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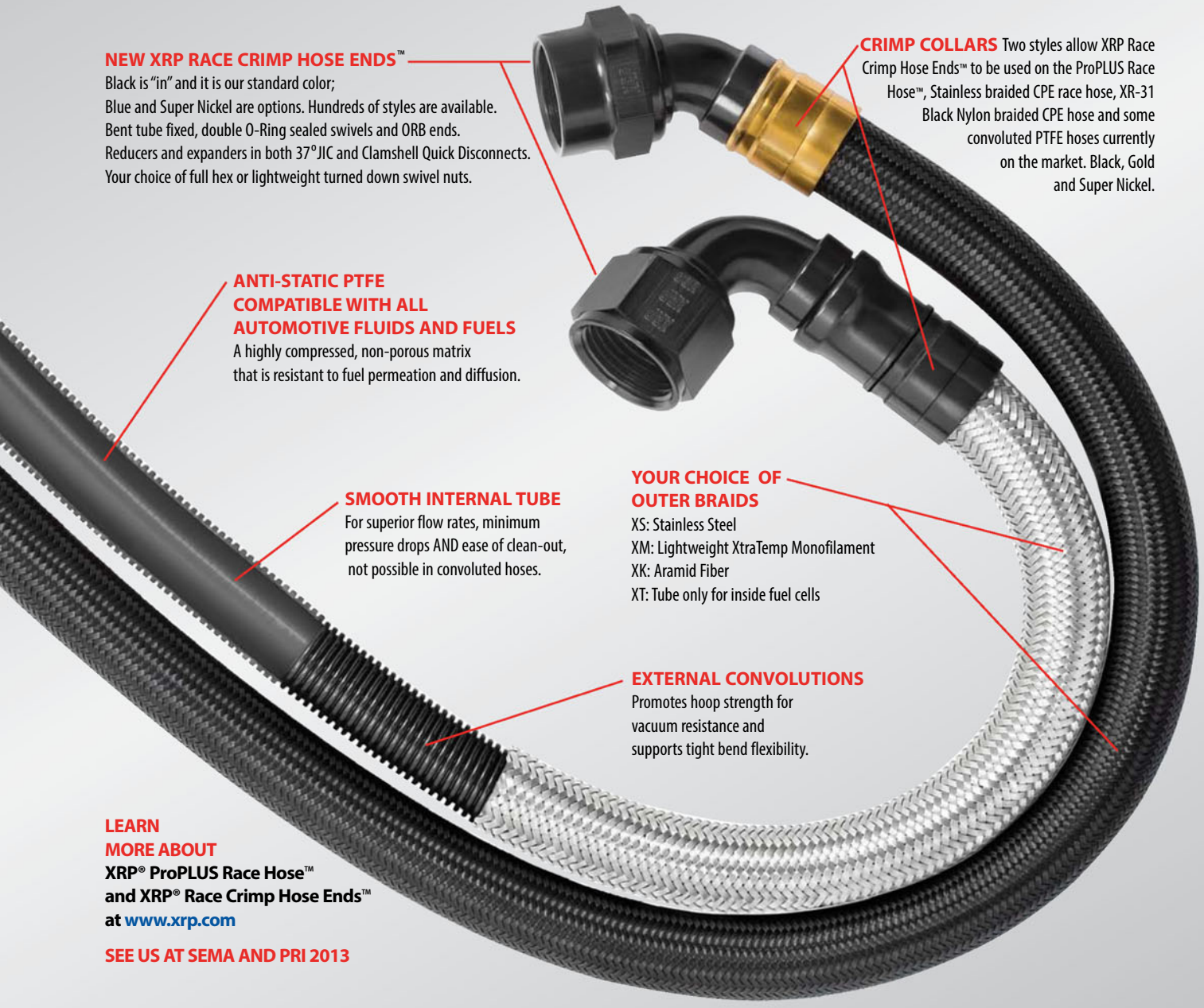

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Culture shockers

Designs with distinct national identities are history, and racing is poorer for it

Those of us who approach motor racing as a way of life should not forget that to the world at large, our sport appears to be an aberration, although not a joke sport like dwarf tossing and gravy wrestling, despite DRS and frangible tyres. The same applies to cultures, inasmuch as they are embedded in nationalities. But have they guided the design of the cars we have seen? One proposes they must, given the relative importance we place on things that are culturally based.

And what can we learn from comparing similar technologies that were designed and built in different countries or cultures? Technical products depend upon technical and non-technical goals as socio-cultural factors determine which projects get funded and how they are conceived, designed and built.

This idea can be analysed by technological style and the social construction of technology (SCOT), which states that construed social groups strongly influence the design of technology, perhaps more than 'purely objective' or quantifiable technical factors. They also define what technological issues come up for discussion. Indeed, 'a problem is defined as such only when there is a social group for which it constitutes a "problem".' SCOT argues that different engineers working in different political environments may well design rather different airplanes, spacecraft and – yes – cars. In aviation, look at fixed versus retractable landing gear for small airplanes in the 1920s and 1930s. The definition of the problem was shaped by society's desire for faster airplanes for military, racing and commercial purposes.

During the same period, there were decisions made between wood versus metal as a material for airplane construction. American designers chose to work with metal, even though they knew less about it than wood, which might have worked equally well for low-to-medium performance aircraft, because they inherently valued metal as a material of technical progress.

Some of this might be caused by local know-how and practice. The UK had a long tradition of metal working, hence metal fabrication uprights in the UK cars, and castings in Italy. Road car characteristics could be defined by nation, as there is little doubt, when first seeing it, where a Citroën DS19 comes from. Think also 'traction avant', 'indice énergétique' at Le Mans, half a century ahead of today's thinking.

Think Mercedes and Auto Union in the 1930s, although they could be seen as aerodynamic efficient juggernauts as a deeper expression of national psyche given the zeitgeist, with not much of the Prussian self-effacement that influenced the German cars of the 1950s and 60s – think Merc, BMW or Audi. Sober, efficient, effective. But we also had Veritas, Horsch and Maybach.

Likewise the American cars of the 1950s and 60s. The initial practical models that changed the artisan paradigm led to fins and chrome, feeding Moloch consumer society-driven engineering, yearly new skin updates and the same underpinnings for decades. It still boggles the mind that pushrod V8s lasted so long. Beam axles? Only on those roads. Even the major racing series with its roots in bootlegging law evading cars is fundamentally based on the concept of individualistic outlaw cherished in theory, but not much refinement.

Early Japanese cars were initially designed and built for the home market, and road and town street size quickly determined the size and power of the cars. It is only after they turned into a exporting powerhouse that Japan lost the small, idiosyncratic styling.

And the English. What could one say? Was handling derived from tortuous roads defined by drunken shepherds taking flock home? UK roads did not seem to have straights, but the aristocracy with their need to do the Grand Tour or nip down to have tea at the 'Promenade des Anglais' in Nice did foster a series of quick behemots, as E Bugatti said: 'Mr Bentley – he builds fast trucks.' The waning of the Empire did have a spark of megalomania in racing with the BRM-supercharged 1950s, but the majority were frugal cycle-cars and the eccentric small sportscar.

LAT

No prizes whatsoever for guessing the country this shot was taken in

Today's F1 is still a child of the FPF and FWMV series Coventry Climax engines, an efficient fire-pump engine that did sterling service in the late unpleasantness of the second world war. It is interesting to speculate on the alternate future of UK racing scene if Coventry-Climax's FPE 2.5-litre V8 Godiva engine had been raced – it is quoted that it had 40bhp more than the equivalent 225bhp Maserati engine.

Ah, the Italians. An artisan culture and individualism, Italian plains and the Mille Miglia, Targa Florio, the Pianura Padana school of sportcars, and a litany of distinctly Italian cars from an endless list of manufacturers. A country where in modern times we can find Lamborghini – a tractor manufacturer that builds a pretty sportscar. Not much chance of JCB or Caterpillar doing the same.

They might have been skewed by fiscal laws (the classic 1300cc engine capacity break is a direct descendant of Italian car tax) but they were always stylish, befitting a culture of appearances.

Even in more modern times when Ferrari started using carbon-fibre, the local industry had the wherewithal to do it quickly, as Parma had a flourishing industry producing autoclaves to fast cure prosciutto di Parma. True story, as related to me by ex-Ferrari tech director Harvey Postlethwaite.

Note that this assessment is personal, and doesn't just end arguments, it buries them and salts the earth.

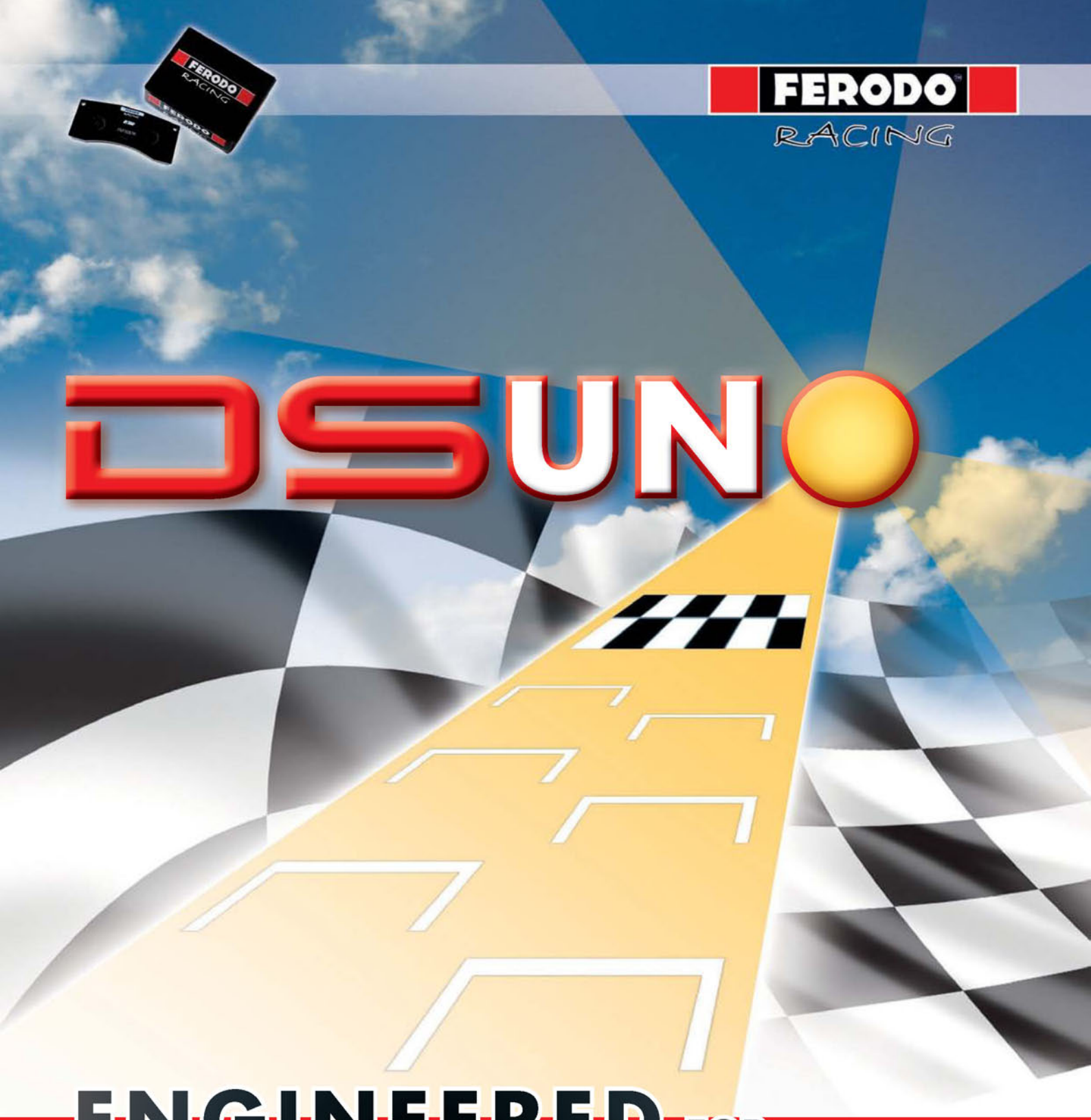
But now, with the accelerating congruence of design and cross-pollination of cultures, we are steeped in a homogeneous culture, with cutting-edge technology now shared by everybody, and very little individual input derived from a culture.

Racing does not ask where you come from, just that you design well, although the teams might have an amalgam of different nationalities and hence cultures, the direction will always be shaped by rules, the spin-off from aerospace and the constant shuffle of team members between themselves. The Teapot Ligier would be unthinkable now, or the Ferrari 312 T3. You knew where they came from.

Road cars styles are now nationless. Where are the quintessentialy French Citroën 2CV or British Morgans?

Welcome to modernity, welcome to blandness.

American designers chose to work with metal because they inherently viewed it as a material of technical progress



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F1 power struggles

Will performance take second place to reliability under the new regulations?

Anxiety seems to be the default mood of F1 engineers and team principals as 'the time to market' grows closer for the radical 2014 regulation engine changes.

Understandable, given the scale of change and the introduction – if not of individually brand-new technologies – at least of a combination of them for the first time in what is now aptly recognised as a 'power unit'.

Reliability – or lack of it – appears to be the greatest concern, with ultimate performance possibly second in priority for once. 'To finish first, first you have to finish' could be the ancient mantra appearing on many an office wall and computer screen. If one needs reminding, there are three main elements that make up the new power units – conventional turbocharged IC engine; energy recovery under braking via a motor generator unit (MGU) being battery-stored and then discharged through the reversed action of the MGU, and energy recovery converting waste heat from the turbo into electric power.

The shrink-wrap packaging of all this machinery and electronics in the back of an F1 chassis is a major concept and design exercise, let alone the extremely complex software needed to make it all work efficiently and in harmony. Oh – and there's the new fuel flow meter allowing you around 30 per cent less fuel as a little extra teaser. Just cooling all these heat-radiating devices, not least the turbocharger, will probably consume as much R&D and design time as the complete car did just a few years ago.

Maybe the priority being given to this may act as the catalyst for some revolutionary approaches to getting rid of waste heat, given also that the principles currently used have hardly changed since the advent of the motor car and the internal combustion engine over 100 years ago.

So could the incredible car reliability that spectators have taken for granted over recent years be drastically changed, with maybe only half the grid finishing, some of them being walking-wounded struggling to make it to the end? It could make results less predictable, but at what cost to the quality of racing and the spectacle, apart from some spectacular blow-ups? Sponsors and manufacturer teams won't be too impressed either.

I have, perhaps over-optimistically, more confidence than the participants that this won't happen. My view is based largely on the fact that a lot of extremely talented and experienced engineers have been working intensively on the 2014 designs, and running not just the prototype power units and transmissions, but effectively the complete rear ends of the cars on the very sophisticated transient engine dynos that are increasingly the norm now. Together with powerful simulation tools, this should reveal fundamental weaknesses should they exist.

The primary IC V6 engine should be no problem, being a conventional racing design. There is ample turbo racing engine experience around to draw upon to make this aspect, if not easy, at least manageable. Where additional knowledge is needed it can be bought in – literally – when the stakes are this high. My guess is that potential reliability issues would centre on any further increased attempts to reduce weight and friction, driven by the need to use every drop of the reduced-allowance fuel for performance and to not waste it. This is likely to create risks with more marginal components and reduced internal cooling.

The greatly enhanced ERS-K (née KERS) is likely to take some sorting, the packaging and cooling of the greater-capacity battery pack being surely a major issue. The MGUs that form part of the package should not in themselves be a problem, given the fact that they have been around for some time. However, in setting the goal for achieving the 690kg car-with-driver minimum weight (2014 F1 cars are getting alarmingly heavy, which might make one question the direction being taken in attaining environmentally-friendly racing?) it is in weight reduction and very frequent charge and discharge reversals where fragility might arise.

Knowledge for running an IC V6 engine should be easy to come by – but the heat-based ERS could cause headaches

One can also predict issues arising with the heat-based ERS which converts waste heat from the turbo into stored electrical energy which, unlike Kinetic ERS now, is a new technology for motor racing.

The devil will, as usual, be in the detail. No amount of even the most sophisticated dyno testing can truly replicate on-track vibrations, 5g braking and cornering loads, shock-loads of kerb-hopping etc which have an effect on all aspects of the powertrain, and this is where weaknesses – like weeds on a well-tended lawn – will pop up unexpectedly and possibly in the unlikeliest places. Similarly so with all the complex electrics, despite the proliferation of CAN-based systems, together with systems plumbing all so tightly-packaged and subject to heat-soak which even the most advanced CFD and wind-tunnel work may not be able to comprehensively model.

Devising and developing the software needed to interlink, control and most efficiently manage the sources of power and torque in combination, along with the fuel flow restriction will be one of – and probably the most important – keys to competitiveness, with the strategies needed to cover a bewildering range of race scenarios that can unexpectedly arise being up an integral and high-order software design direction. There may also be an emphasis on 'get-you-home' mode operation, where some systems of the power unit default to this rather than stopping the car altogether. With points so valuable and hard to get, this could be a viable and vital strategy.

So, who will take the more conservative, less optimised route working on the basis that in this first year reliability could be the key to championship success, knowing that significant performance development in specified areas is initially permitted, versus the risk-takers going for gold, banking on sorting the problems as they arise to take wins later in the season and being further ahead in Year 2?

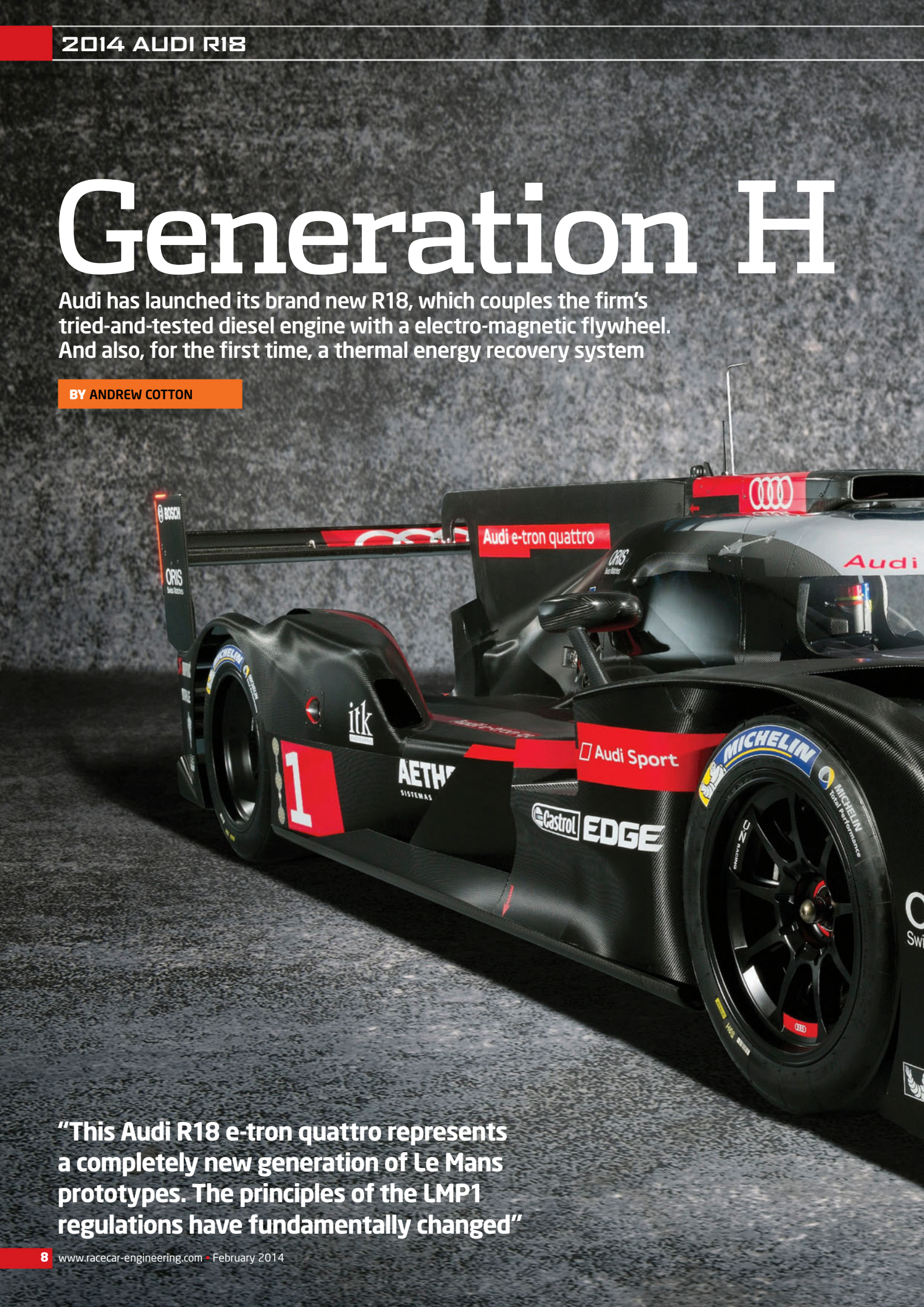
Make no mistake – either route will take a great deal of courage to implement.

Could the reliability that spectators have come to expect be replaced with a situation where only half the grid finish, some limping to the end?

Generation H

Audi has launched its brand new R18, which couples the firm's tried-and-tested diesel engine with a electro-magnetic flywheel. And also, for the first time, a thermal energy recovery system

BY ANDREW COTTON



"This Audi R18 e-tron quattro represents a completely new generation of Le Mans prototypes. The principles of the LMP1 regulations have fundamentally changed"

Audi has given its first public preview to the car that it hopes will deliver it not only victory at the 2014 Le Mans 24 hours, but which will drive forward its understanding of hybrid technology to the next level as it introduces a thermal energy recovery system for the first time.

The car is completely new, including a brand new engine, although the diesel engine does retain its V6 configuration. The company has switched from Dallara to manage the monocoque build as it looks in all areas to optimise its package to face Porsche and Toyota in the World Endurance Championship next season. The kinetic energy recovery system, also completely new, will continue to drive the front axles, with the result that the car will still retain its four-wheel drive characteristics. Also introduced on what is Audi's most complicated LMP1 car to date is a second hybrid system, with an electric turbocharger in the internal combustion engine.

Combined, Audi expects the new car to use 30 per cent less fuel than the 2013 car, although that did run last season with fuel economy that was compromised by up to 20 per cent to drive the now-banned blown diffuser. Meanwhile, the manufacturer will be able to continue to experiment with the use of exhaust gases.

For the first time, the turbocharger of the internal combustion engine (ICE) is linked to an electrical machine, which makes it possible to convert the thermal energy of the exhaust gas flow into

Audi's new car features a second hybrid system with an electric turbocharger in the internal combustion engine

Audi expects the new car to use 30 per cent less fuel, returning to economy over power in the 2014 car

electric energy, for instance when the boost pressure limit is reached. This energy also flows into the flywheel energy storage system. Power delivery can then be released to both axles, as the MGU-K delivers to the front axle and the ICE to the rear.

The chassis is completely new, to meet with new regs that require a higher cockpit, raised 20mm compared to the 2013 car, while the car is narrower by 10cm. The front wheels are narrower, meaning that the bodywork can also too, helping to improve aerodynamic efficiency. The weight has also been reduced by regulation, from 925kg in 2013 to 850kg for a non-hybrid car, and 870kg for a hybrid car.

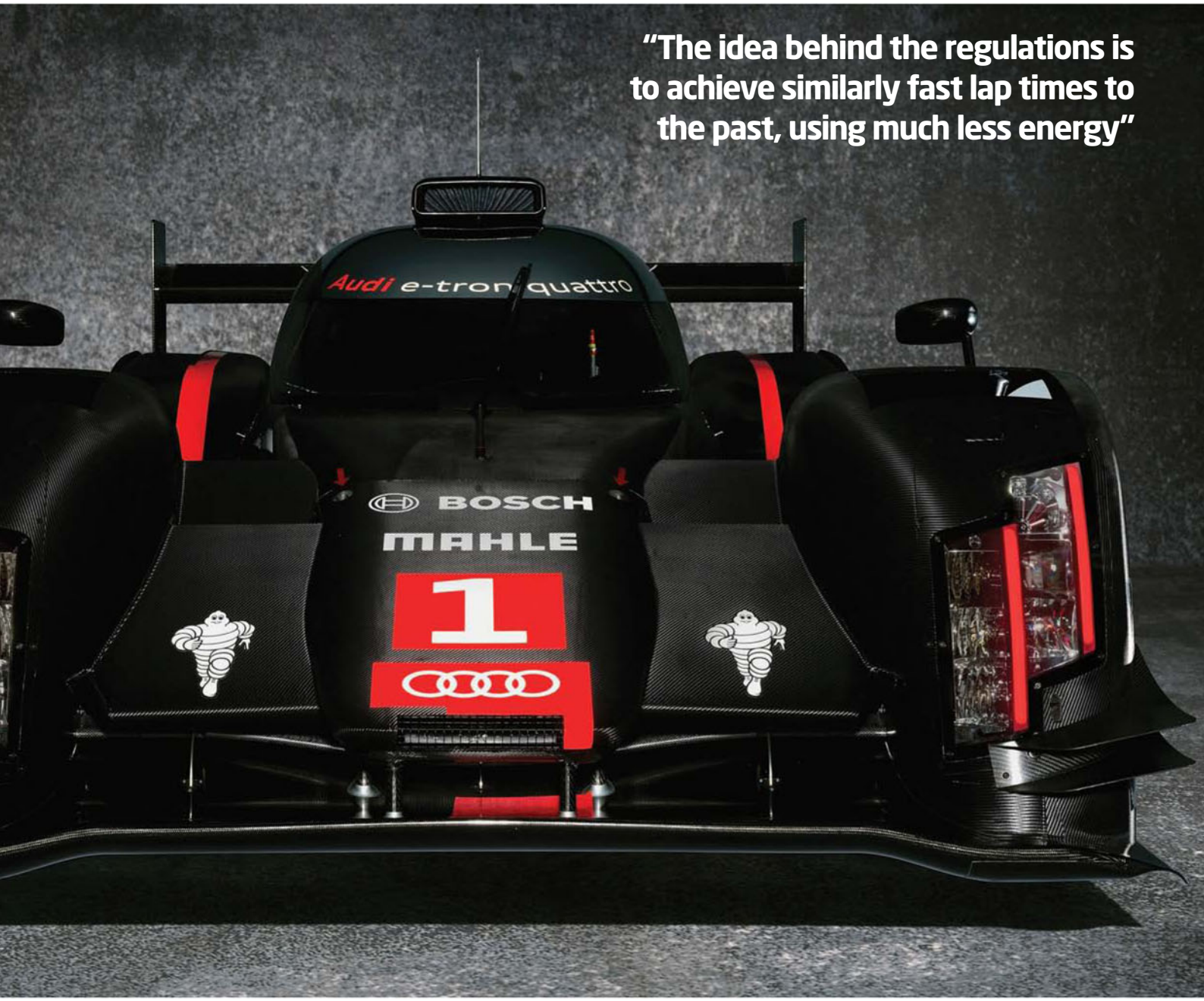
'The next generation Audi R18 e-tron quattro represents a completely new generation of Le Mans prototypes,' says Dr Wolfgang Ullrich, head of Audi Motorsport. 'The principles of the LMP1 regulations have fundamentally changed. The idea behind this is to achieve similarly fast lap times as in the past with considerably less energy.'

WEIGHTY ISSUES

New cockpit regs and narrower chassis required all manufacturers to build new cars, but the weight reduction caused Audi to have to revisit every part of the car in a bid to get below the minimum and still have ballast to play with.

The switch from Dallara, to another Italian firm – Ycom – was just part of an overall review of the complete car. 'We reviewed the possibilities and kept the core technology of layout and packaging with the chassis, and the consortium of how to manufacture has always been a puzzle organised by Dallara,' says Christopher Reinke, head of LMP1 at Audi. 'We look at who is best, because we guide the process – and we felt that there was a more optimum possibility for us.

'For sure the new weight regulation is very challenging, as we try to put more technology in the car, with a dual hybrid system,' adds Reinke. 'It goes in



"The idea behind the regulations is to achieve similarly fast lap times to the past, using much less energy"

hand with what the road car tries to achieve, trying to lower the weight spiral while increasing the hybrid performance.

'The car is 10cm narrower and we have smaller wheels. After that it starts to get tricky. We had to apply the same theory when we created the ultra and e-tron. You have to look at everything, and to question every single thing. What might make sense from a technical point of view we always have to question for the weight.'

Audi engineers went through the chassis, the engine, gearbox, and all structures in a bid to save weight, and believe that they achieved it, although the final figure is yet to be announced.

MYSTERY ENGINE

While Porsche's plan, revealed in a German newspaper to be a four-cylinder petrol engine in a V configuration, Audi would only confirm that it was running a V6 diesel, and kept the capacity under wraps.

'It is a brand new engine,' says head of engine tech Ulrich Baretzky. 'It is a brand new rulebook – the conception is completely new. We could never do for next year what we did from 2012-2013 – that would be the wrong way to go. We always have to save weight, but I don't know how much we saved, and I don't care! The most important thing about the engine is that it has to last, and I don't give a shit about the weight. Car people hate me for that. We have saved some kilos, but we are not in Le Mans yet, tests are not finished yet, we have to wait until it is done.'

The MGU-H has to work with the turbo, but Baretzky would not confirm that the company has retained the VTG technology that was developed for the diesel V10. 'It has a turbo, and that is all that I can tell you,' said Baretzky. 'The MGU-H is less of an influence in the design of the engine – it is more complex in terms of overall energy management in the car. You have an amount of energy then you have to use it, and if you waste it you are lost. You have to have the management to do this, part of it by the driver, and some by the electronics. I am optimistic that the influence of the driver will be important.

'The engine design methodology has not changed at all because it was always part of our job to run the engine efficiently. The only thing that has changed is the proportion – only economy or only power – and it has moved more towards economy. You have less quantities of pure performance in the lap than before to take the efficiency and to use the energy, because the energy is still used by the combustion engine, and nothing else.'

The engines have been testing on the bench, but so far

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the manufacturers have yet to sample the latest ultrasonic fuel flow sensor. Gill Sensors has released its new fuel flow meter, and was scheduled to deliver them to the teams before the end of 2013. Previous sensors tested during the year were rumoured to be inaccurate by up to 10 per cent, far shy of the 0.25 per cent target set by the FIA, although it's expected that the new meter will reach this.

ENERGY RECOVERY

Audi continues with the flywheel system that is built for them by Williams, but there are two sources of input energy, one from the MGU-K from a single motor at the front (compared to a dual motor system in 2012 and 2013), and one from an MGU-H, which works with the turbo.

'If you go to battery, you have far more energy there,' says Audi Sport leader of electronic systems, Thomas Laudenbach. 'A flywheel is very good at power, but the amount of energy is less, and in terms of the solution for what we need, this is the lightest one. I am not saying that the flywheel is the best solution, but for what we need and what we know so far, it is the lightest. Nobody would build one into a road car – it has different demands. We are looking at it, and at other solutions, but for

Larger crash structures are required in the new regulations, and in the case of the new R18, this extends beyond the end of the rear bodywork

HYBRID DEVELOPMENT

Thomas Laudenbach left his position at Porsche's head of powertrain and took up the job of heading up a new department within Audi to develop the hybrid system and its efficiency. His arrival was welcomed by the head of Audi's engine programme, Ulrich Baretzky, who famously dislikes electronics in any form.

Laudenbach was appointed to his post early in 2013, and believes that the regulations have been formed in such a way that the development of the new generation R18 will benefit the production car team.

'In general, we are always looking at the road cars,' says Laudenbach. 'That is where it starts, so the road cars we have the issue with CO2, that is not a new story and manufacturers are working on all sorts of solutions, and a very big area is electricity in a road car.

'We're coming from a plug-in hybrid to an electric range, and racing has taken that challenge on, promoting technology. A racecar is used in a different way to a road car, but you still have a conjunction between the two. Then you look at the rules, and there is a clear tendency towards everything becoming too expensive, so we have to restrict. Not in the new technologies, but we restrict a lot of other things that we've had in the cars for many years, because the steps are not that big, and in general they leave it open for all sorts of hybrid systems. This is an area that is growing, and the opportunities are great.

'If you look at the R18, it is integrated. For nearly 100 years, the driver was used to one source of power – the internal combustion engine. Now they have two or even more, but you still have one pedal so someone else has to take over the coordination of the power sources in an efficient way. The driver can't do it, or they would need two or three pedals. Since we have more than one power source in the car, you have to use it in the most intelligent and efficient way. Before it was more intelligent in power density and from 2014 on it is intelligent in efficiency – and there you need a lot of electronic control systems.

'Now the work powertrain becomes a complete new definition because it is extremely complex system of various components, ICE, gearbox and some power sources, and obviously the units where the energy that they recuperate is stored. That makes it complex. It needs to be efficient and lightweight, and it's more complex than we had. Compared to other technologies, this is relatively new. The electric motor is new in the automotive application, so hopefully the steps will be great and that is the whole story. That is where you have to make efficiency.'

An efficient race powertrain is going to be a complex feature, as not only will it have to deliver precisely the correct amount of fuel per lap under normal racing conditions, it will also have to cope with such variables as weather and safety car periods.

'You have got a playground of strategy and you have to use the fuel in the most efficient way, says Laudenbach. 'We all know that the ICE has losses – the efficiency is below 50 per cent, and the hybrid is more.

'The efficiency of a hybrid system doesn't matter because you cannot release more energy than the regulations allow. With the energy release, there are certain megajoule classes and you choose which one you want to be in, because that influences the amount of fuel that you can put in. You can harvest as much as you want, but you cannot release it.

"For nearly 100 years, the driver was used to one source of power – the internal combustion engine. Now they have two, or even more"

'Software is a main area of development because the various electric motors in the car cannot be controlled by a single pedal. You have so many different situations, like when it is raining for example. It will have to be a very intelligent system onboard. You have a certain amount of energy per lap, and we want to use that amount of energy spot on. We don't want to be five per cent down, because then you will lose a lot of lap time. To make sure that on every lap you use the right amount of fuel, a difference of one or two per cent will cost you tenths of a second in lap time.'

As the fleet production car CO2 emissions fall towards 2020, when the average needs to be less than 95g/km, efficiency is key. Why, then, does the new R18 continue to feature a flywheel rather than the batteries that are sold in the production hybrids? 'Something that relates to the road car, you have the intelligent handling of energy,' says Laudenbach.

'First of all the car has be good at the races. We chose the best possibility for the race, and not that much in terms of components that can be transferred to the road car. Software, strategy, and with certain efficiencies, they can be transferred to the road car. The storage system is different, but there is still a lot of synergy.'

Different manufacturers have different solutions to the shape of the cockpit, as per the new regulations – here's Audi's

what we need now it is the best solution, from a technical point of view.

'We had to fit another system in, and we had to get the weight out of the car. The biggest challenge is that the diesel will always be heavier than gasoline, so we made the biggest effort to use the rules in a proper way. Last year we had to gain weight, but before I came here they worked on every little bit. I can't tell you how much they have had to take out. Last year's car there wasn't enough ballast to just take it out of the car, we had to look at everything – the engine, the gearbox, the structured parts, the monocoque, everywhere.'

There was a rumour that the car tested at Sebring without the MGU-H working, and both Reinke and Laudenbach were coy about it. 'It is the right way to go, but it is a tough way to go and we still have some months to go before Le Mans,' said Laudenbach, while Reinke added: 'In the last two years we've fully simulated the complete heat resources of the car, and we can be pretty exact. So far the testing hasn't been hampered by that. We have different variations of the car running at different tracks.'

Extra cooling has not been a major issue for the chassis designers, and Audi would not be drawn on how the system would be used. 'If you have an MGU in the exhaust system, you will always be in the situation to use it as energy recovery as a boost, but it costs you energy,' says Laudenbach. 'You can use it for an anti-lag if you have a problem with it, because it is not the most efficient way of using it. As a first step, you would be happy if you don't need it.'

Final calibrations won't take place until the 36-hour tests planned for early next year before the final specification of the car is set.

'Normally you do one or two 36-hour tests, and everyone looks at the hardware, but you have to do the same as the software,' says Laudenbach. 'We still have some time before Le Mans, and I want to have the software calibration at the last endurance runs.

'The rules have changed. Last year we had an MGU with two electric motors on it, which would mean two systems. You can do it, but then you cannot do anything else. For the FIA they need a clear definition. This is one motor, one control unit.

'The flywheel now exactly fulfils the demands which we have to comply with the new rules. Anything else would be stupid. It is the same principle – some components we took over. A hybrid system is a system, and if you have an MGU with a max power of 170kW, and a storage system capable of 100, you need to work out how much storage you need. You don't take more, because it is weight.'

So, Audi has presented its car, but has kept the final details under wraps.

Its first race, at Silverstone, will be the first indication as to what to expect for the year, but the development of this new technology is going to be fascinating.

LASER LIGHTS

Audi has had another stab at improving its light system on the new generation R18 and has introduced a laser light system in addition to the LEDs that have come to be an iconic feature of the car.

A blue laser beam backlights a yellow phosphorous crystal lens through which the light beam is then emitted. This new light source then provides even more homogenous lighting of the road.

The last time Audi introduced its super-bright lighting system, it blinded the GTE drivers and could have been a contributory factor in Mike Rockenfeller's accident in 2011.

'By using this new lighting technology, Audi is setting yet another milestone at Le Mans,' said Dr Ulrich Hackenberg, member of the management Board for technical development of Audi AG. 'Laser light will also open up completely new possibilities for our production models in the future.

'The new laser light is just one of numerous technical innovations featured by our new R18,' said head of Audi Motorsport Dr Wolfgang Ullrich. 'We're not going to reveal any more than that at this early stage, as in 2014 we're facing an extremely tough competition and a year full of challenges for Audi Sport.'

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The world's fastest front-wheel drive

Faster in the wet than the pick of the GT3 cars, and not too far behind the R8 LMS in the dry, the Audi TTRS is an easy-to-drive racecar that's making serious waves

BY ROB HOLLAND

The Audi TTRS SP4T is something of a car without a natural home. It has raced only once away from the catch-all classes of the Nürburgring's VLN series, at the 2013 Thunderhill 25 Hours, a race it won against more exotic prototypes and GT cars.

The TTRS is a potent machine. In the dry it is a mere handful of seconds off the pace of its much more powerful sibling, the R8 LMS. However, in the wet it is able to lap the Nordschleife quicker than even the fastest GT3 cars.

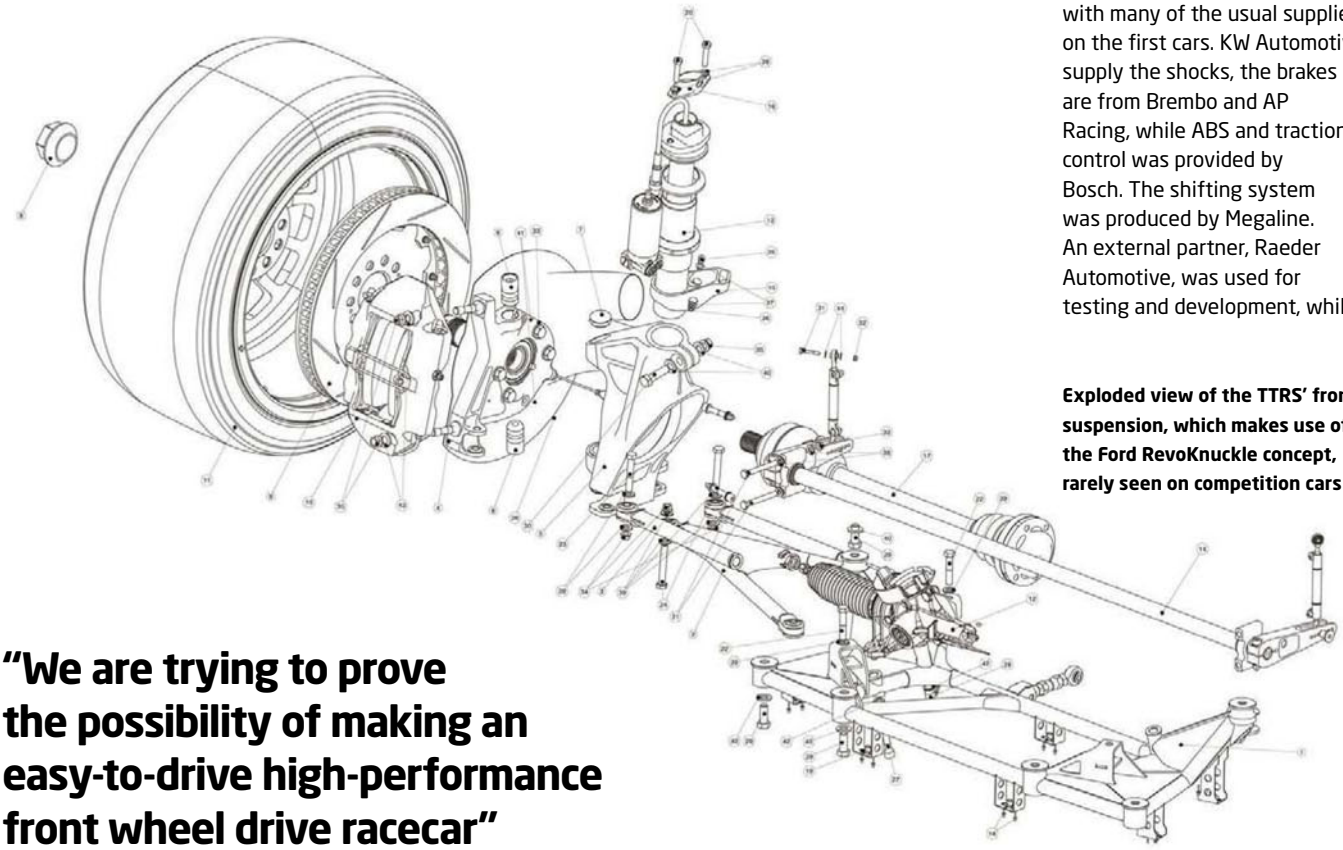
'A small group of race-enthusiastic people in the engineering and development department of Audi came together in 2009,' explains Peter Mineif of Audi Sport Customer Racing. 'We figured out that it would be of benefit for Audi if there would be a easy-to-drive racecar below the Audi R8 LMS. At that time, an aerodynamic concept car was built and went through several wind tunnel tests, to gather the data for the performance calculations.'

That design was shown off proudly by Audi Sport, but then the planned range of cars never materialised. 'The original plan was to develop a family of TTRS racecars – eg GT4, VLN 2-litre, four-cylinder, 2.5-litre – with wide and narrow body, like a racecar construction kit, starting with the top of the line, the car we have now,' Mineif says. 'Changes in the economic surroundings forced us to decide to concentrate on the top of the line. We consider this project a technology project, proving the possibility of making an easy-to-drive high-performance front-wheel drive racecar. It's the fastest front-wheel drive racecar ever built up to now, and we think that it will be for a while.'

The development of the street version of the TTRS with the five-cylinder turbo engine was going on within the quattro GmbH at the time, and it seemed the logical unit to use in the new project.

'The engine has had a long and successful racing history with Audi, and it was self-evident for our team that this engine must be back in racing,' says Mineif. 'It was then that the idea for the TTRS racecar was born. So, a volume study was done on how and where such a race could be driven. At that time there was a GT4 class (SRO) with growing numbers of participants and a booming VLN-Series at the Nürburgring, so we looked at how best to fulfil the different needs for the specific series. There were also options in other race series all over Europe, that were using similar or the same technical rules as the VLN. A performance study was done, which considered the technical regulations and performance studies of concept cars. It concluded that a front-wheel drive car would be the best option.'

Audi's engineers worked with many of the usual suppliers on the first cars. KW Automotive supply the shocks, the brakes are from Brembo and AP Racing, while ABS and traction control was provided by Bosch. The shifting system was produced by Megaline. An external partner, Raeder Automotive, was used for testing and development, while



Exploded view of the TTRS' front suspension, which makes use of the Ford RevoKnuckle concept, rarely seen on competition cars

"We are trying to prove the possibility of making an easy-to-drive high-performance front wheel drive racecar"

The front axle on the test rig. The input data came from measurements derived from Nürburgring and Oschersleben

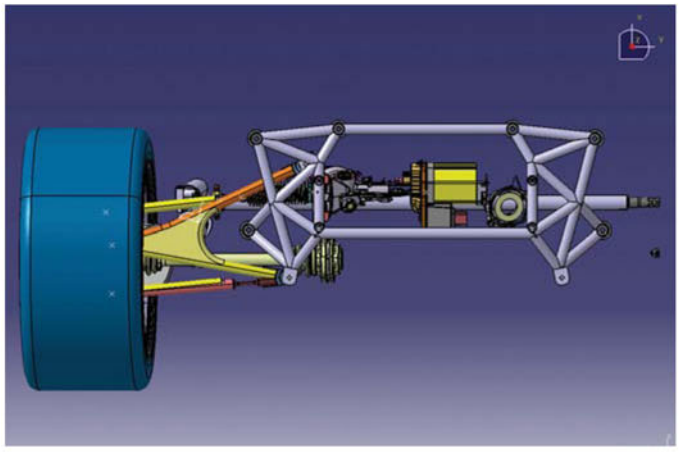
suspension and chassis (roll cage integration) was conducted by Raeder and CP Automotive (formerly Heggemann).

Having driven everything from production touring cars to WTCC S2000 spec cars, I can say without reservation that the TTRS is by far the fastest FWD racecar I have ever driven, and by a large margin.

I spoke at length with Mineif, both during testing for delivery of our team's TTRS and also separately for this article. He was the technical project leader for the TTRS, and helped me to get a better understanding of how the car worked both from a driver perspective as well as an engineering one.

Some – but not much – of the production car remains present on the competition version, with the chassis including rear side panels and roof, albeit slightly modified for roll cage mounts, seat mounts, suspension mounts and drive shafts. The main subframe mounting points and engine/transmission mounting points, however, are not modified. The standard ECU is used, but with different software. Some of the electronics remain standard, headlights and tail lights, steering system and the fuel pump all come from the production line.

A largely standard five cylinder engine is used too, but with some minor changes. 'This is simply a matter of time, development and parts costs,' says Mineif. 'For such a small number of engines there is no way to develop a dry sump engine with a new cylinder head, crankshaft, pistons and tie rods and many other parts with all the testing that goes along with that.'



The suspension was tested to the equivalent of 40,000km, which led to a part lifespan approval of 10,000km

The TTRS featured at the 2013 Thunderhill 25 Hours – its only outing away from the Nürburgring's VLN series – beating several prototypes and GT cars

Some other parts on the TTRS were found in the R8 LMS parts bin, something that further saved costs on the car. The brakes, wheels, uprights, gearshift, seat, rear wing and air jack all come directly from the GT3 car.

One of the interesting parts that resulted from the car's mixed development is the use of the Ford RevoKnuckle concept, something rarely seen on competition cars. 'This principle – which splits the steering and suspension functions – is not completely new, but it has primarily been used on road cars,' explains Mineif. 'For a high-performance front-wheel drive racecar, its use is unique as far as I know. We didn't have to adapt much, as this is a completely bespoke suspension design. Mainly for maximum stiffness we made the outer turning part (where the wheel bearing sits in) out of steel to reduce brake knock-back.

'The chassis with the RevoKnuckle suspension was tested to the equivalence of the distance of 40,000km, which led to a part lifespan approval of 10,000km. The input data for the test rig was generated by measurements from both Nürburgring and Oschersleben. With the measurement data and the same parts on the test rig, the input data deck for the test rig was generated by iteration. The test itself ran for over 400 hours with regular checks of the parts every 10 per cent of the test time. During the regular test period, no damage was discovered to security-relevant parts of the driving gear. The anti-roll bar in the front is nothing very special – we reduced wear and friction by using bearings and tried to make everything 'quick-adjustable' during a pit stop. The rear anti-roll bar, however, is a bit more special. Quick-adjusting without crawling underneath the car is only one

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BRETT KING DESIGN.

"Most of the downforce comes from the front splitter – and the rear wing of course"

aspect of the system. It makes it a lot easier for the layout of the subframe, even with the possibility to make a four wheel drive car out of the TTRS. If you take a look into the wheel hubs, you will find that we use the same as on the front of the car. So integrating, for instance, the possibility of an electric motor on the rear axle is not a big deal on the mechanic side. The layout of the anti-roll bar on the roll cage would allow us to use a third spring – we tried that during testing and found some benefits there. But in the end – we decided due to complexity reasons – not to offer that for the customer cars.'

DRIVING DOWNFORCE

Although the suspension design and development is the most interesting part of the TTRS, aerodynamics play a significant part as well. The car generates approximately 380kg downforce at 200km/h (230kg front, 150kg rear) using the standard Nürburgring setup according to the setup sheet. Lower ride height, more rake and more wing could increase downforce, risking wear to the splitter and of course increasing drag.

'Most of the downforce comes from the front splitter and the wheel diffusers on the splitter and the rear wing,' says Mineif. 'An additional 10-20 per cent of the front downforce is generated by the two sets of diveplanes. The diffuser also does its job, together with the flat underbody. Not to be underestimated is the cooling vent with the gurney flap on the front hood. This system, besides being very effective for cooling, also generates downforce. In drag and downforce, venting the front and rear wheelhouses is important.'

In total, 10 TTRS racecars were built, but only five of them are in private hands, including the car which won the race at Thunderhill. This example, in the hands of the Rotek team, has undergone a number of changes with a JRZ damper replacing the standard KW units as part of a longer technical partnership between Rotek and JRZ.

Rotek had considered developing the car to race in the GX class in Grand-Am (now part of the GTD class in TUSCC) and started to make aerodynamic changes to the car before being informed that it could not take part after all. As a result, the car was sent to Thunderhill to race, where it beat a Audi R8 LMS GT3 with ease. Perhaps this is why the car will not be seen in the new North American Championship!

Rotek will continue its relationship with Audi with a new and as yet unannounced European project.

TECH SPEC

Audi TTRS

Category: SP4T, VLN, 24H Nürburgring rules

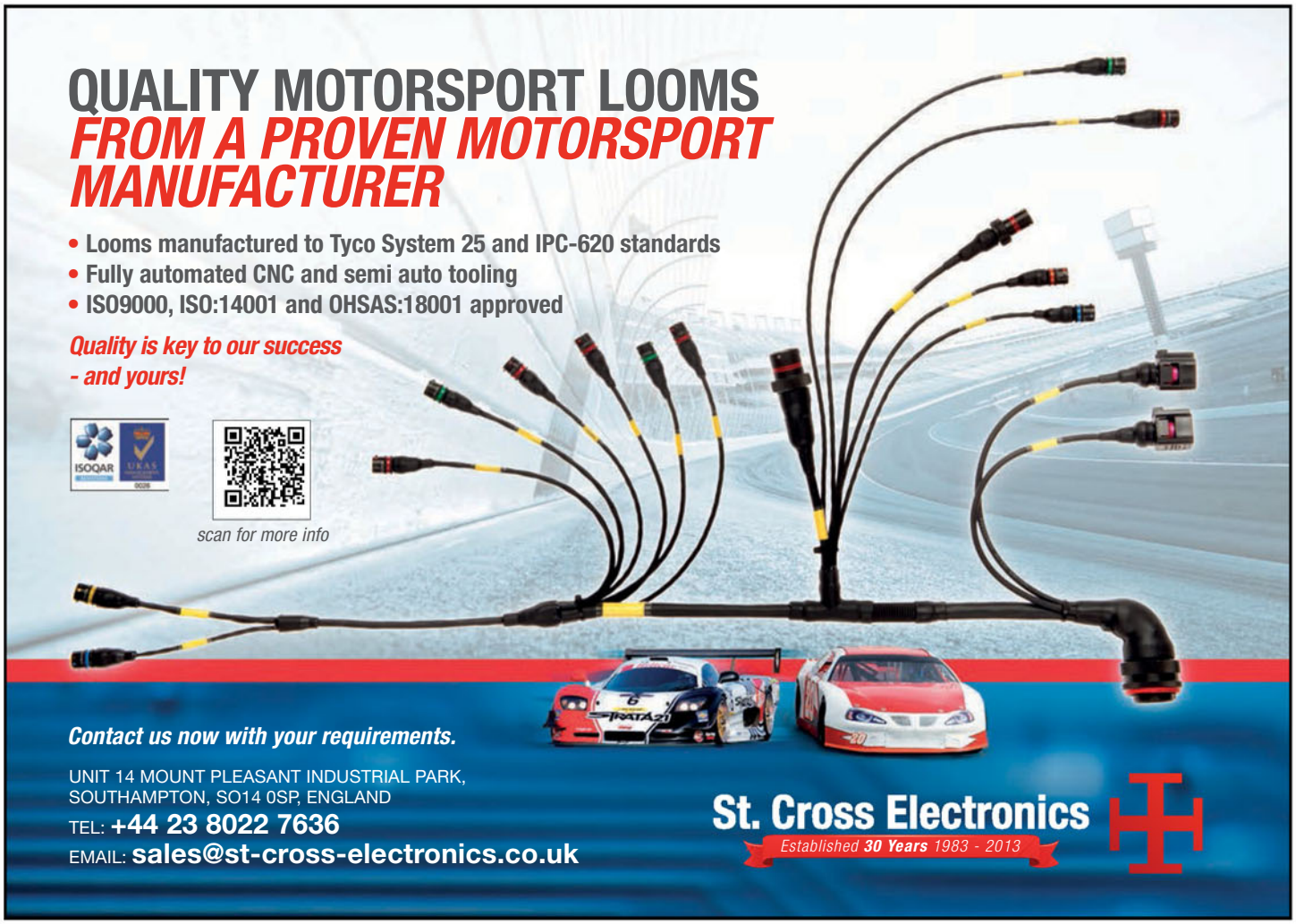
Bodywork: glass fibre bodywork, steel/aluminium hybrid internals

Engine
Type: inline five-cylinder engine four valves per cylinder, DOHC turbo charged, gasoline direct injection (TFSI)
ECU: Bosch Motronic MED 9.1.2
Cubic capacity: 2480cc
Power: 372hp at 6000rpm
Torque: 391ft lb at 2500-4000rpm

Transmission
Gearbox: sport sequential, paddle shift
Clutch: ZF Sachs three-plate sinter metal

Brakes
Front: 355mm full-floating discs with Brembo six-piston racing calipers
Rear: steel brake discs with AP Racing 2-piston racing calipers
Wheels: OZ Racing 11inx18in cast magnesium wheels (R8 LMS)
Tyres: 305-680/18 Pirelli P Zero

Dimensions: length 4765mm, width 1980mm, height 1297mm
Weight (min): 1120kg



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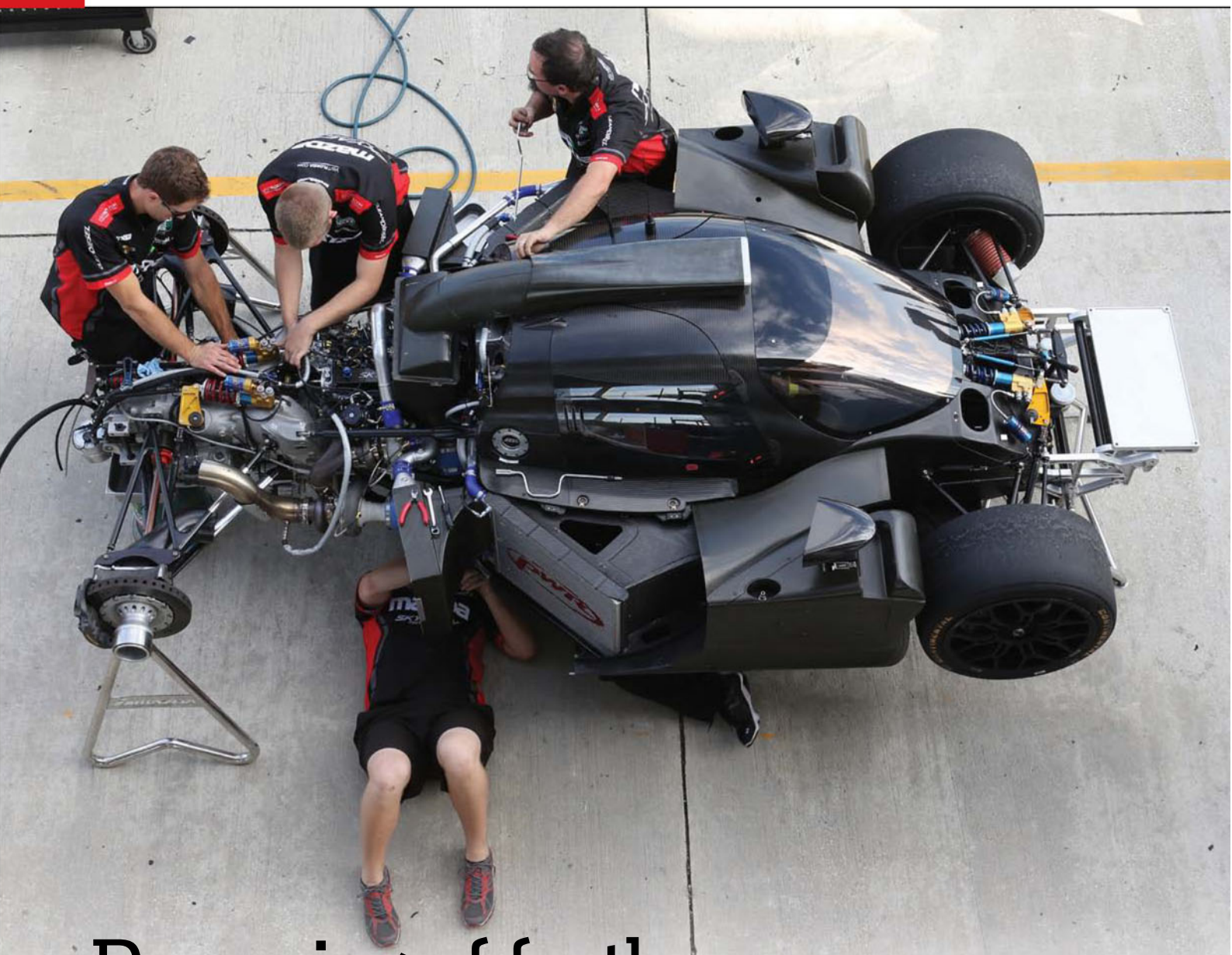


Dreaming of further Le Mans glory

With a promising new turbodiesel powerplant and strong partnerships, Mazda think they have a package capable of getting back to the top of prototype racing

BY MARSHALL PRUETT

Mazda announced its plans to offer its SkyActiv turbodiesel powerplant as a customer LMP2 engine at Le Mans 2011, but following its Grand-Am GX diesel programme last season, the Japanese brand has revised its timeline, pressing the 2.2-litre oil burner into service with a pair of works-support P2 entries in the Tudor United SportsCar Championship for 2014.

'We felt the time was right to take what we'd established with our SkyActiv diesel Mazda6 programme in GX and step it up to P2 where the Mazda brand can compete for overall wins and hopefully, one day, return to race at Le Mans,' said Mazda motorsports manager John Doonan, who oversees the brand's North American activities.

Doonan has entrusted SpeedSource Race Engineering with its P2 effort, which follows the Floridian outfit's GX and RX-8 endeavours on behalf of Mazda.

Longstanding ties with Lola, now headed by Canada's Multimatic Inc., led Mazda to source a pair of P2 coupes to house the SpeedSource-built diesels, which underwent modifications from their tubeframe installation for GX competition.

'To assert 400hp power levels in GX required one stage of build,' said SpeedSource owner/driver Sylvain Tremblay, 'and when we took on the P2 configuration with the ACO mandated restrictor, we had a new 450hp target. We're not quite there yet and continue to work on the overall SkyActiv package to suit our needs in P2. The motor has the same basic internals – the connecting rods, pistons, crankshaft and all of the valvetrain are pretty much identical from one programme to another. The big difference is in the lower cradle, because we had to lower the crankshaft significantly – so that had to be a new piece.

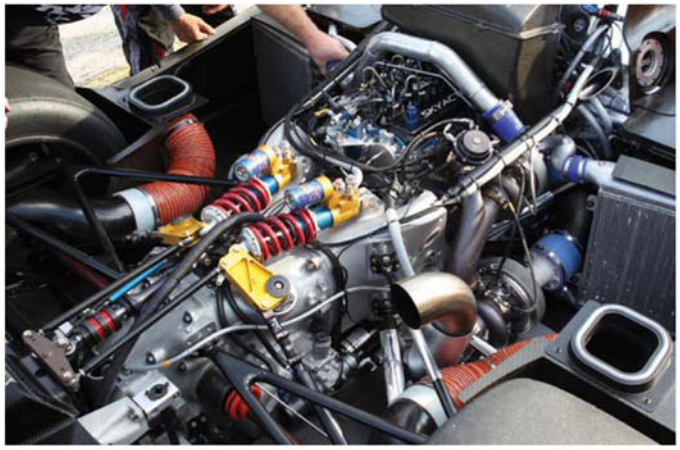
SpeedSource acknowledge that they will be playing catch-up with their rivals on aero and cooling

'Then the front cover is to be a stressed load carrying member, the bi-turbo induction layout is bespoke for P2, the exhaust configuration is new, and the complete cooling system including water pump is also different from one car to the other. It's roughly the same pump in a different location – we basically tried to mount everything just lower and tidier because of the undertray.'

The P2 install reportedly involved a crank height reduction in the 90-100mm range, optimising cg. Providing adequate cooling for the diesel mill, and coping with the prodigious torque the powerplant generates, served as the biggest hurdles for SpeedSource, Multimatic and Xtrac to overcome.

The car's maiden outing at Sebring last October was cut short when the input shaft was severed as a test driver pulled away from the pits, leading to a redesign that has held up through additional pre-season running. High intake charge temperatures limited the speed of the Mazda P2s during their first run at Daytona, but that problem was solved with a chance of intercooler brand, resulting in a 30degF reduction.

'Working with a vendor like Xtrac on the GX cars allowed us to give them the data to extrapolate where you need to be in P2, but until you actually run it in the car, you won't see some of the stresses and loads that come from the racetrack,' said Tremblay. 'That's helped to really refine the gearbox internals, and also in other areas – high stress areas on a high-downforce car. We've also revised drivetrain belts and a few other things in the engine bay that came to light once we started testing.'



In the powerplant, one major difference from the GX and RX-8 programmes can be found with a lower cradle, which required the crankshaft to be lowered

SpeedSource have used ANSYS simulation tools to help refine the new Mazda, as well as their in-house simulation department

The known qualities of the Lola-based chassis has allowed SpeedSource to concentrate on its contribution to the package, making the quest for additional power, torque and reliability the central focus for Tremblay's team.

'The inherent advantage of a diesel engine is torque, obviously, so the torque-to-horsepower number is always a complex formula,' he explained. 'For us right now, it's mostly about driveability and how much torque we can have and actually use. With the power, we're on our way to that target – but we're not there yet.

'We know that the more we work on improving cooling and packaging, the better the engine will perform, but there are also aero concerns that differ from the GX cars. The more cooling we take, the more aero cost that we have, so that's a balancing act we're learning about. Mostly, the driveability, turbo mapping and engine mapping is all a huge learning curve at the moment because it's completely different on the P2 cars.'

SpeedSource continues to employ the same CFD and simulation tools that brought its recent Mazda GT cars to life, which has helped the firm's expanded engineering office to ready its P2 challengers.

"The more cooling we take, the more aero cost we have – that's the balancing act we're learning from"

'We have a wealth of resources to pull from, including the team at Mazda North American Operations in California and the factory in Hiroshima,' Tremblay continued. 'On the pure racing side, it's knowledge in our building and also a lot of the simulation work. We've partnered with ANSYS for three years now. We have an in-house simulation department that does all of the in-cylinder airflow with Fluent, so we use CFD for inside manifold design, pistons flow and all of those bits and pieces that we were able to develop.

'Intake manifold, exhaust manifold to how the turbos are mounted, and all of that is an extension of all the learning that we got through the GX programme. Our competitors have had years of jump on us, so even though we have some extremely new technology, we still are behind the curve. We've taken the best experience that we had from the GX car and tried to incorporate that into a very tight P2 package. You would think that you would have a lot of room in the engine bay, but it's very, very snug because of the aero demands of that particular car, so everything we've done with our software tools has been geared towards making things smaller, lighter and lower.'

Facing stiff opposition from proven P2 solutions like HPD's ARX-03b, an Oak/Morgan-Judd and an Oreca-Nissan will push Mazda to its limits in 2014, as Doonan concedes.

'We chose to bring Mazda back to prototype racing because we knew it would be very hard and extremely challenging,' he said. 'This is as big a technical challenge as we've ever given ourselves, and the decision wasn't taken lightly. We're confident that the SkyActiv diesel can become a winning package – but it won't happen overnight.

'We have dreams of winning at Le Mans again, and want to see our customer engine programme go forward, but before we get there, there's a lot of hard work ahead for Mazda and SpeedSource and our partners.

'Ambition is what's driving this project, and as we improve the engine and the chassis, I expect to see our cars right up front where we want them to be.'

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Different class

It may hold little ongoing interest on the engineering side, but the FIA's new Formula 4 looks set to be a fascinating proving ground for driving talent

BY SAM COLLINS

This year a new global racing class will make its debut – Formula 4. In an initiative led by the FIA, the new class is aimed at cleaning up the bewildering range of small single-seater classes found in each nation. 'The objective is for Formula 4 to become a springboard in each country enabling young drivers to put themselves to the test at a high level, with limited season costs and good media exposure,' says Gerhard Berger, president of the FIA Single Seat Commission. 'In the absence of a real discipline enabling drivers to progress from karting to single-seaters, we decided that the FIA needed to be at the core of this discipline, even though it is a national discipline.'

Aware of the seemingly constantly escalating costs in junior single-seat classes, the FIA decided to put a strict cost cap on the F4 class, with a rolling chassis priced at no more than €33,000. Spare parts have tight cost restrictions too, the monocoque must not cost more than €14,500, and the bell housing must not exceed €750 (see table of costs, p28).

Some of the prices seemed at first glance to be impossibly low, but they were developed in conjunction with the car constructors, particularly Mygale. The French firm was the first to get its F4 design on track in December 2013.

'We have been working with the FIA on F4 for almost a year,' says Bertrand Decoster, Mygale's founder. 'We decided early on that it was a good opportunity for us, and we jumped straight in, initially producing a model for the Goodwood show to allow the FIA to have something to show off. So that's why we are more advanced than the others.

'The price cap was fixed from the beginning, and about 80 per cent of the technical regulations were fixed from the start, but there were some small details that took longer. It was not a big issue for us at least, because we were working so closely with the FIA.'

Mygale developed the car along with its regular partners based around the former home of the French Grand Prix in the Pôle de la Performance de Nevers Magny-Cours. ACE carried out the aerodynamic tests, Ligier-Martini the bodywork and the structural composite elements, Danielson Engineering cast the engine covers and uprights, Sodemo and Texys the chassis electronics, data acquisition and paddle shift, while Mygale managed the project and led the mechanical and bodywork design, the manufacture of parts, assembly, homologation, development and marketing.

'We wanted to make the best engineered single-seater in the world within the cost cap, says Decoster. 'Our aim and the aim of the FIA was to have the car with the most advanced engineering,the most advanced safety and at the same time keep within this cost constraint. It is very complex to do, but we believe that F4 is the future of motor racing, and to make it work from a financial point of view we need to produce a significant volume of cars. This will be a big change in the industry – it will be natural that the wealthy fathers who right now have a confusing choice will now put their children into F4. It's the logical choice.'

The new Mygale F4 is unremarkable in overall terms of engineering, with both the cost cap and fairly tight technical regulations defining many areas. As it is a driver-led Formula, it had to be slicks and wings with a paddle shift transmission. But other areas are designed with other factors in mind.

'In terms of the suspension, the car is very conventional,' says Decoster. 'You are only allowed twin dampers front and rear. The reason for this is that all the cars should be designed as "global" cars. In the USA, for example, mono shock layouts are not popular – they don't like it. So globally as there are some people who don't like mono layouts and from a European perspective a twin damper layout is no issue, a twin damper layout was mandated.'

"The objective is for Formula 4 to become a springboard enabling young drivers to put themselves to the test at a high level"

Dome (above) and Dallara (below) are among the manufacturers that have committed to building F4 cars

The regulations limit freedom in many areas, such as the wheelbase which must be between 2740mm and 2760mm, with a minimum track of 1200mm. The minimum weight is 570kg. But the regulations look more like those seen in F1 than in a junior class, with very detailed restrictions on the bodywork, exhaust layout and side pod area. Even the gearbox shaft spacing and crankshaft height are defined.

'The good thing about the way Gerhard Berger has gone about creating F4 is to make sure he has the best cars, not just the cheapest,' says Decoster. 'He wanted to reduce the engineering to make sure it didn't become a pure engineer's championship.'

The car's monocoque is being built by the long established Ligier-Martini company. Safety has clearly been something of a focus of the FIA when developing the regulations for the new class, with each design having to pass the 2016 Formula 3 crash test standards. This means that the new F4 cars will be built to a higher safety standard than those currently running in the bigger category.

At the rear of the car, Mygale opted to move away from its long-time transmission supplier Hewland to another French supplier. 'We have gone for a Sadev transmission, because they really work hard on the gearbox for us,' Decoster says. 'For us it was new – coming from Formula Ford we were initially closer to Hewland as we knew that product well. While it has not been finalised, I think the car will run with six speeds and will definitely have a paddle shift. As each series defines its own sporting regulations, it's not clear if teams will be able to change ratios through the season.'

But at the heart of the car lies its engine and there is no engine supplier defined in the rules – indeed, there are very few engine regulations at all. It must not weigh more than 135kg, must run for 10,000km between rebuilds and meet the cost cap of €9500. The rebuilds themselves are capped at €4000. If a leasing agreement is used, then that must not exceed €6000 a season, with a maximum €1500 rebuild cost. The number of cylinders is free, as is the capacity, and turbocharging is allowed, but not mandatory. Crucially, the engine performance is restricted with a maximum output of 155bhp, and the whole range has to lie within two power target curves defined by the FIA.

'This was one of the really tricky things about developing the car,' says Decoster. 'I had to push Gerhard Berger – I could not complete the design without an engine. It will always be one engine per country, but the FIA wanted as many engine manufacturers as possible involved, so the rules now allow for a turbocharged engine, which is a good thing. Now we have Ford, Renault, VW and FIAT registered. For us it's a case of integrating the different engines into our chassis but we designed the car to allow that. There will be a special kit for each engine with a different bell housing, but that sort of thing but its not too difficult. The first company to commit to F4 was Volkswagen so we did that installation on the first car.'

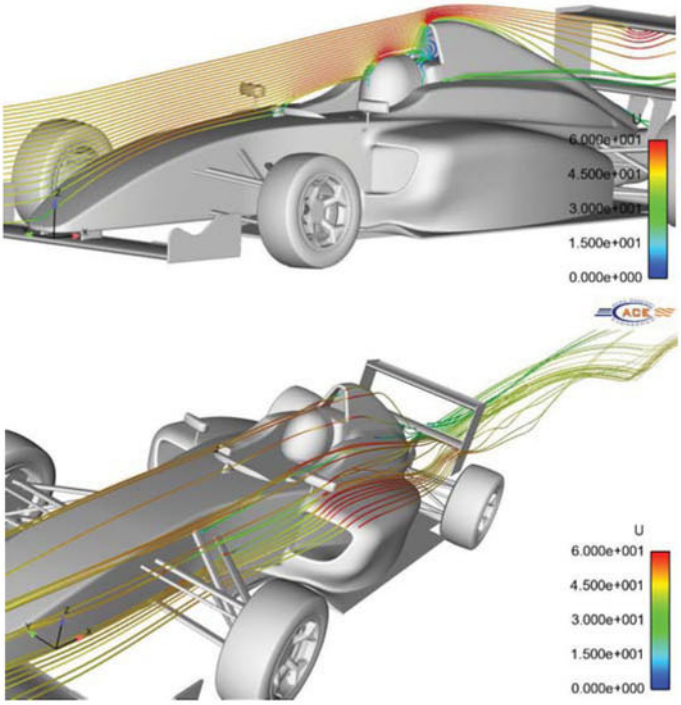
But Formula 4 will not be a single spec series – each nation can select its own car – and Dome, Tatuus and Dallara have all committed to building cars. It is likely that each nation will choose its own single spec car and engine package, so it is possible that none of the new cars will ever race each other.

'The ASNs are not forced to have a spec series in F4, but most will do because it is easier to get

"Gerhard Berger wanted to reduce the engineering – he wanted to ensure that F4 didn't become a pure engineer's championship"

The Mygale concept (shown in full-scale model form, right) was realised and first seen on track in December 2013 (above). It features a Sadev transmission, a move away from the team's long-time partner Hewland

Charting the aero work undertaken by ACE in CFD on the MyGale F4 car



the series off the ground that way,' says Decoster. 'I don't know if there is going to be a Macau-style race where the top cars from each country go head to head. There are no plans that I know of now, but I can imagine that it would happen.'

Indeed, the chances of a international challenge race seem high and the manufacturers including Mygale are developing the cars with this in mind. 'From our side, what we have done is design the car to be the best within the regulations rather than perhaps the most profitable. We did not design it for the cost, though of course that was a factor we built it with a huge R&D programme, lots of CFD and wind tunnel time. When you look at it, you realise that it's not a car that is built just to a cost. This is a car built to take on Dallara, Tatuus and Dome. We designed it like we would design an F3 car. So although there is no plan at the moment, we are ready to fight against the others – and we want to.'

The reason that all of the expensive development work has to be done up front is that once the car is homologated its design is fixed until 2019. So for a constructor there is a significant upfront cost with an unknown market size – which could be something of a gamble – but it seems to be one that at least four are willing to take and *Racecar* understands that there may be at least two other constructors working on projects.

'To make it work, we need to sell hundreds of cars,' says Decoster. 'It's a very demanding market, but we feel that this is the future of motorsport and we think it will work. The whole car is homologated, so you cannot update it. Manufacturers may want different looks, but the FIA wants to keep it to grassroots. We do not know where the aero performance needs to be, so we have done the best that we can within the regulations. We spent a lot of money on the aero side, and we are confident.'

Decoster believes that F4 will not only create a new more structured junior open wheel market, but that it will also reinvigorate its bigger brother Formula 3, which has suffered from low numbers in recent years. As a result he sees F4 as not only a stepping stone for drivers, but for constructors too.

'We will return to F3 after this,' he says. 'We could not return to F3 with a new 2012 specification car, as the market was broken – there were only 20 or 30 cars at the start and that's not enough. There was no room for anyone else there. But in with the '08 car we still know where we need to be, what we need to do to be successful and we will come back in 2016.'

The first F4 series will run this year, with Italy and Germany having confirmed championships, while Japan and the UK will follow in 2015. Australia, Brazil, France, Spain and the USA are all thought to be highly likely to run series too.

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Gearbox (including clutch shaft and output flange)	€8,000
Bellhouse	€1800
Front wing assembly including support	€750
Front crash structure	€1550
Rear wing assembly including support	€950
Rear crash structure	€1400
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Rear suspension comprising (one side): Upper and lower wishbone Track rod Push rod Including uniball joints	€1000
Upright (bare)	€550
Driveshaft (bare without joints)	€300
Wheel bearing	€130
Brake disc	€100
Rims	€250
Anti-roll bar	€210
Radiator	€300
Complete data logging system (including complete sensors perimeter (Article 8.5.2 F4 Technical Regulations) and onboard camera) and complete paddle shift system	€5000

"To make it work we need to sell hundreds of cars. It is a very demanding market, but we feel that this is the future of motorsport"

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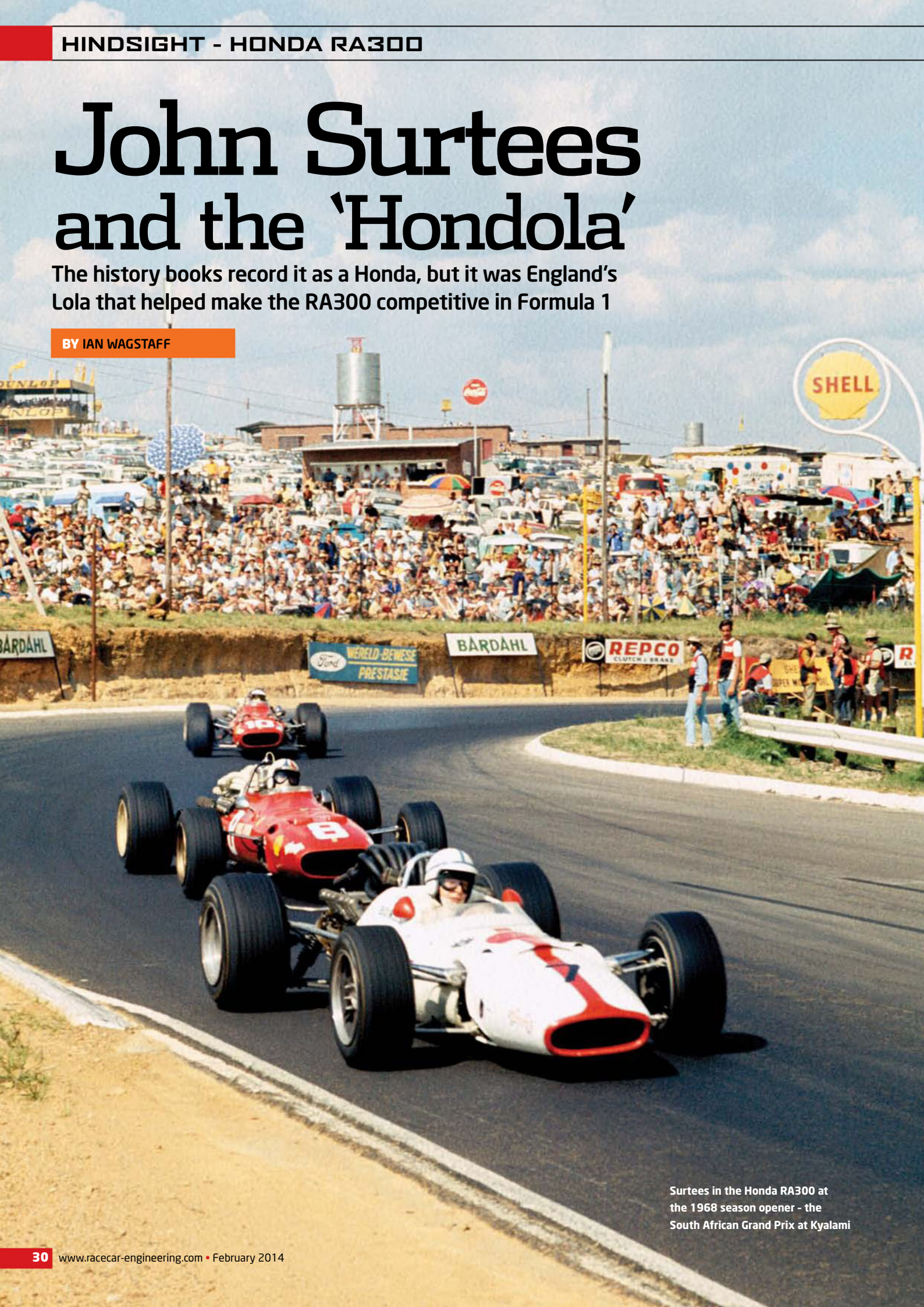
John Surtees and the 'Hondola'

The history books record it as a Honda, but it was England's Lola that helped make the RA300 competitive in Formula 1

BY IAN WAGSTAFF



Surtees in the Honda RA300 at the 1968 season opener - the South African Grand Prix at Kyalami

The name of Lola does not appear in the lists of Grand Prix winners. The initiated know that this is a travesty. John Surtees points out that his last-minute victory in the 1967 Italian GP was really at the wheel of a Lola, although history records is as the Honda RA300. Others refer to it as the 'Hondola'.

Surtees and Honda had both established their world-class credentials in motorcycle racing. Perhaps, therefore, it is not surprising that the manufacturer approached Surtees for 1967 stating that it would only continue in Formula 1 if he joined and helped organise the team. 'I was taken into a new world, that of the Japanese,' he recalls. On his first visit to Honda, Surtees was asked to write on a blackboard what he required from a car and what development changes he had made with the Cooper-Maserati he had raced for the past one-and-a-half seasons.

The Mexican Grand Prix winning 1.5-litre Honda had been unconventional with its transverse engine. Without the benefit of modern aerodynamic thinking, Surtees thought the idea 'rather good'. He was not the only one, when Franco Rocchi left Ferrari he designed an across the frame W12.

The main problem that Surtees found was that an entirely new team had designed the first 3-litre car, so there was no feed over from the previous formula. It was part of Honda's approach to building its R&D in that it used motorsport in this way.

The RA273 had been designed very much on old aircraft principles. With its internal structuring, it was rather like an end of World War 2 aeroplane. At around 1500lb, it was some 400lb heavier than anything else on the F1 grid. Surtees describes the chassis as having felt like a tank and of having been built like the Forth Bridge. The Shoichiro Irimajiri-designed engine was, likewise, far too heavy. The thinking behind the 3-litre, V12 all roller bearing power unit was similar to that of Alfa Romeo before the war with its centre power take off. This meant an extra shaft in the gearbox and that the overall car was heavy. The engine also used low-pressure fuel injection. Many of the temperature change characteristics that Surtees had experienced with the direct injection at Ferrari were there. This system would have been fine if the engine had been running on methanol, but it was not sufficiently precise with pump petrol. Only three engines were available at the start of the season, plus a magnesium-headed version which proved too troublesome to use. Honda had no rebuilding facilities in the UK and there was not always enough money to send the engines back for overhauls. Team manager, Yoshio Nakamura, was very sympathetic, as was Tadashi Kume – back in Japan – who had been responsible for the 1.5-litre engine and a young engineer Nobuhiko Kawamoto, both of whom would rise to the position of president within company.

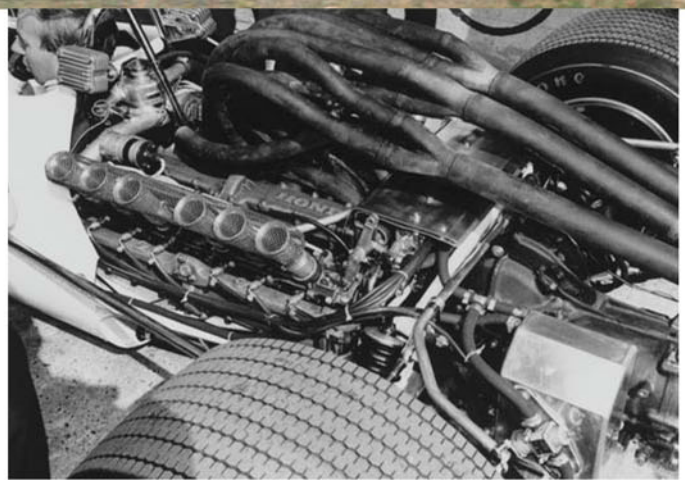
ALL PICTURES: LAT

Top: Surtees in January 1967, in action at the Italian Grand Prix at Monza...
Above: ...and in the pitlane during the same race, which he went on to win

JOINT INITIATIVE

Surtees realised that he would have to take the initiative and, after the German Grand Prix, he suggested that a joint programme with Lola might be undertaken to make Honda competitive. In 1966 he had been testing Eric Broadley's T90 for Indianapolis with George Bignotti, but an accident in a Lola T70 at Ste Jovite, Canada put him out of action and, from his hospital bed, he suggested to entrant John Mecom that Graham Hill should take over his drive in the Indy 500. The then-BRM works driver went on to victory while Surtees's only ever drive in an IndyCar came during the following year's Rex Mays 300 at Riverside.

Because of his knowledge of the T90 – 'quite a nice car to drive,' as he put it – Surtees suggested that it could be the basis for a revised F1 Honda. Nakamura also put the idea to Soichiro Honda, permission was given and the small team moved to Slough. The result was the RA300, which was then designed in conjunction with Honda's Shoichi Sano. History remembers it as the 'Hondola'. All the machined parts were



Top: Surtees at the 1967 United States Grand Prix at Watkins Glen
Above: from the same year, a close look at the RA300's engine

manufactured in Japan, while the chassis was constructed in the UK. The aerodynamically improved project was completed in six weeks and finished just in time for the Italian Grand Prix.

Surtees would have liked to have saved 200lb, but had to be content with 100lb, despite the use of a number of titanium components. There was still an additional mass of engine weight and the fact that its central power take-off required the use of a three-shaft gearbox. Kume, however, lifted the pressure on the injection. For such an overweight engine, the Honda V12 has some strange characteristics, but by running it with very low gears and letting the engine rev for a short period to 10,500rpm, it did the job that day at Monza.

There was a problem on the high speed Italian track in that terminal speed was so high that a suitable gear had to be fitted to achieve it, leading to a difficulty in not getting up to that speed quickly enough. In his battle with Jack Brabham's Brabham-Repco, Surtees would lose out to the Australian for two-thirds of the straight coming out of the Parabolica, only to close up as they approached the Curva Grande. Last lap tactics, however, resulted in a win, first time out, for the RA300.

Derrick White, who had worked with Surtees at Cooper, now joined, and with Sano and the Honda team, they designed a new car, the RA301. Kume became involved with the V12 engine, which incorporated a revised cylinder head with torsion bar valve springs like Honda's highly successful 1966 Formula 2 power unit. The injection system was again uprated. Surtees now found that he could safely use more revs and that the car could be geared to use the power for longer periods with fewer gear changes. One engine was fitted with a magnesium block, but this ran into trouble. Surtees was not the only one to have believed the RA301 could have won the world championship, but for a whole series of niggling problems. 'It was a good car to drive,' he says.

Honda, however, suggested that the RA301 was but an interim car as there was to be a new, compact, plain bearing 12-cylinder. As it was, with air-cooled N600 saloons about to be launched into the European market, Honda instead came up with an air- and oil-cooled V8, the RA302, the development of which delayed testing of the RA301. Honda was in the process of transition from being just a major motorcycle manufacturer to also being a car company and was looking at the cheaper end of the scale. Honda himself believed that this could partly be achieved with the air- and oil-cooled principle in which air was drafted into the engine, not just on to it. The directive had, therefore, gone out, that this should be used for racing. 'Some things Mr Honda got very right. The odd things, like all of us, he got very wrong,' Surtees recalls.

An R302 arrived at the team's Slough works without warning, the programme having been kept very secret. The UK-based Honda engineers appeared embarrassed. Surtees took it out for a test at Silverstone and then suggested that it was firmly parked. All the oil had blown out, while at a subsequent test in Monza the undeveloped V8 simply overheated.

Surtees was not the only one that believed the RA301 could have won the world championship

The car should have remained in the corner of the Slough workshop where it had been sent, but the seeds of tragedy were sown when men from Honda France arrived and took it away in the dead of night. It reappeared at the opposite end of the Rouen paddock from the UK-based operation and its RA301. On the second lap of the race, Jo Schlesser crashed heavily and the car caught fire. The Frenchman did not stand a chance of escape. Surtees admits that there were certain features of the RA302 that would have made it worthy of development. 'If the engine had been a nice, little water-cooled V8, the project could have been very exciting,' he says. 'As it was, it was a car that was not ready to race.'

Surtees had banked on being able to build up the Honda programme to win the World Championship. However, Honda had stopped development of the lightweight V12 engine. With one RA302 still in existence, there was now an air of uncertainty in the camp, which concluded at the end of season when Nakamura had to report to Surtees that Honda's initial F1 venture was over. One good thing that did come out of its closure was that the engineers who had been involved moved back into road cars and built the Civic, which became the bedrock of Honda's success as a serious car manufacturer.

A footnote occurred in 1986, just after Nigel Mansell had won the British Grand Prix in a Honda-powered Williams. A telegram arrived for Surtees from Kume stating that, without his earlier contribution, such a result would not have been possible.

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Ready or not

It's the first car built with a new prototype racing class in mind, but the future direction for the Pescarolo 02 remains undecided

BY SAM COLLINS

In late 2013, the Automobile Club de l'Ouest revealed that it was creating a new prototype racing class for its regional series. The new category designed for small low-cost cars will make its debut in this years Asian Le Mans Series and in the European version the following year. It is not the first time the French club has tried out a junior prototype class, its first attempt – originally called Formula Le Mans – used the Courage LC70/75 chassis mated to a stock GM LS V8. This still forms the basis of the Prototype Challenge in TUSCC.

The precise regulations of the class have yet to be released but regulations seen by *Racecar* suggest that all cars must be carbon chassis designs using a single spec engine, transmission and tyres. But they are otherwise very similar to those used in the FIA CN category. Indeed, in the Asian championship, carbon chassis cars built to the FIA CN rules will be allowed to take part in the first year. The price of the cars will be fixed at €150,000.

The first car to be built to the new rules concept is the Pescarolo 02, originally commissioned by the ACO in 2009 as an open-top racing school car. Sora Composites decided that it would be the perfect basis of a Coupe too.

'The chassis was the same – we had a customer that tried out the open racing school car and he wanted to buy it but he insisted on a closed version, so we started work on it,' says Jean-Philippe Perrier, the leader of the project at Sora Composites. According to Perrier, the car was the inspiration for the LMP3 category, and is included in the list of cars able to be run in the class. 'But rather than a new chassis we kept the same one,' he says. 'In the beginning we had a coupe in mind, so now you just add a special kit which includes the roof and a 15CDV6 steel cage. It is the peculiarity of this car, you could convert one of the open cars to the coupe for about €10,000. The open and closed cars meet the FIA CN rules. The total height of the car is too high for me, but the regulations say that it has to be that high.'

The car was originally intended to be a baby LMP, the LMP3 that the new class suggests, but in the years between the construction of the first car and the eventual announcement of the class, the car has been raced in the popular VdeV endurance championship in France.

'We have been working with the ACO since the beginning of the project,' says Perrier. 'They had five customers in China who wanted to buy smaller cars to run in the Asian Le Mans Series, so we thought this would be ideal for them.

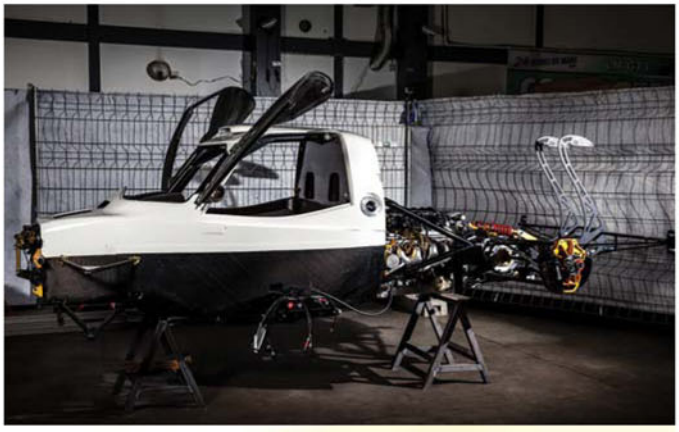
'We did not design the car to be a CN car really, instead it is really just a smaller LMP. It is built to the same crash-test specifications and has LMP style suspension, even the same dampers. The electronics are identical to the LMP too, with Cosworth management and our own paddle shift.'

Meanwhile, the choice of engine in the car has proved to be a source of controversy. While most cars built to the FIA CN rules utilise two litre Honda engines, tuned by companies like Mugen Euro, the Pescarolo uses an off-the-shelf GM LS3 V8. This is the same unit used in the prototype challenge cars. Perrier's car tips the scales at 860kg and the market leading CN car, the Ligier JS53, has a dry weight of 570kg. However, the GM engine produces 360bhp, compared to the 255bhp of the Honda.

'Our car is more powerful, but it has the same lap time as a CN car as it is heavier,' says Perrier. 'We are really just using a standard engine with our own dry sump. The problem is that Honda has stopped making the base engine popular in CN, so now you must buy it from a tuner for €16,000, while the GM engine is $5,000. On a €100,000 car, having more than 10 per cent of the budget on the engine is too much – it's crazy. I do not want to have to fit a CN engine to this car. If you look at the main idea of the LMP3 class, it is this car.'

As a result of the lack of clarity over this, the Pescarolo 02 may never run as an LMP3 as there are moves afoot to force all of the Asian Le Mans series cars to use a CN style four cylinder engine, essentially ruling it out. The Ligier JS53 will likely dominate the market instead.

'It is very political at the moment,' says Perrier. 'We are on target in terms of price, the car is ready, but maybe we will not be allowed to run.'



The 02 has been raced in the VdeV endurance championship in France. Elsewhere, the design team would rather use a GM than a CN engine

TECH SPEC

Chassis: carbon fibre monocoque with twin roll hoops, optional steel safety cage for coupe bodywork

Engine: GM LS3 N/A V8

Suspension: double wishbone with pushrod actuated PKM dampers

Brakes: Brembo steel discs

Transmission: SADEV Gearbox six-speed sequential, limited slip differential

Electronics: Cosworth with SQ6 ECU, IPS power management, Varley Red Top battery

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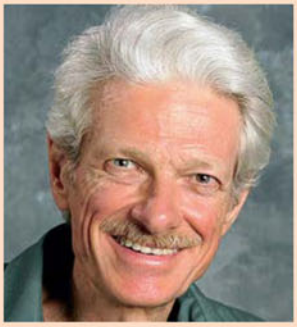

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A primer on powersliding

Is it possible to translate dirt biking principles to racecars?

QUESTION

I was recently reading *Motorcycle Handling and Chassis Design* by Tony Foale, in particular his description of the forces involved while powersliding a motorcycle on a dirt flat track.

I then proceeded to search for a good description of the dynamics involved in a four wheel vehicle powerslide on a dirt or pavement surface. There appears to be very ittle of anything out there in terms of literature, SAE papers, decent chassis books, or on the internet.

My curiosity is now piqued as to the setup implications of powersliding a racecar.

We know that while powersliding we are using a portion of the longitudinal force vector to maintain our curved path, ie to provide a component of force to add to centripetal acceleration, and a portion of that same vector is being used to propel us around the corner.

So what – if any – effect is there from, say, stagger? If we say that a powerslide necessitates rear wheelspin then we would have to conclude that stagger is really irrelevant in this situation. Also, what does our dynamic wedge look like under these conditions?

What setup parameters can we change to promote or increase or decrease the oversteer yaw rotation of a powerslide, besides what might be obvious to make a vehicle oversteer to the extreme?

Or is this more of a driver-induced condition controlled by throttle and counter steering?

And finally, in dry slick conditions on a dirt track (no accumulated rubber, just hard dry dirt with accumulated fine dust on the surface) is this technique even the best tactic to better the lap times?

Mainly, however, what do you consider to be the main chassis dynamic variables in play during a powerslide?

THE CONSULTANT SAYS

As a practical matter, we know that powersliding only works on relatively low-grip surfaces, simply because if we do it with sticky tyres on a high-grip surface, we scrub off too much speed and quickly destroy the tyres. With enough power, and at a sufficiently low speed (as in actual drifting competition), we can powerslide a car on pavement, but it's not normally a way to win races.

It's certainly true that we are using a portion of the car-forward thrust as cornering force and part of it as road-forward propulsion force. I have never heard of anybody actually trying an experiment taking segment times on a relatively low-grip surface, powersliding vs trying to make the car track, and comparing the times. One thing I'd predict, based on my own experience in low-grip conditions, is that when not powersliding, the times would be less consistent, and there would be more instances of loss of control.

When we try to corner at the limit of adhesion on a low-grip surface, the car will often go into dramatic understeer or oversteer on its own, in response to variations in the road surface. It can take a lot of road to recover, and we may lose a lot of speed, or even crash. We can avoid this by going slowly enough, but we don't want to do that if we're racing.

If we powerslide the car, we have oversteer, but the amount is under the driver's control to a fair degree, and we at least know that the car isn't going to simply push into the wall. Cars having a wide range of understeer gradients on their own can be held in a controlled attitude, to a degree not possible without powersliding.

In particular, we can 'drive a tight car loose' by powersliding.

In some cases, it can be unclear whether a car is powersliding or not. Cars that naturally oversteer generally need to corner with some power on. If available power is fairly modest, full throttle may be the setting least likely to spin the car. The 'stab it and steer' technique will be familiar to Porsche and Corvair drivers. Is a full-power oversteer condition

Powersliding only works on relatively low-grip surfaces, as doing it on high-grip ground can eat into speed and wear out tyres

If we powerslide the car, we have oversteer – but that's under the driver's control to a fair degree

a powerslide, when the driver is actually applying that power to minimise oversteer?

The effect of rear tyre stagger does diminish greatly as the rear tyres reach the point of breakaway. A car with ample stagger is easier to get into a slide, and tends to stabilise somewhat once the tail is hung out. A car with little or no stagger is hard to get rotating, and tends to snap loose more abruptly as the rear tyres reach breakaway. So a car with more stagger tends to be easier to drive. The downside is more drag when the rear tyres are not sliding, particularly down the straights. Hence, my usual recommendation is to use as little stagger as the driver can live with.

Compared to a technique of not hanging the tail out with power, does powersliding add or reduce dynamic wedge? Actually, the term 'dynamic wedge' is a bit unclear. It's easy to say that a particular effect adds or reduces wedge dynamically. Anything that adds an upward jacking force at the inside rear adds wedge dynamically compared to a baseline without the effect. But if we wanted to move beyond conversational physics or qualitative discussion, and put a number on 'dynamic wedge', how would we calculate that? How would we output a 'dynamic wedge' value during K&C testing? Would we just calculate diagonal percentage, and call the car unwedged when it's at 50 per cent?

The effect of rear tyre stagger does diminish greatly as the rear tyres reach the point of breakaway

I am inclined to call a car unwedged when the front and rear wheel pairs exhibit identical left percentages, which also implies that the right and left wheel pairs exhibit identical rear percentages. But when the car has its wheel loads very unevenly distributed both laterally and longitudinally, an unwedged condition by that definition is a long way from 50 per cent diagonal.

Suppose we have a car with equal wheel loads statically, that's cornering hard under heavy power and dynamically has 70 per cent right and 60 per cent rear. If the car is unwedged by my definition, the right front has 70 per cent of 40 per cent, or 28 per cent of the total load. The right rear has 70 per cent of 60 per cent, or 42 per cent. The left front has 30 per cent of 40 per cent, or 12 per cent. The left rear has 30 per cent of 60 per cent, or 18 per cent. Here, the diagonal percentage (RF + LR) is 46 per cent. If it were 50 per cent, the rear tyres would be more evenly loaded than the fronts.

Note that this has nothing to do with how sideways the car is. This could be a pavement car, operating at a fairly small yaw or attitude angle. We could also get the same wheel load distribution if the car is accelerating only laterally, and has 60 per cent rear statically.

Since there is no agreed way of expressing 'dynamic wedge', my recommendation for either simulation or K&C testing would be to look at front and rear left percentages, and also diagonal percentage, and let it go at that. To move beyond that, we could look at the ratio of front-to-rear inside or outside wheel percentages, or the percentage point difference between those. However, that would be a measure adopted by a particular team or person, and would not be useful for comparison across a broad spectrum.

Anti-lift in a front-drive car

Is there any way to help reduce or eliminate chassis rise under acceleration?

QUESTION

Your recent discussion of anti-dive geometry brought up a question about other possibilities. As you know, strong acceleration in a front wheel drive racecar causes the front to rise and it loses traction. My question: is there any possible suspension geometry that would minimise or eliminate the chassis rise in a FWD car under acceleration? I have used a system to mechanically oppose suspension rise using a cable and hydraulic cylinder system, but it is somewhat complex and adds weight, although it does help off-the-line traction. The car is a Classic Mini tube frame D Modified (SCCA) with a Modified Acura Integra GSR drivetrain.

THE CONSULTANT SAYS

Rearward load transfer under power does reduce drive traction with front wheel drive, and that is one reason it is not the first choice for a high-powered car.

Front end lift is not the cause of rearward load transfer – it is a result. For a given forward acceleration of a given mass, the amount of rearward load transfer depends purely on the cg height and the wheelbase. To improve, we need to lengthen the wheelbase and/or lower the cg. However, front end rise does have a small effect on dynamic cg height. We can have a slightly lower dynamic cg height by reducing front end rise and also by permitting rear end drop. The idea isn't to prevent the car from pitching, but to keep the car down overall.

It is possible to have some anti-lift in a front-drive front suspension. It is not possible to have an anti-squat or pro-squat effect at the rear under power, however, because there is no ground plane force at the rear contact patches.

Because the front suspension is generally independent, with no gearing in the uprights, there is no torque reaction through the suspension linkage. All anti-lift has to be thrust anti-lift: the geometry has to make the wheel centre move forward as the suspension compresses and rearward as the suspension extends. The side-view projected instant centre has to be above hub height and behind the wheel, or below hub height and ahead of the wheel.

Such geometry adversely affects impact harshness, but that can be tolerated in a racecar. The real limitation on anti-lift is wheel hop. The more anti-lift we use, the more prone the car becomes to wheel hop at the point of front wheelspin. Exactly how much anti-lift will make this intolerable, or make the car slower because of it, is hard to predict. It depends a great deal on the tyres and the road surface. Undamped compliance in the suspension makes it worse, so making the control arms and their mountings as stiff as possible is helpful.

The more anti-lift we use, the more prone the car becomes to wheel hop at the point of front wheelspin

Using stiff low-speed rebound or extension damping at the front can momentarily slow front end rise, but will not keep the front down in steady-state acceleration. Similarly, using soft low-speed compression damping at the rear will reduce overall ride height momentarily, but not steady-state.

Using high wheel rate in ride at the front helps reduce front lift. Using low wheel rate at the rear helps increase rear squat. Since we generally want enough rear roll stiffness to make the car lift the inside rear wheel, this means using very little anti-roll bar at the front, and a lot at the rear.

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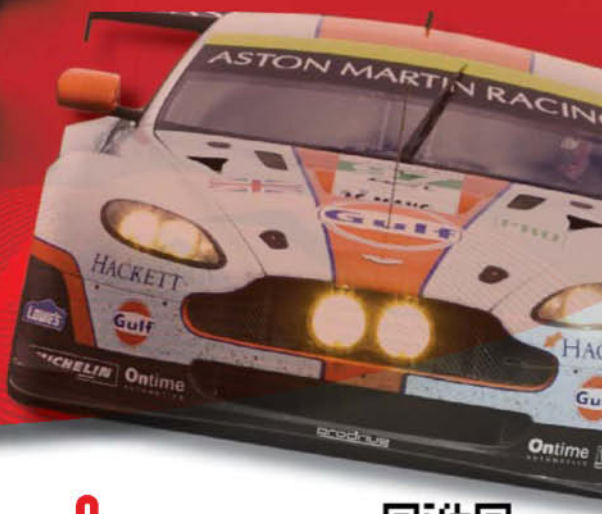

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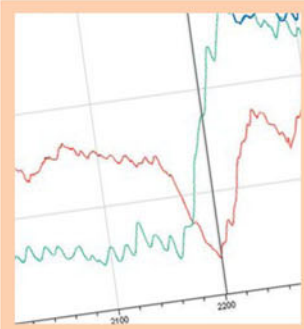
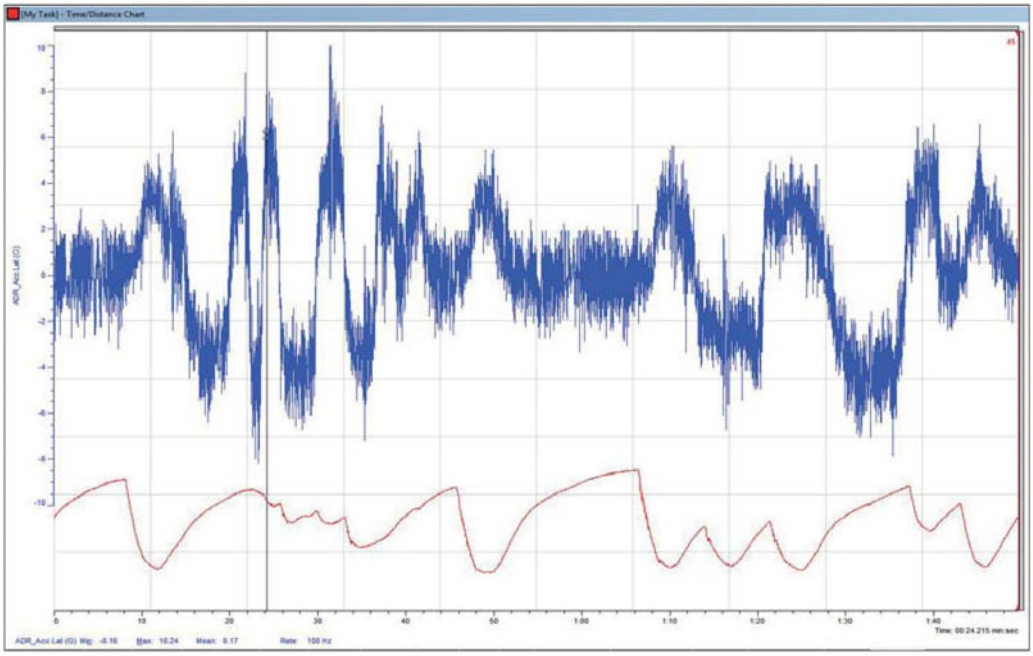


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

Filters in focus

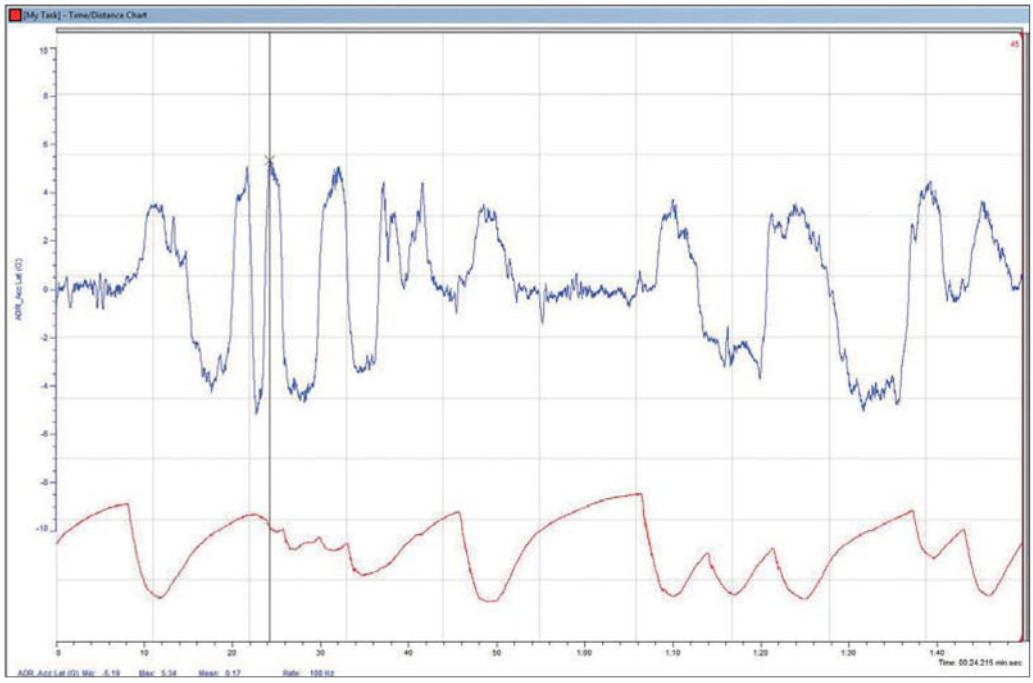
With so much data to decipher, it's vital to be able to clarify the numbers you have – and this is where filters can help



Being able to use the correct data, be it for analysis, control, visualisation – or anything else – is very important. There are mountains of data available on any race vehicle these days, and all of this can be collected at almost staggering rates, so fast that hardly any blip or spike goes unnoticed. This, of course, is extremely beneficial, and those involved in gearbox and engine control wouldn't have it any other way. But for those that are more interested in trends, long-term changes and slow control methods, the fast data rates and noise on channels can pose significant problems when trying to get to the root of a problem or to control something precisely.

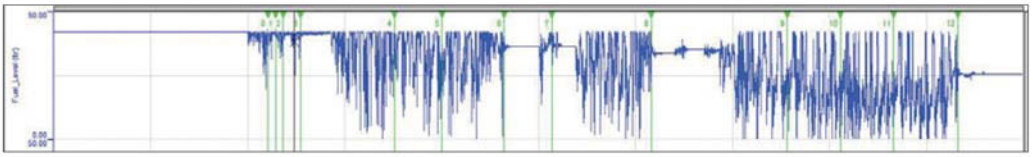
Most data analysis programs allow the use of some filters in order to clarify any data that is being used. A good example is when a noisy accelerometer trace is evened out using a moving average filter. In the case shown above, the accelerometer trace is from an accident data recorder which – due to its nature – normally needs to be hard mounted to the chassis. This of course also means that all the vibrations of the vehicle are shown as well. Using a simple moving average filter with a 0.3s time allows us to remove the noise and look at a more relevant trace (left).

There are many different filters available for post-analysis of any data, and some programs even allow the user to design their own filters. There are, however, also uses for filtering data when it comes to displays. This can be



achieved in a number of ways and it is possible to use a standard time-based moving average filter directly on the display control itself. This can be useful for values that do not change very rapidly, or for values where the mean is more important than any minimum or maximum number.

There are, however, instances where the filtering needs to be a bit more aggressive, and where a moving average might not be adequate. A good example of this is fuel level (see below). This channel can often be extremely erratic, as fuel can be stored in an un-baffled tank and therefore the level will move around significantly and in fact rarely stays still in a racecar. Looking at the problem of getting a good fuel level value is also interesting, as there are two conditions to consider: the value when the car is stationary – which is also when a fast change in the value is acceptable – and the value when the car goes around a track and the level moves around.



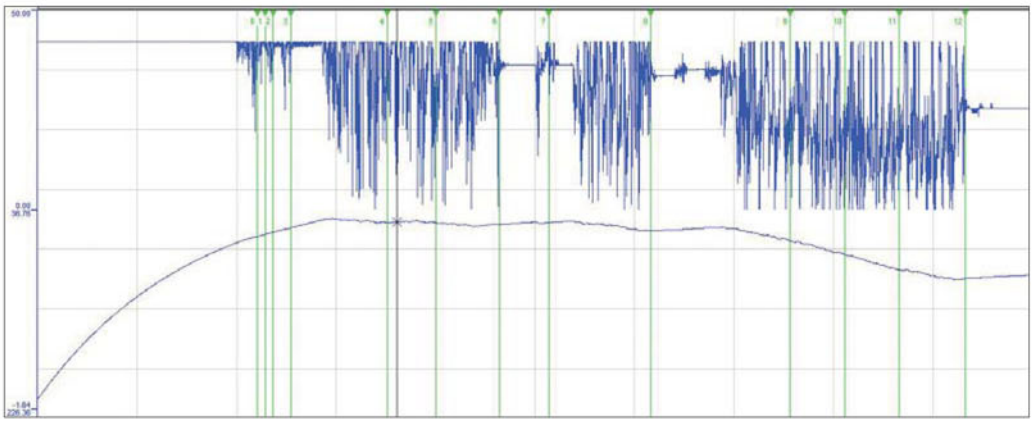
LOW PASS FILTER

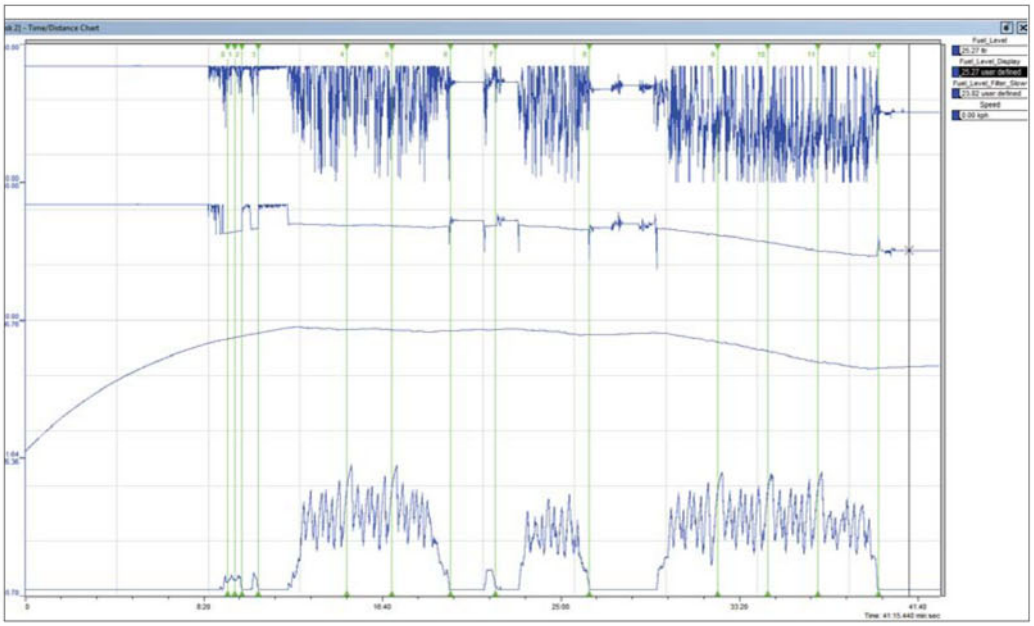
$$\text{Filtered Signal}_t = \text{Filtered Signal}_{t-1} + (\text{Signal}_t - \text{Filtered Signal}_{t-1}) * \left(\frac{\text{Cutoff Frequency} * 2\pi * \text{Sample Time}}{(\text{Cutoff Frequency} * 2\pi * \text{Sample Time}) + 1}\right)$$

Represented in on-board maths as:

```
register @a0;
register @a1;
register @a2;

@a0 = ([Fuel_Level]);
@a2 = @a1;
@a1 = (@a2 + (@a0 - @a2) * ((0.02 * (2*3.142)*0.02) / ((0.02 * (2*3.142) *0.02) + 1)));
@a1
```





If we first of all look at the effects of the aggressive low pass filter (shown left) on this channel (results below left), it is clear that this alone cannot be the end solution, although it offers a significant improvement when the level is very noisy. The areas when the car is stationary are of specific interest, especially the periods before and after the outing. These areas show well how slow the channel reacts to changes.

The next step is to add the conditions to the displayed channel to allow the unfiltered value to be active when the car is stationary and the filtered value to be used on track. This is done with a simple if-else statement seen below:

choose([Speed] > 0, [Fuel_Level_Filter_Low_Pass], [Fuel_Level])

Then, in the graph below left, the channel second from the top is what would be displayed on the dashboard to indicate fuel level. In the beginning we see a gearbox run up or the car being moved around in the paddock that influences the display reading in the beginning, but once the car gets going, the low pass filter does its job. There is also a blip in the value at the end when the switch from a filtered to non-filtered value occurs.

This type of filtering can be very useful to implement on various channels that perhaps have a lot of noise or change rapidly, but the spikes are not of interest. Filtering this at the source in the data system as the car goes around also has significant advantages when it comes to displaying channels.

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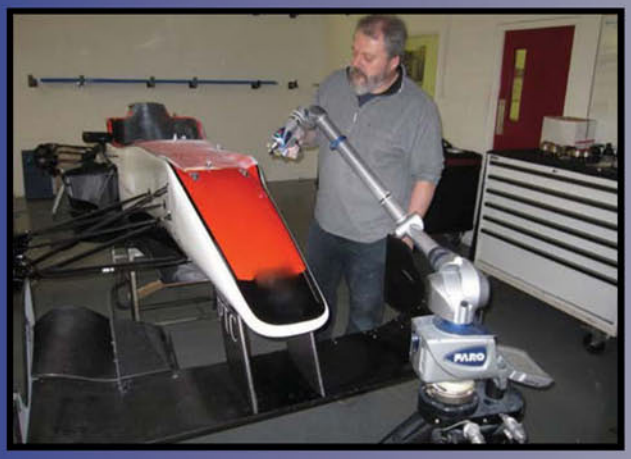

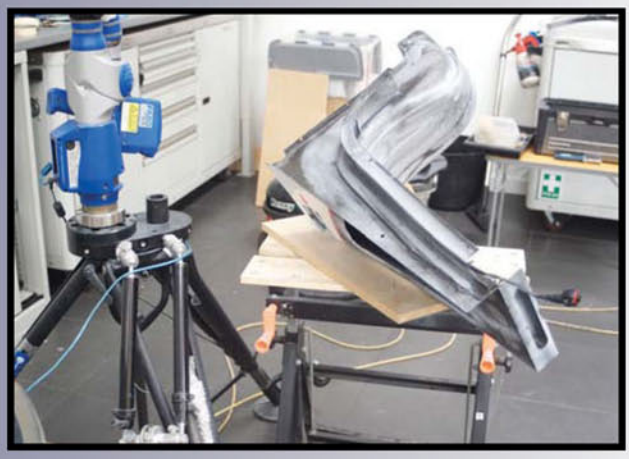

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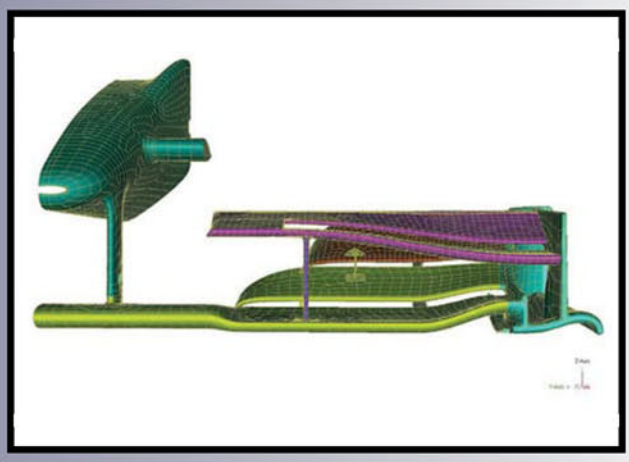

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Continuing studies

This month's instalment of our look at a Formula Student entry unearths wing adjustments that produced fascinating results

Our analysis of the aero of the University of Hertfordshire Formula Student Racing Team's UH16 2013 car continues this month with a look at the effects of some front wing adjustments.

With the students themselves running the session, some very interesting material was produced. To recap, UH16 features a full aero package, comprising front and rear dual-element high downforce wings with main element and flap profiles based on the Selig 1223 aeronautical wing profile. As a reminder, the baseline configuration of 'maximum flaps all round' produced considerably more downforce as a proportion of vehicle weight than the Formula 3 and Formula 1 cars we have tested for this column. **Table 1** gives the baseline coefficients at 40mph.

Cleverly, the design of the UH16 front dual element wing allowed separate adjustment of the inner and outer flap sections, offering greater tuning flexibility.

Front wing adjustments including various flap options and also wing height

But what would the responses be to adjusting each section? First let's look at the effects of dropping the inner front flap section from maximum to minimum, with the front outer and rear flaps at maximum. **Table 2** reveals all.

VARIOUS FLAP OPTIONS

Let's first tabulate the effects of dropping the front outer flap to minimum, with the front inner flap and rear flap both remaining at minimum (the only combination in which minimum outer flap was deployed in competition, therefore the only one in which it was evaluated in the wind tunnel).

Because these two trials were against different baseline configurations, in a sense they are not directly comparable. But focusing on the differences in each case, there are interesting comparisons to be made. Adjusting either section of the front flap from maximum to minimum made significant differences to downforce and balance. But one of the things that stood out is that both adjustments produced a noticeable reduction in drag.

This seemed unusual. Any reductions in drag across the range of front flap adjustment are usually small. However, the magnitude of the differences in -CLfront, and particularly that arising from adjusting the front inner flap, was also very large. And to put a perspective on the differences here, the 2012 Dallara F3 that we tested for these pages showed a 237 count difference in -CLfront for a 24 count reduction in drag between maximum and minimum front flap angle – roughly in the same 10:1 ratio as seen from the change to the front inner flap here.

Perhaps it is worth taking into account that changes to the front inner flaps on the Formula Student car did also produce changes in frontal area (at least, on the left side of the car), whereas altering front flap angle on most open

Table 1: coefficients at 40mph on UH16 with maximum flap angles front and rear

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline	1.158	1.758	0.980	0.778	55.7	1.518

Table 2: the effects at 40mph of reducing the front inner flap angle, the differences in 'counts' where 1 count = a coefficient change of 0.001

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Max/max/max*	1.158	1.758	0.980	0.778	55.7	1.518
Fr. inner flap to min	1.102	1.452	0.417	1.036	28.7	1.318
Difference	-56	-306	-563	+258	-27.0	-200

**Front inner, front outer and rear flaps at maximum*

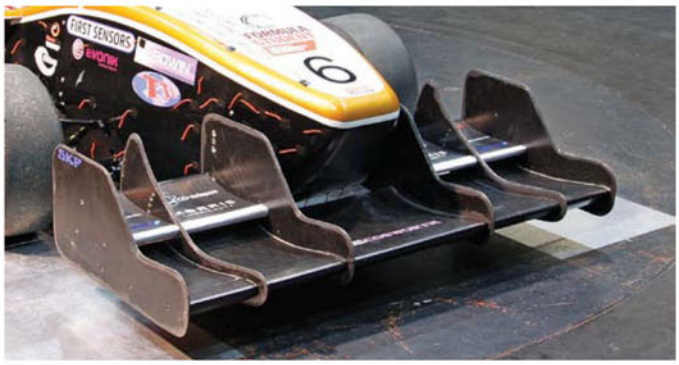
Table 3: the effects at 40mph of reducing the front outer flap angle, the differences in counts

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Min/max/DRS*	0.723	0.791	0.613	0.179	77.5	1.095
Fr. outer flap to min	0.674	0.568	0.261	0.307	46.0	0.843
Difference	-49	-223	-352	+128	-31.5	-252

**Front inner flap at minimum, front outer flap at maximum, rear flap in low drag 'DRS' position*

Maximum inner and outer front flap angle

Minimum inner and maximum outer front flap angle



Minimum inner and outer front flap angle

wheel cars with sidepods aft of the front wing and front wheels does not usually alter the frontal area, although it clearly does alter the downstream flows. However, the 49 count drag reduction on dropping the outer front flap to minimum – which produced a 352 count reduction in –CLfront – still seems disproportionately large and therefore rather surprising, especially as it appeared to allow more air to directly encounter the front wheels.

And perhaps this was crucial, because other cars we have tested have had front wings of regulation-limited spans that did not extend in front of the wheels, whereas UH16's front wing span was effectively full car width. But in the configuration being evaluated, the further 49 counts of drag reduction were certainly useful!

FRONT WING HEIGHT

The design of UH16's front wing included CFD simulations of different ground clearances. That said, the team wisely allowed themselves some options on operational front wing mounting height that enabled this parameter to be mapped in the wind tunnel. The three different configurations of wing flap settings seen in these trials were implemented in turn, so the front wing could be evaluated at three different heights – datum, 20mm higher and 40mm higher.

The three configurations were: front inner and outer flaps at minimum plus rear flap in 'DRS' position; front inner flap at minimum, front outer flap and rear flap at maximum; and all flaps at maximum. For clarity, the interesting results are plotted in **Figures 1** to **3**.

Figure 1: overall downforce, -CL, plotted against wing height changes

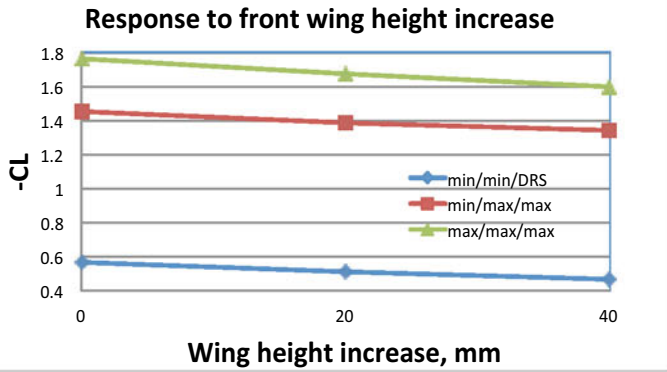


Figure 2: front downforce, -CLfront, plotted against wing height changes

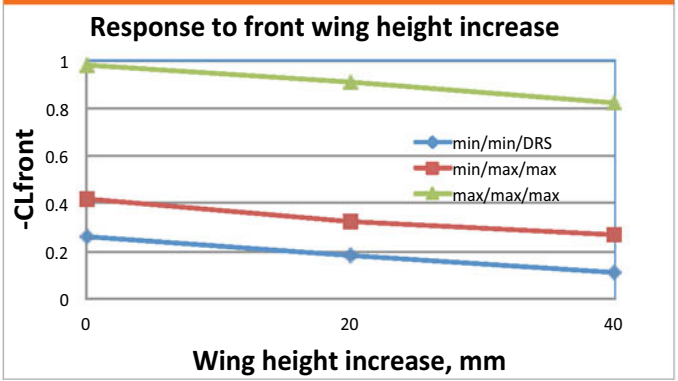
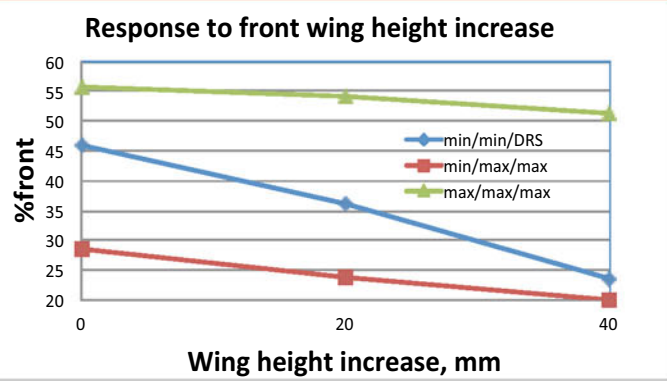


Figure 3: aerodynamic balance as %front plotted against wing height



Although only three data points were analysed for each configuration, it appears that the decline in overall downforce with increasing height was close to being linear over this range. In **Figure 2** the –CLfront only is plotted. Evidently the response of front downforce to raising the front wing was also essentially linear over this range, and this plot emphasises the large difference in potency of the front wing that changing the inner flap from maximum to minimum produced.

Lastly, **Figure 3** shows the response of balance (as '%front') to raising the wing height.

The pattern here demonstrates that in the lowest downforce configuration, 'min/min/DRS', the balance was more sensitive to changes in wing height than in the other two higher downforce configurations. This was simply because the overall downforce reduction from raising the wing height was roughly the same in each configuration, which meant that it was a bigger proportionate change relative to the lowest overall downforce configuration.

Next month we'll look at some yaw trials that produced both similarities and differences, whether turning left or right...

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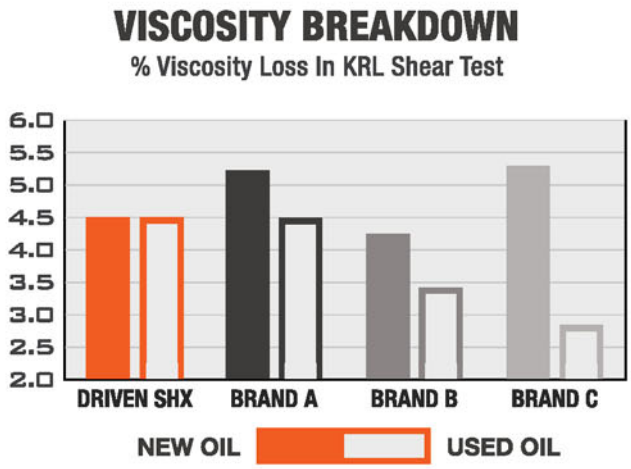

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Changing gears

With so much focus on the new F1 engines, a transmission rule change has slipped through almost unnoticed. But it's created opportunities – and headaches – for manufacturers

BY SAM COLLINS

In recent months, there has been much discussion regarding the new generation F1 power units. These mate 1.6-litre turbocharged V6 engines with a very potent pair of energy recovery systems, and coupled with a fuel flow restriction place the emphasis firmly on efficiency. But little has been written about the impact of the new regulations on the transmission of the cars. Perhaps this can explained by the fact that the technical regs feature hardly any changes to the rules relating to the gearbox, beyond a small increase in the maximum number of gear ratios allowed – to a maximum of eight. All other details in the regulations relating to transmission remain the same, so at first glance the gearboxes do seem not to be the most interesting part of the new cars. But this is far from the case.

'On the face of it, it looks like a relatively unexciting rule change that doesn't give much opportunity in terms of innovation or doing anything differently beyond designing another gear into the gearbox,' says Adrian Moore, technical director at Xtrac. 'But despite the changes in the technical regulations being quite small, the end result is quite significant in terms of the gearbox. It's an opportunity for us to change and to do something quite different.'

One of the key differences comes with the change in KERS regulations doubling the output of the MGU-K in terms of power and increasing the amount of time it can be used per lap. 'That makes a change to the duty cycle and power that is transmitted through the gearbox,' adds Moore. 'It in turn significantly changes the size and configuration of what gearbox we will use. The new rules and new demands mean that we have to design a completely different gearbox. It's a fundamentally different application now, with increased torque and reduced RPM. The engine regulations also include the fuel mass limit and fuel flow limit which makes efficiency one of the key objectives, and that is just as relevant to the gearbox.'

F1 gearboxes have had a fairly fixed design in recent years, with the overall layout remaining much the same. 'In a typical 2013 transmission, you have the gear cluster driving through a bevel gear to turn the drive through 90 degrees, and then you have a spur final drive driving to the active hydraulic differential,' says Moore. 'This configuration is pretty well established and it is all about the aero requirements, allowing the back of the car and the gearbox to be very narrow. At the rear of the unit we have the differential that we can roll around higher or lower to get the gearbox longer or shorter. It appeared in the mid-1990s and has been with us since, and in general terms there is no reason that configuration needs to change for 2014. The aero requirements are similar and we still need a very narrow gearbox at the back of the car.'

However, this does not mean that the overall gearbox remains the same, and even without the change in the demand from the power unit, the 2014 Sporting regulations give teams and gearbox manufacturers a new set of headaches.

SUPER STEEL

Xtrac's new XM033 steel could be a crucial link for some teams struggling to cope with the increased demands of the new power unit, and with rumours of failing input shafts rife in the paddock, the new material could be just what the teams need. It is an ultra high strength (2000MPa) shaft and gear steel, which offers improved bearing properties due to its higher alloy content.

XM033 offers the advantage of high core strength for shafts, but also improved bearing properties for integrated rolling contact surfaces. Due to the balance of alloying elements, properties of surface hardness (>700Hv), core strength (2000MPa) and elevated tempering temperature (300degC) means that the alloy is ideally suited for arduous applications such as cross shafts, integral bearing drive-and clutch-shafts and highly stressed gears.

The properties are generated as a result of a nominal 0.4 per cent core carbon content, an increased silicon level and the addition of vanadium.

The result is a readily carburisable material able to simultaneously exhibit bearing properties and high core strength. This material is readily suited to driveshafts with integral bearings, now becoming popular in many motorsport applications.

'In 2013 the gearboxes had to be sealed for five races, and we counted that as 2750km,' says Moore. 'In that time the gearbox was completely sealed, except for at certain times at race meetings when teams were allowed to open the gearbox under supervision of the FIA. This allowed them to change the dog rings and gear ratios to suit the particular circuit. So at Monaco and Monza you would of course run completely different gear ratios.'

The 2013 technical regs also limited the number of ratio pairs teams could use to 30, which they had to nominate before the first race of the season. From these, the teams had to cover all of the circuits. Before 2010, teams used 70 or 80 ratios through the season and would change them frequently. In 2010 a four race gearbox rule was also introduced, and that had to run 2200km. In 2011 that was increased to a five races. In 2014 the gearboxes have to last six races, 3300km and the only maintenance allowed is an oil change.

'3300km is quite a long way – to put it into context the 2013 Le Mans 24 hours winner covered 4750km,' says Moore. 'We are looking at F1 gearboxes not being a huge amount off what is required to race at Le Mans. It's a demanding target.'

Crucially, the same eight gear ratio pairs are fixed for the entire season, so at the first race the teams will nominate the eight ratios calculated from the engine's crankshaft to the driveshafts and they will have to use those ratios for the entire season. Monaco, Monza, Spa, Singapore all using the same eight gears. This means that at Monaco the cars are unlikely to use the top two gear ratios, as they will be designed to cope with the expected 325-330kph (without KERS or DRS) top speeds at Spa and Monza, while Monaco only has a top speed of 280kph. The ratios themselves will also now have to last 3300km.

"We are looking at F1 gearboxes not being a huge amount off what is required to race at Le Mans"

'One of the reasons for this change is to try to reduce the cost of building and running a Formula 1 car,' says Moore. 'So by restricting the number of gear ratios there is less redundancy of parts, less stock is needed, people buy fewer gears, not so good for us at Xtrac, but good in terms of the overall cost of running the car.'

Unsurprisingly, this has led to a significant change in the design of the ratios themselves. 'In 2008 regulations were introduced that said that the gears had to be at least 12mm thick and that they could be no lighter than 600g,' says Moore. 'That weight limit was reasonably high and quite easy for us to achieve, in fact we ended up designing gears that were heavier than they needed to be, we were adding material to get to the minimum weight. The gear centre distance – the space from the centre of the two shafts – could be no less than 85mm. It was quite a restrictive rulebook, and before that we had a bit more freedom with the centre distance, gear face width and weights. So we had gears that were down to 8-9mm width. The regulations were changed to try to reduce costs and limit development. For 2014, all of those restrictions remain in place but analysis has shown us that the gears will have to be bigger – over 12mm typically. The machining on the 2014 gears is more elaborate in an attempt to get them back down to the 600g limit, whereas we had to add mass in the past. The gear centre distance has also increased to 100mm, and while the regulation still says it has to be a minimum of 85mm, with the increased duty cycle you would have to have a very wide gear.'

While the ratios themselves have to be made of steel, the regs do not specify which steel they must be made from, and here Xtrac has made a major step forward.

'We have four different Xtrac developed steels that we use normally,' says Moore. 'Going back 10-15 years we had our typical high specification gear steel, it's a vacuum remelted steel, a very clean material with a tensile strength of around 1300MPa. But we started a development programme to develop the gear steel to find one that particularly suited the strength and bending requirements we need for a gear.'

In partnership with Corus, Xtrac developed specific new materials with better impact resistance, machinability and carburising qualities. The resulting XM0 range materials enabled Xtrac to make narrower gears that can run at higher temperatures, requiring smaller oil-coolers, improving the aerodynamics of the vehicle.

'As a result of that work, we introduced XM023 – a higher core strength material, and that's proven very useful in a number of general F1 applications, sportscars and MotoGP – it's a very good steel,' says Moore. 'Most of the commercially available coatings have a very high application temperature somewhere between 300-350degC, but the problem with applying that to a carburised gear steel is that you soften the base steel. So XM023 has a temperature capability of 200degC, but if you heat it to 350degC to put a coating on it, the gear hardness will reduce. So you end up with a gear that is not optimised. We worked with the coatings suppliers to develop low temperature coatings which can be applied without any detriment to the gear steel, but those low temperature coatings tended to have a compromised performance.

'So we introduced XM031 at the start of 2013 – another new steel with a different chemical composition. It can handle 350degC without any reduction in hardness. We can develop specific coatings for higher temperature applications and that's been done for the 2014 F1 and 2014 LMP1 products. Going forward we have XM033, another new steel with enhanced properties.'

The shafts in the gearbox will be significantly repositioned compared to every 'box since 2006. This is due to a change in the regulations relating to engine design. The 2.4-litre V8 engines of 2006-2013 had to have a crankshaft centre line height 58mm above the reference plane. In 2014 the crankshaft must be 90mm above that line. 'It defines the internals,' says Moore.

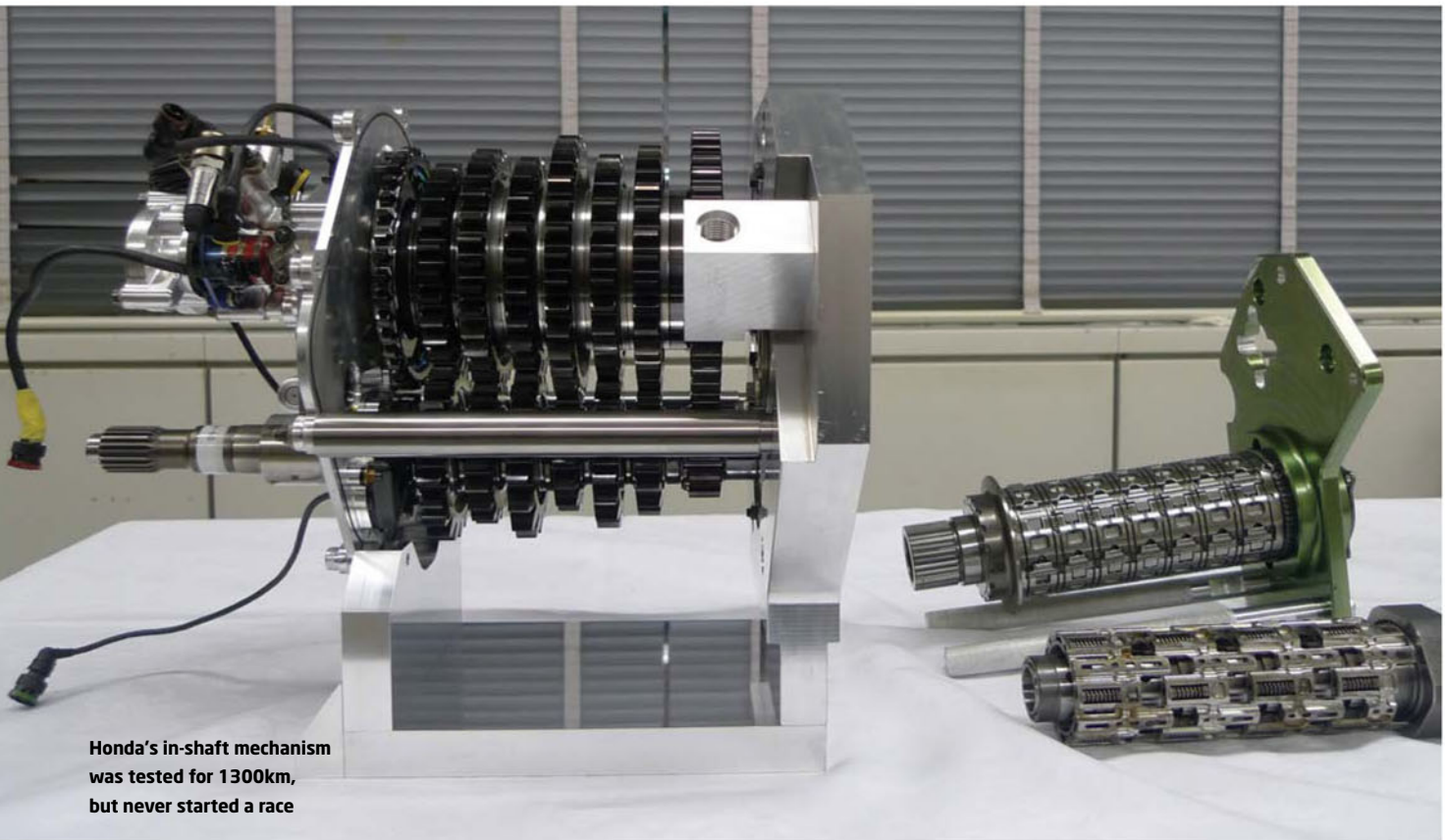
Overall the new transmissions will be bigger, heavier and longer lasting. 'There is a reasonable change of size, mass and position of the gearbox in the back of the car which will have knock on effects in terms of packaging and suspension,' Moore admits.

It is something that will be evident immediately in the upcoming pre-season tests.

Redacted internals from the Xtrac gearbox, which will be used in Formula 1 in the 2014 season

Seamless changes

Before moving on from Formula 1, Honda came up with some unique transmission concepts, including in-shaft shifting



Honda's in-shaft mechanism was tested for 1300km, but never started a race

Not every transmission development of the previous gearbox rules cycle reached maturity. Indeed, when Honda left Formula 1 in 2008 it had just completed work on a new transmission.

When the Japanese marque returned to grand prix racing as a full works team in 2005, following its purchase of the assets of the BAR team, it had never developed a true Formula 1 transmission. But then, as a full team, it had to do so. At the time, the standard shift mechanism worked when the current gear was disengaged. The system went into a neutral state, and then the following gear was engaged.

Honda felt that it could improve the performance of the whole car by eliminating the break in drive to the rear wheels, so that the transmission would not enter a neutral state at any point (unless the driver demanded it).

Honda's seamless shift realised up-shift with a torque loss time of zero, by engaging the following gear and then disengaging the current gear. Normally, this process would lead to damage due to double engagement, but in the developed system, double engagement was prevented and transmission of deceleration torque was enabled by adding one-way clutches with a locking function to the conventional shift mechanism. The selective use of these one-way clutches, positioned between the gear hubs and the main shaft – together with the use of cooperative control with the engine – enabled seamless shifting across all gears.

This approach of achieving a seamless shift was a great success, and the team claim that it directly improved the lap time of the car by about 0.4 seconds. In F1 terms that is a huge step forwards. However, by the end of the following season almost every other team on the grid had copied the concept to a greater or lesser degree, and had seamless transmissions. Honda had lost its advantage, so the engineers at its huge R&D facility in Tochigi, Japan sat down to find a way to regain it.

The engineers felt that the best way to do this was to make the system more lightweight and compact while maintaining the same level of shift performance. To do this, Honda decided to build the shift mechanism into the main shaft itself. This in-shaft shift concept positioned one-way clutches able to control torque transmission and idling between all the shift gears and the mainshaft. Doing away with the shift forks, shift rings, gear hubs and other equipment – which were conventionally positioned between the shift gears – and using only shift gears arrayed in a line enabled the total length of the gearbox to be reduced, along with the weight.

Honda claim that their gearbox concept directly improved lap times by about 0.4 seconds

The in-shaft shift mechanism featured an operating range in which double engagement is used, and the principle of preventing torque loss is the same as that used by the seamless shift mechanism discussed above. However, the configurations

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of the shift mechanisms differ significantly. Each strut positioned between a shift gear and the mainshaft moves in a seesaw fashion by means of small and large balls, producing the following three essential states for shift:

- An in-gear state, in which a strut simultaneously engages and is locked in place, enabling acceleration and deceleration torque to be transmitted.
- A neutral state, in which the angle between the struts and the mainshaft in the circumferential direction is smaller than it is in the in-gear state and the gears and mainshaft idle during both acceleration and deceleration.
- A one-way state, in which only acceleration torque is transmitted.

The state of the struts is controlled by the positions of two large and small balls in the radial direction. The positions of the balls are adjusted by the movement in the axial direction of a slide cam that is provided with a cam groove in the axial direction designed specifically for use with the balls. The movement of the shift bearings in the axial direction adjusts the position of the slide cam in the axial direction by means of a spring. The position of the shift bearings in the axial direction is adjusted by the movement in the axial direction of a pin integrated with the shift bearings, which follows a barrel cam groove formed on the inside of the shift bearings in the circumferential direction. As a result, it is possible to selectively control the three states of the struts by means of barrel rotation.

Top: the original seamless shifting concept from 2008
Above: the gear casing used in the original box

In this setup, the process of shifting between gears is achieved as follows: when the current gear is driving, the current gear is in an in-gear state, and all the other gears are in neutral states. The shift is commenced by the rotation of the barrel, and the struts of the current gear and the next gear are put in one-way states simultaneously. When torque transmission shifts from the current gear to the next gear, the strut of the current gear – which has ceased transmitting torque – is put in a neutral state. The next gear is put in an in-gear state, and shift is completed

The in-shaft shift mechanism was tested on track but never started a race – after 1300km of testing on the single gearbox fitted with the concept, the project was cancelled. Honda had been working towards achieving 2500km for the new technology, but the durability runs were curtailed when – at the end of the 2008 season – the company quit F1.

Honda's engineers set out to reduce the differential's weight and to move it to a much lower position

The shift mechanism was not the only advancement that featured on the new transmission. A lightweight differential was to have been fitted to the firm's RA109 chassis, the car that formed the basis of the title-winning Brawn BGP001-Mercedes.

Honda's engineers set out to reduce the weight of the differential and to be able to move it to a much lower position on the car. Development efforts were concentrated on the achievement of a lightweight and compact differential, with the focus in the initial stage on the centralisation of mass. Previously mounted on the final driven shaft, the bias-adjusting mechanism was positioned on the final driveshaft, helping to reduce the centre of gravity and the yaw moment of inertia. A full pinion engagement planetary gear was employed as the differential gear. A study of the merits and drawbacks of the mechanism resulted in the development of an ultra-short differential (USD), employing a full pinion engagement double pinion planetary gear positioned on the final driven shaft as the differential gear. It was predicted that this would increase the compactness of the unit and reduce its weight by 1.2kg.

The development of this innovative device will be covered in next month's edition.

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Second wave attack

Unfettered racecar development is rare these days, especially on production-based machinery. So enjoy Gobstopper 2 – one of the most highly developed Imprezas in the world?

BY SIMON MCBEATH

Talking with racecar engineers and designers is the most fascinating part of bringing motorsport stories to print, and among the obvious questions to be asked are 'how' and 'why'. In far too many cases, the reasons 'why' designs follow well-trodden paths are all but predetermined by restrictive technical regulations.

So it's always refreshing to look at categories that positively encourage innovation and exciting developments and where the responses to the question 'why?' can tell you a lot about a racecar designer's philosophy rather than that of the regulators... Among the seemingly diminishing number of such categories is Time Attack. And now *Racecar* has been given intimate access to one of the most exciting projects to enter the UK Time Attack arena yet.

Matt Clark, the elder son of late UK rally ace Roger Clark, is responsible for the design and build of Gobstopper 2. This is the latest project to showcase the capabilities and products provided by Roger Clark Motorsport Ltd, the company his father set up in 1991 in Hinckley, UK. The first Gobstopper was based on the earlier two-door Impreza saloon, a project that – according to Matt – generated not only lots of good PR but also plenty of new knowledge and a good deal of tuning business too, for RCM do not advertise – they simply create outstanding showcase projects and then go out and win with them.

'It's important that our projects must connect to what our customer cars are,' says Matt, whose brother Olly is the gifted driver in this highly effective fraternal partnership. He won the Pro Class of the UK Time Attack series in 2008 and 2009 in the original Gobstopper. Clearly repeating that feat with the new car is a minimum target.

This then in part answers the question 'why?', but Matt expands further: 'In our industry – the tuning world – since Subaru stopped rallying, our focus has shifted from rallying. And the thing that excites me about Time Attack is that there are essentially no rules. In rallying, engine intake restrictor sizes are so small and power is so limited. And the power curve drops like a stone above 5000rpm. To me it made no sense and was not interesting.

'So we were moving the business away from rallying and more towards the road tuning side from around 1998. Meanwhile

The Time Attack Subarua Impreza WRX that is Gobstopper 2 in the Roger Clark Motorsport raceshop; behind, upper left is the original Gobstopper

Pirelli slicks and wets are not the usual choice in UK Time Attack – most of the opposition favour Michelins or Avons

The roll cage – created by Custom Fabrications – provides most of the car's strength and stiffness

The Gobstopper 2 on track. The new car comes out of the Impreza hatchback, as opposed to the saloon model which formed the base of GS1

SIMON McBEAT; RCM

Time Attack was slowly evolving in the background – it's a category that got rid of restrictions. And so GS1 came about in 2006 to tackle the UK's series. We came second in 2007 and won the Pro class in 2008 and 2009. The car was built for straight line speed really, it was as fast as hell down the straights and Olly used to rallycross it around the corners!'

So why GS2? 'We wanted to start with a new challenge,' continues Matt, 'and so we chose the hatchback because it is a current model and was different to the saloon base of GS1.

'Also I wanted to test myself too and we really did not want to hack the old car about. And as the project evolved, it absorbed all my ideas and is 99 per cent totally new! We went bigger, stronger and lighter everywhere. Static weight distribution was the biggest challenge. The old car had 60 per cent of its weight on the front, and I wanted to shift the weight as far back as possible. I put the turbo on the left-hand side, lots of other components were moved to the left as well to offset the driver's weight [the car is right-hand drive] or further back. And the engine was moved as far back and as low as possible without creating driveshaft angulation problems. We have ended up at 56 per cent front, which is a lot better.'

NEW SHELL

But we jump ahead. The third generation WRX hatchback bodyshell was selected and old family friendships with Prodrive's boss Dave Richards saw the delivery of the last bare WRX shell from the Banbury-based former works Subaru rally preparation firm. Much of the shell's preparation, including construction of the bespoke T45 steel roll cage was then entrusted to Custom Fabrication in Brackley, the owners being ex-Prodrive Subaru Works Rally Team fabricators themselves. Matt Clark's aim at this stage was to generate much of the car's intrinsic stiffness and strength through the roll cage, which in turn allowed the use of lighter weight exterior panelling, and this also allowed more flexibility on external detail shaping too, of which more later. The inboard suspension mounting points were inserted in locations of Clark's choosing too. And numerous additional fixings were also welded in for items like the rear wing mounts and other components that were not on the original preparation menu.

The suspension itself is based around Prodrive WRC tarmac specification cross members and wishbones, which Matt says are 'really nice kit, with needle roller rod end joints'. 'We've got the widest tarmac WRC specification that Prodrive ran,' he adds. RCM made the beautiful billet uprights, and the struts are Ohlins TTX46, more often found on GT and touring cars and featuring integral linear potentiometers for logging suspension movement.

The brakes come from AP Racing, with a choice of iron or carbon/carbon discs. The weight benefit of the carbon/carbon discs is considerable, 'they're about 50 per cent lighter,' says Matt, 'but they are definitely trickier to drive with, they have a narrower temperature range within which they deliver optimum performance. So we have the choice of selecting which material to use according to the track characteristics and the prevailing temperatures.'

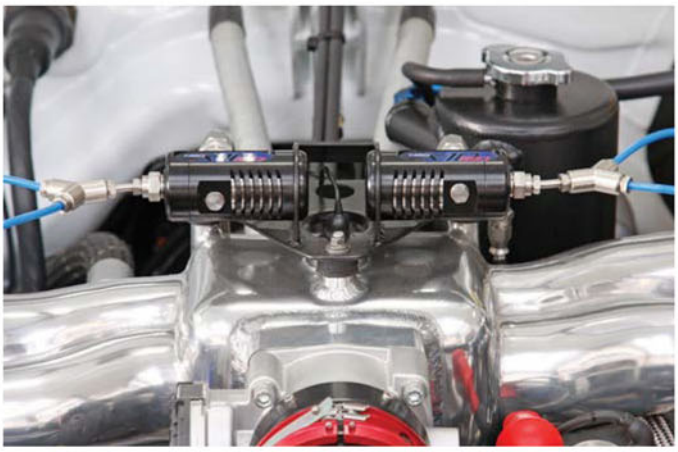
Even the Team Dynamics wheels on GS2 are custom machined by Rimstock from solid forgings, and bear the Gobstopper 2 name on the rim. And RCM are slightly unusual in using Pirelli race tyres, most of the opposition favouring Michelins or Avons, but 'Pirelli provide us with excellent on-track support,' says Matt.

Give Clark's own reference to GS1 essentially being built for straight line speed, expectations were high for the engine in GS2. And it will not disappoint, for its peak output has indeed been increased over that which propelled GS1 to back-to-back championship titles. But RCM have

RCM billet alloy uprights and Ohlins TTX46 struts

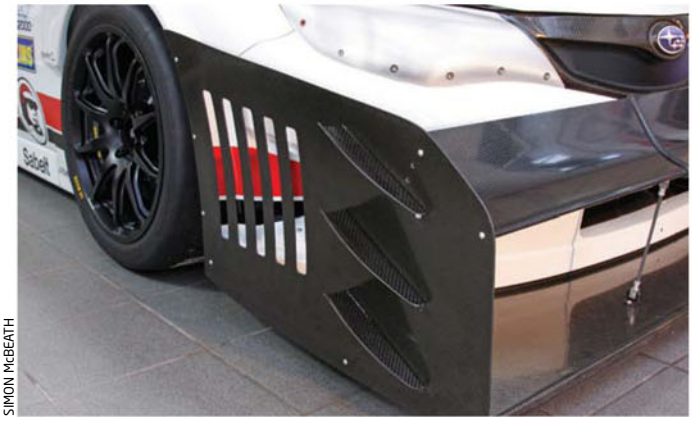
Garrett GT4094 hybrid twin scroll turbo, big for a 2-litre engine – normally


The engine bay showcases the immaculate preparation standard


The progressively controlled nitrous oxide injection system helps match the big turbo to the 2-litre engine

The visible steering column on the right-hand side demonstrates that the turbo has been moved to the left

And if you thought the front aero was a bit severe – here's the even more aggressive rear wing



SIMON McBEATH

Closeup of the aggressive front aero kit

Wind tunnel testing revealed all, including the rear wing's induced downwash

been competing at a high level for long enough to know that driveability is just as crucial as peak output. Certainly, however, effort was focused on upping peak power, as Matt describes. 'The capacity is 2 litres like the old car, but the conrods and pistons are stronger and lighter, the valves are bigger and the cams give more lift and duration,' he says. 'I went through everything really. And we gained another 50bhp to give us an "easy" 780bhp.' Maximum revs on GS2 are 9250rpm.

So although there is much that is totally new in the beating boxer heart of GS2, 'proven and reliable' describes the choice of turbo, a Garrett GT4094 unit. 'It's big for a 2-litre engine,' Matt says, 'but it was really good on the old car. It's a twin scroll turbo and has a new billet compressor design that enables the centre hub to be smaller and more streamlined, and the blade shape to be more refined.

'Power and its delivery is all about the turbo and mapping really. The engine just has to be strong enough to cope! So it's more a case of specifying the conrods and pistons to withstand 800bhp rather than worrying about how to get 800bhp. There is massive torque too, so it's pretty heavy duty.'

One might be forgiven for thinking that 780bhp would be enough to get the job done. But, again, because the regulations allow such a free hand this is where nitrous oxide, otherwise known as 'laughing gas' makes its entrance. 'Yes,' says Matt, 'nitrous adds more internal loads again. But it helps with turbo spooling out of corners and on some straights too.' But this is certainly no 'open the tap wide and dump bucket loads in' nitrous oxide injection system.

Indeed, this is a progressive system that uses solenoid valves carefully controlled to add mid-range torque and to help make the 2-litre engine work well with the big turbo. The weighty part of the system, the gas bottles and associated paraphernalia, are located at the back above the diffuser to help with the weight distribution.

GEARING UP

All this power and torque then drives through the lightweight RCM flywheel and AP Racing quad-plate carbon clutch to the paddle-shift operated sequential shift gearbox. The shift mechanism of choice was Zytek's electrically operated system because RCM did not want the complexity of pneumatic or hydraulic plumbing. And this helped drive the choice of the Syvecs engine ECU too, which – Matt says – 'offered two CAN BUS channels, one of which interfaces with the shift system and the other which we use for everything else. It also has a very fast processor – a good ECU for the type of complexity we have.'

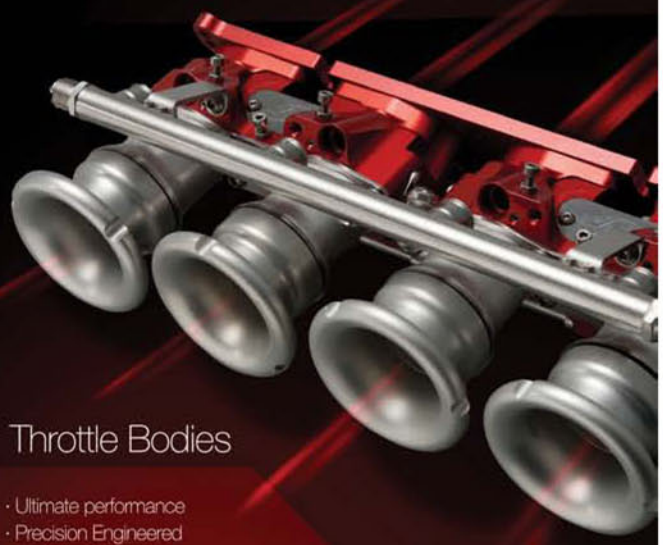
Six forward speeds with RCM's ratio choice then drive to the centre differential unit which is governed by a MoTeC differential controller taking in steering angle, throttle position, brake pressure and wheel speed inputs. Four maps are available, Matt commenting that 'a tighter setting helps to tame oversteer, so it's a progressive control. This diff unit is available on some road models – we've just elected to control it with the MoTeC controller.' The front and rear differentials are conventional plate type units and ramp angles can be altered if desired.

If there is one thing that clearly distinguishes GS2 from its predecessor when viewed from any angle, it is the extent to which external aerodynamics has been exploited. Yet this was not uppermost in Matt Clark's mind at the outset. And initial exterior work just focused on modifying the WRC shell in areas like the wheel arches, the bumper, scuttles, sills etc so that moulds could be taken. From these, KS Composites made some very high quality, lightweight carbon panels. For example, the doors may now be super-light competition versions,

"The capacity is 2 litres, like the old car, but the conrods and pistons are stronger and lighter'

at power

Engineering Performance



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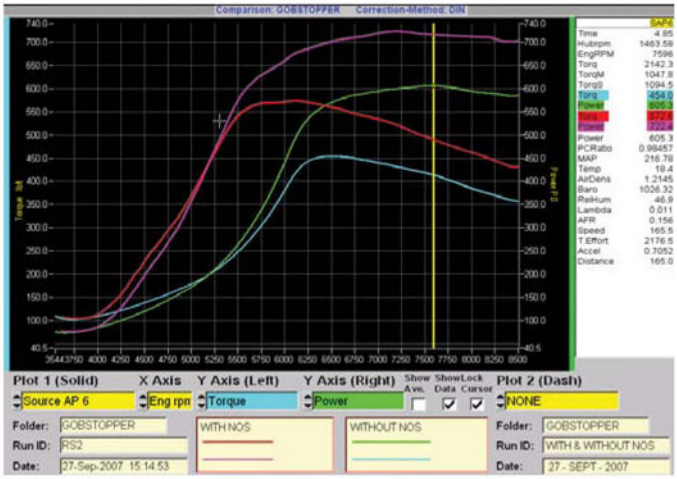
but they shut with an executive car 'clunk', testimony not only to the quality of the components but also of the installation.

The tailgate is an alloy STi item, and this did prompt Clark to ponder just how he was going to attach a rear aerofoil to the car. When *Racecar* first encountered the Gobstopper, the external aero pack essentially comprised a nicely made but quite modest front splitter with integral diffuser sections beneath, and a WRC-style tailgate mounted rear wing. Then, between our initial visit and the wind tunnel session chronicled in our Aerobytes section, GS2 sprouted one of DJ Engineering's superbly manufactured rear wings – a full car-width, well-cambered dual-element device, and a much more aggressive front end package featuring a larger, rectangular planform splitter (again with integral diffusers), with tall end fences that also supported a small chord DJ Engineering full-width wing element. A set of small dive planes adorned the outer faces of the front end fences, which interestingly also featured gill-like vertical slots. The car sits very low to the ground, and so the full flat floor will be capable of generating significant downforce, although currently the diffuser features quite a gentle roof angle and modest volume. The 'upper' aerodynamics kit makes Peugeot's 208 T16 Pikes Peak car look somewhat understated in comparison, however!

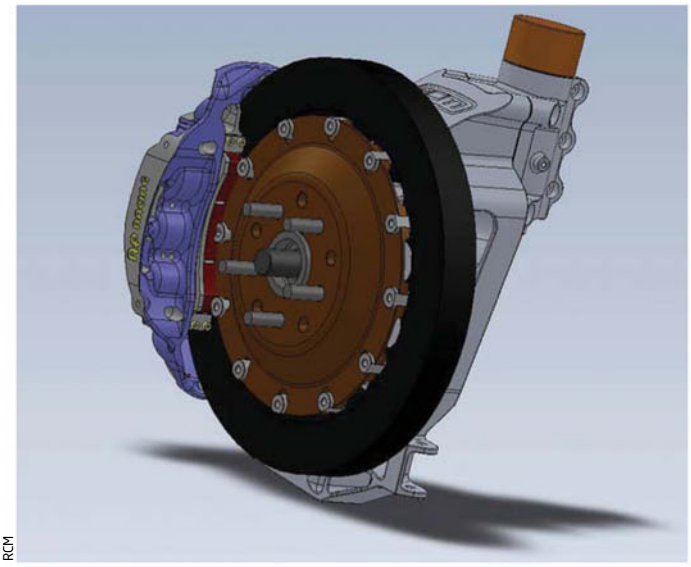
To summarise *Racecar*'s wind tunnel analysis, the car demonstrated that it was generating pretty substantial downforce, with its potent rear wing working surprisingly well considering the fact that it was on the back of a hatch. Indeed, our smoke plume trials showed the airflow to be turning down the back of the hatch much better than your writer anticipated, perhaps in part because of those vortex generators along the rear of the roof, perhaps in part because of the wing's own induced 'downwash'.

Nevertheless, the net result was a car with about 75 per cent to 80 per cent of its downforce on the rear wheels, which with a weight distribution of 56 per cent front, 44 per cent rear, might be expected to create aerodynamic understeer. However, RCM's chassis dynamics analysis suggested that the car was going to oversteer whenever power was applied, so a rear-biased aerodynamic balance of around 70 per cent to 75 per cent was said to be preferred. Following GS2's August 2013 initial shakedown at Silverstone, Clark lowered the wing slightly to achieve a better aerodynamic (and aesthetic) balance.

At the car's next test in November 2013, also at Silverstone, and running with modest boost, Matt reported that he was 'pleasantly surprised' at the benefit of the aerodynamics, and that the car was able to corner and lap faster than GS1 had been able to on competition boost levels, even though straight line speeds were down because of the lower boost used in GS2's test. This bodes well for 2014, and is an ominous signal for the UK Time Attack opposition.



The dyno plot from Gobstopper 1's engine shows the potent effect of the nitrous oxide system (purple power curve, red torque curve) over the non-nitrous output (green power curve, blue torque curve)



RCM

SolidWorks CAD rendering of GS2's front upright and brake assembly

HARD GRAFT

That Matt and Olly Clark work hard to make their business the success that it is will be obvious. But this also applies to the creation of Gobstopper 2, which in essence is a spare time project fitted around the running of the business. So the passion and attention to detail that has gone into making this superbly prepared machine should not be underestimated.

This same attention to detail should stand the team in good stead too. 'Starting in rallying first was great training technically because that was all about reliability and strength,' says Matt. 'That has helped a lot with the "no limits" projects we do now. My job is to make a car that Olly can drive like he stole it AND will get to the finish.'

And this goes to explain why RCM's extensive fanbase has had to be patient before it sees GS2 compete, because the approach has been to ensure the car is fully ready, insofar as that is ever possible, before hitting the track in anger. Spring 2014 is keenly anticipated then, when hopefully Gobstopper 2 will pit itself against what is becoming a better UK Time Attack field each year.

And one can't help wondering too how the car would fare against some of the radical Time Attack opposition worldwide...

TECH SPEC

Subaru Impreza WRX 'Gobstopper 2'

Category: UK Time Attack , Pro class

Chassis: WRX GRB shell, T45 steel roll cage by Custom Fabrications, Krontec air jacks

Body/aero: KS Composites lightweight carbon panels, STi aluminium rear hatch, DJ Engineering wings, carbon/honeycomb floor, splitter with integral front diffusers, rear diffuser

Engine: flat four, 2 litre, EJ20 block, closed deck, Garrett hybrid GT4094 turbo

Transmission: four-wheel drive, six speeds, RCM sequential shift mechanism with Zytek electrical paddle shift, AP Racing quad plate 140mm carbon clutch

Electronics: Syvecs engine ECU, MoTeC PDM, Motec centre differential controller

Suspension: Prodrive wide track tarmac spec WRC cross members and wishbones, RCM custom inboard pickups, RCM billet uprights

Dampers/springs: Ohlins TTX 46 struts, Eibach springs

Brakes: AP Racing, iron 365mm front and 340mm rear discs; carbon 380mm front and 340mm rear AP Racing calipers, AP Racing hydraulic handbrake

Wheels: Team Dynamics forged, custom machined 18 x 10-inch
Tyres: Pirelli 285/645-18 slicks & wets

Fuel tank: Premier Fuel Systems/ 38 litres

Wheelbase: 2662mm
Track front: 1555mm,
Track rear: 1575mm
Weight: 1180kg

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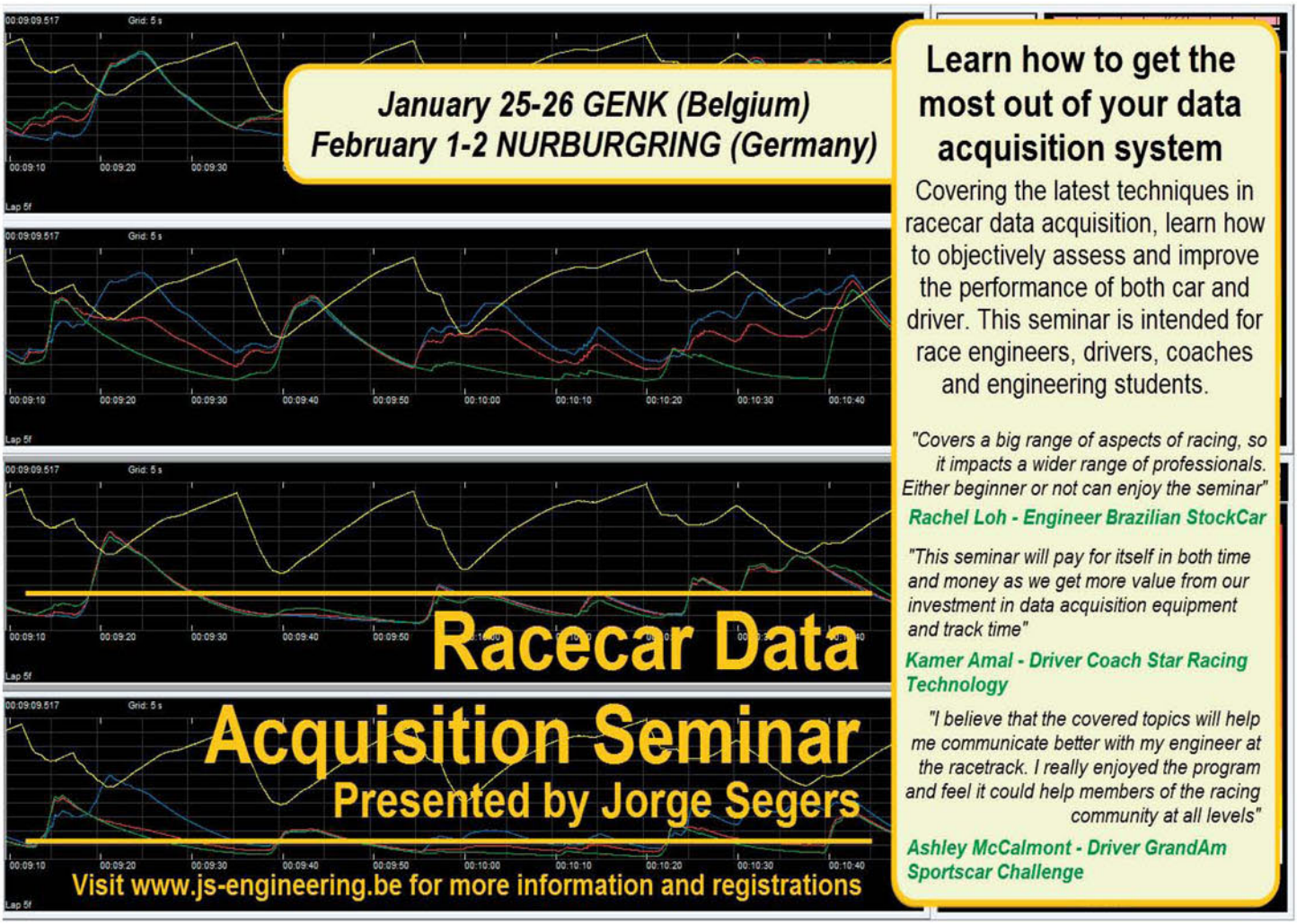

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Kamer Amal - Driver Coach Star Racing Technology

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Ashley McCalmont - Driver GrandAm Sportscar Challenge

Braking news

In motorsport, you need braking efficiency to generate a fast lap time. Thankfully, a host of manufacturers make the brakes their life's work...

BY GEMMA HATTON

An F1 car can stop from 300km/h in just 135 metres. In fact, it takes less distance to stop an F1 car from 160km/h then it does a road car from 100km/h. Under deceleration, F1 cars pull 5G, whereas even the highest performance road cars only clock 1G. This is all down to the ever-increasing rate of brake development – and motorsport brakes are in a class of their own.

Racecar braking systems rely on the same principles as road cars: the driver applies a force to the pedal, hydraulic pressure amplifies this force and transmits the pressure to the pistons in the calipers which then forces the friction pads against the brake discs and slows the wheels.

However, in true motorsport fashion, it's a bit more extreme than that. The brakes can withstand temperatures as high as 1500degC and pressures of 2000psi. Air that is used to cool the brakes comes out some 400degC hotter than when it went in, while the force applied to the brake pedal can be up to 100kg and is pressed between 600-800 times per race. In fact, brakes are becoming so good that their development has had to be restricted to prevent them from further improving which would result in shorter braking distances, less overtaking, and angry fans.

BRAKE DISCS

Arguably the most important part of any braking system is the disc, and the ones used in racing are either drilled or grooved. This allows effective heat dissipation which, when you consider brake disc temperatures peaking at 1200degC, is an essential requirement – particularly in the 2013 F1 season which saw the introduction of the 2kg heavier and softer compound tyres, resulting in higher tyre wear. However, the holes introduce stress points, which can propagate cracks and lead to disc failure, and explains why grooved disc designs are becoming popular.

Discs can also either be solid or have a vented section between two faces. Usually the solid design is lighter, but the vented disc dissipates more heat, so F1 teams compromise by using vented discs at the front as this where 60 per cent of the braking force is, and solid discs at the rear where it is 'cooler'.

Yet still every unnecessary gram is extracted, as shown by the world leader in brake technology, Brembo, who supplied five F1 teams last season. They use ventilation holes between the two faces to deal with the heat, and after CFD studies with the race teams, Brembo decreased the weight of vented discs, while improving the heat dissipation by increasing the number of holes and decreasing the diameter. This results in an exponential increase of the carbon surface that is open to the airflow and, therefore, thermic discharge.

In 2008, the design featured 30 holes, 2011 saw 200 holes and in 2013 it increased to 1000 holes. In terms of carbon specification, CER is the current material used by the teams and has evolved from the original CCR, offering excellent warm-up time and bite. It operates well under a wide range of temperatures and has smooth friction performance.

Motorsport brakes can withstand temperatures up to 1500degC, and pressures of 2000psi

The Pagid RSL 1 (above) has been designed for endurance applications, and features excellent pad wear rate and disc life. It's less aggressive than the company's RST, resulting in optimum brake balance, modulation and consistency of friction

(Right) a previous design of a carbon vented F1 brake disc and caliper from Brembo

StopTech's AeroRotor features a patented vane design that minimises turbulence, and allows 61 per cent more air to flow through the disc, resulting in even better cooling

Drilled and grooved StopTech brake discs

For over 10 years, Brembo has also been developing carbon ceramic brake discs that are 50 per cent lighter than the traditional cast-iron discs. Furthermore, the high thermal conductivity, durability and versatility increase its life. Brembo can offer CCM for road cars and CCM-R specifically for high-performance, or full racing applications.

Endless Brake Technology is another manufacturer renowned for its high quality products for the racing industry, and this year marks their 10 year involvement with Formula 1. Their rally and GT Racing discs use multi-vane technology as Mikael Schöllin, marketing manager explains: 'The benefit to using a multi-vane brake disc is that you get better airflow in the disc, and a larger cooling surface inside the disc which is more efficient. The wider air gap and the use of more vanes per diameter also makes the discs lighter, which has a big impact on unsprung mass.'

An F1 brake disc is essentially carbon-fibre suspended in a carbon matrix and weighs approximately 1kg, less than half the steel equivalent – which demonstrates the value of utilising the right material. 'Disc materials are open for development unless the rules state they must be ferrous, in which case cast iron is still the material of choice,' says AP Racing's chief of brakes, Richard Bass. 'Where the disc and pads materials are free, carbon/carbon tends to be the material of choice as it's extremely light and very thermally efficient.'

AP Racing's S-Vane brake discs will be one of their many products displayed at the Autosport Show in January.

The fundamental difference between carbon and traditional steel brake discs is wear. The carbon breaks down in the presence of air and is oxidised, creating a black dust which can be seen when the car brakes heavily. This chemical process activates around 600degC and results in a non-linear wear rate. This is why brake cooling is essential – to keep the temperature of the discs below this 'activation temperature'.

BRAKE PADS

'Different types of motorsport definitely require different brake systems – particularly brake pads,' explains Schöllin, 'this is why we have more than 40 different compounds of brake pads that are specifically designed to each type of motorsport – we even have special compounds for different driving styles.' The material selection of the pads is vitally important to not only achieve the specified level of friction, and therefore braking, but also the required thermal management. Brake pads are either carbon, carbon metallic or cerametallic, and the choice of material depends on the desired friction level throughout a temperature range, the wear rate and the bite/release characteristics. In F1, a single carbon pad is used and weighs only 280g.

To operate effectively, the pads need to be around 500degC, and if they're much hotter the conductivity will drop, resulting in brake fade. The size of the pad does not actually affect the amount of braking as this is primarily down to the pressure applied, the coefficient of friction and the disc diameter. However, a larger pad will absorb more heat and have better wear characteristics.

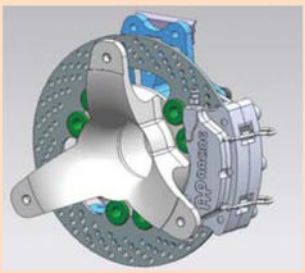
TMD Friction is the world leader in brake friction materials and invests over €25m each year in its technology, while manufacturing one million brake products per day. Pagid is a TMD aftermarket brand that focuses on innovative brake pads, explains Michael Schorn, director of engineering and product development.

'The developments of efficiency in the Pagid RS racing brake pads are ongoing in various directions,' he says. 'Firstly, by generating more heat-resistant compounds, there are major improvements in performance and lifetime. Furthermore, the pads are designed to have low compressibility and generate low taper wear to reduce residual brake drag under off-brake conditions. Finally, the pads generate a homogeneous temperature input pattern to the disc for improving the crack performance.' The compounds that Pagid use are complex formulations with a high content of ceramic materials, offering better thermal insulation due to

The fundamenal difference between carbon and traditional steel brake discs is wear

AP RACING & TEAM BATH

AP Racing also recognise the importance of providing top-quality products to the IMechE-run Formula Student Competition. One team that has made the switch to AP Racing is the University of Bath Formula Student Team (Team Bath Racing), who have consistently been one of the UK's top teams since 2006. 'Team Bath Racing are now using AP Racing brake calipers all round for their 2014 TBR14 car. In the search for reduced mass and rotational inertia, this year's car uses 10-inch diameter wheels, and the AP Racing (CP4227-2SO) caliper allows brake disc size to be maximised within this constraint while also reducing unsprung mass over other options. These calipers also offer a stiffness advantage leading to improved brake pedal feel, explains Adam Phelps, TBR14 chassis manager.



Team Bath Racing's 2014 brake setup in CAD utilising AP Racing's products

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AP Racing's brake calipers, suitable for all forms of motorsport.

V3 disc retention technology from PFC, which requires no torque wrenches

the higher heat resistance and low heat conductivity of ceramics when compared to iron. Therefore, less heat from the brake disc is transferred through the pad which prevents overheating the calipers. In fact, the use of ceramics is so effective that some of Pagid's racing pads can withstand 60degC higher than their metallic competitors.

A further unique Pagid design is the patented system that ensures the friction material does not delaminate from the steel backing plate, and is attached by either adhesive bonding or mechanical retention. The latter features brass studs which are welded on to the steel backing plate and grip the friction material to retain its bond right until the end of the pad life. Pagid make the only race pad to features a retention system which not only connects the steel backing plate with the under-layer, but also with the friction material itself.

Half of the 2013 Spa 24 Hour race lineup used Endless Brake Technology Racing pads, made from the ES88G compound. 'ES88G is an endurance pad with sprint pad characteristics,' says Schöllin. 'It has a high initial bite, a fantastic modulation/feel to it and is easy for drivers to use as well as having the lowest pad and disc wear.

'ES88G also works well under warm conditions and does not fade out. Our next generation of endurance compounds are already developed and will be launched this year, one of which is ES99G that has even higher performance without sacrificing wear. It has been developed to handle high stresses even under harsh temperatures, and will be seen on many GT race cars in 2014.'

BRAKE CALIPERS

Often seen as the 'ultimate' caliper design is the monobloc construction with multiple pistons, which are used in F1 and LMS. The titanium pistons are different lengths to achieve consistent pad pressure and provide an optimum level of wear along the length of the pad. The regs restrict the material of the caliper to an aluminium alloy, making it a technical challenge to achieve the best performance, says Bass, 'Caliper materials were developed for maximum stiffness and minimum weight. This is now limited by the rules which state that the brake caliper material must have a maximum modulus of elasticity of 80GPa. We could make them lighter, but in practice whatever we add to reduce the density will also increase the modulus. We are therefore limited to strength improvements, particularly at temperature.'

BRAKE FLUID

Brake fluid is incompressible to give the driver a firm pedal feel. Unfortunately it's also hygroscopic, so it absorbs water, which means that it can still perform effectively on road cars, but not racecars. At very high temperatures, any water in the fluid will evaporate and these gases will drastically decrease the boiling point, reducing its capabilities.

AP Racing's Bass explains: 'Race brake fluid targets are high boiling point, low compressibility, and good lubricity. There are many other things that a brake fluid must do as a matter of course, but these are not targets for development – merely things that are required to be maintained while developing, such as compatibility with the parts it is in contact with.'

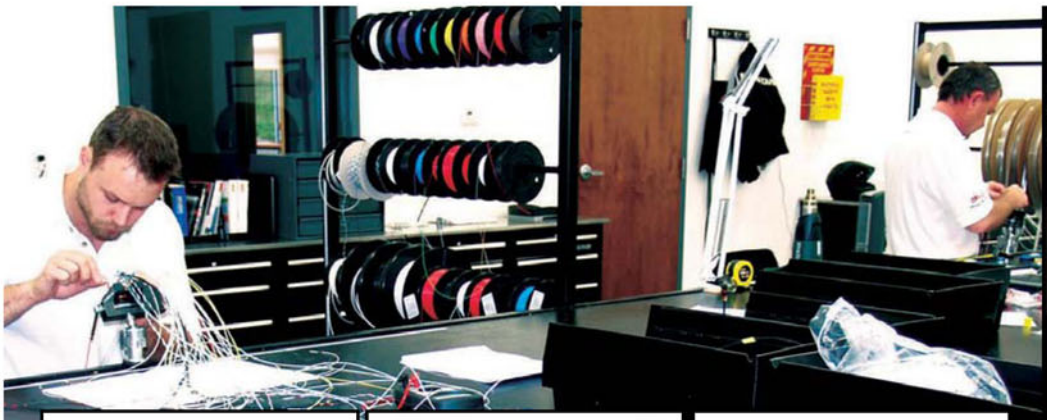
Quickly becoming the highest-spec brake fluid in the motorsport world is RF-650 from Endless Brake Technology that is used in F1 (specifically Mercedes AMG Petronas F1), WRC and Touring Cars. The high velocity and even viscosity gives a fast yet precise response. With a dry boiling point of 323degC and a wet boiling point of 210degC, many teams are noticing improvements in brake fad resistance. The fluid is based on polyalkylene glycol ether and has extremely low hygroscopy.

INTO THE FUTURE

'The future of braking systems will be mainly determined by regenerative braking, with all its implications to the standard foundation of current brakes,' says Schorn. 'These implications are mainly more predictable friction performance to guarantee an optimal blending between friction and regenerative braking as well as corrosion protection of the "underutilised" foundation brakes.' AP Racing's Bass agrees: 'As the rules on braking get tighter, we concentrate more on the details. The recent F1 increase in KERS has had a knock-on effect, as the rear calipers for many teams will be much smaller next year. A new market in actuation has opened up due to the sophistication of variable control between KERS and conventional friction brakes. How far KERS will go is unknown, hopefully not 100 per cent, otherwise friction brakes won't be needed any more!'

CAPARO AP BRAKING & T1

Caparo AP Braking were one of the companies that joined the famous Caparo T1 project. The 480bhp, 2.4-litre V8 road and track car weighs 465kg with a power-to-weight ratio of 1000bhp/tonne. The system supplied by Caparo AP Braking provides incredible stopping power, bringing vehicles to a standstill from 100mph in under three seconds. The brake disks measure 14 inches in diameter and 1.3 inches thick front and rear, gripped by six pot (front) and four pot (back) callipers made from high-strength aerospace-grade aluminium billet. 'Our aim is to move the performance envelope up to current sports-prototype levels, thereby setting a new benchmark for a road car exemplified by its agility and handling abilities,' said Ben Scott-Geddes, a T1 designer who previously worked on the McLaren F1. 'We've spoken to owners who have become frustrated and bored with their regular sports and racecars, whose potential is heavily restricted through constrained engineering and race formula regulations. In that respect we've torn up the rulebook to give customers what they ultimately desire: a road car with an uncompromised yet safe performance experience.'



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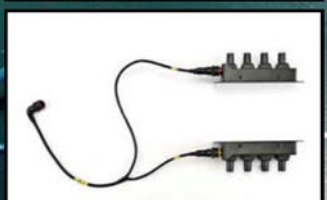
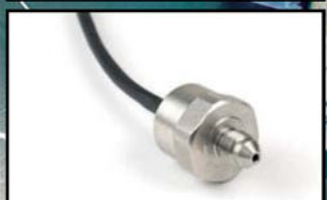


CARBON COIL PACK



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Revisiting our stability calculations

Our resident simulation expert might have inadvertantly given you a few headaches last month. But for those left confused, all is not lost...

BY DANNY NOWLAN

In my last article I discussed the calculation of stability index using accelerometers at both ends of the car. The background for it was discussed and some techniques and the validity of these was firmly established. However, based on some feedback from some of my colleagues, I've deduced a better method of reviewing this data. This is what we'll be discussing in this article.

To kick things off, I'd like to take this opportunity to correct a mistake I made in my first article. The error came in calculating the lateral moment from the accelerometers. The original formula for this is in **Equation 1** on p68. However, it should actually be as shown in **Equation 2**.

The error came from the fact that I needed to correct for the weight distribution when calculating the lateral acceleration.

However, the good news for those of you that have already applied this, is that there is no need to panic. The original form of **Equation 1** simply over-scaled the lateral moment. In some respects this is not such a bad thing because it protects against the case when the car is very neutral or you have bad signal noise. So, the techniques we discussed in the last article are still valid. That being said, they will overestimate the value of the stability index. But as a rough rule of thumb it will still put you in the right ballpark.

That being said, when I re-derived the result it hit me on the nose that what we need to do is separate the steer from the side slip components of the lateral moment equations. This became clear once I started to delve into the bicycle approximation of the car. The lateral moment of the vehicle can be expressed as in **Equation 3**.

The crux of what this equation tells us is that the lateral moment of the car is a function of the steer angle, yaw rate and lateral acceleration. All that fancy maths in front of the a_y term is effectively the stability index we're trying to find out. Also, a_y is representative of the sideslip angle of the car. I go into more detail in my book *The Dynamics of the Race Car*. That being said, you should be getting the picture that we have a little work to do.

Adding accelerometers to a Ford GT results in excellent data to help calculate the front forces

LAT

EQUATIONS

Equation 1

$$N = \left(\left(1 - wdf\right)\cdot a_{yf} - wdf \cdot a_{yr}\right)\cdot g \cdot wb \cdot m_t$$

Equation 2

$$N = \left(1 - wdf\right)\cdot wdf \cdot \left(a_{yf} - a_{yr}\right)\cdot g \cdot wb \cdot m_t$$

Here we have:

N = lateral moment of the car (N.m)
wdf = weight distribution of the on the front axle (%age/100)
a_{yf} = lateral accelerometer reading at the front of the car (g)
a_{yr} = lateral accelerometer reading at the rear of the car (g)
g = acceleration due to gravity (m/s^2)
wb = car wheel base (m)
mt = total mass in kg

Equation 3

$$I_Z\dot{r} = \left(a \cdot C_f + \frac{\partial N}{\partial \beta}\cdot\frac{C_f}{C_T}\right)\cdot \delta_s + \left(\frac{\partial N}{\partial r} + \frac{C_r' \cdot b - C_f \cdot a}{C_T \cdot V_x}\right)\cdot r + \frac{a \cdot C_f - b \cdot C_r'}{C_T}\cdot m_t \cdot a_y$$

Equation 4

$$wdf \cdot m_t \cdot a_{yf} = C_f\left(\delta - \frac{a \cdot r}{V_x} - \beta\right)$$

Equation 5

$$r \approx \frac{a_y}{V_x}$$

Equation 6

$$wdf \cdot m_t \cdot a_{yf} = C_f\left(\delta - \frac{a \cdot a_y}{V_x^2} - \beta\right)$$

Equation 7

$$F_{yf\_STEER\_COR} = F_{yf}\cdot\left(1 - \frac{\delta - \frac{a \cdot a_y}{V_x^2}}{\alpha_{MAX}}\right)$$

The new terms are:

$F_{yf\_STEER\_COR}$ = front lateral force corrected for steer
F_{yf} = measured front lateral force
amax = peak front slip angle in radians
V_x = forward speed m/s
a_y = lateral acceleration at the cg (m/s^2)
a = moment arm from front axle to the centre of gravity

Fortunately it will not be as onerous as you might think. Using some sensible assumptions, the front axle force can be approximated by **Equation 4**.

Here, a is the moment arm from the front axle to the centre of gravity, r is the yaw rate and β is the side slip angle, while C_f is the tyre force gradient as a function of slip angle. Effectively what we are doing here is taking a linear approximation of the tyre force curve. Not ideal, but it's a useful approximation. Bear with me, the results are going to be worth it.

We can simplify **Equation 4** by using an approximation we used to construct the neutral steer channel. An approximation for the yaw rate of the car can be found with **Equation 5**.

I realise we will be missing a few transients here. However, the reason we are doing this is that most racecars don't come equipped with yaw rate sensors, so we have to fill in the blanks with what we have. This is one of the most essential skills of any race and data engineer worth their salt, so make your peace with this. Anyway putting **Equation 5** back into **Equation 4** we arrive at **Equation 6**.

What all this means is that we are now in a situation where we can separate our inputs from the lateral acceleration components. All of this should lead to a more accurate calculation of the stability index.

Our final piece of the puzzle is to correct the lateral acceleration for the influence of side slip/lateral acceleration. To do this we are going to have to take an educated guess, but it isn't that much of a stretch. What we are going to do is scale the steer and yaw inputs by the max peak slip angle. Mathematically what we are doing is generating our peak force at the peak slip angle – we are taking an estimate of how much of a component the steer and yaw inputs are taking.

Consequently, the corrected front lateral force will be that seen in **Equation 7**.

I realise that at first glance we are taking a leap of faith here, but do hang in there. The results will be worth it.

Before discussing the results, it would be wise to summarise our updated procedure for determining the stability index. This is to:

- Calculate the front and rear axle forces, using either accelerometers our strains.
- Correct the front lateral force as discussed in **Equation 7**.
- Use the corrected front lateral force and rear axle force to determine the yaw moment.
- Then plot lateral moment vs lateral acceleration to determine the stability index.

To put this into practice I reviewed some old F3 simulated results I had, to test what we had discussed here. A plot of the relevant variables is shown in **Figure 1** on p70.

At first glance we're taking a leap of faith – but hang in there

As can be seen from the last plot, which is neutral steer vs actual steer, this particular car is very neutral on turn-in and pushes to understeer in the mid-corner. This is confirmed by looking at the third and fifth plots where initially the moment is low and the axle forces are very comparable. However, by the time we get to the mid-corner they have diverged significantly. Looking at the lateral acceleration plots (fourth plot) compared to the yaw moment, you could actually zoom in and do some rough calculations for the stability index at that point. But it clearly shows stable behaviour once the car has generated significant grip.

This is confirmed by looking at the plot of lateral moment vs lateral g. This is illustrated in **Figure 2**, also on p70

A number of years ago I did a similar plot of the same F3 car and while there where some clear trends at low g, the plots as the g increased got very noisy. What you are seeing in **Figure 2** is a very good step up from what we discussed in that article. To put this in perspective, I took the same curve as last time and

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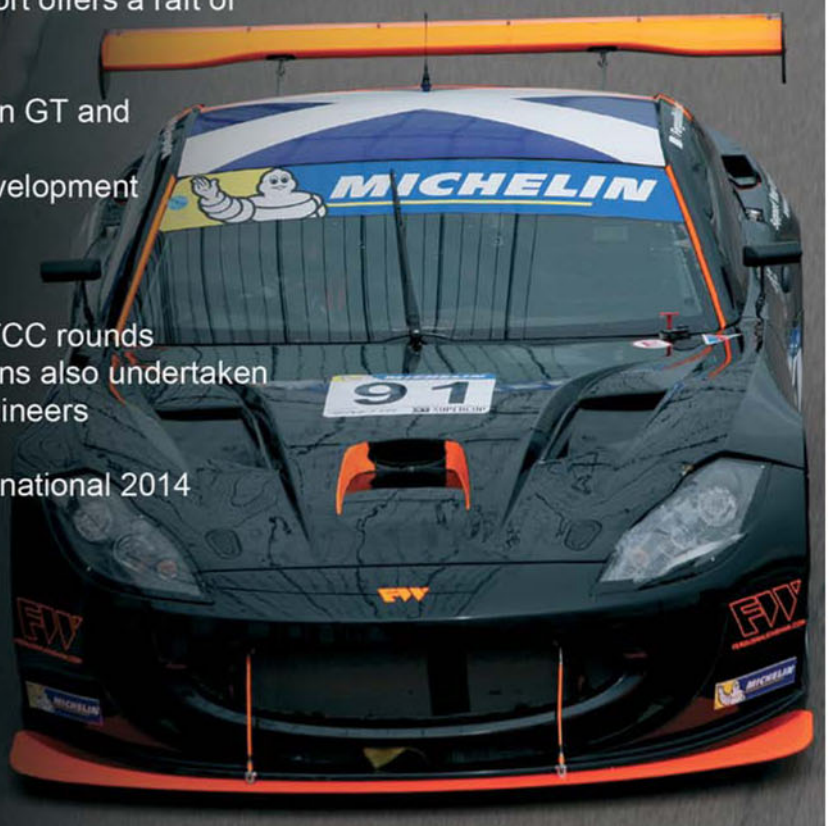

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we had a polynomial with an R squared value of 0.64. This is illustrated in **Figure 3** below.

Effectively the derivative of this equation with respect to x or lateral acceleration is the stability index. As we can see, this curve fit mirrors what we have seen in the neutral steer plot as well – so we are well on the right track.

This is further confirmed by zooming in on one of the turns to take a closer look. The results of zooming in on the low speed turn is shown in **Figure 4** on p72.

As we can see there is a night and day trend emerging here. We can see on turn entry that the car is borderline stable. Then, as the grip builds up, the car gets more stable. This knowledge is invaluable since it really gives you a good handle on classifying stability. We can now examine this from corner to corner.

More importantly though, with the new techniques we have discussed, we have really been able to get a handle on the fact that the stability index is a living, breathing thing. Because this car is being driven on the edge, we know that the neutral steer vs actual steer plot gives us a good indication of the stability or otherwise of the car. This has been reflected by the results we have presented here which show that our assumptions have got us a good way down the road. This is a really good improvement on where we were, and that was a good start point. It will also be a great back-up if you have a driver who is not pushing the car to the edge and you need to answer some fundamental questions about the car's stability.

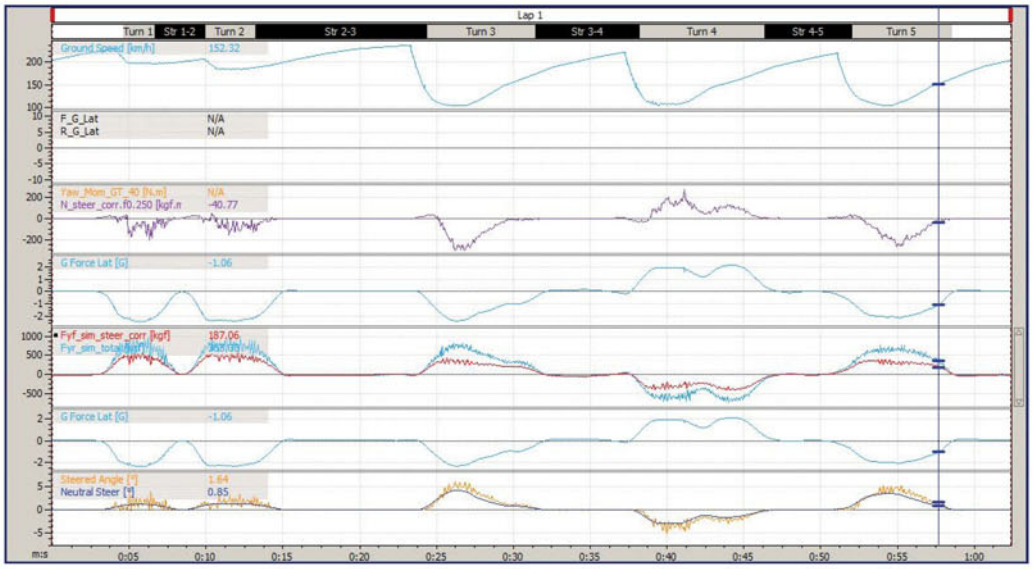

Figure 1: plot of relevant moment variables

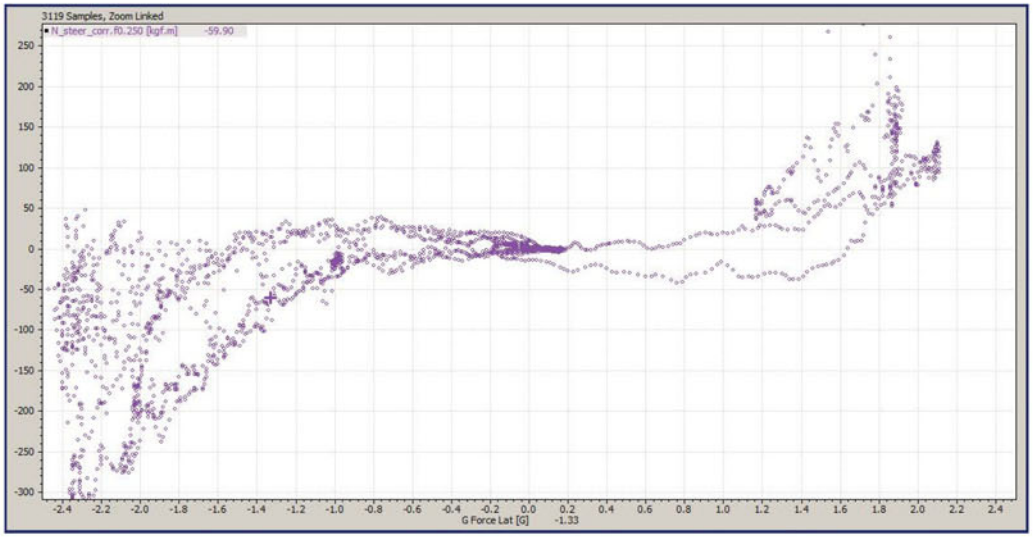

Figure 2: overall plot of lateral moment vs acceleration

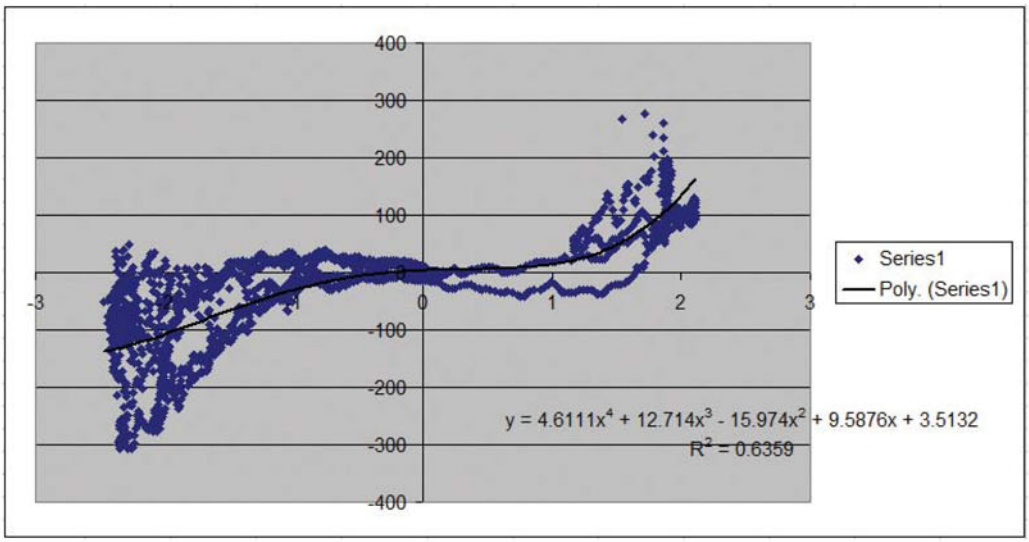

Figure 3: curve fit of lateral moment vs lateral acceleration

ADDING ACCELEROMETERS

The great thing about this is that we can apply the same techniques that we have just discussed to when we have accelerometers fitted to the car. Revisiting the Ford GT example, the plot of the relevant variables that we presented in **Figure 1** for the F3 car are shown in **Figure 5** (p72).

As can be seen, the same trends that were seen in **Figure 1** are repeated here. This is particularly apparent in the third plot which shows the corrected lateral moment as presented in using **Equation 7** to calculate the front force. Looking at these plots alone you can start to see clear trends forming with the plot below it that shows lateral g. The sign of the plots look a little strange, due to the fact the moments are reversed. However, the opposing signs show that we do have stability. Also, I would draw your attention to the fifth plot which shows the moments. The red and orange traces are the front and rear moments calculated directly from the accelerometers. Again there are clear and distinct differences in the moments. They are also in the same order as the numbers that were read of the simulation moments in **Figure 1**,

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so this cements the validity of using accelerometers as a method of calculating moments.

One thing I do want to discuss in detail is the corrected lateral force from **Equation 7**. Most of the time it's a bit under the front force. But sometimes it does diverge. This typically happens with low speed corners with high yaw rates. It can also happen when the driver has applied too much steering lock or you have not estimated the front peak slip angle correctly, so be mindful of this.

Again, as per the F3 example, the plot of corrected lateral moment and acceleration shows clear trends in the stability of the car. This is illustrated in **Figure 6**.

As per the previous article, the lateral moment was filtered at 4Hz, and the lateral acceleration was filtered at 10Hz. As can be seen, as per the F3 example, we have some night and day trends here. At low g, the slopes are low, which reflects what is going on with the neutral steer for a particular corner. However, as the g increases, the slopes go up showing stable behaviour. In both cases, to calculate the stability index you simply take a curve fit and apply the techniques as discussed in my previous article.

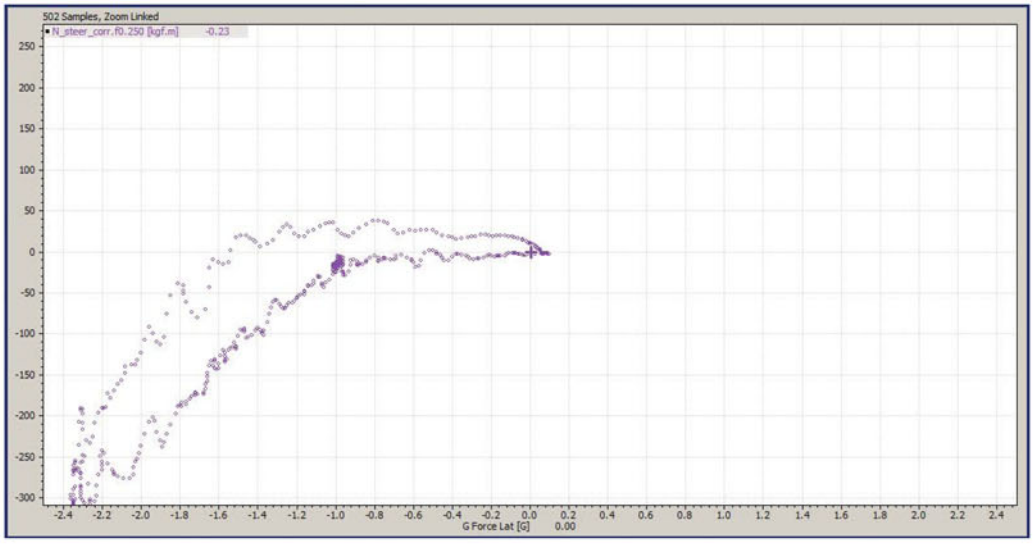

Figure 4: lateral moment vs lateral acceleration plot for a low speed corner

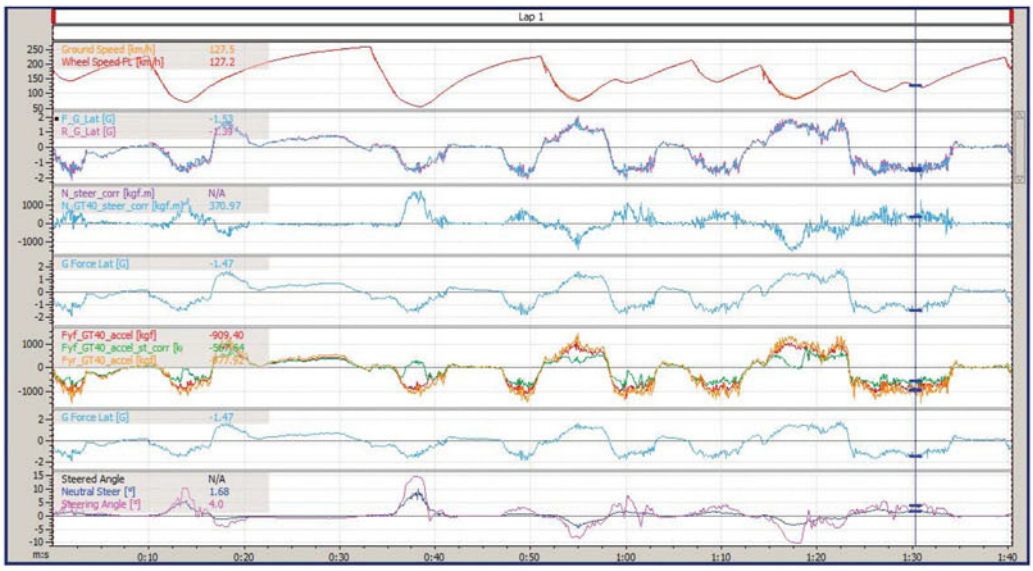

Figure 5: plot of lateral moments for a Ford GT derived from accelerometers

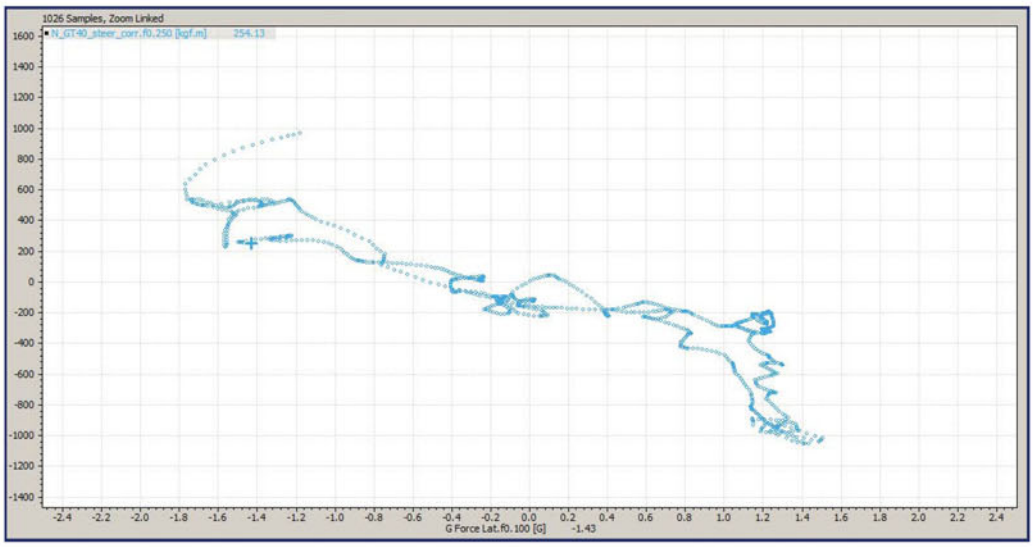

Figure 6: corrected lateral moment vs lateral acceleration for a corner

MIXED RESULTS

At this point it would probably be wise to reflect a little bit on what we have done here. Yes it shows promise, but it is not without its drawbacks. Firstly we have had to base this off an approximation, and consequently this won't be totally bulletproof. However, as we have seen it is reflecting what we have seen when we reflect neutral vs actual steer.

Also, looking at **Equation 7** and **Figure 5**, this approach will get into difficulty if we don't estimate front slip angle correctly and if the driver is applying too much steering lock. The first case is pretty easy to sort out. If the slip angle is off, the plots will be off everywhere. Too much steering lock will overestimate the stability, but given that we are using this to see that the car is stable, there could be worse things in the world. Also, just remember that in a lot of cases part of the art of a data and race engineer is to make do with what you have. This is not a bad start.

In closing, we have discussed some powerful techniques for nailing down racecar stability. While our assumptions were a bit of a stretch, our corrected version of front lateral force laid some excellent groundwork for the results we discussed which allowed us to quantify clearly what was going on. The next step I now leave to you, the reader.

If you have strains or lateral accelerometers on both ends of the car, go through what we have just discussed. The results should be very revealing.

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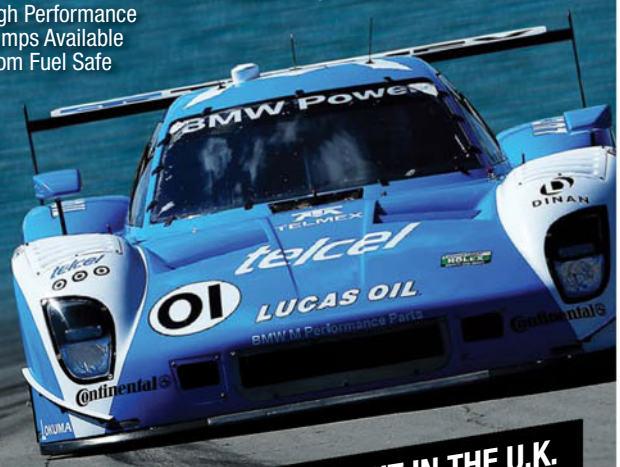

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Old dog, new tricks

Porsche turned a swan into an ugly duckling with its 991 in 2013. But, for their newly-confirmed 2014 programme, it now boasts a comprehensive update kit

BY ANDREW COTTON

Porsche's 991 may have won at Le Mans, but it has struggled everywhere else. So, for 2014, the manufacturer introduced an upgrade kit with a difference.

The story of Porsche's GTE has been an interesting one. From the first test at Sebring in March to the first race, at Silverstone in April, it turned from a swan into an ugly duckling.

Fuelled by optimism following that test in Florida, Silverstone was something of a shock for the team and drivers. At Spa, it got even worse as high rear tyre wear compared unfavourably to the Aston Martin, which double stinted its tyres and was still fast.

Something happened to the car, and team members were coy about discussing it. 'That was our test car, and for the racecar there were some minor changes for homologation. We think that was the problem,' says lead driver, and engineer Marc Lieb. 'There were some small issues, changes from departments that we thought wouldn't be a big influence on the car, but obviously they were.

'It was a surprise for us because we were optimistic in the winter. At the end of last year we had some good tests, we were happy with the consistency of the car, we had one really good test at Sebring where we thought this was the way to go, but it wasn't.'

Amid rumours of sandbagging and short-filling the tanks during the Silverstone 6-hours and at Spa, Porsche was given a larger air restrictor for Le Mans, and was able to keep pace with, although not beat on speed alone, the Aston Martin Vantage. Rivals claimed that this highlighted the sandbagging, but for the rest of the year, the Porsches struggled, up to the point of the introduction of the new car at the final round in Bahrain.

There, the update kit was introduced, and it caught Porsche's rivals by surprise. It was not the speed that caught them off-guard – the two 991s qualified first and second – more the pace of development.

Under the regulations, a manufacturer may update a new car once within the first two years, but has to race that update during the car's first season. The final round of the World Endurance Championship in

The front bumper more closely resembles the aero kit that the manufacturer raced at Le Mans in June, as Porsche sought better aero balance

The new aero balance meant a change to the suspension kinematics, although Porsche denies that the 2014 car has a new rear axle

Bahrain saw Porsche turn up with a host of changes that led some to question whether or not this was a completely new car.

'We changed the aerodynamics for next year's car, the aero balance more to the rear, and that hopefully helps the drivers to be not always just on the edge and have good lap times for one hour or one-and-a-half hours,' said Marco Ujhasi, project leader for the 991 RSR. 'For the low speed stuff there are also some changes. We increased the chassis stiffness and changed the kinematics, so the car is more driveable than the 2013 cars.'

Porsche has made the car stiffer from front to back, and has made changes to the roll cage, reducing the diameter of the tubes, and the fixing to the chassis. Porsche has also changed the fuelling system, the aero balance including a wider rear wing and a wider rear wheel, both of which were on extra waivers agreed by all other GTE competitors, and a slight modification to the engine cooling system.

'The chassis was changed for the stiffness,' says Ujhasi. 'We wanted to have a more consistent stiffness from front to rear and also we wanted to improve the durability of the chassis. For the aero balance, we have a shape on the front bumper that can compare to the Le Mans aero, so there's less downforce at the front and more at the rear thanks to the wider wing.'

The aero package is more aligned with that raced at Le Mans, but the balance suits the car much better, and takes the handling and tyre degredation back to levels previously seen on the test car. 'It wasn't working with the aerodynamics,' says Porsche's motorsport director Hartmut Kristen. 'You have to get everything properly in balance and not just in theory but in reality to make it work. These are the main points that we had to address to be able to run the weight balance as it was supposed to be again.

'We slightly changed the aero balance in a way that didn't work properly for the early 2013 car as it was raced. We got one more waiver for the width of the rear wing because we had the smallest rear wing compared to the other cars and the still existing technical regulations – the rear wing is linked to a percentage of the standard car. This is actually crazy when you compare that to the racecar that is within a few centimetres, so we got an additional waiver there.

'We made a change to the fuel cell, because there we had some problems with the refuelling from time to time, so that had to be homologated. But that is mainly it. The more parts you homologate, the more parts you have to change. There are a few suspension parts with modifications, but nothing completely new, a new concept or anything like that – just adjustments.

'We still use the 997 engine, but in the engine there are a few details optimised, a small change to the air intake and the filters.' The engine, taken from the 997, lacks the direct injection option enjoyed by Ferrari, and even by the 991 road car. As detailed in *RCE V23N7*, there is no appetite to develop a new engine with new regulations coming into force in 2016, and regulations are not due to be announced until Le Mans, 2014.

In short, then, the car has a new, stiffer chassis, a new roll cage, a wider rear wing and wider rear rims (although not wider rear tyres), modifications to the suspension and a change to the fuel cell. This was a huge effort by the company, which confirmed that it will continue to compete in the World Endurance Championship with the Manthey team in 2014.

This means that, for the first time, Porsche will field two factory teams in the same championship as the LMP is due to make its public debut at a test in Sebring, and then its race debut that Easter weekend at Silverstone. This is an exciting time for the company's racing department, and clearly there is huge commitment to on-track success.

'We increased the chassis stiffness and changed the kinematics, so the car is more driveable'

New air intakes for the engine may have slightly increased power, but not enough for engineers to start boasting

Wider rear wing and wider rear rims were crucial to managing the rear tyre wear on the 991. Waivers were needed for both

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Additive advances

As 3D printing gains more traction in motorsport, with increased demand for race-ready components, printing materials are growing in sophistication

This case-study is aimed at describing how a fully functional intake manifold has been built with 3D printing technology and laser sintering materials. The part has been realised for Magneti Marelli Brazil, which supplies automotive parts to manufacturers around the world.

Magneti Marelli and CRP Group have worked together on other automotive projects that have required the use of 3D printing and performance laser sintering materials. For this application, CRP has used its WindformGF2.0 (windform.eu) material for the manufacture of this new part. This consists of a polyamide-based powder reinforced with glass fibres and aluminium.

The project was aimed at producing a fully functional intake manifold in a short time. This part had to guarantee proper flow dispersion in the intake runners, to improve the torque and the engine power at a reduced fuel consumption.

During the design phase, CRP Engineering technical staff built the part according to Magneti Marelli's instructions, taking into account the threaded bushing that was required to be inserted into the housing. They wanted to ensure that the part was ready to be mounted on the car for immediate testing.

The part had to be manufactured with a material able to resist high temperatures, and it needed to be fully fused to avoid any risk of vacuum loss or leaks. Windform GF2.0 was chosen as the most appropriate 3D printing material from CRP Group for this application.

This material has good UTS per density equal to 35.89Mpa/(g/cc) and it has good resistance to liquids when treated with a special filler. Other key technical details that it boasts are: melting point 179.60degC (ISO 11357-2), tensile modulus per density unit equal to 3052.48Mpa/(g/cc) and flexural modulus per density unit equal to 2432.62Mpa/(g/cc).

The intake manifold created using WindformGF2.0

CRP Group offer many other materials beside WindformGF2.0, such as the latest Windform SP – the top level material of the range – as well as Windform GT, Windform XT2.0, Windform LX2.0 and Windform PS. All of CRP's SLS products are characterised by specific mechanical features and they can be used in multiple applications.

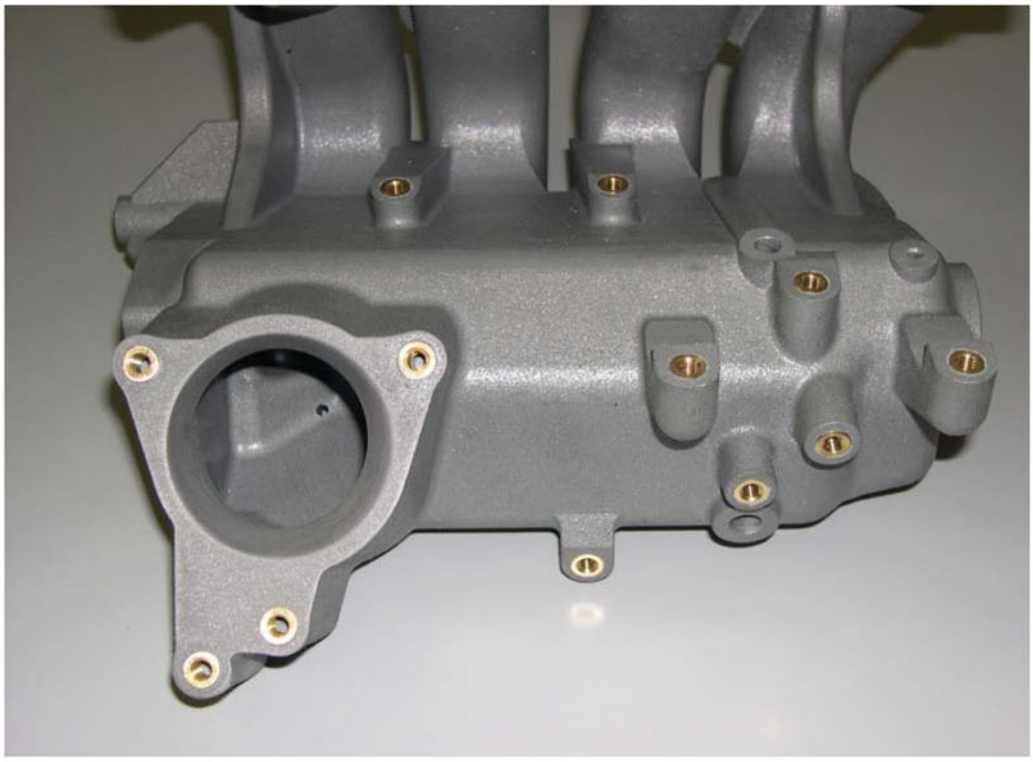
In this case, after analysing the part and its requirements, the technical staff at CRP decided to submit the intake manifold to a series of pressure tests in order to be sure that the prototype built with WindformGF2.0 was waterproof. The part passed all tests and was mounted into the car for track testing.

Once printed, the part was ready to be tested in full race conditions

As proven in recent times with high-profile projects such as the DeltaWing, components manufactured with Windform can be considered finished parts ready to be tested. With this in mind, Magneti Marelli could have mounted the intake manifold in the car and gone to the track for testing in full race conditions.

At this stage, the intake manifold was submitted to a series of tests in order to record the performance. In particular, after positioning it in the car it has been used for on-track tests and in three different uphill and downhill trials with an acceleration from 0-60km/h and from 0-100km/h.

In regards to the internal pressure, the intake manifold works under vacuum, and in this application it is not



Close-up view of the 3D printed intake manifold, featuring threaded bushings

The finished part mounted in the car, ready to undergo full track testing

New technologies paired with innovative 3D printing materials such as Windform, allow technical staff to create functional components that can be submitted to severe testing

turbocharged. Tests were done with a pressure value equal to 50+/-5kpa.

Other studies have been carried out with the aim of testing its strength and the fundamental requirement of overcoming temperature and vibration tests. In regards to the temperature test, the intake manifold recorded a working temperature that goes from -30degC to 130degC.

Tests took into account the following three parameters:

- Parallel to engine axis
- Perpendicular to the engine axis
- Parallel to the pistons axis

Subsequent dynamometer tests have been carried out to measure the torque, power, and fuel consumption, with measurements taken up to 6000rpm. The results of this portion of the analysis led to positive results, because more power (about 4hp) at a lower fuel consumption had been recorded.

Thanks to the results obtained and the confirmation of the 3D design by the customer, it has gained the proper improvements, and they have now approved the new design of the intake manifold manufactured using 3D printing and WindformGF2.0. This new design is going into mass production with conventional mould tooling, and with full confidence that the design will meet the required goals.

The construction of the intake manifold for Magneti Marelli Brazil represents a new approach that many companies are pursuing internationally in the highly competitive field of automotive design. New technologies, paired with 3D printing materials like Windform, allow technical staff to create functional components that can be submitted to severe testing. This represents a fundamental step in the manufacturing of a new part, as it can be analysed directly mounted in the car, recording the results of testing.

The CRP technical staff have taken the methods utilised for racing teams on the track, and translated this expertise and experience into the production of the intake manifold of Magneti Marelli Brazil – and as far as they're concerned, the results have been more than satisfying.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Formula 1 set to introduce budget cap for 2015 season

A budget cap is to be imposed in F1 from the 2015 season onwards after agreement was reached during a meeting of the F1 Commission and the F1 Strategy Group in Paris in December.

Details on how the cap will work have yet to be ironed out, and a working group is to be set up with the brief of finalising a set of regulations. This group will include F1 team members, representatives of the commercial rights holder, plus FIA representatives.

A budget cap has been discussed in Formula 1 for a number of years, but has been brought sharply into focus recently as a number of teams have struggled in the face of the ongoing global economic downturn. Back in 2009, the then FIA president, Max Mosley, suggested a cap of £30m for the 2010 season, which was subsequently increased to £40m, but the teams rejected this and the resulting fallout almost led to a schism in the sport. At the time of writing the level of the cost cap for 2015 had yet to be arrived at.

LAT

Questions remain about how a budget cap would be policed in the sport

The main issue for the teams is how the cap is policed, as the current Resource Restriction Agreement (RRA) has been seen as a failure. Many believe that because F1 has been unable to work within the lesser constraints of the RRA, it will never be able to work to a full cost cap.

However, during his last press conference as team principal at Mercedes GP, Ross Brawn – who has been linked with a role overseeing F1 cost control at the FIA – insisted that a cost cap could work if it was controlled by the governing body: 'I think the conclusions for me on the RRA is that there was a structure of a system that could work, but quite clearly wasn't a system that could work with self-regulation from the teams themselves. It was a system that had to be policed – we believe by the FIA – but it seemed that we couldn't get enough agreement within the teams that that should happen, so it failed on that basis. I don't think it failed because it wouldn't work, in my view it failed because we couldn't engage the governing body in policing the system.'

Brawn added: 'I think whatever system we have is going to affect the competitiveness of teams, and therefore it has to be controlled by the sporting body. The teams are very competitive and will always be looking to push the boundaries.'

PFC brakes for new Renault Sport rally car

Renault has revealed its new turbocharged rally car, which is based on the Clio model. The R3T, which was demonstrated at the Rallye du Var – the last round of the Renault Sport Rally Trophy season in 2013 – is a heavily updated variant of the Clio RS R3, first launched in 2006. Renault has sold over 373 examples of the R3 and hopes for similar success with the R3T.

Taking as its template the Clio RS 200 EDC, the R3T has been designed 'to open up new horizons' for the crews that drive it. It's fitted with a turbocharged 1618cc engine developed by Renault Sport's engineers. The car update kit comprises a six-speed sequential manual gearbox, with steering-wheel paddle shifts offered as optional in the asphalt version. In offering its customers a cohesive and reliable package, Renault Sport Technologies relies on renowned suppliers such as Sadev for gearboxes, Sachs for shock absorbers and Cosworth for electronics.

The brakes on the car are supplied by PFC, something of a new avenue for the South Carolina based firm. The pads, discs and calipers incorporate a number of key innovations, such as piston cap insulators to deliver exceptional performance on tarmac and gravel while still adhering to stringent cost and technical requirements.

With the engine generating more power than the existing R3 car, PFC Brakes' engineers set out to develop a durable brake system to withstand the higher loads and temperatures generated.

The piston cap insulators reduce temperature transfer to the brake fluid by as much as 55degC, minimising risk of boiling fluid. Larger and wider front discs are specified for tarmac to improve heat dissipation, even under increased loads.

PFC's engineers specified a derivative of its proven ZR34 caliper, the forged monoblock aluminium caliper offering the best blend of weight and stiffness. Brake pads offer a larger radial depth, providing a larger contact area to deliver improved stopping power.

To enable drivers to use the brakes right from the start of a stage, PFC specified brake pads designed to work at low temperatures and the unique metallic matrix construction aims to ensures consistency for the duration of a stage.

'With the Clio RS R3T, our aim has been to come up with a high-performance, reliable vehicle adaptable to every type of surface, all for an operating cost below that of the product it replaces,' said Renault Sport Technologies motorsports director Arnaud Boulanger. 'The success enjoyed by the first generation has bolstered our belief that this formula is especially well suited to meet the requirements of our customers. This class has given us the opportunity to find our feet and to excel in a number of markets, several of them outside Europe, with our cars now present in Asia and the Pacific, Latin America and Oceania.'

'Initial tests have been promising and a lengthy development has been scheduled in the lead-up to the kit's approval.'

The car is expected to receive approval early in the second half of 2014.

FE boss says business plan lured big names to championship

Formula E's CEO says that the reason the championship has managed to attract so many big names from the world of motorsport and business is because of its unique model.

The championship for electric racecars has recently announced that Virgin is to enter a team, run by Alex Tai – who ran its F1 operation in 2010-11 – while Hollywood star Leonardo DiCaprio has also announced a joint venture with Venturi Automobiles, a company with experience in electric vehicle record breaking. The arrival of these two teams means the grid for the inaugural season of FE is now complete.

Joining Virgin Racing and Venturi on the full entry list are: Drayson Racing, China Racing, Andretti Autosport, Dragon Racing, e.dams, Super Aguri, Audi Sport Abt and Mahindra Racing.

FE CEO Alejandro Agag told *Racecar* that he believes the reason for the new championship attracting so many high calibre entries and sponsors is partly down to its business model. 'The business plan is: cost control, cost control, cost control,' he says.

'This has to be a championship that is in the region of cost of a Formula 3 championship, for example, but with a revenue model that is much higher. And this is where in this car you have your profit. And it's working. We are having partners who are coming to us, really attracted by the whole model.'

Agag also said sponsors are coming on-board because FE's green ethos is an easier sell than mainstream motorsport. 'The biggest sponsors are signing because of the concept of sustainability and sustainable racing,' he says. 'These companies were looking for a sustainable alternative in racing where they could invest their money, and this is it. We're finding it – not easy because it's never easy – but we are finding it very positive and successful to sign with these big companies that are becoming our partners.'

The FIA Formula E championship kicks off with a race around the streets of Beijing in September. All of its events are to be street races, and the championship will also visit Rio, Los Angeles, Berlin and London.

SEEN: DALLARA IL-15

Early renditions of what the new-for-2015 Indy Lights car will look like have been released by its constructor, Dallara. The IL-15, which will take over from the current 2002 vintage Lights Dallara in 2015, is a joint effort between Dallara's Italian headquarters and Dallara LLC in the US. The car will be assembled at the company's US headquarters located near the Indianapolis Motor Speedway.

Teams competing in Indy Lights in 2014, as well as all teams placing orders by 15 March, will receive a reduction in the price of the new chassis. Dallara is also offering a finance/lease option to spread costs over a three-year period to defer initial ownership expenditures. Long-term partnerships with Performance Friction (PFC) on a brake package and Cosworth for electronics (looms, steering wheel and data system) for the IL-15 have been confirmed, while a new engine partner will be announced soon.

Growth grant secures £10m R&D funding for Lotus Cars

Lotus Cars has secured a £10m grant from the UK Government to help it with its research and development.

The grant, which is for £10.44m in total, is from the Regional Growth Fund, and will enable the company – not to be confused with the F1 team of the same name – to create 313 new jobs at its Norfolk, UK factory.

This grant is a further boost for Lotus, following a £100m investment by its owners DRB-HICOM which Lotus says has allowed the company to enhance its engineering, productivity, efficiency and quality.

Aslam Farikullah, chief operating officer at Lotus, said: 'This grant is part of a wider strategy, created to ensure that we thrive and grow. We are responding to increased global demand for our cars and engineering consultancy services – and this grant will help to position Lotus at the forefront of global automotive innovation.

'We have very exciting plans for our sportscars and it's a very positive move for Lotus that we're in a position to create new jobs and to significantly contribute to Britain's automotive industry.'

The Regional Growth Fund (RGF) is a £3.2bn fund operating across England, from 2011 to 2017. It supports projects that are using private sector investment to create economic growth and sustainable employment.

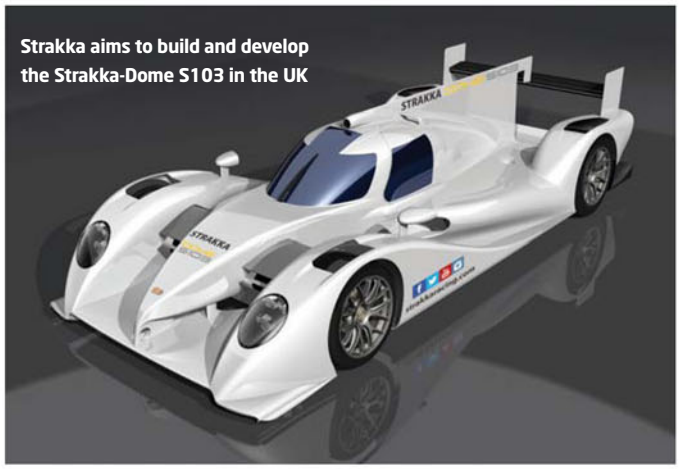
Business secretary Vince Cable said of the Lotus grant: 'Lotus is an iconic British car maker, and the car industry is one of Britain's great success stories, employing over 130,000 people and helping to build a stronger economy by contributing £11bn a year.'

Dome teams up with Strakka for WEC LMP2 project

British endurance racing outfit Strakka Racing has joined forces with racecar manufacturer Dome to help get the Japanese constructor's new cost-capped LMP2 design on to the WEC grid.

Strakka aims to build and develop the car, which will be known as the Strakka-Dome S103, at its base in the UK and a pair of the new cars – both powered by Nissan's VK45 4.5-litre V8 LMP2 engine – are now set to contest the entire FIA World Endurance Championship, pending the approval of the WEC selection committee.

Dan Walmsley, Strakka Racing team manager, said: 'Following the difficult decision not to compete in the remaining races of the 2013 FIA World Endurance Championship, we've focused on the engineering challenge of building and testing a brand new car ahead of the start of the 2014 season. It's a very tight schedule, but between Strakka Racing and Dome, we're confident we have the best team of skilled engineers to hit our targets and to debut a fast, reliable and competitive car.'



Strakka aims to build and develop the Strakka-Dome S103 in the UK

Hiroshi Fushida, president of Dome, said: 'We are absolutely delighted to team up with Strakka Racing, in a new partnership that will enable our cutting-edge designed S103 to become reality and race on tracks all over the world.'

Silverstone-based Strakka Racing has contested the Le Mans 24 Hour race for the last six years – winning the LMP2 trophy (and finishing fifth overall) in 2010, and the LMP1 Privateers' award in 2013. In 2012, Strakka Racing was runner up in the LMP1 Privateers' class in the World Endurance Championship, and finished as LMP2 runner up in 2010 and 2011 in the European Le Mans Series. This year Strakka decided to step down to LMP2 from LMP1 after withdrawing from the WEC following its sixth-place finish at Le Mans with its HPD ARX-03c.

Dome was established in 1975 by Minoru Hayashi and over the last 38 years it has become a leading racecar constructor. Based in Maibara in Japan, Dome made its Le Mans 24 Hour race debut in 1979.

Honda to race estate car in 2014 BTCC

Honda intends to use its new estate version of the Civic for its 2014 British Touring Car Championship campaign, marking the return of station wagons to the BTCC after an absence of 20 years.

The new Civic Tourer will be the only estate car on the BTCC grid, and the first since Volvo's famous 850 estate back in 1994. The car has been on sale to the public since December, and it is the first Civic estate for over a decade. Honda expects sales of the Tourer to make up close to 25 per cent of the 20,000 Civics sold in the UK every year.

Phil Crossman, managing director, Honda (UK) said: 'We wanted to add a new challenge to the mix and really show what Honda and the team can do. By racing the new Tourer after several years with the Civic hatchback we can really showcase our growing range and demonstrate that the versatility and practicality of a Tourer doesn't compromise dynamic performance. I can't wait to see the cars out on the track. They're going to look great and there's no doubt in my mind that they will win races.'

Testing of the new model commences in January ahead of its race debut at Brands Hatch for the first round of the 2014 BTCC.

Peter Crolla, team manager at Honda works outfit Team Dynamics, said: 'Racing with the Civic Tourer means no compromise over the Civic hatchback. The weight, wheelbase, layout and suspension remain the same, but – naturally – the length of the car is extended due to the larger tailgate.

'After two competitive seasons in the BTCC with the hatchback, it will be an interesting challenge to ensure the Tourer keeps Matt [Neal], Flash [Gordon Shedden] and the team at the head of the championships throughout next season.'

SEEN: HONDA CIVIC WTCC

Honda has also released the first pictures of its new 2014 World Touring Car Championship challenger, built to the all-new technical regulations. The influence of the new regs are most obvious in the aggressive looking aero package, larger wheel arches, and bigger wheels, but there will alsobe more power on tap. The two works Civics are to be run by JAS Motorsport, while single private entries will be fielded by Zengo Motorsport and Proteam Racing.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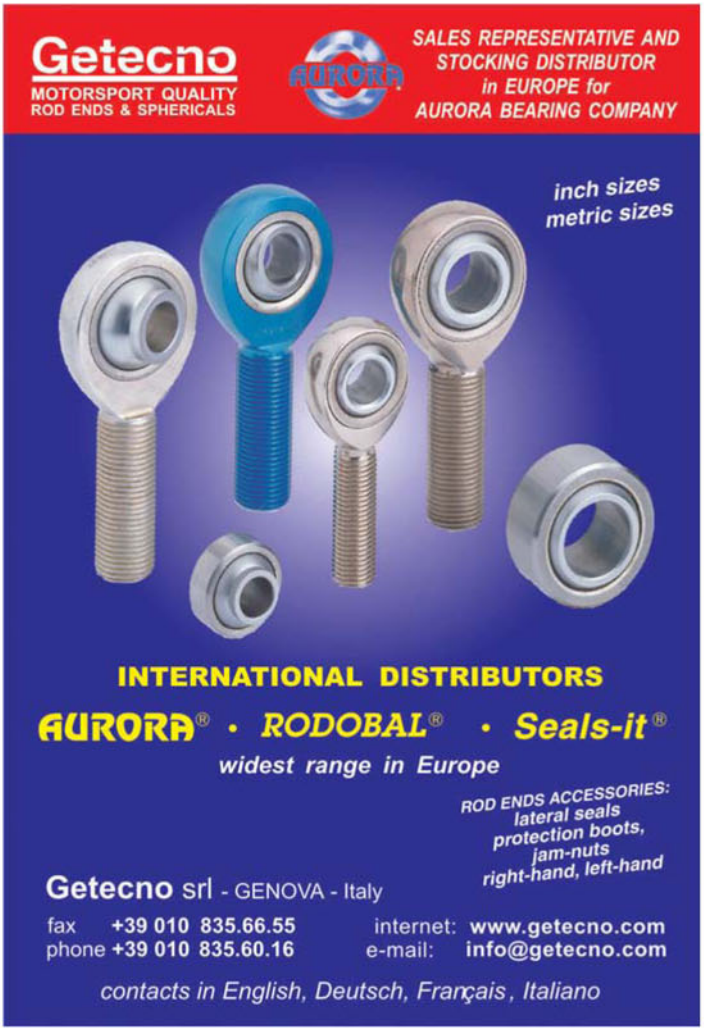
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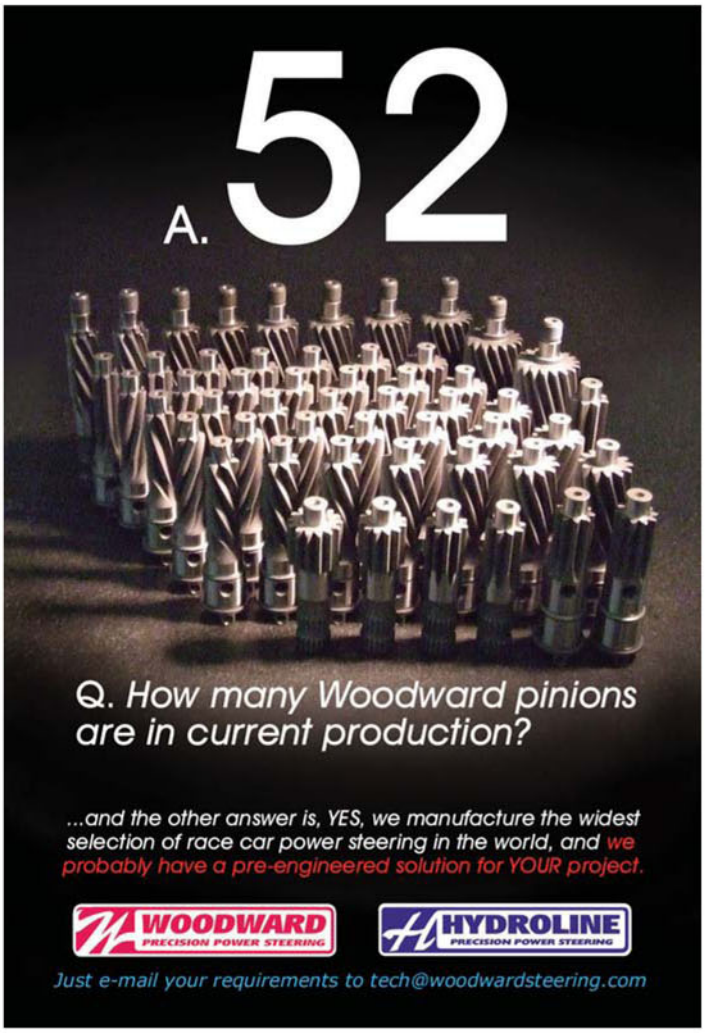
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Cosworth concentrates on new business after F1 loss

British firm Cosworth is concentrating on new revenue streams for 2014, particularly in the medicine and aerospace industries, after taking a finanical hit in 2012 partly as the result of losing a single F1 customer.

Cosworth says that it intends to continue to diversify in order to reduce its reliance on its traditional motor racing market place, building on work it has already started, particularly in aerospace and medicine. It said: 'Historically the business has relied exclusively on motorsport but significant revenues are now earned from other sport markets [such as marine] together with mainstream automotive and defence industries.'

LAT

Brazil 2013 might well have been Cosworth's last race in Formula 1

Cosworth was founded in 1958 by Mike Costin and Keith Duckworth and its engines have powered more winning cars than any other engine builder in F1, except for Ferrari. Cosworth's victory tally stands at 176, although in 2013 Marussia, the sole Cosworth-powered team, failed to score a single point.

The famed engine maker's annual report for 2012 shows that the loss of Williams from its customer base for that year's F1 season contributed to a drop in profits on the previous year of 24 per cent and a £7.1m loss – in 2011 it chalked up a £3.9m profit.

In total Cosworth reported revenues of £41m across the group for the year ending December 2012, down from £55m in 2011. But its financial statement said that this did not come as a surprise: 'This was in part expected as the number of teams supported in Formula 1 reduced by one at the end of the 2011 season,' it said.

In 2013 Cosworth also lost the custom of another F1 team, HRT, and it will no longer be active as an engine builder in F1 for the 2014 season, as its sole surviving customer in 2013, Marussia, will be switching to Ferrari power this season.

State funding paves the way for IMS improvements

The owner of the Indianapolis Motor Speedway has provisionally secured millions of dollars of state funding which it will use to improve the legendary race track.

Hulman & Co will be given the money – the full amount of which was not disclosed at the time of writing – by the Indiana Motorsport Commission, which has approved a raft of changes to the venue. These include a plan to add aprons to all four turns, at a cost of $1m, with the intention of improving NASCAR racing at the track. The aprons will only be used for NASCAR events.

LAT

There will also be improvements made to the road course. 'We'll complete our masterplan next spring, but the first upgrades are already under way,' says Hulman & Co president and COO Jeff Belskus. 'We just completed paving the newly modified road course that will host the inaugural Grand Prix of Indianapolis on 10 May [an IndyCar road race] and be used by MotoGP competitors in August. Our fans also will see a new scoring pylon and new video screens next spring. And that's just the beginning.'

Other improvements are more infrastructure-centred, with seating, traffic flow, restrooms, and concession stands all in line for attention. But a scheme to equip the circuit with floodlighting was turned down, the Commission saying that studies showed there would not be sufficient revenue from night races to justify the estimated $20m of expenditure required to install the lights.

The reason the state is supporting the track is because of the benefits the speedway has shown it brings to Indiana. IMS has an annual economic impact of more than $500m in the state, while the motorsport industry in Indiana supports more than 6200 jobs that pay an average wage of $63,000, according to an Indiana University Public Policy Institute report which was released earlier this year.

NASCAR steps in to buy Iowa Speedway

NASCAR has bought Iowa Speedway, a move that not only saves the troubled venue but also marks the first time the family-run organisation has owned a racetrack.

The speedway's agreement was made with a wholly-owned subsidiary of NASCAR called Iowa Speedway, LLC, and according to NASCAR the aim was 'to expand its commitment to enhancing event experiences and fan engagement, as well as solidify the future of one of the premier racing and entertainment facilities in the Midwest'.

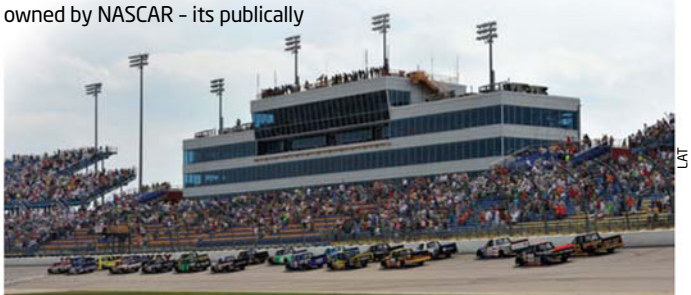
Eric Nyquist, NASCAR vice president, strategic development, said: 'Iowa Speedway is a great entertainment facility with a very bright future. The facility has the support of the region, it's positioned well in the heart of the Midwest, and year in and year out it provides great short-track racing action for motorsports fans.'

Iowa Speedway is now the only speedway wholly-owned by NASCAR – its publically owned sister organisation International Speedway Corporation (ISC) normally sees to the track side of the sport – but the governing body believes its involvement can only be of benefit to the facility.

'NASCAR ownership will allow us to draw on the entire resources of our company,' Nyquist said. 'It also provides us with the opportunity to execute first-hand a number of entertainment ideas and engagement opportunities with fans – much of which we have outlined repeatedly as the core of our Industry Action Plan.'

The track, located in Newton, 30 miles east of Des Moines, features a fast, 0.875-mile asphalt paved tri-oval designed by Rusty Wallace, and has 30,000 permanent grandstand seats.

The Speedway, which opened in 2006, will continue to host a variety of NASCAR categories – although not the Sprint Cup – and also IndyCar.



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BUSINESS INTERVIEW – DR WOLFGANG ULLRICH

Doctor's orders

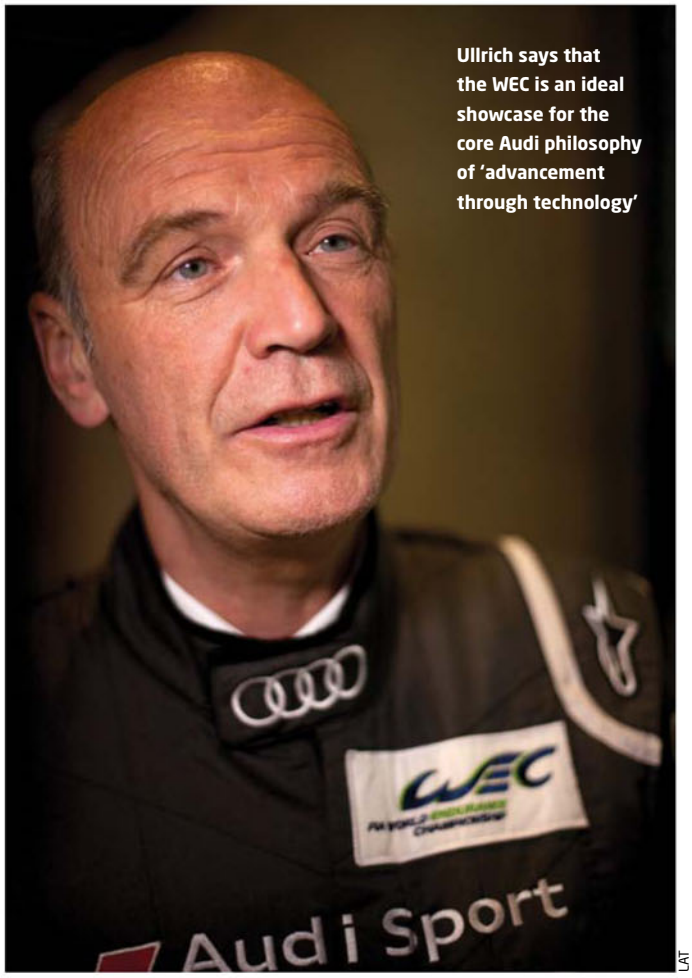
Audi's motorsport boss looks back on a 20-year career with the brand, and explains why Formula 1 is simply not on the agenda

For Audi, 'Vorsprung durch Technik' is more than just an advertising slogan. It is the company's philosophy captured in three words. Roughly translated to 'advancement through technology', it is at the heart of Audi's efforts on the racetrack, and it's also a phrase its motorsport boss Dr Wolfgang Ullrich is rather fond of.

Indeed, Vorsprung durch Technik is the reason that the WEC is Audi's flagship programme. It's also part of the reason it's not in F1, but more on that later – because according to Ullrich, LMP1 fits the philosophy perfectly. 'All the LMP activities with the different new technologies that we've brought first into racing and then into our road cars work very well with Vorsprung durch Technik,' he says, 'because that's how we prove our technology.'

Ullrich has spent 20 years as Head of Audi Motorsport. During that time, he took quattro on to the circuits in touring car racing, and began a Le Mans programme that has catapulted the brand to legendary status at Le Mans. However, it all nearly didn't start at all.

'When I started, it looked as though there wouldn't be a motorsport programme in 1994,' says Ullrich. 'We had a very low profile programme with the Super Touring cars in the French Championship. The automotive industry had a bad year in 1993, and we were at the World Final in Monza, which was a disaster. They were not really competitive. There was quite a lot of discussion before I came about how to continue, and when I started my work – on the Sunday before my first Monday – I got the information that there was a decision of the board three days before to stop motorsport entirely.



Ullrich says that the WEC is an ideal showcase for the core Audi philosophy of 'advancement through technology'

LAT

"There was a big question mark on how to continue in motorsport, and we decided to try to win Le Mans"

That was not a good start, and it is not a start that you think is the basis for 20 years of motorsport.

'We built up a small progamme for 1994. I had support, because if there is someone new in the company it is difficult to send him on his second day of work in front of the board to fight for a new programme. But they managed to get the go-ahead, and we started with the Super Touring Cars in Germany. Three years later, we were running in seven international championships worldwide, and won the titles. Then there was a big issue when meeting the FIA president Max Mosely in Munich after this successful year, and he told us that they would take the decision to ban four wheel drive from circuit racing. All motorsport activities were based in Audi on quattro. So, there was a big question mark on how to continue. Out of that, we took the decision to try to win Le Mans.

'We developed an open-top sportscar from a white sheet of paper, and then with a delay of half a year, a closed car. The British car was just too late in its development, so there was no chance to make it successful. But to come with the first self-built sport prototype and make it on the podium with the R8 was a good start. It was difficult, because the squad that I had was used to taking road cars and making racecars out of it. We had to learn, and learn quickly, and it was a thrilling period of time. Then, after all that we learned in the first two years, we designed the R8 – and this was a very successful car from the beginning to the end. It was a special racecar because there are not many that remained this competitive for five years.

'It had many nice ideas, such as changing the rear end. It was a future-orientated modern sport prototype. After years with the R8, we continued the road of future-orientated technology.'

In 2001, Audi introduced the direct injection system into the 3.6-litre V8 Audi engine, with immediate benefits in power and fuel consumption. 'When the R8 was done, we started immediately to see how the Vorsprung durch Technik principle could find ways in this new area of sports to use it for the brand and to bring technologies that fit,' says Ullrich. This path led to an introduction for diesel in 2006, and hybrid technology in 2012.


LAT

'The most difficult technology, with the expectations that were behind it, was for sure the TDI for racing. But I have to say that the very last project, the TDI with the hybrid system, was so much more complex that it is a little difficult to compare. When we started the hybrid programme, we said we needed some hybrid specialists in the company, but the last hybrid specialists came in after we had raced already, so it was very much in the hands of those who were already there. They had to push their knowledge into a completely new system. Now we have the specialists in to help improve, but they have proven that the first way was a good one.'

There have been tough times, too, however, and none more so than in 2001, when Michele Alboreto crashed to his death in an R8 following a tyre deflation. Although the accident occurred in private testing, Audi called on the FIA to help examine the accident and ensure the safety of Le Mans Prototypes.

'One accident like this is one too many,' says Ullrich. 'When it happened, it was a big hit for all of us, a very big hit for myself. Michele was very much a part of the family, we had close personal relationshipa and it was the toughest day of my life, and I don't need something similar. What happened could not have been avoided – we knew that two days later – so we started to make sure that in future it will not happen, and that is all you can do. I always had my drivers together, we knew exactly where the driver that overtakes should stay behind the car in front and where not. Two years later we had improved the rulebook and the cars enough that we didn't need it any more, but what I could do, I did immediately.'

Looking to the future, Ullrich will not commit to life at Audi beyond the age of 65. However, he is well placed to comment on the future of Audi's racing activities.

'Full electric is coming with Formula E, but is this is how all racing is coming? I doubt it,' says the 63 year old.

And then there's the age-old question: will Audi go into F1?

'All the rest was always based on road cars, or linked closely to road cars, and this has always been the main reason why we are not in F1. We have never seen the rules relevant enough to what is to come in the road cars of the future. And it's not only the engine, it's all the concepts, all the ideas.' And as for the talk that VAG pushed for the new F1 engine formula, Ullrich is clear: 'We did not go for a V6.'

Surely it must be annoying to have to answer this same question time and again, regarding F1? 'No,' says Ullrich, 'it's normal if you are in top motorsport that people ask you why you are not in F1. You can also see it as a positive, because if they ask you why you are not there, they at least think you could do it.' And could Audi do it? 'We are sure that we could do it. But we never wanted to do it.'

RACE MOVES

Williams has bolstered its aerodynamics department with the recruitment of two new members. **Dave Wheater** joins the team from Lotus to become head of aerodynamic performance, while **Shaun Whitehead**, who previously worked at Red Bull, joins the Grove-based team as its head of aerodynamic process.

Philippe Dumas is to join LMP2 squad OAK Racing as its team manager. Dumas, who previously headed the now defunct Hexis GT team, replaces **Sebastien Philippe** in the role. Philippe has now joined ART Grand Prix, and his former duties as managing director will now be shared between Dumas and **Serge Lapierre**, who is OAK's executive manager.

Chad Johnston is set to be crew chief for **Tony Stewart** at Stewart-Haas Racing in the 2014 NASCAR Sprint Cup Series. Johnston, who was previously crew chief for **Martin Truex Jr** at Michael Waltrip Racing, replaces **Steve Addington** in the role.

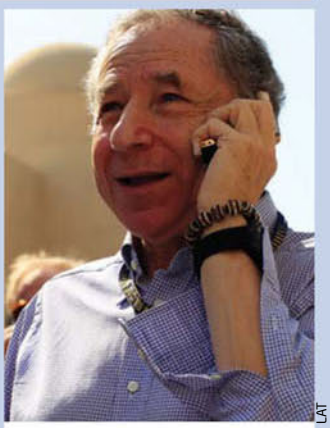
Tom McCullough is to leave Sauber, where he was head of track engineering, to join Force India after just one season with the Swiss outfit. McCullough has been in Formula 1 since 2003, when he joined Williams from Reynard. He left Williams to join Sauber at the end of the 2012 season.

Greg Zipadelli, former competition director at NASCAR operation Stewart-Haas Racing, has now been given the new job title of vice president of competition. He has also taken on new duties, which includes overseeing the running of SHR's four cars.

Also at Stewart-Haas Racing, **Daniel Knost** has been promoted from race engineer to crew chief, and will now work with new arrival at SHR, **Kurt Busch**, while **Matt Borland** has moved from his role as crew chief to become vice president of engineering.

The Roush Fenway Racing NASCAR outfit has reshuffled its personnel to reunite crew chief **Mike Kelley** with driver **Ricky Stenhouse Jr** for the 2014 Sprint Cup Series – the pairing won back to back titles in the Nationwide Series in 2011-12.

As part of the RFR reorganisation, **Scott Graves** – who was crew chief for Stenhouse in the Cup in 2013 – will move over to the team's No 60 Nationwide Series entry.


LAT

Jean Todt has been confirmed as FIA president for a second term. Todt's only rival for the position, **David Ward**, pulled out of the election after failing to secure enough support to be nominated. Todt now has four more years at the helm of the organisation, which not only governs world motorsport but also looks after the interests of most of the national motoring organisations across the globe.

Veteran NASCAR crew chief **Steve Addington** is now competition director at NASCAR Sprint Cup team Phoenix Racing. He will also work as crew chief on the team's No 51 Chevrolet. Addington has served as a crew chief in the NASCAR Sprint Cup Series for 10 years and during that time he has amassed 20 wins, 66 top five, and 105 top 10 finishes.

Chad Norris will be crew chief on the Roush Fenway No 6 Ford in the NASCAR Nationwide Series in 2014. Norris has previously worked with drivers such as **Mark Martin**, **Matt Kenseth** and **Carl Edwards**, and also led **Trevor Bayne** – the driver of the No 6 car – to his first Nationwide Series win in 2011.

NASCAR Sprint Cup outfit Earnhardt Ganassi Racing has hired **Keith Rodden** to be **Jamie McMurray's** crew chief on its No 1 Chevrolet. Rodden comes to EGR from Hendrick Motorsports, where he was the lead engineer on the No 5 car. Rodden has also worked for Evernham Motorsports, Richard Petty Motorsports and Red Bull Racing during a 10-year NASCAR career.

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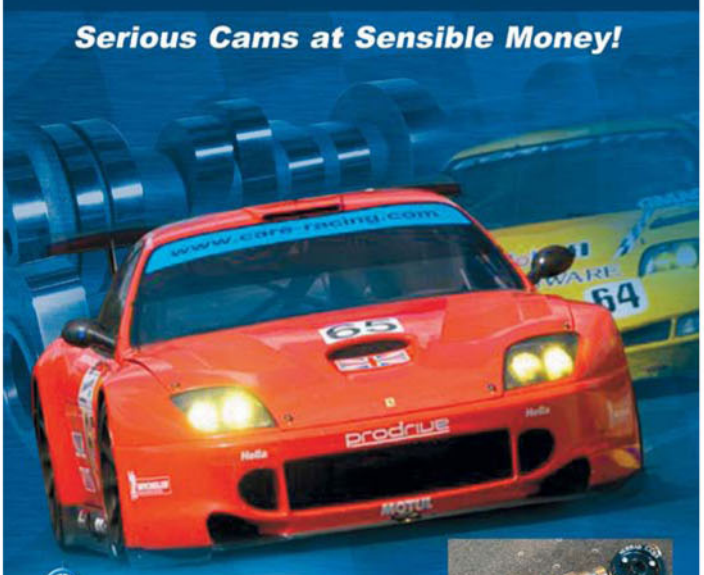

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It's the perfect time to leave Mercedes GP, says Brawn

Ross Brawn has said that the introduction of the new-for-2014 regulations in F1 meant that the end of the 2013 season was the right time to stand down from his position at the top of Mercedes GP.

Brawn's departure from Mercedes came after months of speculation over his future, and the team will now be run by its executive directors, Toto Wolff and Paddy Lowe. But Brawn insists that his departure from the team at the end or 2013 – which sees the introduction of a new engine formula plus other big changes – was well-timed.

'The most important consideration in my decision to step down from the role as team principal was to ensure that the timing was right for the team in order to ensure its future success,' said Brawn.

'The succession planning process that we have implemented during this year means we are now ready to conduct the transition from my current responsibilities to a new leadership team composed of Toto and Paddy.

'2014 will mark the beginning of a new era in the sport. We felt that that this was the right time to simultaneously begin a new era of team management to ensure that the organisation is in the strongest possible competitive position for the years to come.'

Brawn also said he was confident that recent investment and organisation changes at Mercedes means that the team will continue to be successful. 'Mercedes-Benz has invested significantly in both the personnel and infrastructure at Brackley and Brixworth engines. Thanks to the one-team approach, we have implemented between the two facilities, the team is uniquely positioned to succeed in 2014 and I am proud to have helped lay the foundations for that success.'

Mercedes non-executive chairman Niki Lauda said that he had tried to persuade Brawn to stay on: 'We have had long discussions with Ross about how he could continue with the team, but it is a fairly basic fact that you cannot hold somebody back when they have chosen to move on.'


LAT

SPONSORSHIP

LG has ended its relationship with **Formula 1** after a five-year deal to sponsor the sport came to an end. The Korean company, which among other things is the world's second-largest TV maker, will now 'refocus its sponsorship strategy towards regional platforms from 2014 onwards,' it said. LG came into F1 in November 2008 as the sport's technology partner.

Mistic will be the co-primary sponsor on the **KVSH Racing** entry driven by **Sebastien Bourdais** for the 2014 and 2015 IndyCar seasons. The car will carry the electronic cigarette maker's branding at seven races this year.

Australian V8 Supercars outfit **Ford Performance Racing** will retain its support from **Orrcon Steel** into the 2014 season. This will be the eighth year Orrcon has sponsored FPR, and its 13th consecutive year of involvement in V8S.

RACE MOVES

Curtis Martin Jr, a crew member for Gallagher Motorsports in the NASCAR Camping World Truck Series, has been indefinitely suspended from all NASCAR competition after violating the strict substance abuse policy.

James Small is switching codes and countries with a move from the Australian V8 Supercars series to NASCAR. Small, who was race engineer to **Mark Winterbottom** at Ford Performance Racing, will now work as a number two race engineer at Richard Childress Racing.

Kenny Mitchell is now managing director of NASCAR's brand and consumer marketing, with responsibility for leading and implementing the company's overall brand direction and overseeing the strategic growth plans for several critical segments, including youth and multicultural.

The Royal Automobile Club has awarded **Lord Drayson** with its prestigious Simms Medal, in recognition of his contribution to motoring innovation, after his successful World Electric Land Speed Record runs. Lord Drayson drove the B12 69/EV developed by his company Drayson Racing Technologies to set a new flying mile record for the category at 205.139mph in October 2013.

Trent Owens is to be crew chief on the famous No 43 Richard Petty Motorsports entry in the NASCAR Sprint Cup in 2014. Owens was crew chief on the Turner Scott Motorsports car of **Kyle Larson** in the second-string NASCAR Nationwide series in 2013.

Two of Formula 1's biggest names, **Sir Jackie Stewart** and **Niki Lauda**, who both still hold positions in the F1 paddock, are now to be represented by motorsport marketing giant JMI. Stewart comes to JMI from IMG, the company that had represented him for more than 20 years.

HWA, the Mercedes works team in the DTM, has appointed **Ulrich Fritz** to its board as a director. Fritz will focus on commercial operations and team management. He was previously senior manager for marketing communications at the AMG Driving Academy and Customer Sports arm at Mercedes AMG.


LAT

Dario Franchitti, who has been forced to call time on his illustrious IndyCar driving career after a crash at Houston left him with spinal injuries, ankle fractures and concussion, has said that he is now talking to team boss Chip Ganassi about taking on a role with the team on the other side of the pit wall.

Mark Jones has left his position as chief executive of the British Automobile Racing Club (BARC), with **Bill Coombs** assuming executive responsibility in his place. Coombs is the CEO of the Ian Taylor Motor Racing School and is closely associated with the Thruxton circuit, where the BARC is based.

ACO president **Pierre Fillon** will have the honour of starting the 2014 Rolex 24 at Daytona, the inaugural race of the new United SportsCar Championship. **Jim France**, the creator of Grand-Am – which has amalgamated with ALMS to form United SportsCar – was the starter at the Le Mans 24 Hours in 2013.

Caterham Group co-chairman **Tony Fernandes** has been awarded with the Commander of the Legion d'Honneur by the French government for services to the economy of France in the automotive and aviation industries – Fernandes is also Group CEO of Air Asia. The Commander of the Legion d'Honneur is the highest award that the French government can give to a non-French citizen.

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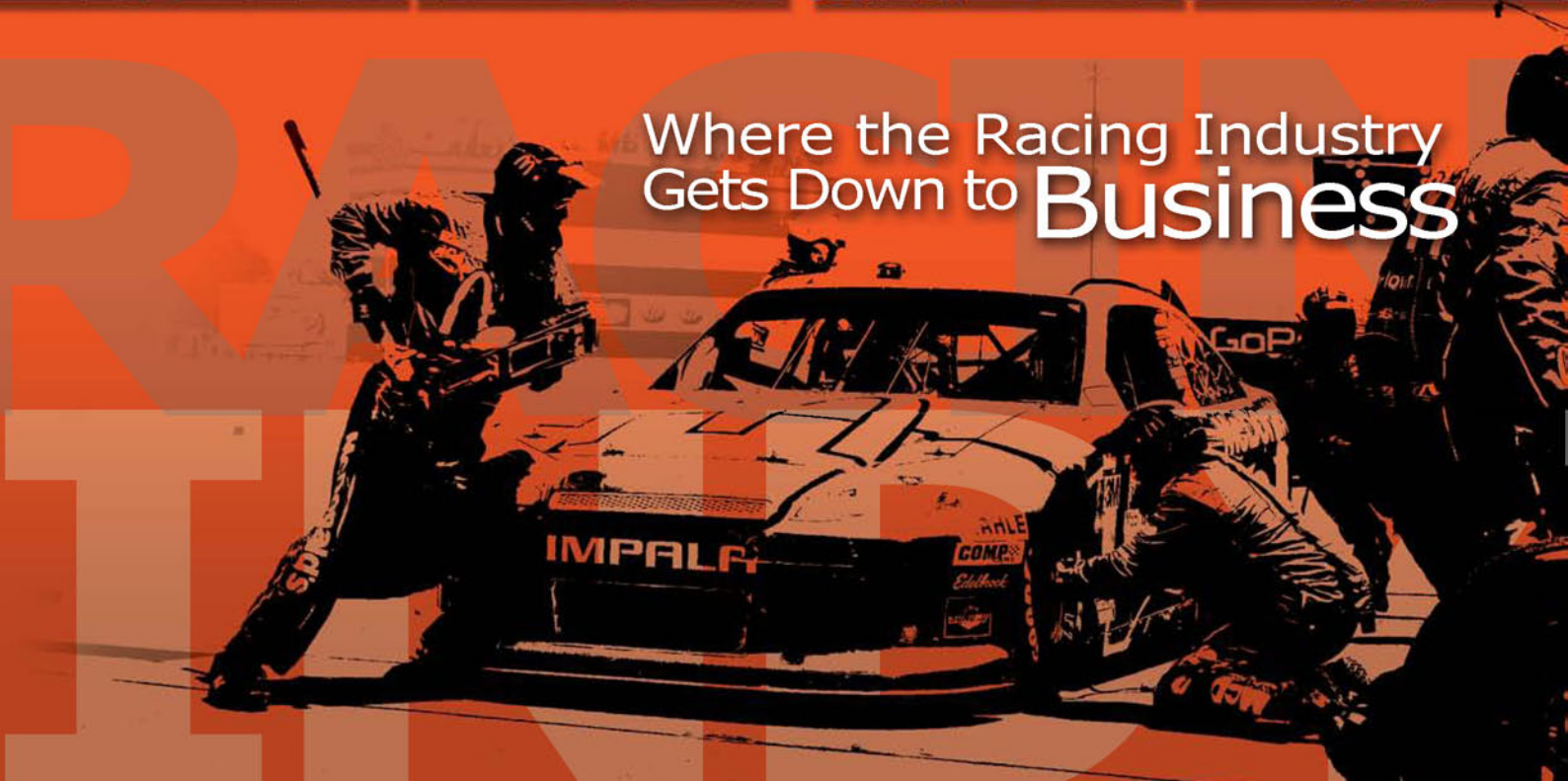

Where the Racing Industry Gets Down to Business

BUSINESS TALK: CHRIS AYLETT

Make the most of 2014

With so many new rules, there's plenty of potential new business out there

I wish you a happy New Year and a prosperous 2014 ahead. This is the MIA's 20th anniversary year, and having attended all the shows – with just Autosport International to go as this is written – I reckon our anniversary year is going to be a real cracker! There is a great deal of business to be done this year.

At Autosport International, the results of our National Survey into motorsport engineering and services in the UK will be launched. These show that sales have doubled in the past decade, and that output from the industry employees is more effective than ever.

Why am I so confident that 2014 will be the breakthrough? As the economists say, there are 'macro' and 'micro' reasons.

From a macro perspective, the major economies in the established motorsport markets are improving fast. UK, USA and Germany are posting significant increases in economic growth and employment, with Italy and France beginning to wake up, but growing at a slightly slower pace. In the emerging world markets, their economies are still growing strongly and several have specific plans to grow motorsport activity – India, China and Russia are just some of the new markets opening up and providing new business opportunities.

Indeed, new opportunities are opening up in the race series around the world, mostly as a result of 'cost reduction' schemes. These always seem to create plenty of new business as the legislators do their best to outwit the supply chain, but quite often failing to do so. There is an old saying that there's always good business to be had when the rules change, and 2014 has plenty of those ahead.

There has been a massive spending within Formula 1 linked to the new engine change, in addition to the usual substantial spend during the closed season. During this winter, however, with the new engines likely to produce unpredictable results, every team has been working extra hard and spending what is necessary to secure every small advantage they can.

In the USA, new plans for IndyCar and Indy Lights are opening up new business, as is growth in both drag racing and off-road. However, in my opinion, the big opportunity will exist in the new United SportsCar series, which launches at the Rolex 24 at Daytona at the end of January. Huge grids of cars; rules being changed constantly to make sure the racing is close; updates being needed on a regular basis; and loads of testing as well as racing throughout the year. This will produce excellent new business and I recommend that you join the MIA group of UK businesses that are visiting the inaugural race. Take a look on our website – www.the-mia.com – and join us to pick up your share of this new business. All the big players in US racing will be there, so don't miss it. We are also taking a group out to off-road racing on the West Coast of the USA in March, and details of that are also on our website.

Rally cross, in the US and elsewhere, is ready to grow with new promotion from IMG, and it is good to see WRC waking up too, with a battle between Ford, Hyundai and VW, and others to come in the future. All the series now needs is a good TV deal and it will fly.

NASCAR continues to be opening its doors and considering new innovation, having appointed a new VP. They need to race fast, but also address low emissions and low carbon targets, to meet the demands of their OEM partners. Good business is to be built here on the back of McLaren and other UK companies, providing good solutions for electronic fuel injection. The MIA is taking a group to both NASCAR and Indy in May, and this must be the year you join us to find your share of this business.

Rule changes mean a raft of new opportunities are opening up in race series around the world

Take the initiative and capitalise on new avenues for business

I am exhausted simply writing this article, let alone going out and getting hold of all this business in 2014!

We then have all the change in technologies that will bring new business – hybrid, electric, turbo and many more. Formula E will take off from September and attract attention for new energy-efficient business into motorsport, no matter how close the racing is.

Finally, we will find business in new sectors, particularly in automotive and defence in the UK. Both of these are making a major push to link up with motorsport companies who, for automotive, will produce R&D and prototypes in low carbon solutions, and in defence, re-fitting and improving their returning fleet from the battle zones of Afghanistan.

Both sectors plan to spend billions, not millions, over the next few years, and they need a fast response from suppliers with innovative ideas. That is a call that motorsport should heed.

The MIA is constantly running Motorsport to Automotive and Motorsport to Defence events, to break down these barriers and create new business, so make sure you join us.

Now you see why I think 2014 is going to be a belter! It is the perfect 20th anniversary year for the MIA and maybe this is the year you should consider joining us. We take the initiative in developing new business in many areas; we find new contacts, and we make business happen for our members. We try and offer them an extra pair of hands to hustle for this new business, so they never lose sight of the importance of their primary area, which will always be motorsport.

So make sure that 2014 is a prosperous year for you and come and work with us to achieve your aim. And if you read this article while in Birmingham, I hope you enjoy our Green Conference, and do come and visit the MIA at stand 8005 and say hello.

BATTERIES

DC Electronics lithium battery

UK-based wiring specialists DC Electronics recently unveiled a new integrated lithium battery solution for racing applications. The unit features two 13.2v DC lithium-ion battery packs, capable of providing up to 1800 amps of cranking power for one second, or 1440 amps for 10 seconds. During cranking, both batteries are energised, but during usual running only one battery is utilised. The unit also features much greater functionality than the average battery. There is a built-in BMS to ensure optimal charging, as well as selectable rollover and accident automatic shut-off and CAN bus outputs of current draw, starter current draw, three-axis G and time until battery empty, all of which interface with a vehicle's electronics system using an AS connector. **www.wiringlooms.com**

FUEL ADAPTORS

New adaptor from Earls

Fluid transfer specialists Earls has recently released a new adaptor to allow -6 and -8 AN fuel fittings to be attached to GM, Ford and Chrysler quick-connect fuel fittings. They feature dual internal O-ring seals, OEM-style internal snap retainers and an external securing clip to ensure that they cannot become accidentally disconnected. The fittings can be used for attaching fuel lines to factory-fitted fuel tanks or injection systems, greatly easing integration into racing vehicles. **www.earls.com**

SENSORS

Two new Reventec sensors

Motorsport sensor specialists Reventec has released two new sensors: a contactless linear position sensor and a multi-turn torque sensor.

The linear position sensor relies on a magneto-resistive sensing element to provide reliable positional feedback in harsh environments. The biggest benefit of the system is that the sensor and sensor target can be separated by other metallic objects and still operate. So, for example, the target could be mounted on a float within a fuel tank, while the main sensor body could be mounted outside. The sensor has a 12-bit resolution and a 10KHz update rate, making it suitable for measuring high frequency events such as suspension movement. Reventec can also create custom designs to suit particular applications.

The torque sensor incorporates an integral slip ring to allow for multi-turn measurement of components such as steering shafts. With a normal input torque range of up to 20Nm and an over range of up to 140Nm, it is suitable for a range of applications in racing vehicles. It's housed in a durable aluminium/PEEK body, making it suitable for use in harsh operating environments, and is available with either a Deutsch AS connector or flying lead. **www.reventec.com**

FUEL VALVES

Viper shut-off valve

Viper Performance is now offering quick-action fuel shut-off valves as part of its AN fitting range. The valve is a useful safety device to shut off fuel to the engine by means of a manual tap, either in the event of an accident, or to isolate parts of the fuel system during maintenance.

The valve is machined from 6061 billet aluminium, and is available in both DASH 6 and DASH 8 sizes. **www.viperperformance.co.uk**

BRAKING

New Brembo braking applications on the market

Renowned brake supplier Brembo has recently released a number of new products to market, including three new calipers. The first is a GT racing caliper, intended for use with discs featuring a large annulus, allowing the use of a 30mm pad, increasing pad life in endurance racing applications. The geometry of the caliper has been carefully optimised to increase stiffness while reducing weight. Another useful feature is the inclusion of a quick-release pad system, allowing for rapid changing of pads during pit stops.

The GT caliper is joined by two rally-specific units, aimed at differing ends of the market. A new water-cooled caliper has been produced for WRC competitors, providing superior heat dissipation than the air-cooled units currently used. It is entirely machined from billet and has a particularly lightweight structure, similar in the design to a standard caliper with the addition of a few specific features such as the reservoirs and radiating surfaces for liquid circulation required for cooling. Despite the additional complication of the water-cooling system, the calipers only weigh 200g more than Brembo's air-cooled variant.

The second rally caliper is aimed squarely at the cost-conscious R5 market, and is a forged rather than CNC-machined unit, allowing for lower per-unit costs. Despite its budget conscious design, the caliper still features optimised cooling ducts and the option of a lower weight caliper body for weight-sensitive applications.

Also available is a new rally pedal box. Originally developed for WRC applications, the unit is floor-mounted and optimised to provide exceptional rigidity in order to improve driver pedal feel. Features include a dual throttle position sensor to provide redundancy in event of a failure, and a unique two rail fixing system to simplify installation. The system is designed to be completely customisable to suit different driver requirements, and the total unit weighs in at just 3.5kg.
www.brembo.com

CAN BUS PANEL

MoTeC switch panel

MoTeC has recently launched a new CAN bus switch panel to aid the integration of the company's PDM systems into vehicles. The pad can be programmed to perform any function that the vehicle's CAN system allows, and only requires a four-wire output to operate. Customers can design their keypad layouts at www.racegrade.com and then customise the function of each key using MoTeC's PDM management software. Beyond the benefits provided by the level of customisation available, the keypads are rated to IP67 to ensure reliability in racing environments and housed in a compact, easy to install housing.
www.motec.com

IN BRIEF

FW MOTORSPORT
FW Motorsport specialises in GT and sportscars. They are experts in racecar preparation and development, offering services including chassis set-up and composites, driver tuition and race weekend support.
www.ferguswalkinshaw.com

FISCHER CONNECTORS
Fischer's new MiniMax connector meets ethernet 10Gb/s Cat 6A Telecoms performance, and consists of 20 signal/four-power contacts, developed for harsh environments. Other features include -30degC to +70degC resistance, IP68 sealing and cable with a Kevlar structure.
www.fischerconnectors.com

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CARTEK
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AUTOSPORT INTERNATIONAL Engineering Show
In association with Racecar engineering

Making the most of the show

Autosport Engineering takes place on 9 & 10 January – so for the uninitiated, here's a quick recap of some tips to help best make attendance work for you

One of the main benefits of attending an exhibition is that you can meet large numbers of useful people in one place. However, you need to plan ahead to make the most of these opportunities. It's worth setting up appointments in advance so that you don't waste too much time browsing and talking to people that you already know. It's vital that you focus on meeting the most useful people for your business.

To find out more about events that could help your business, ask colleagues in your particular field or contact the Motorsport Industry Association(MIA) who have a large presence at the show, and they will be pleased to advise you. Keep tabs on the comprehensive Autosport International website – **autosportinternational.com**.

It is the perfect forum to network with the world's leading suppliers to the motorsport industry. The organisers can provide detailed information about the type of companies who exhibit at their show, including their business activity, and particularly products materials and technologies that will be on show.

OPPORTUNITIES

Exhibitions provide the chance to meet suppliers, check out new developments and keep a close eye on your competition. You can get your hands on new products launched, attend demonstrations and compare features and prices. The main thing is you can meet exhibitors and ask them detailed questions. Don't leave your meetings to chance. Before the show, it's worth making contact with the key people you want to see, such as new suppliers. Make arrangements to meet and ensure that you have their stand and mobile telephone numbers. Do your own research before an event so you are well prepared for your meetings. Plenty of business cards and a notebook are a must.

NETWORKING

Make time to attend relevant events that are running alongside the show. Speeches by important industry figures, workshops, seminars and panel discussions can be informative and attract many of the key players in a particular sector. Check with the organisers – they can supply the programme of events – or contact the MIA.

These events are ideal environments for networking. Introduce yourself – everyone is wearing a badge and is there to talk business.

To get the most out of exhibition attendance, it is worth setting specific targets so that you can measure the success of the exhibition after the event.

DO...

- ... give yourself enough time. If you are visiting a core show within your industry, you will be meeting people you should be speaking to in every aisle. Manage your time to ensure that you manage to cover every aisle.

DON'T...

- ... expect to 'do' the whole show in one go. Even smaller events may need two days, or at least two half days. Exhibitions are places where meeting the right people on the right day can fall naturally into place, but equally you can quickly become frustrated when you keep missing the main person you wanted to see. If it's feasible, schedule at least two half days. That way you have an opportunity to ensure you don't miss that essential person. Also, you will have a chance to go back and check out that stand you missed first time, or the brand new product that you would like to know more about.
- ... just focus on the companies you came to see. You'll be surprised by the number of totally different companies that offer similar services.
- ... be afraid of being cornered by an exhibitor. We've all walked through an exhibition frightened to make eye contact with keen exhibitors in case we get hauled on to a stand never to be seen again. Make eye contact, smile and remember that a quick conversation could result in an invaluable find.
- ... waste the information gathered at the show. I dare anyone to admit they haven't returned from an exhibition with a briefcase full of brochures and a pocket full of business cards which never see the light of day again.

So, expect to see the world's motorsport supply chain, exhibiting the latest in leading-edge products and technologies at Autosport Engineering.

See you at the show!

Tony Tobias

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Casio Edifice are the official watch partner of Formula One™ champions Infiniti Red Bull Racing, bringing together two brands at the forefront of speed, accuracy and technical design. As a result, these timepieces are both designed and worn by the team's drivers and engineers and we're givng two away to our readers.

Over the course of four years, Infiniti Red Bull Racing's feedback and technology sharing has created an elite line of advanced men's watches, at an affordable price.

The EQW-A1200RB comes packed with Edifice's most advanced materials and technology, from the sapphire glass protecting the face to its vibration-resistant structure. The latter of which has been tested to withstand the demands of Formula One™ – from the turbulence of the racing cockpit, to the rigours of a tyre change. The EQW-A1200RB guarantees the whole race team, whatever their role, a perfectly accurate timepiece.

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It's the closest the UK has to Motor City – with Ozzy Osbourne in place of Marvin Gaye – and has witnessed some important milestones in the country's engineering history

For those new to the show, there are quite a few things that you may not know about Birmingham, so here are some facts. It is the second largest city in the United Kingdom with just over 1 million residents, humans (or hominids) have lived there for at least 500,000 years, and it is the home town of Nigel Mansell.

But Birmingham is best known in Britain as being a city of industry and innovation. Benjamin Franklin travelled to the city on more than one occasion to 'improve and increase Acquaintance among Persons of Influence.' In the late 18th century, major advances in steam engines were made in and around the city, part of a history of innovation only surpassed in recent years by Silicon Valley in the USA and Silicon Fen in England. Which is why it is a fitting place for the Autosport Engineering Show to be hosted.

One of the leading lights during the industrial revolution was James Watt who, in 1784 patented a two-speed transmission. The wording of that patent reads: 'Motion is communicated to the axle-tree of one or more wheels of the carriage by means of the "circulating rotative to machinery" formerly patented by the inventor. Two or more loose wheels of different diameters are placed to be locked on the axle and impart extra power for bad roads or steep ascents.'

In other words, he was already thinking about an early version of the eight speed seamless transmissions seen in F1 with hydraulically-actuated shifting. Technology which will of course be on display in the Engineering show with companies such as Sadev (8620) and Xtrac (E162) showing their wares.

Meanwhile, five years before Watt invented paddle shifting. Matthew Wasbrough came up with the Pickard engine. It was a direct development of Thomas Newcomen's reciprocating engine and featured – for the first time – a crank and flywheel. Things that Arrow Precision (E762) and TTV Racing Performance (E130) will be thanking him for.

But years after Wasborough paved the way for the 1.6-litre turbocharged V6 F1 engine, one of Watt's employees – William Murdoch – came up with the bell crank, which of course is now seen on just about every competition car going. If you want to see what people tend to attach to his work, visit Nitron (7525) and check out their dampers. Murdoch's other employer, Matthew Boulton, was concerned with plating fine silver, an industry that of course led directly to advanced DLC coatings.

Jump forward through history, and Birmingham has become a hub of the automotive industry – indeed Rolls Royce, MG, Rover, Austin, Jaguar and Supermarine all had factories in and around Birmingham. Birmingham was – and is – Britain's equivalent of Detroit, the original Motown. And like that city it had a great music scene, albeit of a slightly different stripe – where Motor City had Marvin Gaye, Stevie Wonder and The Supremes, Birmingham boasted Black Sabbath, Napalm Death and Judas Priest.

More to the point, from 1986 to 1990 Birmingham hosted its own version of the Monaco Grand Prix, called the Superprix. It was for years an FIA International F3000 (the equivalent of GP2) championship round, and before local political self-interest killed the event, negotiations were under way for the British Grand Prix to be held there. The remains of the circuit can still be seen near New Street Station.

So if you want to be at the cutting edge of European racing technology, you really should take the chance to visit the Autosport Engineering Show at the NEC, and drink in all the history around you.

BOOK YOUR TICKETS NOW

The Autosport International Show runs from 9-12 January at the NEC in Birmingham. It uniquely caters for industry professionals and motorsport fans alike, incorporating two trade-only days (9 & 10 January) to allow visitors and exhibitors to meet in a business to business environment and two busy and more relaxed public days (11 & 12 January) dedicated to motorsport enthusiasts.

Featuring every level of motor racing – from karting up to Formula 1 – and with exhibitors ranging from specialist engineering companies to major manufacturers and everything in between, Autosport International truly brings together the world of motorsport under one roof.

Tickets cost £26 in advance or £28 on the door. The show is open from 9am to 6pm each day.

HOW TO GET TO THE SHOW

By air
The NEC is a few minutes walk from Birmingham Airport (BHX), which is served by more than 50 international airlines.

By land
London is only 70 minutes away from Birmingham International Station, which itself is linked to the NEC. Trains also run directly to regional towns and cities. London Midland and Virgin Trains operate services direct to Birmingham International from London and Birmingham. There is a short covered walkway between Birmingham International and the NEC. Driving is not recommended due to very high on-site parking charges and heavy traffic.

By sea
You can't, although there is a canal vaguely nearby if you fancy attempting barge travel.

Where to stay
The Hilton and Crowne Plaza Hotels are on site, and the 'networking' is legendary at both – but there is a wide selection of hotels in central Birmingham. Other hotels in the NEC area tend to be some way from the halls.

Racecar Engineering
Come and see us on stand E384 at the Autosport Engineering Show, held in association with *Racecar Engineering*, and take full advantage of special one- and two-year subscription rates. The editorial and advertising team will all spend time on the stand, as will some of our contributors. Additionally this year, we are also present on stand 8324 in the main show over the full four days, so if you don't get to us in Engineering, please come and find us over the weekend – we'll be pleased to see you.

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The International Journal of Motorsport Technology

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Take the experts on the gravy train

We are at the start of what is about to be an epic journey in 2014, as Formula 1 and endurance racing both give public debuts to the new regulations that have been touted for so long. For seemingly aeons, we have written about the theory, but this year we will see the new regulations, systems and hardware on track. This is the start of a new era of motor racing, which aims to make cars more efficient both on the track and on the road. Yet, we cannot underestimate how difficult this challenge is, and it is not helped by the fact that, by the nature of motor racing, technical development is kept under wraps.

As Christmas approached and both Audi and Porsche unveiled their new prototypes, the details were missing. Porsche confessed that it still had to fix various elements of its package, having struggled with the engine (revealed in a German newspaper as a four cylinder in a 'V') and the suspension. Just before Christmas, new signing Mark Webber had his first laps in the car, and achieved more than 600km in a day. This, for Porsche, was something of a positive to take into the Christmas break, given the testing woes that they have suffered so far this year.

Audi did not consider that to be much of a triumph, although rumours suggested that it was struggling to get its second MGU working properly, and engineers admitted that they still had six months before Le Mans to get it sorted out properly. Audi launched its R18 with a few more details than Porsche, including the engine retaining its V6 configuration, but would not be drawn even on its capacity.

The parameters in sportscar racing are still not clear enough

This will be revealed before Le Mans, and probably at the test at the end of March, but there is still a lot of work to do on the engine, and the two energy recovery systems that are fitted to the car. The final engine testing will reveal how the ultrasonic fuel flow sensor really works in race conditions, and will determine the final specification of the engine.

In the world of Formula 1, around Christmas we understood that some teams will be forced to miss the first test in Jerez, because they cannot get the radiators in time. The suppliers are completely overbooked and there is no wiggle room. Privately, one of the three engine manufacturers has admitted that it is not looking at the first test as its deadline. You don't score points in testing, and the global spotlight will be on the Australian Grand Prix on 16 March.

There are rumours of fires and failures, although verifying them is not easy. Porsche flatly denied that it burned one of its 919 hybrids at Paul Ricard in testing, although the bongo drums have not been silenced completely with this denial. Similarly, Mercedes had to call the fire brigade to its Brixworth facility, although apparently this was a mere procedure. The rumours were entertaining, and we cannot know if they are true or not, but when at the Porsche end of season party I walked past a fire marshal, I couldn't help but wonder what he was doing there (it was Romain Dumas's birthday and they had to put a candle on his cake).

Formula 1's regulations are tight, while still leaving room for development. Engineers have clear parameters, yet have room to experiment and the engines will be completely different in their design and their development stages. Likewise in sportscar racing, although the regulations are much more relaxed, and therefore exciting both to engineers and to motor manufacturers, but there is a cloud on the horizon.

While the theory behind the regulations allows for greater freedom and development, there is a nagging doubt that the parameters in sportscar racing are not clear enough, and that they are open to abuse. The FIA must listen to those who are designing and working with the hardware, and – increasingly – there is a feeling that they are being ignored.

Brave regulations would allow technical freedom to establish which system is best for our production cars, which is what the pinnacle of the sport should serve, but neither F1 or endurance racing is the right arena for this. There has to be competition, and that comes down to lap time.

What is needed in sportscar racing are the brains to allow development within this parameter, while also controlling costs, and maintaining a playing field that will encourage new manufacturers to join. The technical element of the regulations is too complicated for a politician, and the job of an engineer is to write the rules, and then find the unfair advantage within them. The application of the rules, as the cars take to the track, and real-time testing and racing begins, relies on a relationship that has the best of both worlds – the best politicians and the best engineers. Some of the leading engineers feel that they are being pushed out, and that's a dangerous place for Le Mans to be.

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