different ways depending on the circuit,' says Isola. 'With Bahrain you tend to find that there is more thermal degradation, but at Barcelona and Spa you tend to get a lot of wear, especially on the left-hand side in Barcelona with all the long right-hand corners. Monza is tough too, as the speed is so high, and as the tyres cool down suddenly you might hit a kerb hard.'

Unlike the Formula 1 tyres which are produced in Izmit, Turkey, the GP2 tyres are produced at a new Pirelli factory in Slatina, Romania.

While many in the F1 paddock are critical of the tyres used there, the GP2 organisers asked Pirelli to replicate the exact same behaviour in the junior class. As was the case with the F1 teams, a cold winter in Europe left them in the dark regarding tyre data. 'In GP2, the teams can run a decent amount of sensors, but the teams had to adapt very quickly,' smiles Perrin. 'The problem was that the winter testing took place in Spain early in the year, but the temperature was so low that the tyres did not behave like they would in decent temperatures, so after the first two rounds in Malaysia and Bahrain they had a lot to do.'

Not everyone is keen on the changes, however. Adrian Newey does not feel that GP2 is offering the best solution to young drivers currently. 'We seem to be in a situation in GP2 where experience counts hugely, and quite often it will be drivers in their third or fourth season that win the championship, which seems to me quite an unhealthy way to be,' he argues. 'I think also now, with the way the tyres are behaving, then to have junior formulas where the tyres are lasting three or four laps before they've gone off heavily is not good. Young drivers need mileage, they need seat time and it concerns me that the way the lower formulae are going they're just not getting that.'

But Perrin defends their new stance on tyres. 'GP2 is not only a driver championship – it is also a team championship, so the teams have to change and adapt the car, and to do so they have to work with the driver. They have the same basic tools to work with as they did last year. I said that we did not change anything on the car, but the change with the tyres is bigger than anything we could have changed mechanically, apart from the aero.'

The order of the GP2 field will almost certainly change throughout the season as teams start to get an understanding of how to use the rubber. But once they do, they may have to start again. Pirelli is yet to sign a supply contract for the 2014 F1 season, and besides that the cars will be very different indeed.

"The tyre change is bigger than anything we could have changed mechanically, apart from the aero"

'I have a big problem for 2014. It is the end of the cycle for the current car, so normally we would develop an all-new car, but the new car should last for three seasons and I don't know what F1 will be like in 2014, visually or in performance terms. I am unable to define a new car,' he says. 'We may have to delay the new GP2 car to 2015. We need to ensure that the new GP2 car behaves like a Formula 1 car. People are focusing on lap time, but we are focused on the way it behaves. If there is something done that changes the Formula 1 cars then the GP2 car must react in the same way. There is only one way to do that and that is following the philosophy of the new Formula 1 rules. If with the new engine package the car becomes smaller, and teams get more from the rear wing, we need to do the same to be able to prepare the new drivers for F1.'

So nobody, including Perrin, seems clear on what will happen next year, or how they will cope with it. Something of a trend across motorsport right now.


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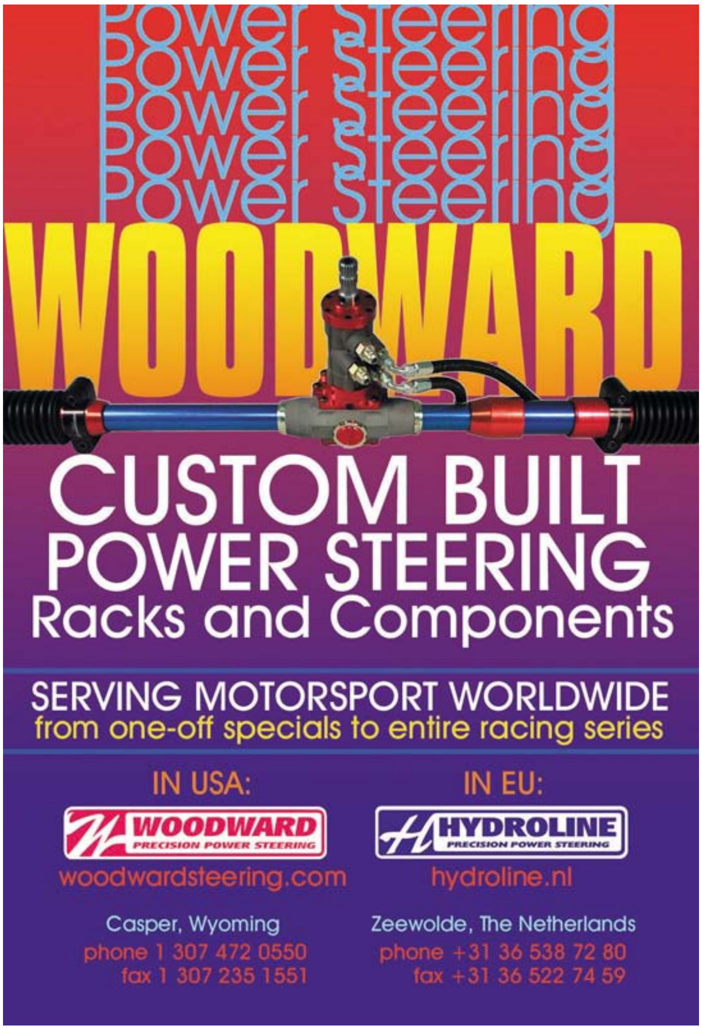
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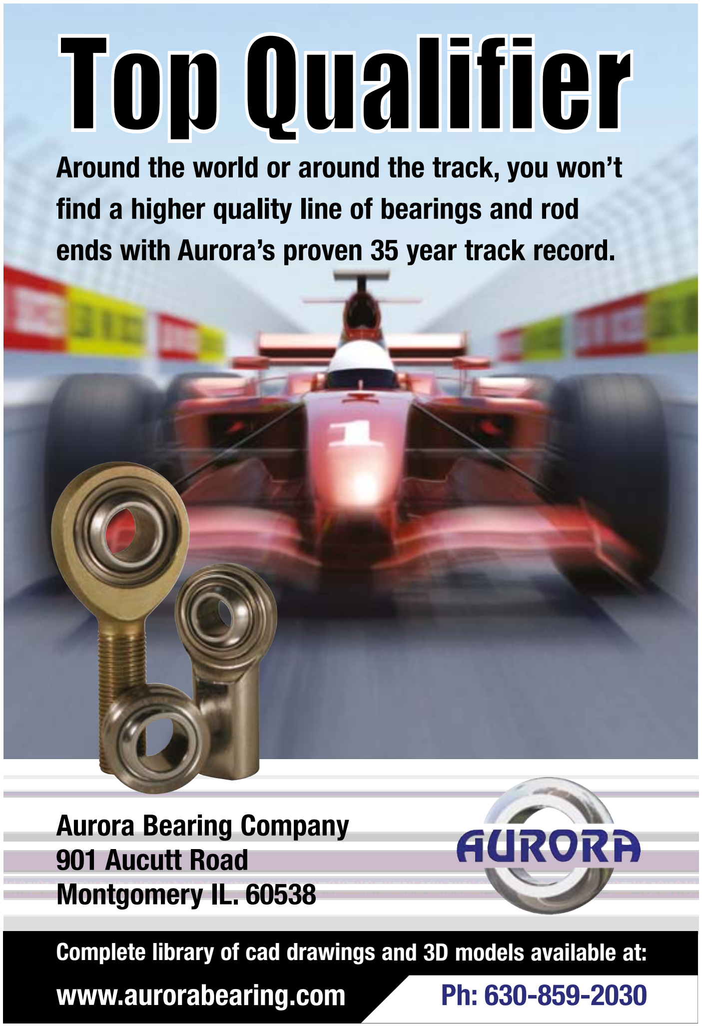
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Honda confirms return to Formula 1 in 2015

Honda is to re-enter Formula 1 as an engine supplier to McLaren in 2015. The Japanese car giant says that next year's change in engine formula has enticed it back in to the sport.

The company was last involved in F1 in 2008 but pulled out after an unsuccessful season, citing the onset of the global recession as its reason for leaving. However, it now says the new engine rules, and particularly their focus on energy recovery, have attracted it back.

Takanobu Ito, president and CEO of Honda Motor Co Ltd, said of its decision: 'Honda has a long history of advancing our technologies and nurturing our people by participating in the world's most prestigious automobile racing series. The new F1 regulations with their significant environmental focus will inspire even greater development of our own advanced technologies and this is central to our participation in F1.'

Ayrton Senna driving the dominant McLaren MP4/4 Honda in the 1988 Spanish Grand Prix

LAT

McLaren is still contracted to Mercedes for 2014, the first year of the new Formula, but its racing head, Martin Whitmarsh, says he is now keen to start working with Honda. 'Like McLaren, Honda is a company with motor racing woven into the fabric of its heritage,' Whitmarsh said. 'We're proud and thrilled to be joining forces once more to take on the world in Formula 1. While both companies are fully aware that we're embarking on a very demanding journey together, we're hugely committed to the success of the partnership, and we'll spend the next 18 months working together to ensure that we're fully established and competitive ahead of our first grand prix together in 2015.'

Honda is a powerhouse of the automotive world, bringing in revenues of $5.3bn last year, but the company's last spell in Formula 1, which ended at the end of 2008, was largely unsuccessful.

However, as an engine supplier Honda has enjoyed huge success in F1, particularly during its last spell as a partner to McLaren in the 1980s. The Honda-engined MP4/4 of 1988 (pictured) was so dominant in the hands of Ayrton Senna and Alain Prost it won all but one round of the championship, and the McLaren-Honda pairing went on to clinch three more crowns.

The company started in F1 as a constructor in 1964, taking its first victory the following year. It withdrew from the sport in 1968, only to return as an engine supplier in 1983. It supplied Spirit, Lotus, Williams, Tyrell and McLaren before quitting again at the end of 1992. In 2000 it returned as an engine supplier to BAR, a team that had morphed into a full Honda works effort by 2006.

PEELING BACK THE STICKERS: NUMBER 15: MARTINI

This year vermouth maker Martini celebrates its 150th anniversary, while 2013 also marks the 45th anniversary of its first motorsport sponsorship effort in 1968. But it was in the following year that 'Martini Racing' really got going, with the tie up with Porsche that was to become legendary.

The Martini colours graced Porsche sportscars right through the '70s – even rivalling Gulf for the most aesthetically pleasing 917 livery, perhaps – and then it was seen on Lancias in Group C and in rallying. There was also a tie-up with Brabham in F1 in the 1970s as well as a number of Alfa Romeo Touring Car programmes in later years.

Now the well-known livery is back in racing in a partnership deal with the F1-supporting Porsche Supercup. This will see nine-time WRC champion Sebastien Loeb competing, on at least two occasions, in a '911' that bears a striking resemblance to the car that won the 1973 Targa Florio.

Martini Vermouth and Italian Sparkling Wines, as the company is known, is now part of the Bacardi group of companies, the largest privately held spirits producer in the world. The group chalked up sales of US$4.6bn last year, which equates to a staggering (perhaps literally) 62 million nine-litre cases of its various drinks brands.

Jonas Krauss, the head of the Porsche Supercup said: 'We're excited to be once again partnering with Martini in its 150th anniversary year.'

UK race engine builder clinches Chinese deal

Race engine manufacturer Swindon has sealed a deal to supply an all-new powerplant to the Chinese Touring Car Championship.

The deal, which is similar to the company's existing arrangement with TOCA in the British Touring Car Championship, sees the UK-based operation providing an unbranded 1.6-litre turbocharged engine to teams.

However, this is not a spec engine for the championship, says Swindon's managing director Raphael Caille: 'It's an unbranded engine that anyone can fit into their touring cars and it comes off the shelf, in a similar way as we run the project in the BTCC.'

The engine, which Swindon engineers have been developing for the past six months, is also quite different to the 2-litre unit it supplies to the BTCC, Caille explained: 'It's a much smaller engine, because it's a 1.6-litre, and it is dry sump, whereas with the BTCC it is wet sump. It's a completely different unit.'

Swindon Engines will sell the powerplant through a company in China, but it will be on hand to support its customers at the races. 'Because China is quite a bit further away, we do have a CTCC company that handles the deals,' said Caille, 'so we sell to them and then they deal with the teams. We're too remote, really, to do the day-to-day business with the teams. However, our engineers and technicians will be there for the races, to give support as we do in the BTCC.'

Caille adds that while it's still very early days for the engine – and as of the time of writing no teams had signed up to use the unit – he hopes this deal might lead on to more work in Asia: 'It's a nice foot into Asia for us and from this I'm hoping we can do other things,' he said.

Swindon Engines was setup by John Dunn in 1971 and it remained in the Dunn family, working on engines for everything from F1 to rallying, until January 2010, when Caille bought the business.

BRIEFLY

Less is more for Ferrari

Ferrari is to cut production of its road cars by at least four per cent, despite an increase in sales. It says the reasoning behind the move is to preserve the exclusivity of the brand and Ferrari chairman Luca di Montezemolo has stated that he intends to cut the output of the Maranello firm to below 7000 vehicles – it sold 7318 last year. The idea is to protect the resale value of Ferraris, Montezemolo explained. The Italian company has already seen a growth in revenue in 2013, posting sales of €551m for the first quarter, which is up eight per cent, and chalking up a net profit of €54.7m, an increase of 36.5 per cent.

Marussian front

It's been reported that Lloyds Development Capital (LDC), the private equity division of UK government-owned Lloyds bank, has sold its 25.3 per cent stake in the Marussia Formula 1 team to the Russian sportscar maker the team is named after. The sale of the Marussia team shares to Marussia Motors means that the Russian car producer now owns 92.7 per cent of the outfit, with the remaining 7.3 per cent taken by former and current members of the team's management.

Williams: "It was really nothing"

The Williams Group made a loss of close to £5m last year, despite an upturn in fortunes on the track which included its first grand prix victory in eight years, and a 22 per cent increase in turnover.

The £4.7m loss, which compares to a £7.4m profit in 2011, has largely been put down to a technicality in the accounting by Williams, which says a £9.4m pay-out it received from Formula 1 for committing to the championship for the next few years was not taken into consideration.

'This £9.4m of revenue was a one-off payment from FOM following a new commercial agreement for our continued commitment to Formula 1,' Williams communications executive James Francis told *Racecar*. 'We felt strongly that this should have been included in the results, as the only way this would have to be repaid would be if we withdrew from the sport at some point before 31 December 2015 – which if we did, Williams wouldn't exist.'

However, even if the FOM payment was taken into account, the profits for the group would still be down on 2011 (at £4.7m), although Williams insists this is because of continued investment by the company. Williams did report an increase in turnover in 2012, with its core business seeing an increase from £102.3m to £124.3m, while there was an increase in overall group turnover of 22 per cent to £127m, compared to £104.5 in 2011.

Renault plugs in to Formula E racecar programme

Formula E's credibility has been boosted massively with the news that Renault has signed up as a technical partner to its car constructor, Spark.

The 42 Formula E single-seaters built for the beginning of the first season will now be named Spark-Renaults. The organisation behind the championship – Formula E holdings – has also released new images of the racecar (see right).

Formula E boss Alejandro Agag said the importance of getting a major motor manufacturer involved in Formula E, which kicks off next year with a series of 10 races around city street venues, could not be underestimated: 'Renault and Formula E both share the same commitment to innovative technology and sustainable motoring and we're delighted to welcome them to the championship as a founding partner.

'Not only is Renault one of the world's leading car manufacturers, with a very successful motorsport pedigree, it is also a pioneer for electric vehicles – being the first full-range car manufacturer to market zero-emission vehicles. To have a manufacturer of this calibre onboard is a great testament to the growing appeal of the FIA Formula E Championship.'

Philippe Klein, executive vice-president, corporate planning, product planning and programmes at the Renault Group, said. 'We believe that motorsport is an efficient manner to promote the efficiency of new technologies, and we're eager to use that single seater in FIA Formula E championship to show our technology is the best.'

Frédéric Vasseur, CEO of Spark Racing Technology, said of Renault: 'Their record and involvement in high level motorsport speaks for the brand. In addition, Renault has always been at the forefront of innovation and having their expertise and know-how is invaluable at such a key moment in the creation of the FIA Formula E World Championship.

'This partnership with Renault is a new cornerstone in a building harmoniously taking shape at all levels.'

SEEN: SEAT LEON CUP RACER

This offering from SEAT might well form the basis of a new Touring Car from the Spanish company, its motorsport boss says. Unveiled at the popular VW meeting in Worthersee, Austria, SEAT says the car is prepared for a wide range of racing series worldwide. It packs a 2-litre, four-cylinder turbocharged engine which should produce 330bhp with 350Nm of torque. Power is fed to the front wheels via a six-speed DSG dual-clutch gearbox and an electronically controlled differential lock. There is also to be a special variant of the Cup Racer for endurance racing which can be equipped with a sequential racing transmission with a shift lever on the centre console and a mechanical differential lock.

A preliminary price for the Leon Cup Racer has been set – the version with DSG transmission will cost €70,000, while the endurance car is priced at €95,000.

Jaime Puig, head of SEAT Sport and the man responsible for the brand's motorsport activities, said of the new racecar: 'We expect to be able to offer the Leon Cup Racer to our customer teams as early as the 2014 season. With the two versions for sprint and endurance racing, the Cup Racer is ideal for an extremely broad palette of racing series – from the ETTC to the VLN Endurance Cup on the Nürburgring.'

Puig also said that a modified version of the car might see action in the WTCC, in which the Spanish manufacturer last competed as a works entrant in 2009: 'We can also envisage further developing the Cup Racer to create a WTCC version with a 1.6-litre engine. After all, we have a great tradition to defend there,' Puig said.

Ultrasonic sensor ready

The ultrasonic fuel flow sensor that is at the heart of Formula 1 and the World Endurance Championship regulations in 2014, will be available for Formula 1's young driver test at Silverstone in July.

British company Gill Sensors has developed a product that has met all the criteria set by the FIA, and will make the sensor available for final evaluation.

There has been a delay in the homologation of the product, and the consequent delivery to teams and manufacturers, all put down to finalising the commercial arrangements.

Nigel Mills, engineering manager at Gill Sensors, said: 'The meters will be available in the timescale set. We are a manufacturer of meters and we will make them available for the F1 test at Silverstone in July.'

Fabrice Lom, head of the FIA's drivetrain department, said: 'All of the technical issues are cleared as far as I am concerned. The last validation test proved that the sensor is able to match the FIA's requirements for both petrol and diesel.'


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Formula Ford attracts new chassis manufacturers

There are signs of a small resurgence in chassis manufacturing in Europe on the back of the launch of the all-new Formula Ford 200, with two more racecar producers now lined up to compete in the UK championship.

The new be-winged Formula Ford 200 currently features chassis from Mygale and Sinter, but Formula Ford Championship of Great Britain manager Sam Roach told *Racecar* he is hopeful that two more cars might make their debuts soon. 'We've got two chassis manufacturers represented currently, with the hope that there are going to be one or two more before the end of this year,' he said.

One of these new cars will be from well-known Formula Ford manufacturer Ray, while the other will be the product of French concern Beta Epsilon, which is known for the work it did on the current Formula Renault.

Gavin Ray, at Ray Racecars, told us he is hopeful its new car, the GR13 (chassis pictured), will be ready by the end of the year. 'It's moving along nicely,' he said. 'The chassis is there, it's all designed, we just haven't done the bodywork as yet. There's a chance that it will be out this year, if we can get customers for it, and we have already spoken to a number of teams.'

Ray added that the GR13 will be priced at around the £40,000 mark and while the chassis has yet to undergo its crash test – the new Formula Ford needs to meet the FIA's stringent new spaceframe regulations – he is confident it will pass without a problem. Ray also says he believes the car will be around 10 per cent smaller than the current offerings from Mygale and Sinter, thanks to a careful interpretation of the regulations.

The chassis from Beta Epsilon has already passed its crash test, says Roach, who believes the French concern is close to completing its car: 'They are a long way on in the process,' he said.

Formula Ford is now perhaps the only multi-chassis professional-level single seater formula in the world, apart from Formula 3, which is currently dominated by just one manufacturer, Dallara.

Silverstone in frame for lottery millions

Silverstone circuit has taken the first step towards scooping a £9.1m grant from the body which distributes lottery money to sites of historic interest.

The British Racing Drivers' Club (BRDC) and Silverstone Circuits Ltd have been awarded a first round pass for a £9.1m bid to the Heritage Lottery Fund (HLF) for its project 'Silverstone Heritage Live'.

The initial funding allocated by the HLF for this project is £446,068, to which the BRDC will add further cash and volunteer input to allow development work to a total value of almost £892,136, helping the BRDC and Silverstone progress its plans to apply for the full grant in 2014.

Silverstone Heritage Live, set to open in 2016 creating up to 50 jobs, will feature the BRDC archive, a heritage trail and live interactive experiences within a 'Heritage Hub' located at the entrance to the circuit.

SEEN: HYUNDAI I20 WRC

LAT

This is the first look at the new Hyundai i20 WRC that will makes its championship debut in 2014

The car completed a shakedown in a private test session, in which the team checked systems and different set ups, while particular attention was paid to collecting feedback on the i20 WRC's 1.6 litre turbocharged engine as part of the continuing development of the powertrain. The car completed more than 550km over three days. 'I think that we are starting from a good base that we can use to carry on working, says Team Principal Michel Nandan. 'This is crucial considering the tight schedule we have until the end of the year. We have now a lot of useful feedback to digest for the next steps of our preparation.'

The i20 WRC will continue to test around Europe and on different surfaces to reflect the conditions that the car will face in competition. 'We are not disclosing our specific test venues or the names of the various drivers we will have, but we will ensure that every aspect of the car's performance is put to the test and thoroughly evaluated without leaving anything to chance,' said Nandan

BRIEFLY

D&R takes R&R

Dreyer & Reinbold Racing has said it will no longer be taking part in the 2013 season due to a lack of funds, and this year's Indy 500 will be its final appearance. The team says it will retain a core group of employees at its Carmel, Indiana base, while it is also eyeing up opportunities in other racing series.

Made to measure

Renishaw has received a prestigious Queen's Award for Enterprise. The company was given the award, in the Innovations category, for its REVO five-axis multi-sensor probing system, used on co-ordinate measuring machines (CMMs) to improve accuracy and through-put. It is the company's 16th Queen's Award since its formation in 1973.

Testing times

F1 teams have discussed bringing back in-season testing at the Spanish Grand Prix. It's believed that the idea has been pushed by Ferrari, which not only has its own test track at Fiorano but also owns Mugello. However, the majority of the teams voted against the proposal.

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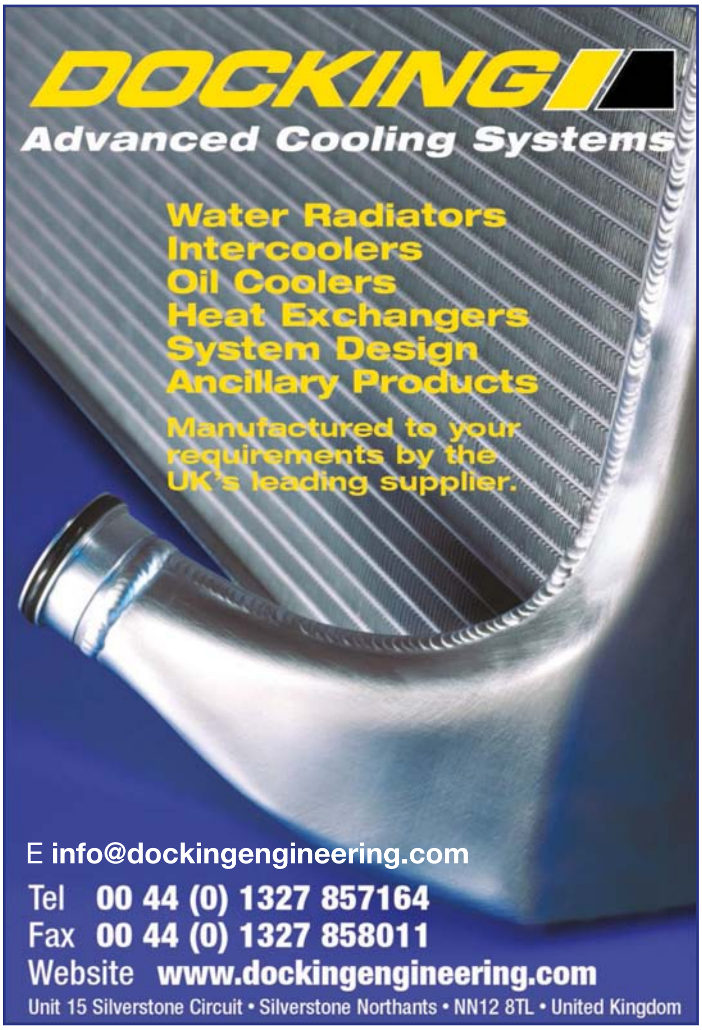

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INTERVIEW: STEVE THOMPSON

Steve Thompson, European motorsport manager at Kumho Tyres, is a trained engineer and has been at the company for 11 years. Before joining Kumho, Thompson worked for Michelin for 23 years, running the French company's UK motorsport programme for a time towards the end of his spell there. Kumho supplied the F3 Euro Series until the end of 2011, and it's still the control tyre for the Zandvoort Masters event, but since 2012 its primary motorsport programme has been Auto GP.

Is there anything that has surprised you since Kumho became involved in Auto GP?
We have different compounds as they do in Formula 1. But where the F1 teams change all four tyres, in Auto GP there are fewer people able to work on the cars at the pit stops so they only change two tyres at a time, so at some point we have a mixture of the two compounds that are available for that particular event. It was a surprise, but it's very interesting, and I think you will find it's the only single-seater series where this happens.

How counter-intuitive is it for a tyre manufacturer to design tyres that are meant to degrade?
It's totally against the philosophies of the tyre designers and I don't think we've really mastered it yet, to be honest. It's a case of, how far do you go with this? It seems it's the fashion at the moment, because of what's happening in Formula 1, people want you to produce tyres that create problems, but that is totally against the philosophy of tyre design for racing cars, for me anyway.

What changes have been made for your second year as tyre supplier to Auto GP?
We've changed all three of the compounds that we used last year, based on our experience. We've made the medium and the soft tyre both slightly softer, and we've made the super-soft tyre that we use in Marrakech slightly harder.

The rallying you're involved in is an open competition as far as tyres are concerned. Is that preferable, and would you like this to be the case in racing?
I suppose so. There's more kudos to a win if you are actually in competition with others. My view is that, certainly in the top levels of motorsport – Formula 1 and WRC for instance – it should be open to competition for everything. Whether it's the cars, tyres or engines, it should be a competition.

What other forms of motorsport are you involved in?
We're also doing some endurance racing in the VLN around the old Nürburgring Nordschleife. We've worked for a couple of years now with Peugeot with their RCZ, but this year we've signed a deal with a team called Twin Busch which runs an Audi R8. So we've been developing some 18in slick, intermediate and wet tyres for that.

The Nürburgring Nordschleife is unique. The tarmac is completely different, then there's the length of the track. The grip levels change there all the time – it's a lot more bumpy, and there are lots of crests where the cars get airborne, so there are a lot of differences.

You can test on the grand prix track at the Nürburgring and your tyres work perfectly well, and then when you go to the Nordschleife there are completely different performance parameters, so it's very interesting.

Lotus plays down impact of Allison departure

Lotus team principal Eric Boullier has said he believes that the loss of its highly regarded technical director James Allison (pictured) will not have too much of an adverse impact on the performance of the team.

Lotus announced that Allison had left the team in May, and that he has been replaced in the role of technical director by Nick Chester. Allison had been with Lotus since 2005, first as deputy team director when the outfit was still known as Renault, and as technical director from 2009. He was also a member of the team at the start of his F1 career, in 1991, when it was known as Benetton.

Allison has been given credit for much of Lotus's current success – at the time of writing it was third in the constructors' standings, just behind Ferrari, with one victory to its name – but Boullier was keen to play down the effects of his departure: 'James is going to be a loss, but I think we have a smooth transition with Nick Chester taking over,' Boullier said. 'Nick's been with us for 12 years, he knows everybody, and obviously I had time to prepare the transition, thanks to James telling me he was leaving in good time. So I don't think you will see any difference, to be honest.'

Chester has been promoted from within the team, which he joined in 2000 after five years with Arrows. 'Nick is well known to everyone at Enstone having been with the team for over 12 years,' said Boullier. 'He is already directly involved with this and next year's cars, ensuring a smooth transition which has been under way for some time.

'It's an illustration of the strength and breadth of talent at Enstone that we can draw on personnel of the calibre of Nick and it's something of an Enstone tradition for new technical directors to be promoted from within,' Boullier added.

At the time of writing it was not known where Allison would be going next, although there was some talk that it could be Ferrari.

Racing's richest rank high in wealth stakes

Motorsport personalities have once again featured heavily in the *Sunday Times Rich List*, a popular guide to wealth in Britain and Ireland.

Unsurprisingly, top dollar taker from the racing world is Bernie Ecclestone, who is listed at number 26 with estimated assets of some £2.5bn, which while down three positions on the list is the same wealth estimation as last year. Incidentally, Ecclestone's ex-wife Slavica still comes in ahead of any other motorsport personality (at 116) with the £740m she pocketed as a divorce settlement.

Next up on the list is Paddy McNally (at 209th), the man behind the F1 Paddock Club and Allsport, which handles the trackside advertising at F1


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IndyCar signs up Walker to new head of racing role

Derrick Walker (pictured) is to join IndyCar as its president of operations and competition, a post that will see him responsible for all the technical and sporting aspects of the premier US single-seater series.

The former team boss and team owner will now hold one of the most senior posts in IndyCar, with senior vice president of operations Brian Barnhardt, race director Beaux Barfield and vice-president of technology Will Phillips among those reporting directly to him.

Mark Miles, chief executive officer of Hulman & Company, IndyCar's parent organisation, said of the hiring of the 68-year-old Scot: 'We're pleased to welcome Derrick Walker to this vital role. We spoke with many of our constituents about an ideal person for this job, and Derrick's name emerged early and often.'

Miles added that Walker's experience was central to him being awarded the job, which is a newly instituted position within the organisation: 'After speaking with many talented candidates, Derrick stood out because his decades of experience in North American open-wheel racing blend ownership and management for his own race teams and other teams.'

Among Walker's responsibilities will be enhancing communication with team owners, manufacturers and suppliers, fostering innovation within the current technical platform with an eye toward future development and sustaining safety initiatives.

'I'm from the team background – I never have crossed over to the official side. So this is for me not only an opportunity, but a real challenge that I'm looking forward to,' Walker said. 'I feel if I can give something back to the sport, then I'd love that opportunity.'

Walker, who has most recently been team manager at Ed Carpenter Racing, has enjoyed a four-decade career in motorsport and has worked with teams such as Ferrari in sportscar racing, Brabham and Penske in F1 and Porsche and Penske in IndyCar, in addition to his 19 years as a team owner at Walker Motorsports.

SPONSORSHIP

The Williams Formula 1 team has picked up backing from the Kazakhstani investment business, **TAK Group**. The deal involves Astana, the capital of Kazakhstan, being promoted on the car and the city's name has been positioned on the outer nose struts on the Williams-Renault FW35 since the Spanish Grand Prix. Astana has been the capital of the Republic of Kazakhstan since 1997 and is a UNESCO World City. Situated on a bank of the Ishim River, it has become one of the largest business centres in the region and is to be the site of Expo 2017.

Paint and coatings company **Sherwin-Williams** has signed a multi-year deal to sponsor **NASCAR**, where its product will now be the official paint. As part of the deal, the company will provide the fastest lap award in the NASCAR Sprint Cup. With sales of $9.53bn a year, Sherwin-Williams is the USA's number one paint and coating company.

Luxury timepiece manufacturer **TAG Heuer** has signed on as Official Timekeeper, Official Watch and Chronograph and Technical Founding Partner of the **FIA Formula E Championship** for electric racecars.

RACE MOVES

Eddie Jordan came close to buying Team Lotus in 1990, the year before he came into Formula 1 with his eponymous team. The news emerged when documents were unearthed that showed that in November 1990 the Allied Irish Bank in Northampton contacted lawyers acting for Team Lotus to confirm that Jordan had the necessary funding (£1.5m) to purchase 100 per cent of the equity of the team.

There have been a number of changes in the management structure at Le Mans and WEC organiser the Automobile Club de l'Ouest, chiefly focused upon the setting up of four operating departments. Head of the new Development department is now **Patrick Maitrot**, formerly of Eurosport. Meanwhile, Current AVO marketing and communications manager **Fabrice Bourrigaud** will head up the Esprit Le Mans department, while the Le Mans Resort department will be headed by **Ghislain Robert**. **Vincent Beaumesnil** will be in charge of the Sporting department. The new structure will come into place at the beginning of July.

James Warburton is the new chief executive officer of V8 Supercars, the company behind the premier Australian motor racing series. Warburton replaces **David Malone** in the role, the latter having stepped down. Warburton is described as a 'world-class senior executive with vast expertise in the media, marketing and advertising sectors'.

Former CART boss **Chris Pook** has joined the board of the New Jersey Grand Prix as assistant to its chairman, **Leo Hindery Jr**. A well-known figure in American motorsport, Pook founded and ran the Long Beach F1 race and has also been involved in other well-known US street races, including Detroit, Las Vegas and Dallas. The inaugural New Jersey race is currently set to take place in June of next year.

Jackson L Dodson II, a crew member in the NASCAR Sprint Cup Series, and **Frank W Earnhardt**, crew member in the NASCAR Nationwide Series, have both been indefinitely suspended from NASCAR for violating the sanctioning body's strict substance abuse policy.

Former Formula 2 co-ordinator **James Gornall** is now head of motorsport at insurance broker Ellis Clowes. Gornall has an in-depth knowledge of the motor racing scene, gained during his time at MotorSport Vision and during his 18 years as a competitor in karting, single seaters and GTs.

Mick Ronke, the owner of Australian V8 Supercar venue Winton Raceway, has passed away. Ronke was said to be fiercely proud of his facility, for the great racing it often hosted as well as the unrivalled track views it gave from most of its spectator areas.

Ferrari technical head **Pat Fry** was taken to hospital during the Spanish Grand Prix weekend after he was diagnosed with appendicitis. Fry underwent what was described as a routine operation on the Saturday afternoon and at the time of writing he was expected to be back in action for the Monaco Grand Prix.

Sue Brownson, a senior independent director at UK motorsport governing body the Motor Sport Association (MSA) has died following an illness. Brownson became the first female MSA board member in 2008 after a successful career in the motor industry.

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


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GAUGES

Viper Performance Durometer

In recent times, Viper Performance has been releasing new products at a rate of knots, and the latest addition to its professional tool range is a Shore A Durometer. The Durometer is designed for testing the hardness of various rubber, polymers, elastomers; making it ideal for assessing tyre compounds to ensure consistency from wheel to wheel. The gauge can measure from 0-100 Shore A units and is powered by a single battery, making it an ideal addition to any pit box.

For more details, visit www.viperperformance.co.uk

INSTRUMENTS

MoTeC colour cockpit display

The current must-have products from high-end dashboard suppliers are full-colour displays. MoTeC is the latest company to join the party with its new D175 colour display. The dash features an anti-reflective 5" LCD screen that delivers exceptional brightness and crisp graphics, even in direct sunlight. Users can choose from eight screen layouts, all designed with maximum visibility in mind. The D175 also features an integrated array of high intensity LEDs for use as shift lights, warnings or other driver alerts. The function, colour and brightness of each light is completely programmable, which allows teams to develop unique communication strategies for the driver. The new display is designed for use with any MoTeC data logger, current or superseded, connecting via CAN and using the logger's software to configure the screen layout and LEDs. In future the D175 will also have its own configuration software, allowing it to run standalone with full customisation of the screen. A smaller D153 display is also available, which is ideal for mounting on the steering wheel.

Visit www.motec.com for more information

PIPEWORK

DEI 'Titanium' Pipe Shield

This is the latest offering from thermal protection specialists DEI – a pipe shield that provides heat protection up to 732degC. The 'Titanium'-branded pipe shield doesn't actually contain any titanium, but it does provide excellent protection from high radiated heat. The outer layer of the shield is made from powdered volcanic rock, tightly woven into a heat-proof weave made from high silica content threads. This proprietary fibre technology, combined with a standoff bracket design to create an air gap between the shield and pipe, provides maximum cooling and heat dissipation. The heat shield is intended to provide protection in critical areas such as near transmissions, brake lines, wiring, fuel tanks, pipes and other sensitive areas.

More information available at www.designengineering.com

MACHINING

Haas HRC210

Machine tool manufacturer Haas recently introduced its HRC210 rotary table for Haas three-axis mills, adding a fourth working axis. The high speed, cam-driven rotary table provides cutting and indexing speeds up to 830deg/sec. It also has 149Nm of spindle torque for synchronous four-axis machining and a pneumatic brake that yields 182Nm of holding torque for stationary work. Six radial T-slots simplify fixture and workpiece mounting, and both manual and pneumatic tailstocks are available for additional workpiece support. Because the roller drive is preloaded during assembly, the system yields high stiffness, high torque and high speeds, while providing low wear characteristics and reducing maintenance.

For more information visit www.haascnc.com

THROTTLE

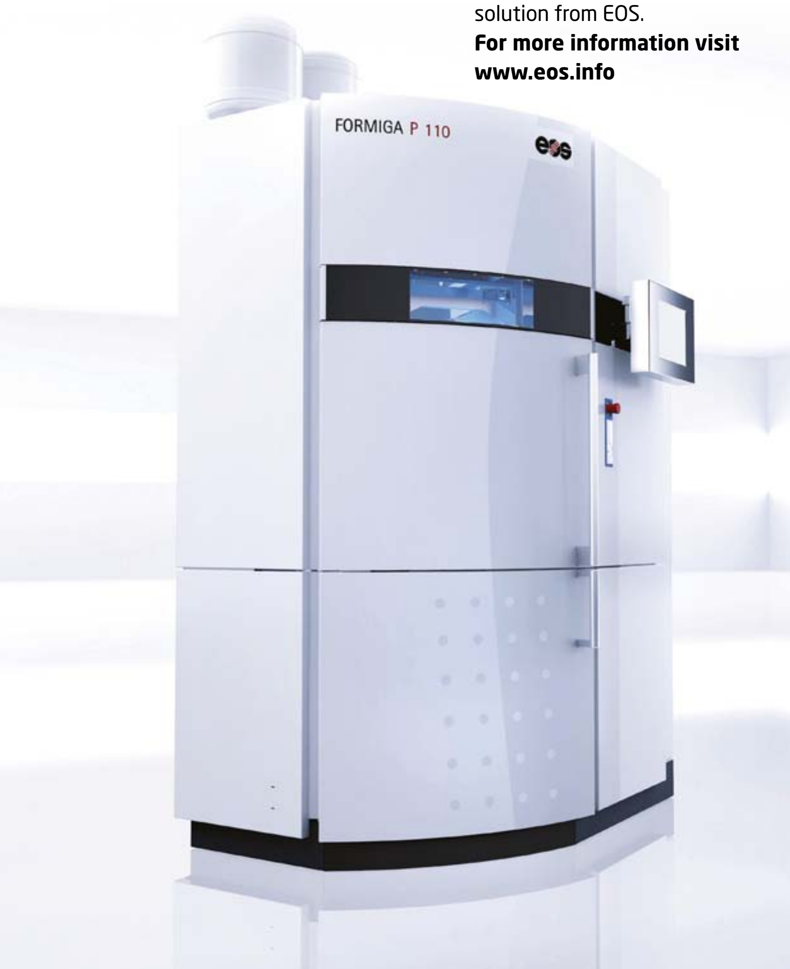
Jenvey TAP48i throttle bodies

Since the 1960s, the Weber 48IDA carburettor has been a stalwart of the racing world, fuelling engines as diverse as Porsche Boxster sixes and Detroit V8s. To help bring these engines into the 21st century, fuel injection specialist Jenvey has introduced a throttle body designed to directly replace the IDA carburettor.
While at first glance it may appear that any throttle bodies designed to replace Weber IDFs would suffice, IDAs in fact have a larger bore spacing; 120mm as opposed to the IDF's 90mm. The new throttle bodies are available either singly or in pairs, while Jenvey also produces dedicated fuel rails.
For more details, visit www.jenvey.co.uk

3D PRINTING

EOS Formiga P 110

German additive manufacturing system manufacturer EOS has introduced a system for 3D printing components by laser-sintering plastic powder. The EOS Formiga P 110, which has a build envelope of 20x250x330mm and a 30W CO_2 laser, manufactures products made of polyamide or polystyrene directly from CAD data within a few hours. EOSPPACE software allows parts to be nested within the build chamber to make optimal use of the available space, production times and costs. As data preparation takes place conveniently at the integral workstation, the system is suitable for decentralised production areas. Integration of the system into industrial production environments is supported by the newly developed Integrated Process Chain Management (IPCM+) solution from EOS.
For more information visit www.eos.info



SOFTWARE

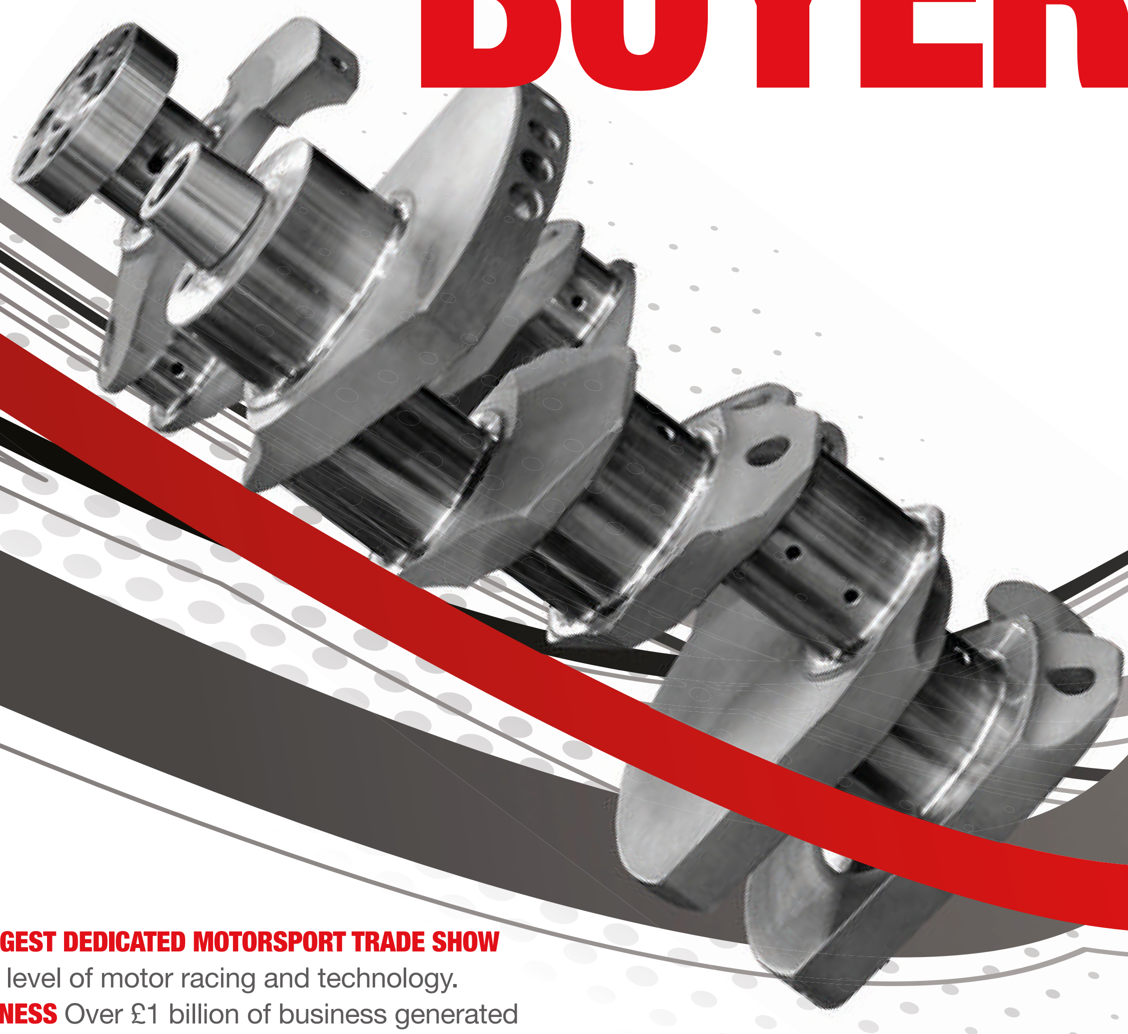
Altair PBS Analytics

High Performance Computing (HPC) specialist Altair recently announced the release of its completely redesigned PBS Analytics 12.0 data analysis and visualisation tool. The web-based tool has been released in response to a burgeoning demand for more comprehensive analysis of HPC usage within organisations.
To provide superior, more insightful data analyses, PBS Analytics 12.0 furnishes new ways to visualise HPC operations, track job and resource use and perform root-cause analyses.
A particularly helpful feature of PBS Analytics 12.0 is its new presentation capabilities, notably the ability to create dashboards and slideshows. Dashboards are collections of charts that detail such information as trends in cluster usage, individual usage, most popular nodes and other data. Slideshows can include regular charts, dashboards, and even locally created slides and graphics, and cycle through the visualisations in a continuous loop.
For more details log on to www.altair.com

CONNECTORS

SFC Hydraflow 14J21 Clamshell connector

Specialty Fasteners & Components has been announced as the global distributor for the new Hydraflow 14J21 clamshell connector.
The 14J21 is completely interchangeable with existing clamshell connectors and improvements include an integral safety strap, articulated hinges, thicker flanges and internal bonding wires.
The results are increased performance, durability and safety – with no weight penalty. Finished in easy to identify red, the 14J21 series is offered in all tube diameters from 0.5" through to 4" with butt weld aluminium flanges and seals offered to complete the package. CAD models are also available upon request.
More details available at www.specialty-fasteners.co.uk



The build up starts here for Autosport International

Racecar Engineering is proud to once again be the official media partner of Autosport Engineering, an integral part of Autosport International. The show takes place at the NEC Birmingham 9th - 12th January 2014.

The build up to the show season has already begun with a host of new companies looking to build on their successful programmes and preparations are already underway for the Autosport International Show which starts on January 9th, 2014.

Leading companies from all over the world come to showcase their latest products technologies and materials. Many of these companies return year after year as they enjoy networking and building relationships with people they have met at the show.

Here at Racecar Engineering, media partners to the Autosport Engineering show, we consider that your company will receive a host of benefits by attending the show. You will have the opportunity to meet and network, with more than 28,000 trade visitors from across five continents - all focused on the practical use of leading edge technology and components used in the motorsport industry. You can deliver your message directly to a trade audience, looking for solutions products and partners, raise your company profile and increase brand awareness, and launch new products or services.

This exhibition offers the ideal launch pad for new developments, products and services in front of the leaders in motorsport technology from the world's leading race teams, as well as leaders in the world of powertrain, drivetrain, chassis, and electronic industries.

You can meet your existing clients, exhibit your products to the 85% of visitors who state they intend to make a purchase directly at the show, and get exposure all year round through mail, telemarketing, email, web and social media activities.

A new website is currently under construction and is being launched shortly. It will contain all the latest ticketing information.

The world comes to Autosport International

Arrow Precision, a UK company based in Leicestershire who manufacture connecting rods and crankshafts, exhibited at the first show in 1993. They were then a small company. However, they are now a leading global supplier to both the motorsport and OE car manufacturers. The company's MD, Ian Arnold, is certain that his company owes its success to his presence at Autosport Engineering.

Already booked into the show this year from overseas are some of the world's leading companies; **Brembo SpA** (Italy), **Bosch** (Germany), **Electronz** (New Zealand), **Ferrea** (USA), **Pistal** (Italy) **ARP** (USA), **Supertech** (USA), **Swedish Motorsport Industry** (Sweden), **Total Seal Piston Rings** (USA).

In addition, you can see the latest technology from; **Arrow Precision, Earls Performance, Kulite Sensors**, **DC Electronics**, **Motec Europe**, **Nicholson McLaren Engines, Xtrac Transmissions and Zircotec.**

For further information on how to exhibit, or to attend Europe's premier motor sport show, please contact our head of business development, **Tony Tobias**

tony.tobias@haymarket.com.

HIGHLIGHTS OF THE 2013 SHOW

Launch of the Ralph Firman-designed MSV F4-013 for the all-new BRDC Formula 4 Championship, the all-new Radical RXC, and the Sin R1 sportscar project

Versarien drew acclaim for its revolutionary new heat transfer material for constrained environments, VersarienCu. The micro-porous metallic material won the Graham Jones award for technical innovation.

Ole Buhl Racing Showcased its all-new Power Control Module, the PCM2, which follows the success of the original unit, launched in 2006, as one of the first computer-controlled battery power junctions

Neil Brown Engineering Launched its new Formula 3 engine in conjunction with project partner and ASI exhibitor Cometic Gasket. The engine is built for new regulations allowing totally bespoke engines, moving away from the use of production blocks.

Zircotec unveiled two new products; a gold heatshield and a gold finish for its carbon composite coatings, offering up to 98 per cent reflectivity

DC Electronics launched a Motorsport Electronics Engineer Training Programme

Vero Software displayed its newest CAD/CAM releases, ALPHACAM, EDGECAM and VISI

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More green shoots for eco racing

The return of Honda to the Formula 1 world championship is a welcome addition to the list of engine suppliers. There is talk that the Japanese manufacturer will also run a Le Mans prototype next year, circumnavigating the RRA that governs F1. However, according to some, the likelihood is that it may not enter the World Endurance Championship. WEC, too, is governed by a testing restriction.

Why did Honda decide to return? According to Takanobu Ito, president and CEO of Honda Motor Co Ltd, the official reason is this: 'The new F1 regulations, with their significant environmental focus, will inspire even greater development of our own advanced technologies, and this is central to our participation in F1.'

Formula 1 is pushing the green agenda, with 1.6-litre engines and powerful energy recovery systems. Bernie Ecclestone has tried to delay the introduction of these regulations, and openly criticised the potential lack of noise that the small capacity turbo engines may produce. Renault responded by revealing details of its 2014 engine to *Racecar* last October, and highlighted the investment it had already made.

Mercedes and Ferrari were also pushing the development of their engines, and all the teams are worried about a) the cost and b) the effect on results should anyone make a miscalculation and produce a below-par engine – or indeed the reverse, that someone gets it so right that they disappear into the distance.

For Honda to be returning on the green credentials says more about F1's standing in the world as a brand than it does about technical development. The hybrid systems will be interesting, and the new engines will be smaller, but as Peter Wright highlights on page 44, there is far more potential to be gained from synthetic fuels, environmentally sustainable and with a plan to make them carbon neutral, than there is to follow the hybrid path. Or Formula E, for that matter.

As Aston Martin demonstrated at the Nürburgring 24 Hours, hydrogen fuel is also a possibility, with the opportunity to mix gasoline and hydrogen, or to run on the different fuels independently. So, should you wish to drive through town on zero emissions, or drive to Italy for a weekend away, you can theoretically do so in the same car. This makes it more attractive than electric alternatives, where a recharging network still needs to be established while manufacturers are working on extending range, reducing recharge times, and reducing the reliance on rare minerals.

Audi has had its 'air hybrid' system declared to be not conforming to the rulebook at Le Mans, wasting 15 months of development. This could have been a disaster for the endurance racing programme, except that there was such a benefit from other areas of development – the blown diffuser and the tailoring of the MGU to deliver more power at the slower tracks in the WEC – that it was not all that relevant. However, the push for technology is there.

And it goes on. The 2013 FIA Junior WRC Championship is running on a blend of gasoline, bioethanol and bio-methanol, which has a largely increased biomass limit and reduces the impact of greenhouse gases by more than half compared to regular fuel. There are solutions being sought throughout racing, with companies looking to enhance their green credentials through performance, as well as taking advantage of rulebooks that are sensitive to our transport problems.

Powerful hybrid systems are interesting, but there's more potential in fuels

F1 is a global brand where success can be magnified exponentially, as can failure. 'We have the greatest respect for the FIA's decision to introduce these new regulations that are both highly challenging, but also attractive to manufacturers that pursue environmental technologies and to the Formula One Group, which has developed F1 into a high value, top car racing category supported by enthusiastic fans,' says Ito. F1 has won the support of Honda, but there are so many racing series that are offering the opportunity for impressive experimentation that it would not surprise me to see many new manufacturers opting for a race programme once the 2014 season gets under way. Porsche's involvement at Le Mans in 2014, and Honda's in F1, is only the start.

Correction: In our June edition, we repeated a misconception that 'Jubilee clip' is a term for a type of small hose clamp, without acknowledging that it is in fact a trademarked product originally patented by L. Robinson & Co (Gillingham) back in 1921. We will take care to ensure that this error is not repeated. Our thanks to Jubilee Clips Ltd for bringing this to our attention.

EDITOR
Andrew Cotton

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