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Renault R31

Is this the most innovative car in Formula 1?

Formula Ford
Re-birth of an iconic racing class

Pat Symonds
Controversial designer comes in from the cold

Formula E
Electric series gets green light

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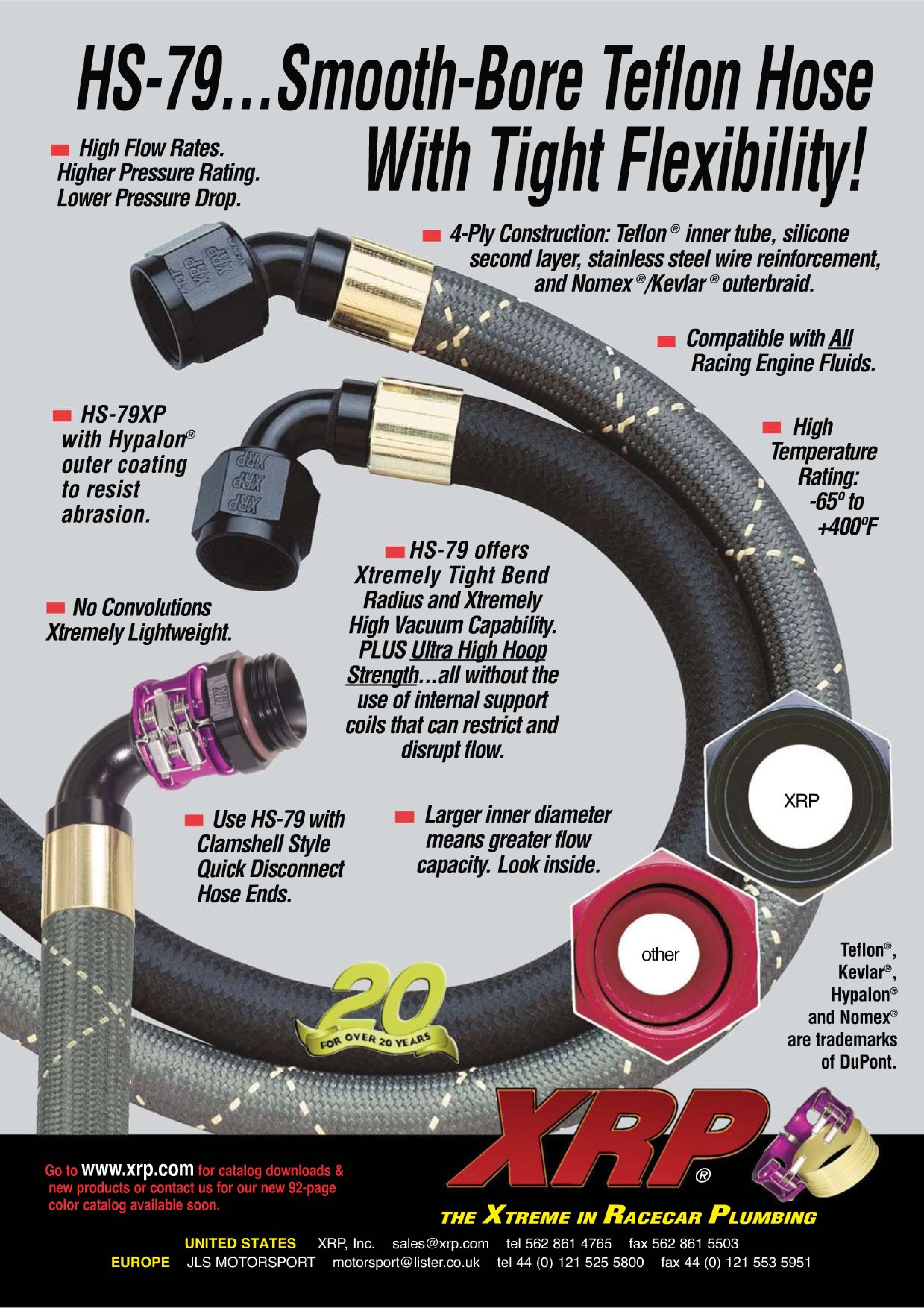
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Having signed up to an agreement that will see emissions from production cars dramatically slashed in the next 15 years, the majority of car manufacturers are working on innovative drivetrain solutions, including solar power, hybrid and electric cars. For a while there, it looked as though motorsport was in danger of being left behind, but the electric racecar market has suddenly burst into life. Formula E, Time Attack cars and an assault on the electric lap record at the Nürburgring on the Nordschleife have featured in the news in the last two months.

This month we have taken a good look at the new Formula E regulations, a series that, it is hoped, will speed up the development of electric technology, and the exciting new project from Drayson Racing Technologies.

Danny Nowlan presents a case for the return of active suspension, as used by the Force India team in testing, and which he feels offers a practical production car application. It seemed appropriate in the midst of this technical innovation that we should also feature the Renault R31, possibly the most innovative Formula 1 car on the grid this year. The car has not fulfilled its potential in terms of results but, in terms of showcasing new technology within the tight confines of the regulations, it is a cut above the rest.

The new Formula Ford features the company's latest and most fuel-efficient engine, while the McLaren MP4-12C has the lowest emissions of the current breed of supercar, as the GT World Championship regulations open up to allow it to compete next season.

It is an exciting time in racing, and one that former editor, Graham Jones, would have enjoyed greatly. But early in September, Graham passed away after a long illness. The tributes we have received paint a picture of a well-respected gentleman, who was passionate about his racing and who sought perfection in everything he did. He was a consummate professional in his work, and our sympathies go to his partner, Sheila, and his brother, Trevor.

EDITOR
Andrew Cotton

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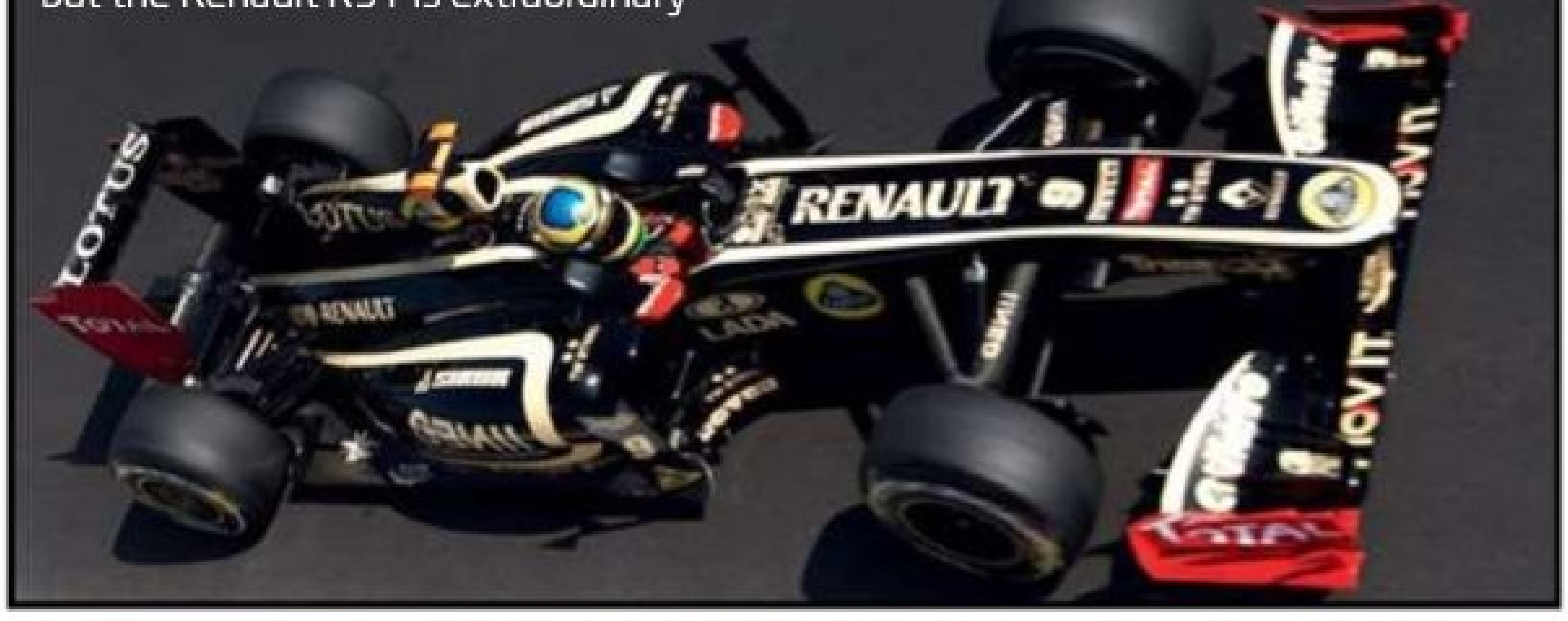
It may not show it in the record books, but the Renault R31 is extraordinary



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FORMULA 1

Red Bull scoops works team status

Dominant F1 team to have input into V6 design

After producing one of the best F1 chassis over the past two seasons, Red Bull Racing will go into future years with even greater technical potential, following a tie-up with Renault that effectively makes Red Bull its works team.

It's believed the new deal, which was signed in mid-September, means the Red Bull team is now obtaining its engines for free. But perhaps more importantly it will also be able to have a major influence on the design of the 1.6-litre V6 turbocharged engine under development at Renault for 2014, with Red Bull chief technical officer, Adrian Newey, now having greater input into the packaging.

Renault said: 'Within the new agreement, a technical joint venture will be set up, in which Red Bull Technology and Renaultsport F1 will collaborate to develop innovative technical solutions for the V6-based power unit that will be introduced from 2014. Red Bull Technology and Renaultsport F1 will contribute their respective know how, experience and specialist personnel to the project to achieve a competitive and reliable powertrain to be used by Red Bull Racing and other customer teams.'

The deal is for five years, and Bernard Rey, president of Renaultsport F1, believes this will give the partnership the stability it will need to succeed: 'We are delighted that the Red Bull Racing-Renault partnership has been extended for a further five years, which will take us to a decade of collaboration [for the past five years Renault has been the Red Bull engine supplier]. Red Bull Racing and Renault share the view that stability is a fundamental condition to perform at the top levels of competition. As well as being a unique opportunity to showcase the performance of the Renault engines at the highest possible level, it is also a fantastic arena to develop the technology and expertise within the Renault-Nissan Alliance.'

Red Bull could also benefit from the KERS expertise of Renault group partner, Nissan (its Infiniti prestige brand is already a Red Bull sponsor), particularly in the area of battery cooling, the Achilles heel on the current RB7.

THE NAME GAME

One curious by-product of the deal is that the team once owned by Renault and which is still known as Renault, is no longer its primary team and, at the time of writing, did not even have an engine deal with Renaultsport F1 in place for 2014.

It is now widely expected that the Renault team, which is sponsored by Group Lotus, will be known as Lotus next season, following a thaw in the long-running legal spat between Renault and Team Lotus on the use of the illustrious name. Reports suggest that the naming row could be resolved by the end of the year, with Team Lotus probably changing its name to Caterham. Tony Fernandes, the boss of Team Lotus, owns the sports car operation and its name already adorns the Lotus racecars, while his GP2 outfit races under the name Caterham Team AirAsia.

That said, it's no easy task for a team to change name in F1, and there are possible complications with the TV monies in particular, so it should be no surprise to see a works Renault Red Bull racing against a Renault Lotus, and a Lotus Renault in 2012.

GT RACING

World GT opts for GT3 spec for 2012

GT3 cars are to form the basis of the revamped FIA GT World Championship for next year, although current GT1 cars will still be allowed to race as long as their performance is equalised.

It had been previously announced that the 2012 championship would involve a performance-balancing formula, allowing GT3, GT2/GTE and GT1 cars to compete. Following a series of meetings with the governing body and team representatives, however, series promoter Stephane Ratel has agreed with the FIA that the championship should adopt uprated GT3 cars as the main category.

From 2013, every GT World car on the grid will be built to GT3 spec

Ratel cited the current economic situation as a major driver in the decision: 'In light of the current economic climate, this GT World specification is the correct solution to secure the future of the FIA GT1 World Championship.'

World championship GT3 cars are to be uprated, while performance-balanced GT1 cars will also be allowed to compete, but only for 2012. There is, however, no place for GT2 / GTE cars in the new World GT vision because, according to SRO, every manufacturer currently in GTE also makes a GT3 model. GT World cars will have carbon brakes, no ABS and 'GT1 noise levels', says SRO.

The main reason for the change is to help attain SRO's ultimate goal of attracting 10 two-car teams, each of which will represent a different manufacturer. By embracing GT3, it has now opened itself up to a number of high profile new cars, such as the McLaren MP4-12C, as well as offerings from BMW, Ford, Mercedes, Audi, Lamborghini, Nissan and Ferrari.

'The meetings have been extremely encouraging, and today we have a clear goal of what we can achieve in 2012,' Ratel said. 'Using regulations adapted from the ultra-successful GT3 category is the correct way to go. It has been agreed with the teams and manufacturers that rather than bringing GT3 cars up to GT1 levels of performance, we will adopt a GT World level, to which the current GT1 cars will adhere, reducing development costs significantly.

'GT3 is the most successful GT category in the world and almost all of the major manufacturers are building cars to these specifications. Using the FIA Balance of Performance, current GT1 cars would be able to race with performance restrictions to bring them into line with the 2012 GT World specification.

'2012 will be a transition year, with the current GT1 cars able to compete alongside the new cars. But in 2013, every car on the grid will be a GT World car, which will reflect the growing demand for GT3 cars in national and international motorsport around the world.'

The 2012 GT World entry announced at Spa in July featured existing GT1 teams All-Inkl Munnich, Marc VDS, Young Driver, JRM and Belgian Racing, plus GT3 squads Vita4one and WRT.

NASCAR

It takes two to tandem...

NASCAR has taken action it hopes will limit the tandem racing that has been a mark of Sprint Cup races at restrictor plate tracks this season.

Tandem racing, where cars have been shown to be quicker running in close proximity, has been a feature of superspeedway events this season, thanks to better track surfaces and the frontal aerodynamics of the current Cup car.

NASCAR initially moved to stamp it out in the run up to the Daytona 500 early in the year, mainly by limiting the grille opening to reduce the cooling effect, thereby hampering cars running in the draft of other cars for long periods. However, this has not been particularly successful.

Now the governing body has decided to allow the cars an extra 7-10bhp when they race at Talladega on October 23, in the hope that this extra power will in some way reduce the reliance on two-car drafting. The power hike is available thanks to bigger openings in the restrictor plates.

NASCAR has also tinkered with the cooling system again, with the relief valve recalibrated to reduce pressure by around 8lb/in^2, which should stop the engines running on the very limit of their temperature ranges. The aim of this move is to force the following car out of the draft more often to prevent it overheating.

NASCAR vice president of competition, Robin Pemberton, said the decision to open up the restrictors came after pressure from drivers: 'After the last few superspeedway races, we've heard many drivers express their desire to open up the size of the restrictor plate some and we thought the time was right to do that. We anticipate these revisions in the rules package for Talladega will help continue to provide competitive and exciting racing for the fans.'

However, it remains to be seen how effective these measures will prove to be. Some drivers have already pointed out that a 10bhp power hike in a 410bhp car might not make much of a difference. Also, previous attempts to restrict cooling were easily countered by drivers, who were able to adapt their drafting technique to cool the cars, while the fact that the race takes place in the autumn also means cooling isn't quite as vital as it was when the Cup last ran at superspeedways in the summer.

Officials at Talladega were happy with the tweaks, though. 'We applaud NASCAR's efforts to continuously monitor the competition at Talladega Superspeedway and be willing to make changes when necessary,' Talladega chairman, Grant Lynch, said. 'Being open to suggestions that improve our sport is beneficial to everyone involved.'

More power and cooling tweaks aim to reduce the advantage gained by drafting

BRIEFLY

Tester zone

Limited in-season Formula 1 testing is to return next year after the teams agreed to drop one of the pre-season tests and replace it with a four-day test at Mugello in early May. This will come just after the first four flyaway races and before the main European season rounds. It will be the first time the F1 teams have run a test during the season since Mugello and Jerez in 2008. Teams will also be allowed to conduct up to eight straight-line test days and eight filming days – the latter of which are run to a 100km maximum. The full test schedule for 2012 is: Jerez (February 7-9), Barcelona (February 21-24 and March 1-4) and Mugello (May 1-4).

New Generation

Honda works outfit, Team Dynamics, is to build an all-new BTCC car to the NGTC (Next Generation Touring Car) regulations for 2012. The car will be based on the new Honda Civic, launched at the Frankfurt Motor Show in September. The team is the first manufacturer-backed outfit to commit to the NGTC rules, which have been introduced this season. Meanwhile, BTCC outfit Triple 8 Engineering has also announced it is to build an NGTC car next year, although it has not yet said what car it will be based on.

FORMULA 1

FOTA prepares to fight for greater share of F1

In what might be seen as a statement of intent, FOTA has hired top corporate financial advisers, DC Advisory Partners, to help in future negotiations for greater control of the sport and a bigger share of F1's income.

Currently, F1 is split three ways between venture capitalist CVC (represented by Bernie Ecclestone's Formula One Management), the FIA and the teams. But FOTA (the Formula One Team's Association), which represents the interests of the teams, has long maintained that more of the profit should be ploughed back into the sport.

At present the teams take 50 per cent of the sport's revenues, with the rest going to CVC, but it's believed FOTA is pushing for up to 75 per cent when the current Concorde Agreement comes to an end next year.

Speaking in the *Independent*, McLaren F1 boss and FOTA chairman, Martin Whitmarsh, said: 'Formula 1 is owned by venture capitalists and one would suspect that they can't hold the sport in their funds *ad infinitum*.'

In a possibly related move, FOTA has also announced the appointment of Oliver Weingarten as its new secretary general. Weingarten comes to FOTA from the Premier League, where he was the in-house lawyer.

Whitmarsh said: 'I'm delighted to welcome Oliver to FOTA, where his experience... together with his commercial, legal and public policy expertise, will be extremely valuable.

'The next few years will be a crucial time for the sport of Formula 1, and, working in close collaboration with the FIA and FOM, FOTA will play a very important role in shaping the future of our great sport.'

Meanwhile, it has emerged that Formula 1's income should not be hit by the much publicised cancelation of this year's Bahrain GP because, remarkably, the race organisers still paid the fee for staging the race, said to be around £25m.

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DRIVETRAIN

COSWORTH IN A CRATE

Renowned engine manufacturer, Cosworth, is continuing its long association with the Blue Oval, thanks to a new range of crate Duratec engines. The engines are suitable for a range of applications up to and including all out race and rally cars. Cosworth start with all the individual parts direct from Ford, add their own tuning components such as forged pistons and connecting rods, high performance bearings, cams, modified cylinder heads, barrel throttles and air filters. Engines are available as short or long blocks in 2.0 and 2.3-litre capacities and states of tune from 205bhp (standard was 145bhp) to 280bhp (or 300bhp on some specially built race engines). A number of options can also be included, such as dry sumps and roller barrel throttle bodies. Cosworth Duratec crate engines start at £5499 ($8550), but each one is built to order and price will be according to spec. **For further information visit www.cosworth.com**

HARDWARE

GT-K TURBOS

Forced induction specialist, Owen Developments, is now able to supply the new Turbonetics GT-K range of turbochargers. The units cover power outputs ranging from 350bhp to over 1000bhp, with A/R ratios from 0.48 to 0.96. All are compatible with a Garrett T3 or T4 mounting flange so will suit many popular vehicle platforms and are suitable for street, strip and circuit use. Equipped with the company's latest HP compressor wheels and F1 turbine wheels, the GT-K turbos are designed to optimise efficiency at high boost pressures and capture the maximum exhaust gas energy to produce unrivalled performance. The inlets feature machined slots, designed to limit the effects of surge and flow in large volumes of air at high boost pressures, while still delivering a cool, efficient intake charge. Known as 'map enhancement porting' this feature allows the GT-K's compressor wheel to operate at maximum efficiency across a broad rpm range, and combined with ceramic bearings provides excellent response during spool up and transient throttle periods. **For further information visit www.owendevelopments.co.uk**

MEASUREMENT

HANDY PROBE

3D measurement specialist, Creaform, recently unveiled its new HandyProbe arm-free CMM system. The system features the company's TRUaccuracy technology, which generates accurate measurements down to 22μm (0.001in). The compact and sturdy device has shed 0.5kg over its predecessor, weighing in at just 450g, and is capable of measuring up to 30 points per second.

Its highly portable nature makes it ideal for tasks such as reverse engineering components outside of a factory environment, allowing rapid development of CAD models. **For more information visit www.creaform3d.com**

ANCILLARIES

TIME FOR TS

UK-based hose and plumbing specialist, Viper Performance, has launched a new range of alloy T-pieces for coolant or induction applications.

The components are made from 6063 T6 aerospace grade aluminium so can be welded easily if required. The main pipes are 100mm (4in) long and have a wall thickness of 5mm, with CNC machined and TIG-welded take offs. Additionally, the fixtures feature bevelled ends for secure hose clamping, with various diameters from 38-76mm available for main pipes and 16-25mm for the take off. **For more information visit www.viperperformance.co.uk**

The rivals

Putting two teams of designers on the same project in one team produced some friendly competition, and this season's most innovative F1 car

BY SAM COLLINS

Adrian Newey is known for taking a good look at the designs of rival teams, so it is interesting to note that he cites the Renault R31 as the most interesting grand prix car of 2011. The car is the 30th to be constructed by the team now known as Lotus Renault Grand Prix (LRGP), but which in the past has been known as Toleman and Benetton.

The team is in something of a new era. Backing from the French car manufacturer has been reduced substantially and the team is owned now by Genii Capital. Eric Boullier, the man in charge, offered the engineers a new challenge with the R31: 'I gave the engineers *carte blanche* to be innovative and to come up with some crazy ideas. I though the time was right,' reveals Boullier. 'And it worked very well. The concept we had was funny because we have a way where we develop the car in two different teams and it created a competition between them. It was funny to see how competitive they became.'

The result, though, was a car which had been re-thought and re-designed in every area, but with a simple underlying approach, as laid down by Boullier himself: to do better, to make a lighter, more rigid car, to find more speed and to be more inventive.

At the launch of the R31 in Valencia, most people admired the retro Gold Leaf-inspired livery (a reference to the title sponsor), and looked over what seemed to be a conventional Formula 1 car. But, as people started to pour over the detail images, something unusual became apparent – it had no exhausts!

SOMETHING STRANGE

'At the launch we had a good laugh as we had this idea that we did not want to show it to the press straight away, we wanted them to find it for themselves. We knew there was a media leak about something strange on the car so we designed some special covers so when the car was unveiled nobody could see the exhausts,' laughs the Frenchman.

What they came up with was a rear bodywork section that was continuous, aside from the exit duct for the gearbox oil cooler. The exhaust exits instead were to be found at the front of the sidepods, just below the radiator ducts, something that shocked the whole paddock. Renault technical director, James Allison, alluded to the benefits of the layout during the launch: 'It represents our attempt to extract the absolute maximum aerodynamic performance from the regulations, which have changed quite significantly for this year, and to further develop the concept of using the exhausts to blow the floor.'

What Allison was doing was using the hot exhaust gasses to drive underbody aerodynamics in a more extreme way than any other team in the paddock. It meant that the Renault engineers had to route the exhaust pipes forward, rather than rearward, from the conventionally located engine and exhaust manifold, along the side of the tub and out through the sidepod. It is clearly something

> “an attempt to extract the absolute maximum aerodynamic performance from the regulations”

of a thermal management nightmare, and the pictures here show just how complex the layout is, with the tailpipe wrapping around the lower impact structure of the monococque.

'I remember when James first came to me and proposed the front exhausts and I just looked at him and said 'why?' He took a piece of paper, sketched the basic layout and explained it to me,' recalls Boullier. 'I said to him, 'well, let's go first to the wind tunnel and, if it works like it's supposed to and it looks promising, go ahead.' I'm not entirely sure whose idea it was in the first place but I pay tribute to that person. It works very well. Actually, to be honest, it works brilliantly.'

TORQUE SWITCH

The exhaust layout took advantage of one of the characteristics of the Renault RS27 V8 engine, which is thought to be the best in grand prix racing for off-throttle blowing. At its most basic level, this allows the engine to run at 100 per cent throttle 100 per cent of the time, with the drivers' pedal acting as a torque switch. The reality, of course, is far more complicated, as Rob White, Renault Sport F1's head of engine operations, reveals: 'Independent of exhaust blowing, matching the torque delivered by the engine to the torque required by the driver and accepted by the car is a big juggling act for many reasons. The type of engines we have are quite tricky to control – an engine that will pull cleanly from 3000rpm to 18,000rpm is hard to do without spitting, backfiring, popping and farting. They do need to be in that range too, as the hairpin at Monaco is a bit over 4000rpm.

'The precision with which we need to deliver the torque required by the driver is extremely fine, and the precision with which the torque needs to be delivered to deal with the miracle of choreography that is the seamless gearshift, is a big ask. But getting the engine torque to respond in milliseconds in order to satisfy both requirements really is a tall order.

'Opening the throttle a long way and firing a small number of cylinders is widespread road car practice. Cylinder disabling is very common too, and overall it's more efficient to use the small number of cylinders with the throttle wide open than all of the cylinders with the throttle almost closed. It is this phenomenon that has been exploited because one can use the energy in the exhaust stream exiting the tailpipe as a kind of fluid amplifier to generate downforce. The exhaust blowing strategies are a further use of something that exists for other reasons, and with all of these things there are trade offs. For example, it takes less fuel to use four cylinders instead of eight cylinders but, because you have the number of cylinders coming back again you have a driveability trade off. Plus there is the risk of a hesitation as the other cylinders come back or drop out that some drivers don't like. If our mapping is not absolutely spot on, it will not be acceptable to the driver, and mapping activity is an integral part of the track support we give to LRGP.'

Jad Sherif

The radical exhaust system on the R31 works its way forward from the engine bay, under the radiator housing, though the sidepod and exits just forward of the lower impact structure, visible here in silver (the exhaust outlet is the duller pipe with the D-shaped exit). The exhaust layout could not be fully simulated in the wind tunnel, particularly at low speeds, and that hurt the R31, but it came into its own at higher speeds

One of the key challenges of the new exhaust system was cooling, but the team was determined to find workable solutions. It was not all plain sailing. Two major fires caused by issues related to the exhaust concept caused substantial damage, the second instigated by a driver over revving the car during a pit stop, leading to a nitrogen bottle exploding in spectacular fashion at the Hungarian Grand Prix. But changes were made to the car (and the driver line up) to prevent that issue re-occurring.

FIA INVESTIGATION

The biggest challenge facing the team, though, was when the concept was banned mid-season. Being such an integral part of the car's design, dropping the forward exhausts would be no simple task. 'When we heard in Monaco that the FIA was investigating the system, and that they were very serious about the hot blowing being banned,' says Boullier. 'We were a little bit nervous because our whole concept was based on hot blowing,' reveals Boullier. 'So we had to dedicate some resources to rear-facing exhausts because we believed our solution would be banned. During those weeks we didn't develop much on the forward exhausts, but then we found out it wasn't going to be banned after all, so we had to switch back all our efforts onto the original concept. It was lucky that they were not banned as we were not convinced that we could manage the rearward exhaust properly. It would have been a disaster for us if it had been banned, but we still probably lost six weeks of development time due to that.'

The rest of the R31 did indeed follow Boullier's mantra of 'be daring, try to innovate, take risks'. 'Words like 'aggressive' and 'innovative' are very much *en vogue* in Formula 1 at the moment, but where the R31 is concerned we feel that those adjectives are appropriate. It's true to say that the car has been designed in an ambitious manner, and a quick glance at the layout will confirm that its entire concept differs considerably, not just from last year's car, but from any car this team has ever produced,' says Allison, with a hint of pride. 'It is very difficult to compare the R31 to the R30 in any meaningful way.

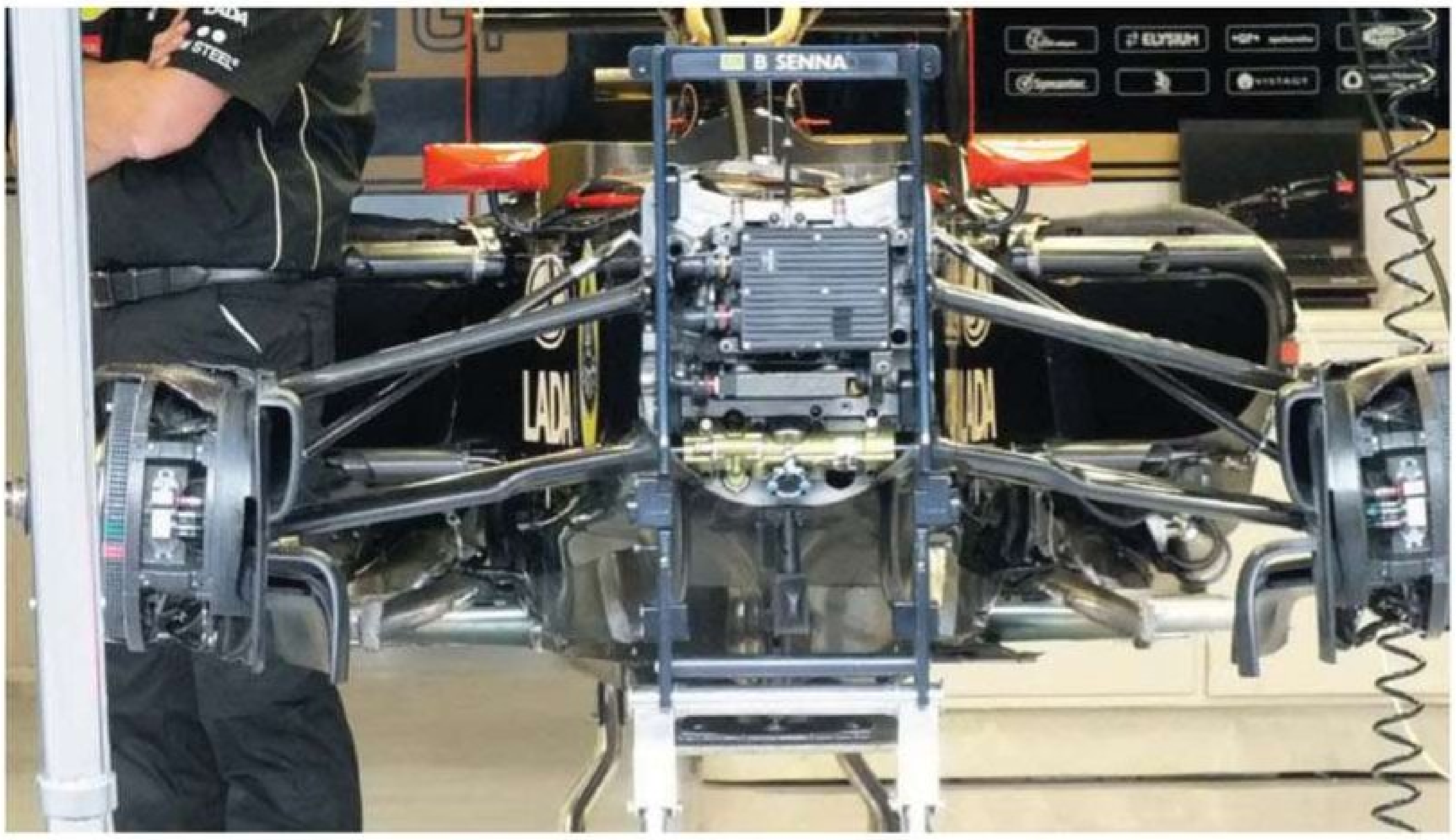
> **"Boullier's mantra of 'be daring, try to innovate, take risks'"**

2011 is a different year with a new set of regulations and that's why the R31 is a very different car. For example, KERS came back this year and the car concept was completely re-engineered to accommodate that system in an efficient way. We set out to try and conceive a car that wasn't just smaller, lighter, stiffer etc, but one built to what are quite a different set of regulations this year. That was going to give us the best chance to jump up the grid. The guys up top said they were okay with us taking some risks, and to have a go at something that was different that will hopefully bring us an advantage. The risk is that the layout of a Formula 1 car has been settled for some while, and it's quite tricky to package all of the stuff you need into the space that is available. You make much of a change to that and you are in virgin territory, where you find out as you go along what happens. We have gone with a layout that is different - different to last year, different to any year I can remember.

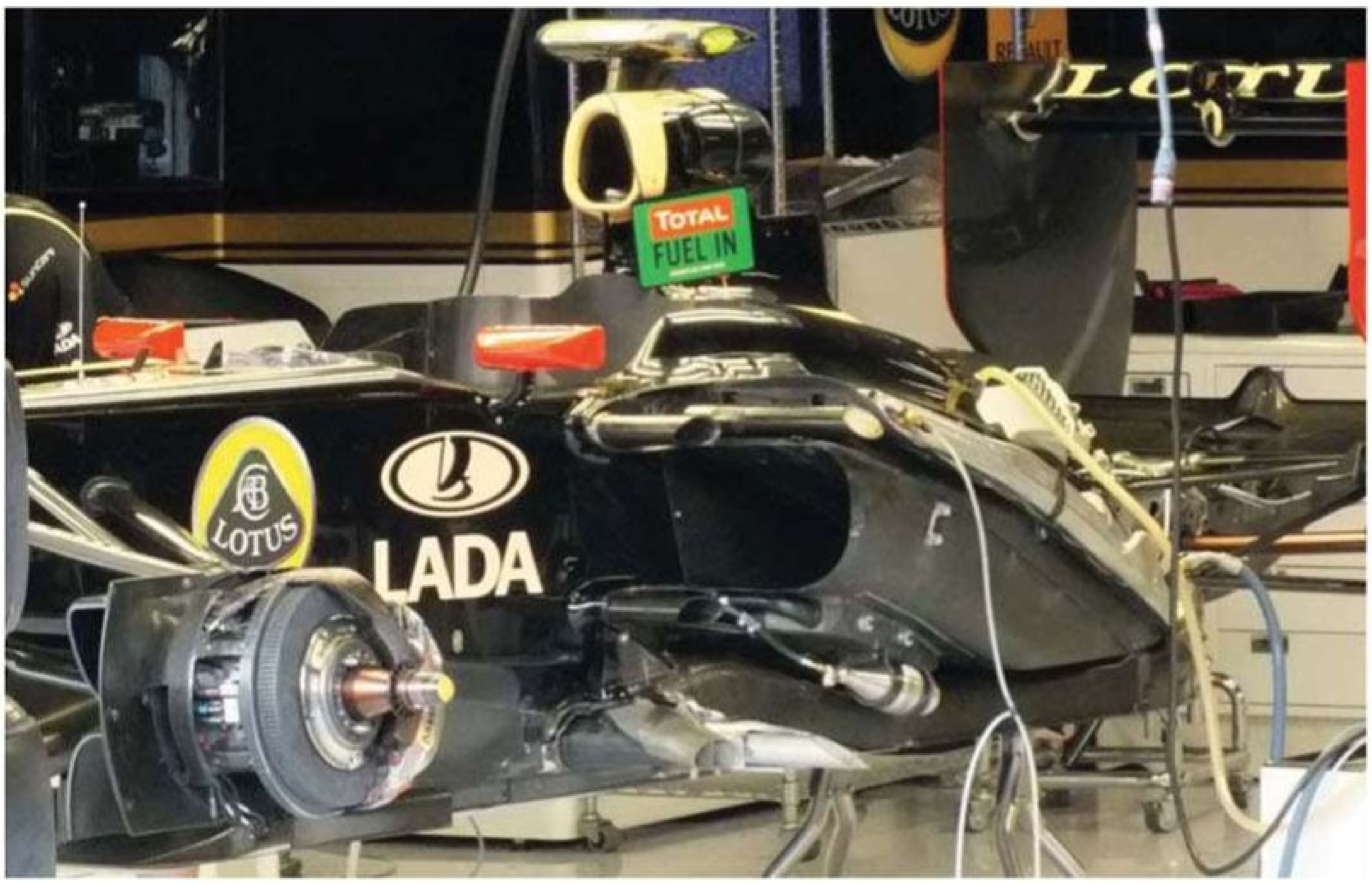
INTEGRATING KERS

'The only real difficulty with KERS was that although we ran it in 2009, we didn't have a great experience doing so. You had to be mindful, though, that the rules are now very different. There were a number of things that make KERS a more attractive proposition than it was in '09, so it was relatively easy to decide that we needed to have KERS

Jad Sherif



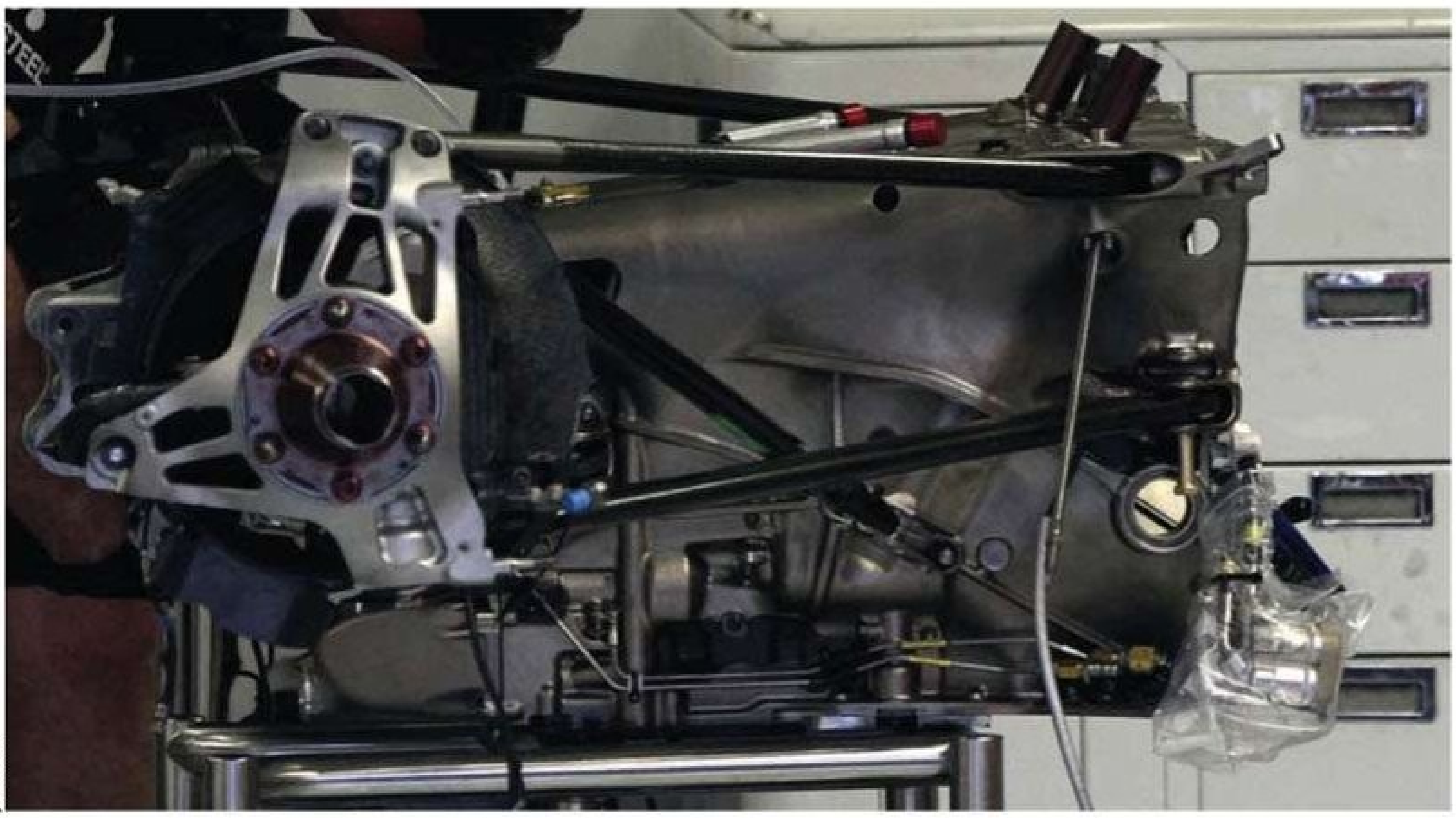
LAT



Top: experiments with a conventional exhaust showed that it produced more downforce at the rear, particularly with the high rear ride heights used at slow circuits like Singapore. At low speeds the R31 was found to be very sensitive to geometry changes – another factor in the team's poor form at some tracks

Middle: the front suspension and bulkhead is fairly conventional, with the McLaren ECU mounted at the front of the chassis

Bottom: after the Hungarian explosion, the composite nitrogen bottle was replaced with the metal unit seen here in place at Monza



Jad Sherif

For the R31, LRGP adopted a pull rod rear suspension layout, although James Allison claims that in aerodynamic terms there is not much to choose between this concept and a more conventional push rod set up

Jean-Francois Galeron

In Montreal the car was tested with this ultra swoopy rear wing in an attempt to reduce drag. It is identical in concept to a similar wing trialled, but not raced, on the R30 of 2010. This is one of the very few carry-over items

as part of the car. We needed to make a better job of it than the first time round, though, and make it have less impact on the car as a whole in packaging terms. And make it much, much lighter.'

The R31 KERS is based on the Magneti Marelli system, which debuted in 2009 and was used by Toyota, Red Bull and Ferrari, and the KCU and battery cells are located in the fuel cell area.

The rear of the car was one area where the changes were instantly noticed at the car's launch, and not just the missing tailpipes. The R31 also had a different suspension concept. 'We chose to change the layout of our rear suspension by opting for a pull-rod system for the first time in decades,' Allison continues. 'And, as I said before, anyone can see that the treatment we have given to some specific areas is completely new compared with anything we have done previously. All of those things are aimed at trying to maximise the R31 under the 2011 rules.

REAR SUSPENSION

'There is a lot of discussion over the rear suspension. It's not surprising really, as the fastest car of last year, the Red Bull RB6, had a pull rod, so I would imagine every team in the pit lane would have seriously evaluated the idea. Eventually, we came to the conclusion that in aero terms there wasn't a lot in it.'

Like all the 2011 F1 cars, weight distribution is largely fixed by the regulations, with only a tiny amount of scope for adjustment, but this was not something that worried Allison's team too much: 'It removed one of the main degrees of freedom the engineer has in his set-up arsenal, but it applies to everybody equally, so it just means you have to fall back on the other tools available. I don't think it is much of an issue, after all it is not the only thing that will impact the balance of the car. The challenge for us as teams is that aside from the one per cent of the weight distribution we can move around, we use all the other degrees of freedom on the car to get the most out of it.'

TECH SPEC

Lotus Renault GP R31

Chassis
Moulded carbon fibre and aluminium honeycomb composite monocoque, manufactured by Lotus Renault GP. RS27-2011 V8 engine installed as a fully stressed member

Front suspension
Carbon fibre top and bottom wishbones operate an inboard rocker via a pushrod system. This is connected to a torsion bar and damper units that are mounted inside the front of the monocoque; aluminium uprights and OZ magnesium wheels

Rear suspension
Carbon fibre top and bottom wishbones with pull rod-operated torsion springs and transverse-mounted damper units located in the top of the gearbox casing; aluminium uprights and OZ magnesium wheels

Transmission
Seven-speed, semi-automatic titanium gearbox with reverse gear; 'Quickshift' system to maximise speed of gearshifts

Fuel system
Kevlar-reinforced rubber fuel cell by ATL

Cooling system
Separate oil and water radiators located in the car's sidepods, cooled using airflow from the car's forward motion

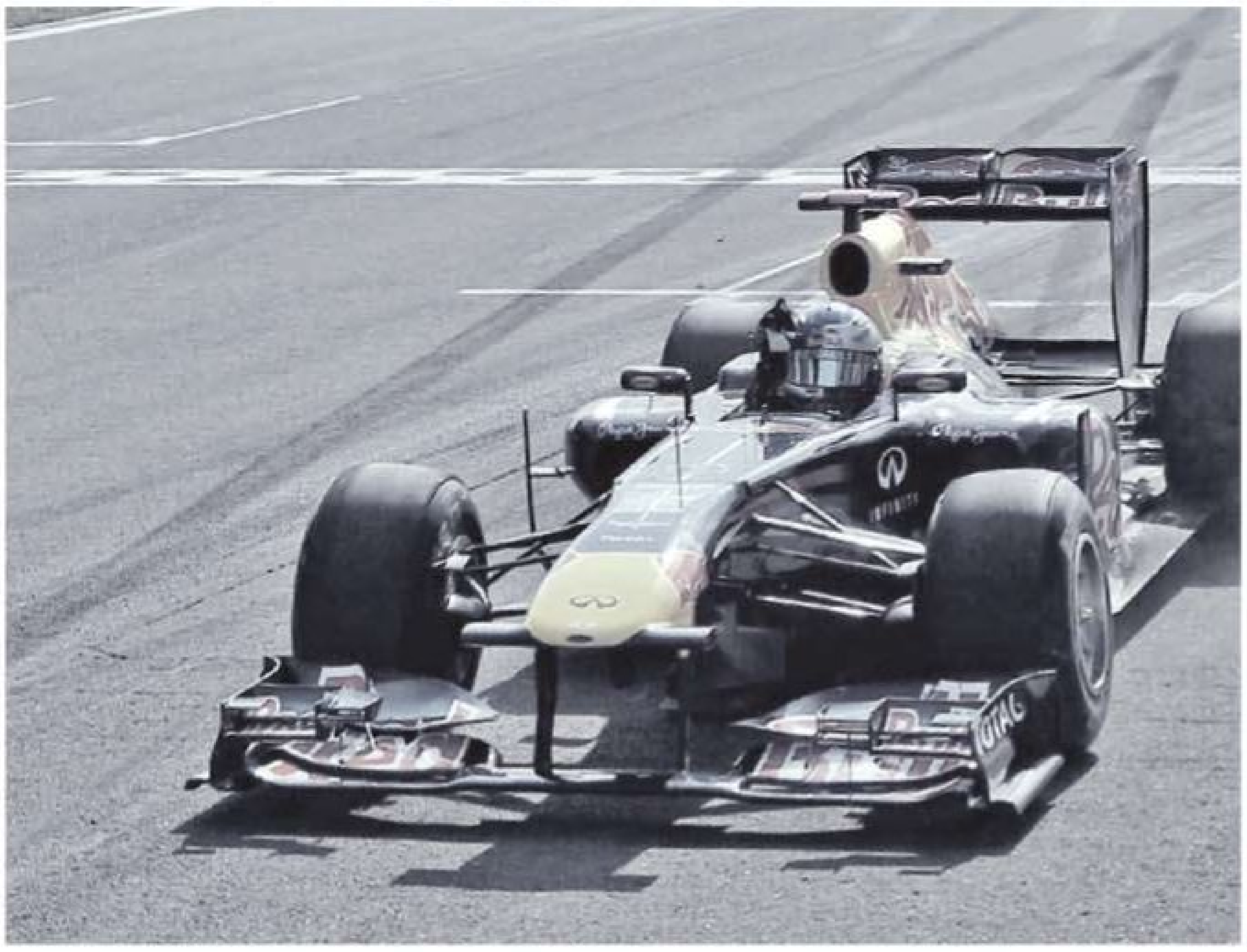
Electrical
MES – Microsoft standard electronic control unit

Braking system
Carbon discs and pads; AP Racing calipers; master cylinders by AP Racing and Brembo

Cockpit
Removable driver's seat made of anatomically formed carbon composite; six-point OMP racing harness; steering wheel with integrated gearshft system and clutch paddles; rear wing adjuster

Dimensions
Front track – 1450mm
Rear track – 1400mm
Length – 510mm
Height – 950mm
Width – 180mm

KERS
Motor generator unit driving into front of engine with batteries as an energy store; motor generator supplied by Renault Sport F1; electronic control unit by Magneti Marelli



Congratulations to RED BULL RACING and their engine partner RENAULT for winning the constructors and the drivers championship in F1 2011.

Red Bull Racing

RENAULT SPORT F1

capricorn AUTOMOTIVE

According to Boullier, innovation on the R31 is not limited purely to the unusual exhaust layout, but he refuses to be drawn on some of the other features of the design. 'There are some other very innovative things on this car that are hidden, and I will leave them that way!'

In pure results terms, it is probably fair to say that the R31 has so far under performed. With only two podiums in the book, and a smattering of other points finishes, Lotus Renault Grand Prix is, at the time of writing, in a disappointing fifth place in the Constructors' Championship. It didn't help that, shortly after setting the fastest time in the final day of the opening pre-season test, driver, Robert Kubica, was badly injured during a stage rally. The loss of its lead driver really set the team back, as Boullier admits: 'It is difficult to assess the amount of loss that situation caused us. When a driver is pushing your team to deliver, and helping your team to deliver, losing him is a big blow. We could be fighting for the first position in the championship today, definitely we could be third if we had not lost Robert.'

The R31's development has slowed down now, with focus turning to 2012's R32, and once again Boullier has given his engineers the chance to be innovative. 'The car will be more conventional because of the regulations, but we still have some things to play with...'

Ultimately, like all team principals, Boullier is tasked with winning the World Championship and, in a couple of years, it may be hard to bet against them.

RENAULT RS27 V8

The Renault RS27 that powers the R31 has its roots in the RS26 engine of 2006. Rob White, deputy managing director engine at Lotus Renault Grand Prix, explains how the engine has evolved over the years: '2007 was the first year of the homologation process so all [current] engines have their roots in an RS26 engine we supplied to the FIA around October 2006.

'After that we were allowed to make a certain number of modifications – some for installation reasons and some minor re-workings for the first rev limit that we had, which was 19,000rpm. At that point the homologation only applied to the fundamental engine architecture, not to the pumps and ancillaries or the inlet.

'At the beginning of the 2007 season we provided another engine and drawings to the FIA, knowing that once we had done so, all of the rest of it it would be fixed up until the end to 2010. That was the rule framework as it stood on that day.

'Leading into that 2007 engine there was a big development effort going on as at that time we were in the middle of trying to win the World Championship. That took priority.

'In a completely unconstrained environment we probably would have done some more development on the RS27. Subsequently, through 2007 we were able to work on the auxiliaries and the inlet system, but then in 2008 the FIA homologation perimeter was extended to include all of the peripheral stuff as well.

'But over the years we have made a lot of detail changes for the installation of the engine in different cars. We also made changes to accompany all of the other rule changes that came along. The engine life example is a good one – today we validate engines to 3000kms on the dyno, whereas the RS26 and the first RS27s were validated to half of that.

'You are not allowed to make a change just because it makes the engine go better, or because you've discovered a new magic coating, or whatever, but that's not a particularly frustrating situation because there's not a bandana of silver bullets rushing around that nobody had thought of before the homologation process arrived.

'Over the years we have gained a fantastic understanding of the control of the operation of our engines. There is a much smaller spread in performance between the engines that we produce now and we have a much smaller deterioration of the performance in its lifespan than we did before.

'The spread in the pit lane over the life of the engine is between one and three per cent, and that's up to about 20bhp at the end of the life of the engine. I'd like to think that we are at the happy end of that spectrum.

'The sum of all the small changes, though, is a big development programme. You shouldn't underestimate how finely optimised these engines are, or how close to the edge they are. It's all about how to extract the smallest element of performance we can, even if we're not able to make any mechanical change. We will seek to make best use of how we operate the engine, the fuel and the temperatures. Even the oil is specially developed by Total for our engines.

'The biggest, baddest example of changes in operating conditions for the engine is the hot blown diffuser, which came around in the past 18 months, and now most of the cars on the grid have it. Both LRGP and Red Bull are particularly sophisticated users of that concept and we've used it to help exploit the potential of the engine and of the car.'


Jad Sherif

A long development process has resulted in a highly optimised engine, but one which is essentially the same as the 2006 RS26 it is based upon

TECH SPEC

Renault F1 RS27-2011 engine

Capacity	2.4-litre
Architecture	90-degree V8
Weight	95kg
Max rpm	18,000rpm
ECU	MES SECU
Fuel	Total
Oil	Elf (a brand of Total)
Battery	Lotus Renault GP

FIRST PRINCIPLES

Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

The perfect compromise

Achieving that all-important balance

With any racecar, the opening 'baseline' run achieved on the first visit to the wind tunnel generally dictates the path the rest of the session must follow. However well prepared a team might be, that first run will objectively show what the front-to-rear downforce balance of the car actually is. So we continue reporting this month on a session with two very different and distinctive sports racers – CTR Developments' Arachnid closed coupé and the Force LM of Force Racing Cars.

The aim, as usual, was to achieve an aerodynamic balance that approximated the front-to-rear static weight distribution with driver and half fuel aboard, hopefully providing an unchanged handling balance throughout the speed range encountered on track. It's a simplistic approach, taking no account of dynamic changes of ride height, pitch, roll or yaw, but it usually provides a better balanced steady-state set up in the right ballpark, which can then be refined on track. As always, we must remind ourselves that the MIRA wind tunnel has a fixed floor, albeit with a boundary layer control fence in place, and that the racecars' wheels do not rotate during testing, both of which affect the absolute downforce numbers obtained. The fixed wind tunnel floor tends to reduce the downforce generated by low-mounted front wings, splitters and underbodies, so if anything it is better to aim for a slightly lower front downforce percentage, as measured in the tunnel, than static front weight percentage.

Let's take another look at the baseline numbers found on the first runs with these two cars, as shown in table 1, below.

Clearly, the starting balances of the two cars, as given by the '% front' value, were completely different and, as such, the subsequent test programme implemented on each was tailored accordingly. We'll look this month at the Arachnid's session.

VALIDATING EXPECTATIONS

It was expected from prior track use that the Arachnid would be short of front downforce at the outset, and the wind tunnel validated that expectation, showing just 10.6 per cent of the car's total downforce to be acting on the front wheels, compared to a front static weight percentage of about 45 per cent. Initially, it was felt best to add downforce at the front rather than reduce it at the rear, so the first adjustment saw the front ride height lowered from 66mm to 51mm. Although CTR Developments' Richard and Matthew Chamberlain thought this to be an impractically large adjustment, they were keen to see the magnitude of the effect. The changes are expressed in table 2 in counts, where a

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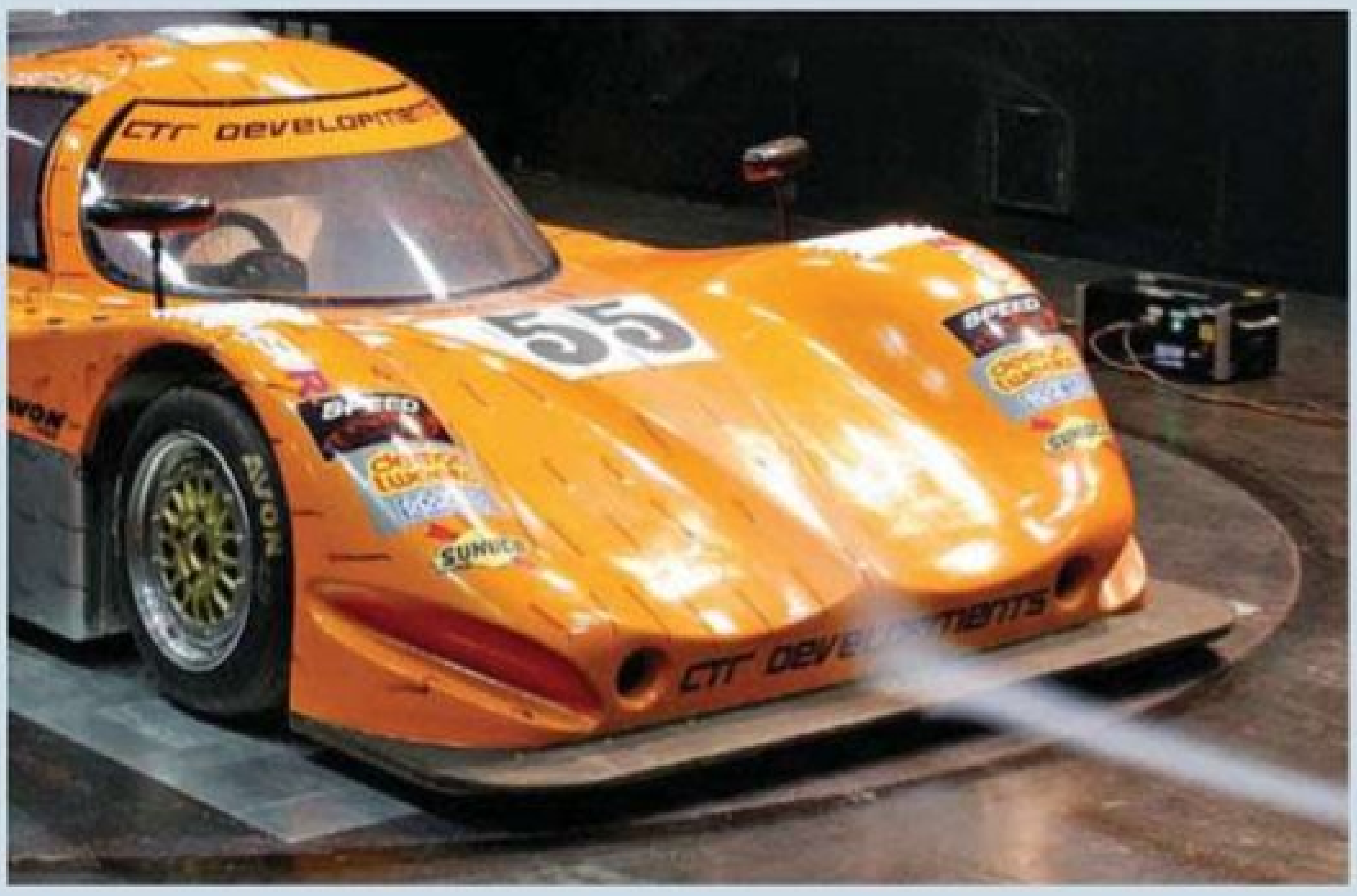


The Arachnid featured a non-adjustable splitter beneath a bluff 'air dam'

Lowering front ride height shifted the aerodynamic balance significantly

Table 1: starting coefficients on the Arachnid and Force LM at 80mph

	CD	-CL	-CLfront	CLrear	%front	-L/D
Arachnid	0.534	1.084	0.115	0.969	10.6%	2.030
Force LM001	0.676	1.263	0.725	0.539	57.4%	1.868

Table 2: the effects of dropping front ride height by 15mm

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
FRH down 15mm	-4	+81.5	+94.5	-12.5	+7.37	+166.0

Table 3: the effects of fitting small dive planes, in counts

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Add front dive planes	+26.5	+152.5	+148.5	+3.5	+9.195	+169.5

These small dive planes were surprisingly efficient

Reducing the rear wing angle overall shifted the balance

Dropping the rear flap angle shifted yet more balance

Table 4: the effects of reducing overall wing angle

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Reduce wing angle	-42.5	-107.5	+32.0	-139.0	+5.055	-13.5

Table 5: the effects of reducing flap angle to minimum

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Reduce flap angle	-64.5	-239.0	+67.0	-431.5	+14.825	-194.0

Table 6: the effects of raising ride height to 61mm

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
FRH up 10mm	-1.0	-56.0	-46.5	+9.0	-2.21	-120.0

Table 7: the baseline and the 'balanced' numbers, with the changes in counts

	CD	-CL	-CLfront	-CLrear	% front	-L/D
Baseline	0.534	1.084	0.115	0.969	10.57%	2.030
Balanced	0.449	0.915	0.410	0.505	44.81%	2.038
Change, counts	-85.0	-169.0	+295.0	-460.0	+34.24	+8.0

coefficient change of 0.100 = 100 counts. The Greek letter Δ (delta) represents the change to each parameter as a result of the configuration adjustments.

As expected, this substantial front ride height change had a large effect on total downforce and distribution by adding a significant increment of front downforce. The effect on drag was minimal, so the efficiency (-L/D) also increased.

As is often the case with sports racers, there was no provision for splitter length adjustment on the Arachnid, which may well have been another efficient means of gaining more front downforce. Having said that, the car already carried quite a long splitter, so the downforce gains from further lengthening this might not have been all that significant. So the next adjustment was to add small front dive planes (see table 3).

EFFICIENT GAINS

Compared to changes effected by dive planes we have previously seen in Aerobytes, these produced very efficient gains. There was a small increase in drag, but a 5.75:1 downforce-to-drag gain, with nearly all the extra downforce at the front end, produced another useful forward shift in the aerodynamic balance, and another gain in efficiency.

The next changes involved reducing rear downforce, with the first adjustment being to reduce the overall wing angle by two degrees, as shown in table 4.

Once again, the balance shift here was substantial, so this was deemed another step in the right direction. However, total downforce and efficiency had now reduced in the quest for aerodynamic balance, indicating where the priority was placed.

The rear wing flap angle was decreased next, from its middle setting down to its minimum setting, corresponding to a three degree overall angle reduction, as seen in table 5. This produced an even bigger change than the previous wing angle adjustment, overshooting the desired balance by a couple of percentage points. Clearly, significant downforce had been sacrificed and, although drag reduced, efficiency dropped, too.

Rather than adjust the rear flap angle up by a small amount to recover the balance, it was decided to raise the front ride height again to a level that was just 5mm lower than the baseline setting, this being the setting that could be accommodated without regular front end bottoming. See table 6 for the effects.

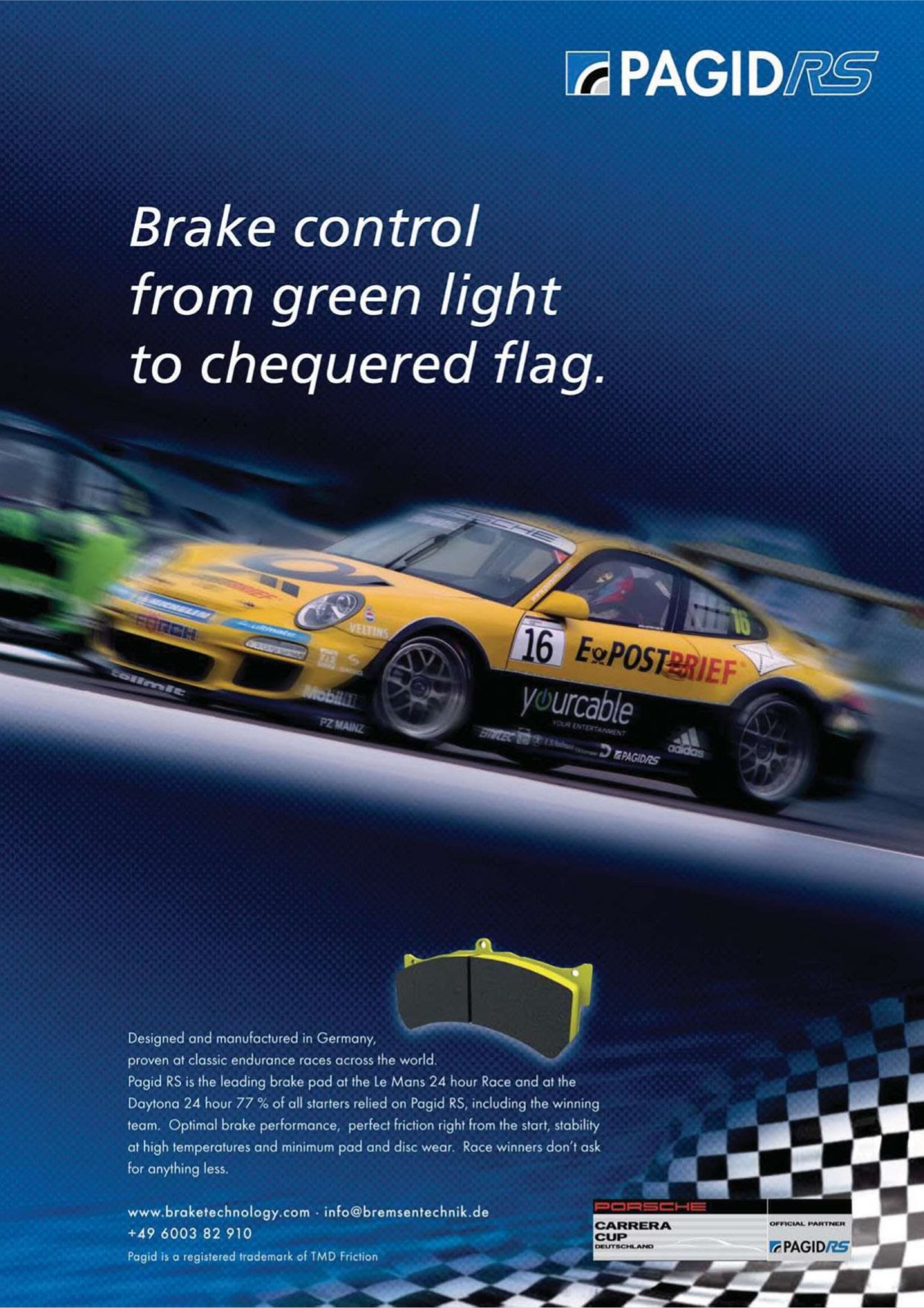
This took the proportion of front downforce to 44.8 per cent, a fraction under the static front weight percentage, and in the aerodynamically balanced ballpark. Finally, the coefficients at the end of this part of the exercise are shown in table 7, along with the starting numbers again for comparison.

SUGGESTIONS TO IMPROVE

So balancing the Arachnid produced lower downforce and lower drag, which saw the efficiency almost unchanged. The improved balance would almost certainly enable the car to be driven quicker, despite the 15.5 per cent loss of total downforce. That loss of downforce might best be addressed with a more aggressive rear diffuser, and possibly driving that diffuser harder by lowering the rear wing (as we saw on the ADR in our August issue) in order to retain or improve the car's efficiency.

Next month we'll compare the balancing process implemented on the Force LM.

Thanks to CTR Developments, Force Racing Cars and Graham Wynn for their assistance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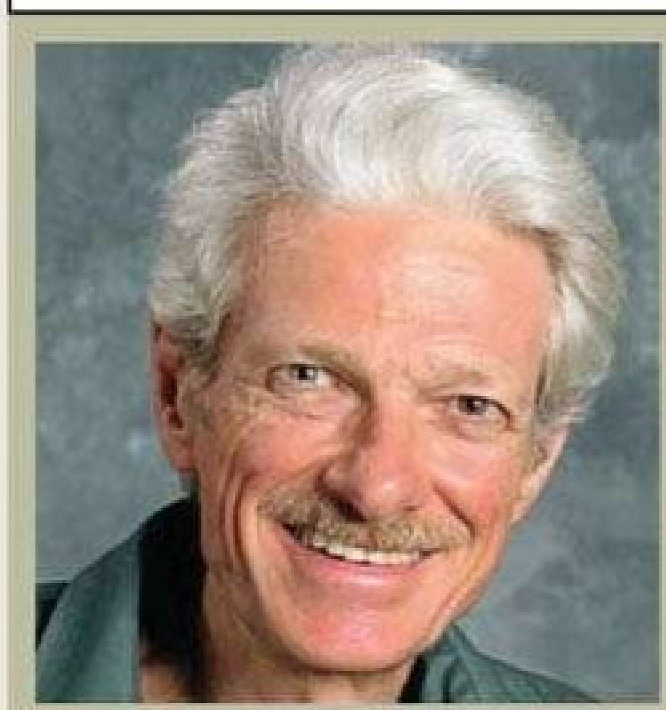

FIRST PRINCIPLES
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European Formula Vees are, it seems, very different animals to their US counterparts

Rolling with the Vees

The question of anti-roll bars on Formula Vees revisited

It has been brought to my attention that Formula Vees as raced in Europe, including the UK and Ireland, *do* use anti-roll bars at the rear. In my previous communication on this subject, I was responding to a questioner who wondered why we use anti-roll bars at all. I said that when there is ample geometric roll resistance, and a problem with jacking (as in the swing axle suspension at the rear of a Formula Vee), an anti-roll bar is undesirable. However, European-style Formula Vees it seems have both front and rear anti-roll bars, as well as rear coilover dampers arranged to act in both ride and roll. This is similar to the system used on older, US-spec Vees.

On current Vees in the US, though, one never sees this set up. Modern ones all have rear springing that acts only in ride and, unlike the European Vees with their external front anti-roll bars, one of the multi-leaf torsion bars at the front is replaced with a solid anti-roll bar, still inside the tube. The reason for the confusion is that I was under the impression that external bars at the front were illegal in SCCA. It turns out that that's not quite the case. Here's what the 2011 General Competition Rules say:

9.1.1.C.3 Suspension

A. The front suspension and steering shall be standard VW Sedan as defined herein, or an exact replica of the same material and dimensionally identical. The following modifications are allowed:

> **1. Removal or modification of spring packs, including the use of ride height adjusters incorporated into the front beam, provided they are not adjustable from the cockpit. At least one spring pack shall be retained as the primary spring media for the front suspension.**
>
> **2. The use of any anti-sway bar(s), mounting hardware, and trailing arm spacers.**
>
> **3. The use of any direct acting, tube-type shock absorber(s) mounted in a longitudinal, vertical plane and acting through the standard mounting points. Spring shocks and linkage activated shocks are prohibited.**
>
> **9. Caster, camber, and toe in / out settings are unrestricted. Clearancing of carrier or trailing arm to eliminate binding is permitted. Offset suspension bushings and alternate locating spacers are permitted.**

"I was under the impression that external bars at the front were illegal in SCCA..."

There is a front track limit of 52.5in (133.35cm) maximum. Track is defined as the distance between rim centres. No height is specified, so this would have to mean the centre vertically and longitudinally, as well as laterally. That would appear to mean that the front wheels can have considerable negative camber without running afoul of the track width rule by being too far apart at ground level.

So it actually would be legal to add an external front bar, and make it adjustable as well, if desired. The front bar on the European-spec car in the illustration is non-adjustable, as far as I can see in the photos. The rear one, however, is adjustable, via a series of holes for the drop links to attach to.

The rear bar on the European Vee is very slender and willowy, with fairly long arms, so serves as a fine-tuning device only. The front bar is visibly thicker, with shorter arms, and therefore inevitably higher in rate.

The European Vee is also visibly longer than a US-spec Vee, and has rack and pinion steering, as well as pushrod and rocker-actuated front dampers. Those would be illegal in US Formula Vee, and there would be no room for inboard dampers anyway. SCCA rules call for an 81.5in (207cm) minimum and an 83.5in (212.1cm) maximum wheelbase. The European Vee driver also still sits back near the engine, so the longer wheelbase implies less front percentage, and the tyres are different to the US-spec car. In dry to moderately wet conditions, it runs on treaded radials, the same size front and rear, whereas US cars run on bias-ply slicks with the rears wider than the fronts.

This means the US car has more rear tyre relative to front, and more front weight relative to rear, compared with the European Vee. That would explain why the latter needs some extra front bar. If the rules allow the front bar to be adjustable, it's hard to see the need for the rear bar but, if the front bar has to be non-adjustable, it starts to make sense to have a soft rear bar that is adjustable.

The European Vee also has a rear z-bar, and it is apparently stiffer than the anti-roll bar. The z-bar runs inside a frame tube, so it is impossible to see how fat it is, but the arms are short compared to those of the anti-roll bar, and that is really slim. The car therefore has three rear springing systems: a stiff one that acts in ride only, a soft one that acts in roll only and a soft one that acts in both ride and roll. Really, a car only needs two of those systems, or so one would think. It doesn't appear that there is any significant non-linearity designed into any of the three systems.

Would that combination be legal in SCCA? As I read the rules, no. Here's the wording:

B. The rear axle assembly shall be standard VW sedan as defined herein with axle location provided by a single locating arm on each axle.

Rear anti-roll bars on European Formula Vees are soft, and adjustable, so are used as a fine tuning device, in combination with the fixed front bar

These are commonly used in Europe because the cars are longer and have less front percentage than their US counterparts

1. The rear axle tube may be rotated about its axis.
2. Coil spring(s) shall provide the primary springing medium, with telescopic shock absorber(s) mounted inside the spring(s). Cables, straps, or other positive stops may be used to limit positive camber. An anti-roll bar or camber control device may also be used. When said anti-roll bar or camber control device is removed, the required coil springs shall continue to perform functionally.
3. The shock absorber mounts may be modified.

A 'camber control device' is a simple device that limits jacking by increasing wheel rate in ride without increasing wheel rate in roll. A z-bar qualifies as such a device. I have seen Formula Vee rear suspensions where a torsional z-bar was the only springing device, but apparently that is no longer legal. There now has to be at least one coil spring that has to hold the car up and have a shock concentric with it. But there can be just one. I have seen a Formula Vee rear suspension with two additional shocks to damp, but not spring. Apparently, that is legal, too.

> **"a set up with lots of roll stiffness will have more overall grip"**

So you can have a single rear ride spring, which gives you the same effect as a camber compensator, except it's not one, legally, because it's the required coilover that holds the car up. You can then add a camber control device *or* an anti-roll bar, but not both. You cannot therefore have the same combination as a European Vee on a US Vee, but you can have a coilover that acts only in ride, additional shocks that act only in roll, and an additional torsion bar that acts only in roll.

Under what conditions would the anti-roll bar be desirable? When it is possible to put enough elastic roll resistance on the front to make the car understeer. Current US-spec Vees corner reasonably neutrally, but their front camber is not optimal. The front grip would benefit from more static negative camber, and / or less roll. The trailing arm front suspension has zero camber recovery in roll. If the outside front tyre can be kept more upright, more load transfer at the front can be allowed. That gives us less load transfer at the rear, and therefore more cornering power at the rear as well. If we encounter either inside front wheel lifting, or more understeer than we want, we then might benefit from a rear anti-roll bar.

The objective should be to run the front wheels at optimal camber, not degrade their cornering power with poor static camber. You also want to minimise roll to minimise front camber loss due to roll, then add rear roll resistance to keep the inside front wheel at the point of incipient lift most of the time, or as close to that as front grip will allow without excessive understeer. At least on smooth surfaces, a set up with lots of roll stiffness will have more overall grip due to improved front camber, and some of the front grip can then be traded as needed to improve rear grip.

However, even though such a set up might involve using a rear anti-roll bar, the rear suspension will still have a greater wheel rate in ride than in roll, unlike other independent suspensions with anti-roll bars.


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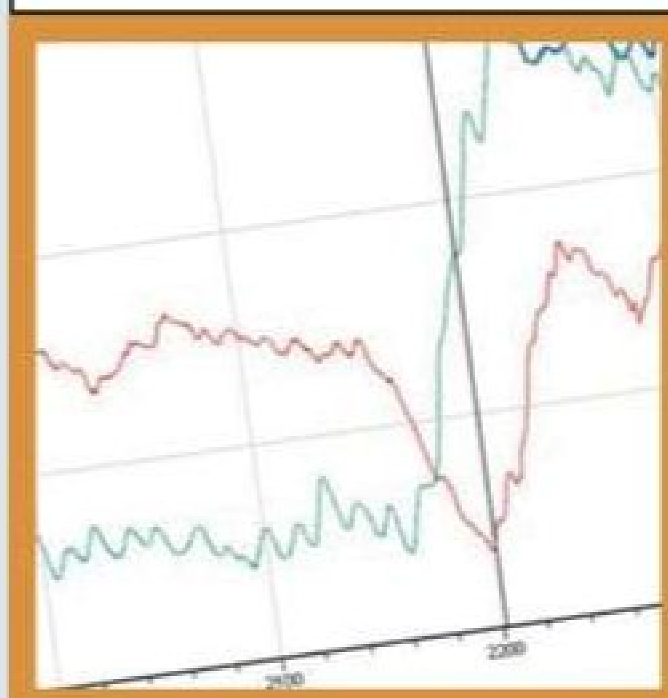


FIRST PRINCIPLES

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

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

Compare and contrast

Using variables to create miniature programmes within programmes

The subject of maths channels is a recurring theme in analysing racecar behaviour, and there are many helpful things that can be calculated using them in most software packages. However, only the best tools allow you to create small programmes that can, for example, count or compare different samples.

In the Databytes challenges last month, the question of how to calculate the number of gear changes was raised. The answer to this challenge will be used as a basis to introduce registers or variables in maths channels, which enable us to do some fairly complex calculations and effectively create miniature programmes.

For those that understand programming languages, the concept of variables will be well known. These can hold values that are later used in calculations, but the values can also be changed by the programme itself, should the need arise. The gear counter challenge has a number of different solutions but, in this article, the focus will be on one type of solution that will work even if the gear position is calculated, rather than coming from a specific sensor.

The idea is to compare the current gear position channel value to the one in the previous sample. This means that a register is needed to hold the value of the gear position for one sample. The maths channel will then start counting if the gear position has changed and stop in the next sample unless the gear has been changed again. This means that the channel will only increment once for each gear position change. In order to achieve this it is important to set the maths channel calculation, or logging rate, to the same value as that of the gear position (see figure 1).

Figure 1: the maths channel could look something like this in code form:

```
register @A; // holds the value of the gear position in the previous sample
register @B; //holds the value of the number of gearshifts so far

@B = choose( floor([Gear]) != @A, @B+1, @B); //increments the gearshift register @B of the current
gear number is different from the one in the last sample

@A = [Gear];

@B //returns the value of the maths channel
```

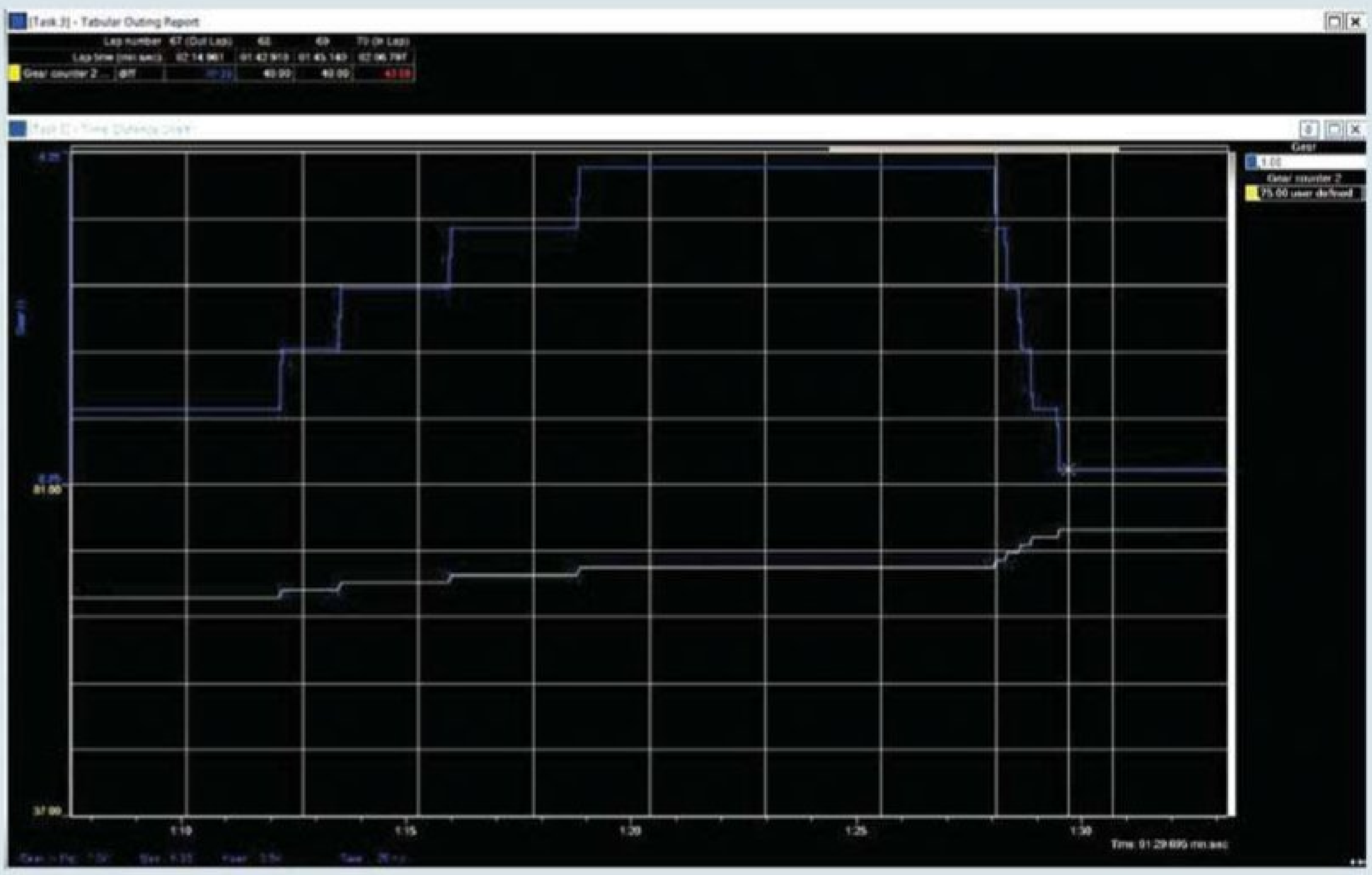


Figure 1: gear position and gear counter channels. The gear counter can be seen to increment both when going up and down the gearbox. At the top, the statistics of the gear counter can be seen as number of shifts per lap in the outing

INTO THE SYNTAX

In this case, the syntax requires an @ symbol to identify registers. The 'choose' function is an if-else statement, where the gear channel is compared with the value of register A and, if it is not the same as register B, is incremented. If it is the same then register B remains unchanged. The != is, in this case, used as a not equal.

The flow through this maths channel might not be obvious at first glance, but the sequence of it is very important in order to achieve the comparison between the current and previous sample. If the 'second' register (@B) is not calculated first, then the maths channel will not work. The 'floor' function is used to make sure that the gear position channel switches only between whole numbers. Even if the gear position comes from a sensor it sometimes

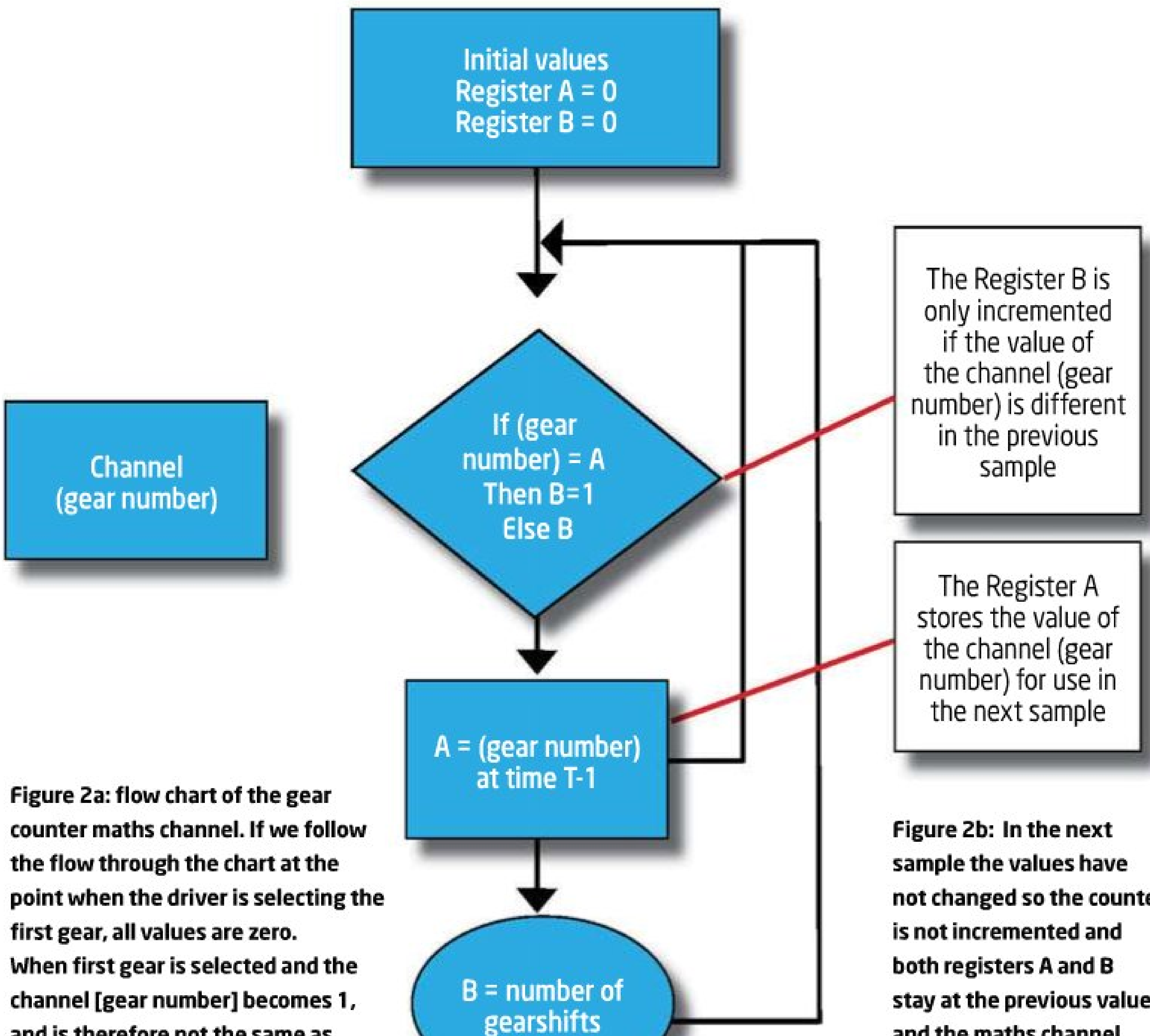


Figure 2a: flow chart of the gear counter maths channel. If we follow the flow through the chart at the point when the driver is selecting the first gear, all values are zero. When first gear is selected and the channel [gear number] becomes 1, and is therefore not the same as register A, the counter will then increment and set register B to 1.

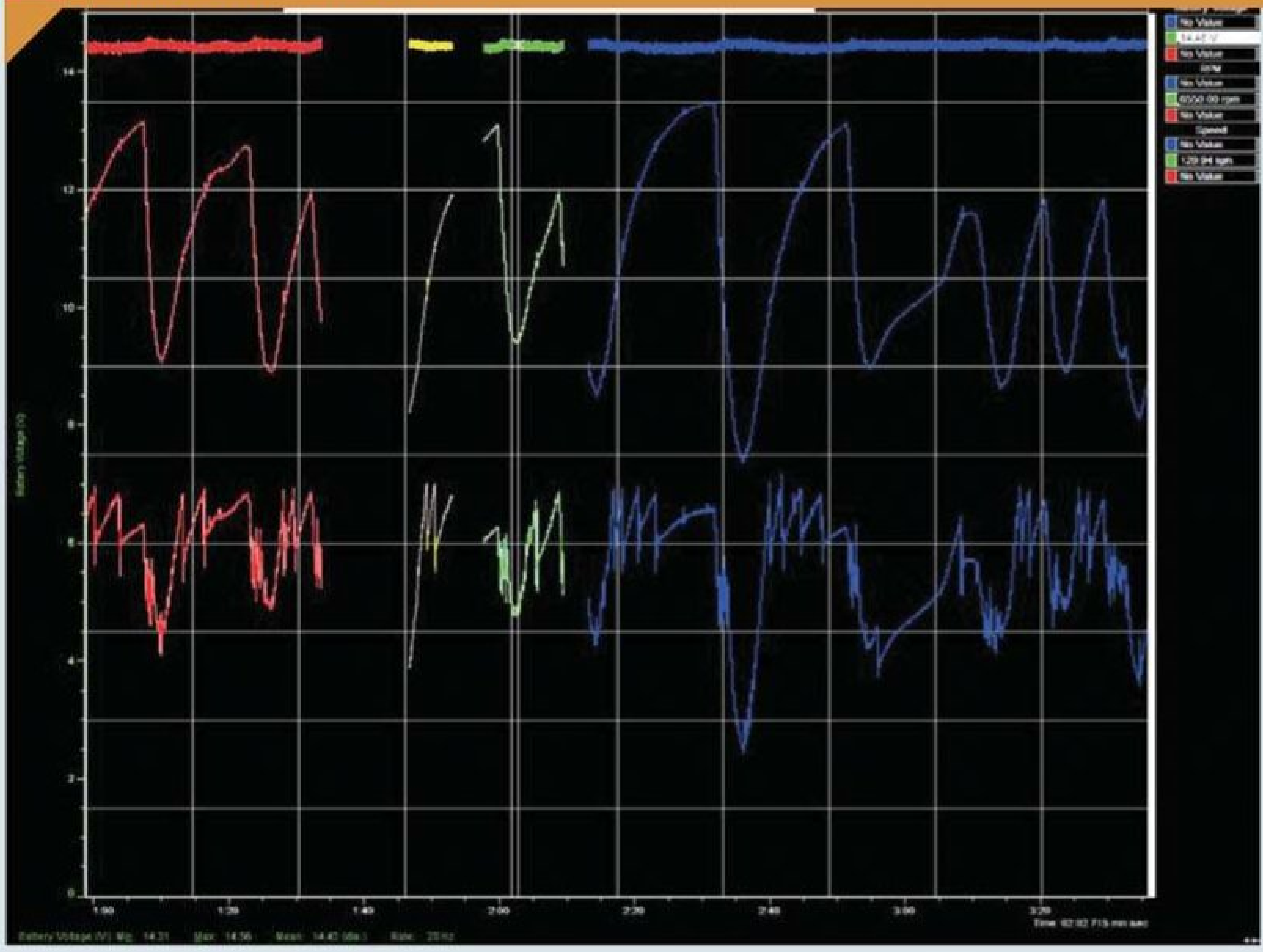
Figure 2b: In the next sample the values have not changed so the counter is not incremented and both registers A and B stay at the previous value and the maths channel goes back to evaluating its initial conditions

does not just jump between whole numbers but increments, which can cause the gear number calculation to trigger more than once for a single gear shift.

The gear counter can then be used as any other channel in the data set and the most useful feature will be a comparison of how many shifts a driver does in a lap. In most cases, that would be best presented in a tabular outing report, along with other statistical information.

When it comes to maths channels and programming in general, there are of course many ways to skin the cat and that is the case here with the gear counter. In the original challenge, channels that switched states when a shift paddle was pulled were shown – one channel for up-shifts and another for downshifts. This information can also be used to count the gears, but the ability to be able to detect when a channel switches states can also be used for various other things, such as re-setting a channel when a new lap begins. The possibilities are endless, it is up to you to make the most of what they are capable of to suit your particular application.

CHALLENGE



Question

A data logger recorded the data shown left in a single run. However, several data files were created and they appear to have a gap between them. What could explain this behaviour and how can we better understand what is occuring in the gaps?

COSWORTH

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Bright sparks

There is no doubt electric cars are coming, but plausible race series that cater for them are few and far between. Could Formula E offer the answer?

BY SAM COLLINS

Even before Formula E was officially announced, two technology demonstrators were already on track – the Mercedes Grand Prix-built Formulec (opening shot) was the first, followed by Toyota Motorsport's Radical-based powertrain showcase (above), which broke the EV lap record at the Nürburgring. Other projects such as the one from Fondtech (top) are aimed specifically at the new-for-2013 championship

Motorsport is not future proof. Whilst the transport world is moving rapidly towards alternative propulsion, its sporting side has barely reacted. The implementation at the top level has been restricted to the rather stumbling introduction of KERS in Formula 1.

But all this looks set to change with the announcement by the FIA of a new championship for high performance electric vehicles, called Formula E.

At its most basic, the proposed series ticks the ever more fashionable corporate social responsibility box for the FIA. But when you scratch the surface you find there is great interest in such a championship, and some very well-known names have already announced projects.

The basic car concept has been laid down by the FIA in its invitation to tender. All cars should be fully electric single seaters capable of running for around 15 minutes between charges at roughly Formula 3 pace, and weighing no less than 780kg. With electric vehicle (EV) technology where it sits currently, this sort of performance can only realistically be achieved with low-drag bodywork.

Three serious contenders have already shown their hands and proposed design concepts, and there are almost certainly more waiting in the wings. But in a situation not dissimilar to the one faced by IndyCar's ICONIC committee last year, the FIA will have to decide which approach to take, whether it be a spec racer or a fully open race series.

The technical part of the new series appears not to be decided at the moment, but there are three possible scenarios. The series would be fully competitive with multiple designs from the

FORMULEC

The Formulec programme started as a direct response to the celebrations of 100 years of grand prix racing and was championed by Eric Barbaroux, the former promoter of the French Grand Prix.

'It became clear that we had to start a new history with cars using the new energies. It took us a little while to define it but we realised that it had to be pure electric and not a hybrid,' the Frenchman explains. 'We identified a team from Matra Segula Technologies who have a lot of experience in EV powertrains, and for the chassis we worked with Mercedes Grand Prix because we knew some of the guys there from our days together at Ligier.'

Despite positive reaction to its prototype, Formulec is currently working on an all-new car

Very conventional in its appearance, the Formulec chassis and bodywork was developed by a team under the guidance of Loïc Bigois: 'It goes back to Brawn GP in 2009 where their future was somewhat uncertain and they were taking on some other work. We had good relationships with the engineers there and, when Mercedes came in, they saw what was going on and let it continue. The chassis is approximately built to Formula 3 specifications as we though that was a reasonable level.'

Together with Matra Segula Technologies, Barbaroux's team selected SAFT batteries and an experimental electric motor from Siemens. 'We chose to work with SAFT because this company has a lot of experience with defence technology and are used to the safety procedures required. For motors we chose to go with Siemens because they developed a high-power motor that had originally come from a bus, but with a lot of modifications.'

POSITIVE RESPONSE

But despite the very positive response to the first Formulec concept car, the team has decided to develop an all-new car. 'One of the first things we realised was that we had to cut the cost. So we have to build another car with cost as a design objective. We also have to reduce the weight. When you build a prototype like this, every single one of your partners wants to make sure their product works and doesn't fail, so everything is perhaps a little bit too heavy. Finally, we have to also increase reliability.'

The original Formulec car is still on a publicity tour, which has taken in, amongst other places, the Le Mans 24 Hours and the Frankfurt Motor Show.

TECH SPEC

Formulec EF01

Class: EV demonstrator

Chassis: Mercedes Grand Prix carbon fibre monocoque

Powertrain: Matra Segula

Battery: SAFT lithium cells

Motors: Siemens twin prototype BLDC

Transmission: bespoke two-speed Hewland gearbox

Performance: 0-100km/h sub three seconds; maximum speed 250km/h; range 20-25 minutes.

Data: 2D, ECU and CAN from FAAR Industry

Weight: not disclosed

Cost: €3m

Number built: one, but new-for-2012 EF02 is aiming at larger volumes

beginning. In that scenario, key suppliers like Bosch and Valeo could join manufacturers in entering cars, but that is probably not very realistic and it is unlikely there would be 20 different cars on the grid. The alternative is to have a single-make car that teams will run. That is more realistic, technically, but is a little bit poor in terms of the fact there will only be one car, and it would not appeal to a car maker developing its technology. The third option is we have a series of perhaps three or four car designs, with three or four teams running a grid of them.

According to Eric Barbaroux, who masterminded the Formulec project (see panel above), there are a number of key concerns that he believes should force the FIA to go the spec racer route.

'We are keen on a single-make series because then you can reduce your R and D expenses because you're providing 20 cars. It cuts the cost of each car. If you have an open championship full of prototypes, it becomes more expensive for everybody. Our prototype cost us more than €3 million. Also, you have to think about the safety of cars like this because when you have 800v in the car you have to be very, very careful. If you have many different technologies there is no way that anybody is going to be able to regulate it. No technical delegate and no marshal will be able to understand how all of the different cars should be handled and it will simply be dangerous. Plus scrutineering will be impossible. If you have just one type of car you can educate everybody at the track – not just the marshals, but the drivers and the technical staff, too. It is important we do not end up with something you can't control.'

Jean Claude Migeot, however, who has developed a Formula E concept at Fondtech in Italy, disagrees, feeling a spec series would be a waste of time: 'The long-term solution looks clear – set free the best engineers' creativity, because time is running out. Formula E should be an open formula because it is the start of a new era and not a market product. Having said that, what is the best way to reach that point in a short space of time when today we effectively start from zero? I think the FIA wants to be pragmatic and explore any other options on the table. But are there any?'

FONDTECH E-11

Jean Claude Migeot's latest racecar took many by surprise when it was revealed in late August this year. The car, which is squarely aimed at Formula E, was entirely developed by Fondtech in Bologna, Italy.

The project can be traced back to computer simulations carried out in 2009 before the project was officially signed off in May 2010. Since then, CFD research has continued, a 60 per cent scale wind tunnel model developed and the chosen motor / gearbox assembly bench tested. Chassis manufacture has also begun, ahead of the car's first track test, scheduled for January 2012.

The four-wheel drive powertrain features energy recovery to extend the range and, unusually, has all of the major electronic components mounted underneath the driver in the safety cell. To answer any doubters, its designers say they will crash test the chassis to weight balanced F3 standards.

'As an engineer it is extremely liberating to work without the usual boundaries and principles that often stifle progress in motorsport,' comments Luc Gasparini, the project's head of engineering. 'With the E-11 it is the level of a technology outside of our control that has proven most prohibitive, so we have had to work hard to overcome a lot of potential pitfalls. Sitting the driver on top of the batteries is controversial, but a deliberate choice to make our technology demonstrator simple but radical at the same time. Our firm decision of having them within the structural chassis and below the driver's seat gives the car its peculiar 'double-decker' look. It is our opinion that this will ensure maximum safety for both the driver, whose cockpit is completely separated from the battery compartment with no possibility of fluid leaks, and those outside the car, since the compartment is conceived to contain the batteries' debris in the event of an accident.'

TECH SPEC

Fondtech E-11

Class: Formula E (proposed)

Chassis: split-level, custom design, carbon fibre monocoque

Powertrain: Fondtech / various

Battery: lithium-ion cells

Motors: 300kW BLDC with energy recovery

Transmission: four-wheel drive; one motor per wheel with reduction gears

Performance: 0-100km/h sub 3.2 seconds; maximum speed 260km/h; range 50km / 20 mins

Data: TBC

Weight: 800kg

Cost: not disclosed

Number built: zero, first car due to be completed in early 2012

LIKELY COMPROMISE

Taking these opinions into account, it seems that the best compromise, and the most likely outcome, would be to have a semi-spec category with perhaps two or three chassis suppliers, as suggested by Vasselon. A pure spec category would be unlikely to impress spectators, and that is key to the success of the project.

The FIA sees the new championship as something of a trailblazer, with the invitation to tender stating, 'It should have the ambition to open a new area of motorsport in the way it is organised and promoted, and the initial view is therefore that it should not necessarily look like "traditional" motorsport. The venues, the format of the races, the relationship with the public and the other main parameters of events need to be considered with an open mindset in order to meet the objective of attracting a new audience. For example, the X Games could be used as a more relevant benchmark for the championship than traditional motorsport, making the competition cutting edge.'

The intention is that the events would be held in urban areas, with courses built in the centres of major cities. Critically, the courses should not feature any long straights, as these do not really suit EVs. Urban racing is a well-proven concept, but it can be vastly expensive, and that could force Formula E into less ideal locations such as parkland.

COOLING CHALLENGE

In terms of its geographical spread, the FIA hopes that Formula E will be global, and that means the cars will have to be able to cope with weather conditions ranging from a cold and wet afternoon in London to a sweltering hot day in the San Francisco Bay area. This alone provides a real technical challenge for the cars, says Vasselon: 'Cooling is critical. There is always a temperature range with batteries. The window is really quite narrow. A battery needs to be reasonably hot to achieve good efficiency. Yes, you could run it at zero degrees but, realistically, you have to heat the battery on a cold day. Alternatively, the battery can also get too hot. On a Formula 1 KERS system a significant proportion of the weight is its cooling system, and still on hot days like at Monza or Singapore you see some cars having issues.'

It may be for this reason that the FIA's preferred format is for short races. Over the duration of TMG's Nürburgring lap record run, for example, battery temperature was not a major issue. Indeed, it was the electric motors that required more cooling than the batteries.

CHANGE OF PACE

Not everybody sees the short race format as a problem, and the Formula E tender states that this could be an opportunity to revise the rhythm of the typical motorsport event, looking to create an action-packed day of competition and entertainment.

'Okay, so we can't do a two-hour race or 300kms with these cars, but why should we be copying Formula 1?' says Barbaroux. 'I would do something different. The 100m is over in just 10 seconds at the Olympic Games, you run 24 hours at Le Mans and the Tour de France takes four weeks, so is not the length of the race that brings interest, it's the way you sell it.'

But with cars like the Formulec capable of running for


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TOYOTA

Toyota Motorsport took a different approach to its electric racecar programme. With its chassis design and manufacturing capabilities well known through its Formula 1 and Le Mans programmes, it needed to prove that it had EV powertrain capabilities, too. So it went out to break the electric vehicle lap record at the Nürburgring, and succeeded. 'It worked on a bigger scale than expected. We had a lot of positive response. We were doing some EV activity and we wanted people to know about it,' explains Pascal Vasselon. 'It started from work in Formula 1 with KERS in 2009. We were the first to run a system and came to the conclusion that the performance was not there, but we had a very good understanding of it and made some serious development around it. During that programme we developed a very good understanding of batteries, battery cooling, management systems, inverters motors, that kind of thing. So when our F1 programme stopped, we decided to start an EV project. With the record car, we assembled some off-the-shelf components, together with our own technology, as an integration project.'

TMG is working on chassis designs for a Formula E car but is also keen to offer its powertrain as an off-the-shelf solution.

It has also developed extensive testing facilities for both EVs and hybrids during the course of the programme.

TECH SPEC

Toyota EV P001
Class: demonstrator
Chassis: Radical SR, tubular steel frame
Powertrain: Toyota Motorsport / Rational Motion
Battery: lithium-ceramic cells
Motors: 280kW 520v twin Evo-Electric motors; 800Nm torque
Transmission: electronic differential
Performance: 0-100km/h sub 3.9 seconds, maximum speed 260kph, range 50km / 20 min
Data: TBC
Weight: 970kg
Cost: not disclosed
Number built: one demonstrator only

15-25 minutes only, and recharge times as long as six hours, the show would have to involve battery swaps (not especially green or easy) or significantly shorter charging times.

Lord Drayson, the former British Government peer and Sportscar racer, is developing his own EV project with Lola cars. But whilst supportive of Formula E, he will not be involved as his project is based around LMP1 lap times and performance over a single lap. However, his project is taking steps to deals with the charging time issue: '[you have to] accept the physics that the energy density of petrol is enormous. The metallurgy and chemistry of batteries is going to improve over the next 20 years, but it is not going to be as good as petrol. The solution is to use dynamic induction charging,' he explains. 'We are working with a group called Halo IPT on this.'

Halo IPT offers a contactless charging system based on inductive power transfer, which uses strongly coupled magnetic resonance to transfer power from a transmitting pad on the ground to a receiving pad on the car.

'You can go to a circuit like Rockingham and have a 12-hour electric race because in the track are imbedded induction coils and the cars re-charge as they go round. You don't need the weight of the batteries and you can change the whole power-to-weight ratio of the car. These cars are going to scream around the track. It is relevant for the road too, because we increasingly spend a lot of time going short distances on congested roads. I think what we are using here as a racing laboratory can show governments and car manufacturers that this can work. The next time they are digging up a road, put in the induction coils and then, when they design the next generation of electric cars, they can put an induction pad in the car.'

THE SOUND OF SILENCE

The show is clearly a critical element for Formula E events and the invitation to tender suggests there should be support events featuring other types of electric vehicles (dragsters are one cited example). But another element often discussed about electric vehicles is the sound. Racing purists crave the sound of a Chevy V8 or an Aston Martin V12. Indeed, Bernie Ecclestone has been insistent that the 2014 F1 cars have to sound good and is trying to get the regulations in that series to ensure that happens. Formula E is no different. The tender insists that the 'noise' environment of the events is seen as fundamental to their success. This could include some musical background, but also some work on the noise that the cars might produce (aerodynamic, rolling noise etc).

'We need to make Formula E events that young people really want to attend. Have *Green Day* playing or something, that would work,' suggests Drayson. 'Who cares about the noise anyway? If you had a 200mph, high-revving electric car it will make a noise. Not like a V8 or anything, but then there is no point pretending it is.'

Interestingly, the team behind the Formulec have gone back to the drawing board to re-develop their concept, and one of the reasons is to improve the sound it makes. 'The car does actually make 83dB when it's running, but we have to provide more. The noise we have is due to the shape of the car, but 83dB is not ridiculous. If we had 16 cars on the track in a city centre, you can certainly make some kind of show,' says Barbaroux.

Lotus, in conjunction with in-car audio specialist, Harman, are working on an alternative approach, dubbed Halosonic. The core of the technology is a software algorithm originally emerged from the Active Noise Control programme. Using inputs from throttle position and vehicle speed, a central processor generates an authentic engine-like sound that is played back through a speaker in the front bumper and through the car's conventional audio system. 'Our system is about generating a sound, not making unwanted noise,' says Harman's director of active noise control, Jon Lane. 'The ruggedised external speaker is placed at the front of the car so it can be heard from further away, but also so that the sound decays much quicker when the vehicle has passed. You don't get that with an internal combustion engine.'

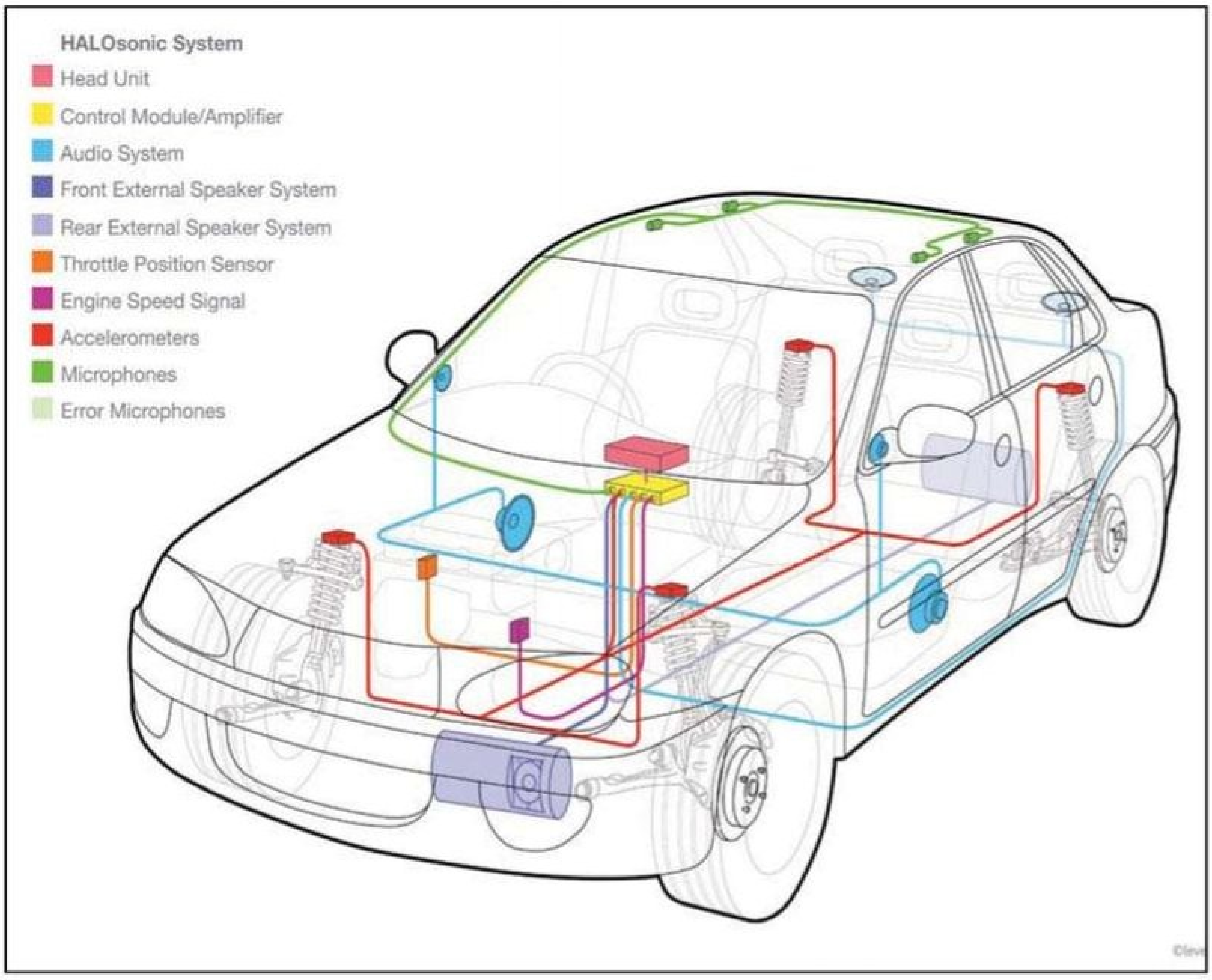
The sound processor mimics the petrol engine's pitch and frequency, initially so pedestrians can identify the vehicle's speed, direction and distance, but when applied to Formula E it could really spice up the show. The cars could be made to sound like a V8 Stock Car, a Rolls Royce Merlin-powered Spitfire or even a Cylon Raider from *Battlestar Galactica*!

Vehicle appearance, of course, is another critical part of the show, with everyone involved keen to move away from the conventional open-wheel / Prototype look.

'Another reason we are re-working our design is because it is a classic Formula 1 design,' continues Barbaroux. 'A car that looks like a Formula 1 car is not the future. Just look at the things they did in IndyCar with the Swift and the Deltawing – we just want something original.'

Finally, the FIA states in its tender one of the hardest elements of all for the engineers to deal with – environmental credibility: 'The championship should strive to be credible and trend-setting in terms of sustainability, efficient use of resources, sustainable logistics, supply chain management etc.' This could challenge those groups insistent on using composite chassis and raises real questions about the battery chemistry. It is already well known that F1 KERS batteries are rarely recycled and it may be suggested that Formula E will worsen this situation.

Throughout 2012, the Formula E regulations will take shape, along with the cars set to take part in it, while the first event will be staged in 2013. However it turns out, it is sure to provide a fresh and exciting challenge, and that can only be a good thing for the engineers involved.

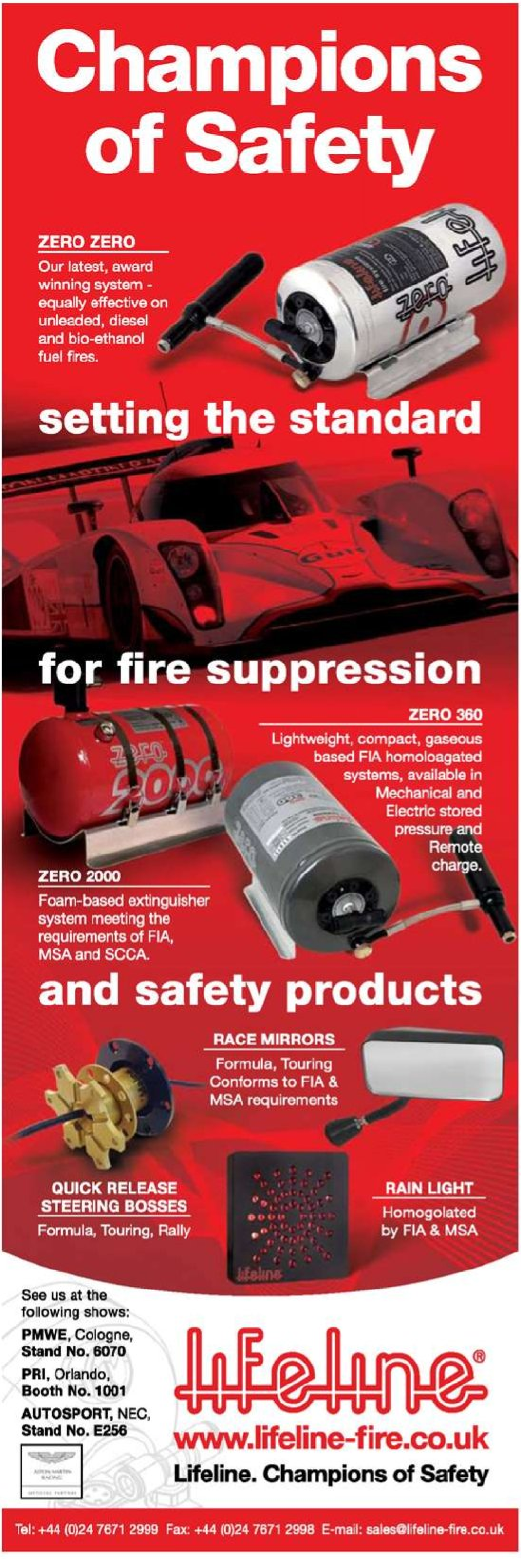


Developed jointly by Lotus Engineering and Harman HALOsonic, this could be the answer to making Formula E cars sound the way the FIA want. Lotus is certain that the system could be fitted to an open-wheel car

OPINION SSC

It seems to me that in some ways Formula E has missed a trick because there are many burgeoning and developing EV projects around, though most are destined for the road. Motor racing is funded by two major groups – manufacturers (be it of cars or energy drinks) and drivers. In reality, the latter group provides the wealth of funding, right up to and including Formula 1. Formula E will probably cost more than F3 to contest, so the drivers will likely not be interested, leaving a very small number of works-backed entries. Take the Delta E4 Coupé (shown below) for example. I drove this car at Silverstone and Crystal Palace this year and was blown away by its handling and acceleration. It is already road legal and, if put into full production, could easily be turned into a very affordable competition car. Tesla, and other similar cars, would slot straight into such a category, too. There could even be a class for the many budge 'city cars' out there. This was part of the two proposed EV championships that surfaced during the winter, but neither of those had the full support of the FIA. I think perhaps any promoter needs to realise that it is highly likely that spectators will associate more with roadgoing EVs than futuristic open wheelers.

The Formula E race format also only serves to reinforce the number one issue with EVs, that of range anxiety. Halo IPT is a fantastic example of what can be done to overcome that, but it will likely play no part in this new series. More's the pity.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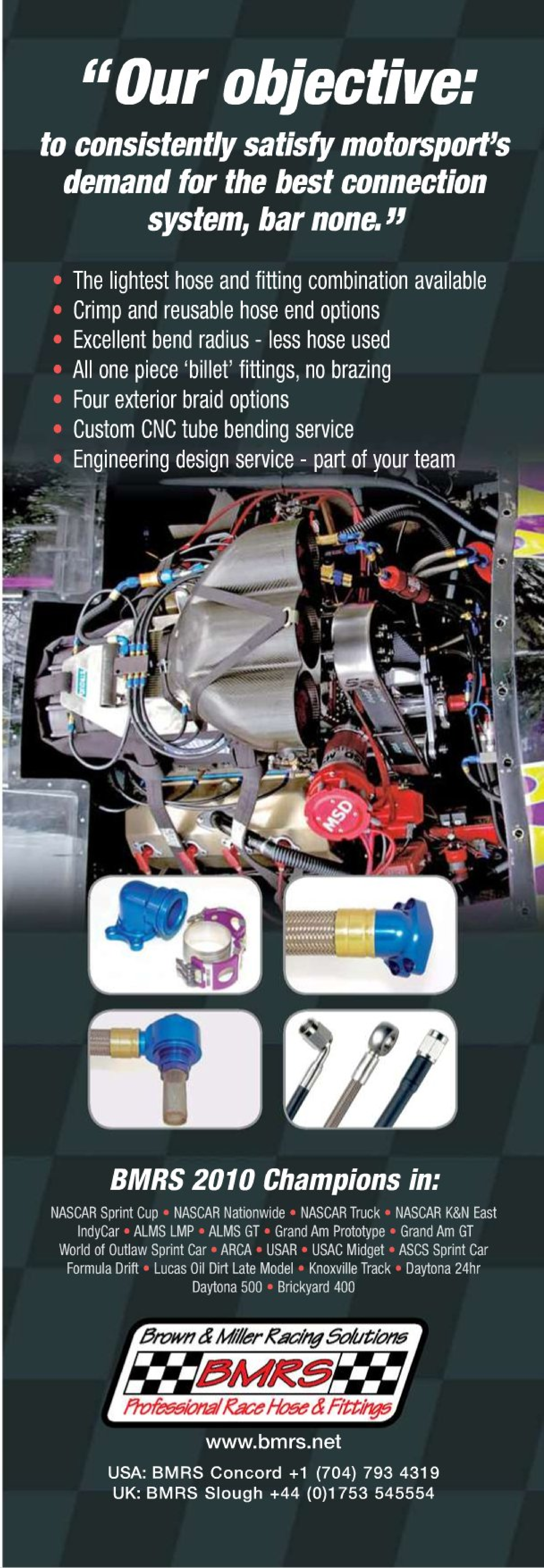
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Controlling freedom

Another new engine, but with a sequential transmission and the restrictions on aerodynamics lifted, this time it's a step change for the popular feeder series

BY SAM COLLINS

For more than four decades, one open-wheel formula above all others has dominated the national open-wheel scene, and it is about to undergo some radical changes. Again. Over the years Formula Ford has gone through a range of incarnations, from its 1.6-litre Kent engine roots through to its current Duratec form and even at one point a Honda engine! But, at the Frankfurt Motor Show, Ford revealed the formula's latest incarnation, along with a renewed commitment to the series.

At first glance, the big change is to move away from normally-aspirated engines for the first time in the class' history. Ford's new turbocharged Eco-Boost in-line four will be found in the back of the new cars in its 1.6-litre guise. But this is just one change in a raft of new features for this well-known formula.

'Our last big change was six years ago with the introduction of the Duratec, and we are just keeping up with modern technology,' explains Mike Norton, Ford's motorsport manager. 'So all of the changes are done under the auspices of keeping the formula up to date, and in keeping with the environmental pressures of today. It's a very lean burn, petrol, direct injection engine. It helps keep the formula in touch with the new technologies in our road cars.'

Unsurprisingly, given the current climate, much of the standard production engine has been carried over to the racing version in an attempt to keep costs under control: 'It is almost completely standard,' says Norton. 'The only big thing we changed was [to go] from a wet sump to a dry sump. It retains the standard inlet manifold, the fly-by-wire throttle, the exhaust manifold, turbocharger and the standard control systems in terms of sensors and so on. We will run our own motorsport ECU and wiring harness, mainly because the security systems on road cars do not really allow us to run the engine in the way we want. Also, a road car ECU doesn't have all

> "it helps keep the formula in touch with the new technologies in our road cars"

TECH SPEC

Formula Ford 2012 concept

- **Engine:** 1.6 Ford Eco-Boost turbocharged in-line four
- **Electronics:** Life Racing ECU
- **Chassis:** tubular steel frame, open to any design
- **Suspension:** free
- **Gearbox:** six-speed sequential transmission open to any design within the regulations
- **Wheels:** single design from Rimstock
- **Bodywork:** spec radiator ducts, cockpit surround and roll hoop shrould

The launch car is Ford's own interpretaton of how the new car will look and is based on the Mygale tubular steel chassis that will remain in use. Body design and manufacture will be free but with certain fixed parameters such as the sidepod inlets, front and rear impact structures and a flat floor

the data logging capability that we need. Everyone will have to run the same LIFE Racing ECU, and they will have certain access to the logging functions, but they have no access to any of the maps at all. This does not end things for the engine builders, who can continue to strip the units down and hone them, and all the things they like to do. From that perspective it is no different to the Duratec.'

The car shown at Frankfurt and pictured in these pages is Ford's interpretation of the new look class, built around a current spec Mygale chassis. According to Norton, Ford will make the data to build the bodies available to anyone who wants it.

Garish Rimstock wheels look more like aftermarket road car alloys but are a further spec part designed to keep costs down. Wheel tethers are also used

TUBULAR BELLES

It may surprise many that Ford has shunned the more usual approach of a single specification carbon fibre monocoque chassis, but Norton believes the tubular steel chassis is as safe as it needs to be: 'The chassis has not really changed in reality, because when we crash tested it and subjected it to quasi-static load tests in 2007 it met the 2008 Formula 3 standards. We did not really see the need to change things there.

'We worked quite closely with the FIA Safety Institute and Andy Mellor for about two and half years. Article 277 of Appendix J had a set of safety regulations for tubular cars but nothing existed in terms of a really detailed criteria. There was no strength stated for the roll hoop, and no real crash testing criteria, so we have been developing those with the FIA and MSA and the new rules are the result of that work.'

Front and rear impact structures have been fitted to the car and these will be control parts for all manufacturers. The front structure is mounted on a square 300 x 300mm bulkhead, which all cars will have to run, and it is around 550mm in length. It will be up to the car designers to accommodate it in the nosecone.

The cockpit aperture is also a spec area, with all cars having to run a Formula 1-style head restraint and a removable seat. Further driver protection comes in the form of wheel tethers and anti-intrusion panels running along the cockpit sides.

The safety components will not be the only parts of the car that everyone has to use. The flat floor, roll hoop shroud and sidepod inlets are all fixed shapes, which all chassis will have to use. Even the wheels are a spec design from Rimstock.

AERODYNAMIC INFLUENCE

'You'll notice with the current cars they have these very low and square sidepods in a very basic shape. That's what the regulations dictated, and they also stipulated that anything that has an aerodynamic influence is not allowed. Clearly that was a nonsense because the entire car has aerodynamic influence and it's just about impossible to police. We have opened up the regulations to allow people to do a lot more sculpting, with undercuts and complex curves all allowed now. Just nothing that obviously constitutes an


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The cockpit aperture is a spec part and includes an F1-style head restraint, removable seat and anti-intrusion bars

Gone are the nonsensical limits on 'anything that has an aerodynamic influence', so expect to see teams coming up with novel solutions and developments to squeeze every last bit of performance out of the 1.6-litre turbo engines

aerofoil. As a result of the control components – our kinetic design elements – the frontal area of all of the cars will be roughly similar, so the aerodynamic effect of the cars will be roughly the same. There is a lot of scope for teams and manufacturers – just look at the nose. As long as it fits the attenuator then it's okay.'

Uniquely for a manufacturer-backed series, Formula Ford will continue to let anyone build chassis, whereas all of the other similar formulae, such as Formula Renault or Star Mazda, require everyone to race identical cars. It is something Norton believes is part of the core ethos of what has made the class a success over the years. 'We don't have wings or DRS to make the racing exciting. Formula Ford is for people coming out of karting and learning to set the car up to get the best mechanical grip. It is not just for drivers either. The engineers, team managers and technicians will want to progress their careers and learn, too. Understand the engineering in full in this class is still a crucial step for everybody, and that is one of the fundamental thrusts of Formula Ford.'

SEQUENTIAL TRANSMISSIONS

For the drivers, the new cars will have one major change – the adoption of sequential transmissions. It means that on the traditional ladder of progression to Formula 1, drivers will not have ever had to race a car with an H-pattern gearbox. This, though, may not be a bad thing, as the likes of Lewis Hamilton and Bruno Senna (both of whom skipped Formula Ford) have proved. The show car was fitted with the well-proven Hewland FTR transmission, but Norton reveals that anyone can offer a transmission, as long as it meets the regulations. 'We wrote the rules based on the FTR / JFR concept, but it is open to anybody, [though] of course you have to fit the rear crash 'box and it has to be a six-speed sequential. We do not want a gearbox war so we have mandated things like the gear weights. Again it was part of bringing the formula up to date. The old LD200 was getting harder to get spares for and it was struggling to deal with the higher output of the engines.'

The suspension concept on the new car is largely unchanged, though the adoption of the FTR transmission will see most chassis manufacturers utilise the rear suspension pick-up points found on the Hewland casing.

EMERGING MARKETS

Ford is clearly hoping that the new regulations will revitalise its formula and open up the doors to new markets. Indeed, launching the concept car at the high profile Frankfurt Motor Show was all about that, as Norton explains: 'We want to get Formula Ford back into markets we have lost over the years, and into new markets. We have had discussions with places like the USA, Russia and even the Philippines. There are many markets that are trying to grow right now, and there are a lot of these going to the FIA and asking them how to do that. We feel that we are right there on hand with the perfect development formula. Formula Ford is cost-effective and,

> "the perfect development formula"

because we used a tubular steel chassis, they can be licence built in those markets and repaired there. Ninety per cent of the time a carbon chassis would have to go back to the manufacturer for repair, or even destruction, but in pretty much every country in the world you can find someone who can weld steel chassis to a good standard and you know when it is bent or broken. That means it keeps those emerging markets safe and long lasting.'

The new Formula Fords will cost more than the current Duratec-powered breed, due largely to the higher specification transmission and increased safety equipment, and estimates suggest that this increase will be in the region of 4000-6000 euros (£3500-£5200 / $5400-$8100).

The new cars will make their race debuts at the start of the 2012 season.

Blood brother

The MP4-12C GT3 not only marks McLaren's return to Sportscar racing, but also showcases some of its new, transferable technologies to a wider audience

BY SAMUEL COLLINS

McLaren has never really been 'just' a Formula 1 team. The first car to bear the M1A name was a sports racer built by Elva. Elvis Presley took to the wheel of it in the Hollywood film *Spinout* where he was told that 'it took some imagination to build the car'. Well, over the years McLaren has used that imagination to build a range of sports cars, peaking with its Le Mans-winning F1 GTR in 1995.

In 2011, the McLaren name returned to Sportscar racing with its MP4-12C GT3, a project that draws heavily on the wide resources of the McLaren group.

The new racecar is based on the MP4-12C road car, the first of a new range of products from McLaren Automotive that follow the ethos of being highly efficient, high quality, lightweight, practical, dynamic, safe, comfortable and visually arresting. 'McLaren has racing in its blood, and it was a natural step to take our MP4-12C road car and turn it into the most reliable, efficient and easy to drive GT3 car,' explains McLaren CEO, Martin Whitmarsh. 'Every car on the grid is performance balanced by race rules, meaning our objective must be to select a technical specification that ensures any driver is able to access the 12C GT3's performance limit with ease.'

Weighing just 75kg (165lb), the 12C's carbon chassis, or 'MonoCell' as its makers call it, was designed and developed by the McLaren Automotive Body Structures team at the company's headquarters in Woking, UK. The chassis composition and construction process were defined over a three-year period as the first, and vital, step in McLaren Automotive's launch as a fully-fledged sports car company.

'It is light, which helps reduce the 12C's CO^2 emissions to

With the outer body panels removed, it is obvious how the carbon fibre MonoCell integrates into the MP4-12C chassis

unprecedented levels for high-performance sports cars. It is also incredibly strong and predictable in form and behaviour, providing a great foundation to world-beating performance. Acceleration, braking, changes of direction and vehicle stability are all significantly better than on any car with an aluminium chassis that I have ever known,' explains Claudio Santoni, function group manager for body structures at McLaren Automotive. 'This is because using a carbon composite means we can manufacture the MonoCell with aerospace industry levels of precision, which is fundamental to accurate dynamic suspension geometry control.'

McLaren Automotive contracted composite experts, CarboTech, to refine the production process and bring to market McLaren's ambitions. Presented with a working concept based on 50 McLaren-made chassis, the Austrian company was challenged to help revolutionise carbon chassis manufacturing.

The chassis is produced in one piece through the Resin Transfer Moulding (RTM) process that, for the first time, uses robots and production lines during its manufacture, systems that these days are commonplace in most car factories.

The production process begins by loading dry carbon fibre into a complex, 35 tonne steel tool before it is pressed together, heated and then injected with epoxy resin. Using a steel tool is also new to the manufacturing process as, historically, carbon chassis have been formed in 'soft' tooling, made of composite materials, which adds production costs and time. The subsequent post-curing process hardens the resin, and the MonoCell then enters a booth where key surfaces are precision machined in preparation for vehicle assembly. The process between forming and curing produces the MonoCell as a hollow structure, and is the

MonoCell, as developed by Carbo Tech and, unusually, for a carbon fibre product, manufactured by robots

key to the chassis' combination of strength and light weight.

'I see no reason why the benefits of carbon should not cascade into more and more automotive product lines,' continues Santoni, 'but it will take a little while. McLaren took three years to develop the MonoCell and its production process. We also had the benefit of no industrial legacy, such as investment in aluminium plants or tooling. Nor do we have existing cars and after-sales processes based on aluminium structures and repair constraints. This gives us a competitive advantage that we will, of course, maintain as we launch our range of sports cars. But I hope that we have proven the benefits of carbon and that inspires both our competition and the car industry as a whole.'

CUSTOMER RELATIONS

One of the frequently-voiced concerns about composite structures, despite their inherent safety, is the difficulty of repairing them in the aftermath of a crash – something that is likely to happen in the rough and tumble world of GT3 – but McLaren Racing's head of vehicle engineering, Mark Williams, is unconcerned: 'The nice thing about that is, say for example you have an off, and you do damage some part of the car, unless it's a very large accident, the MonoCell stays intact, so you can just take that as a given, and then just do your normal checks to make sure there's no delamination or anything happening. You can then say 'right, that's good, I don't need to put it back in the jig, what could be wrong with it?' So from that perspective, you then only have to start replacing the crash structures that are built into the road car and off you go again. So I think, maintenance-wise, it should be very good. At the end of the day, in the event of a big crash they probably have to come back to us anyway. If it's significant, you have to assess how much damage has been done, and that's all going to be part of managing the customer relationship.'

A single plane rear wing is used on the racecar version in place of the road car's automatically-adjusted aerofoil. Ducting has also been revised

> "I hope we have proven the benefits of carbon and that inspires both our competition and the car industry as a whole"

RACING MODIFICATIONS

One of the key differences between the GT3 car and the road car is the extra grip provided by the competition tyres. This has moved the balance of the car further forward and called for some fairly major mechanical changes. 'We'd like to move weight further forward, but what are you going to move? There isn't anything to move and anything you do makes it very different from the original road car, and that's not the concept of the GT3. All we could do was to reduce weight at the rear,' explains Williams.

'A six-speed sequential shift gearbox by Ricardo was selected because a race-specific transmission is 80kg lighter than the seamless shift, seven-speed gearbox used in the road car. All the internal components have been proven in other racing series. We then challenged Ricardo to reduce weight further, meaning the unit has a bespoke casing design. The nice thing is, it's a very low c of g gearbox, too.

'We also had to move the oil tank from its road car location as it sits in the space we needed for the fuel cell volume. But, when you look at the packaging of the car, we had no option but to move it rearward. When you open the engine compartment, there's the engine, there's the exhaust and turbos, there's just no room there, and we didn't want it to go far from the engine, so it's now alongside the gearbox. It did mean we could do a little bit of work on the oil tank, though, and try and make it a bit smaller.'

Despite having a revised c of g, the GT3 largely retains the suspension geometry of the roadgoing MP4-12C. 'We've had to do our own front lower wishbone, but that's really based around packaging and just making that design work. Other than that, we've tried to keep as many standard components as possible.' The car does, however, use Mulitimatic DSSV dampers, while outboard you will find full race Akebono brakes with purpose-designed pads and friction materials – a nod to technical partners of the McLaren's grand prix team. 'We went to those suppliers because we have a good working relationship with them and we could use the same proven technology we've been developing for the F1 car.'

The engine on the MP4-12C


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TECH SPEC

McLaren MP4-12C GT3

Width	1995mm
Height	1145mm
Wheelbase	2670mm
Fuel tank capacity	120 litres

Chassis / body
McLaren carbon fibre MonoCell with aluminium front and rear frames and bespoke carbon body panels

Aerodynamics
Front and rear diffuser, front splitter, dive planes, adjustable rear wing

Transmission
six-speed sequential with steering wheel-mounted paddles; limited slip differential; sintered clutch; driveshafts with tripod joints

Engine
3.8-litre, 32-valve, twin turbo McLaren M838T V8; cast aluminium block, 90-deg v; flat plane crank; cast aluminium cylinder heads; variable cam timing; two water / air charge coolers; plastic composite plenum; cast stainless exhaust manifold; MHI fixed geometry turbochargers

Engine management
MESL TAG400 ECU and CIU 100 interfacing with Bosch ABS and Shiftec control units

Suspension
Double wishbone all round, adjustable for ride height camber and toe

Dampers
Multimatic coilover dampers with DSSV technology and independent bump and rebound adjustment

Front brake
Akebono six-piston monoblock calipers; 378 x 36mm iron ventilated discs

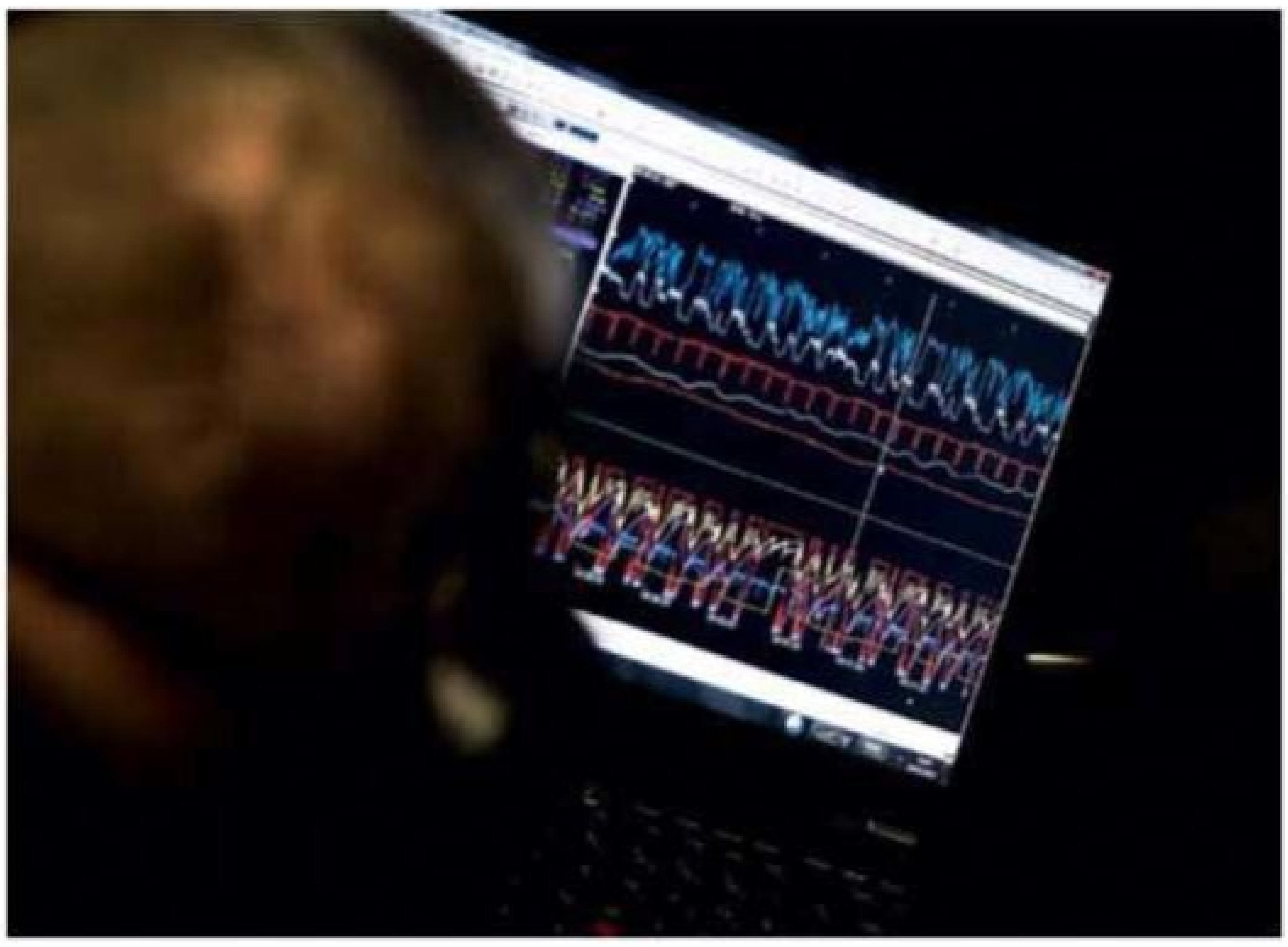
Rear brakes
Akebono four-piston monoblock calipers; 355 x 32mm iron ventilated discs

Steering
Electro-hydraulic PAS

Wheels
Forged aluminium
Front – 12 x 18in
Rear – 13 x 18in
MESL TPS system compatible

Cockpit electronics
Multi-function steering wheel with integrated driver display; central switch panel with systems display screen

Steering wheel
Derived from MP4-24 Formula 1 wheel, retaining integrated driver display, paddle shift and switches



According to McLaren, the integral data logging is designed for ease of use, enabling any team, or driver, to explore the maximum potential of the car

APPLIED TECHNOLOGY

McLaren is no longer just a small English racing team named after a Kiwi racing driver, it is a major force in manufacturing in the UK, with a stock market floatation rumoured for 2015.

Much of the advanced technology found in McLaren's racing projects can increasingly be found in other markets – most famously the Green Jersey competition of the Tour De France, which was won on a McLaren-developed bike called the S-Works Venge. Cycle maker, Specialized, turned to McLaren Applied Technologies to help create the low-drag, ultra-stiff design. Using FEA and the composite process usually applied to Formula 1 car projects, the frame weight was cut to just 950g. It was one of the key factors in the incredibly strong performances of sprinter, Mark Cavendish, on the classic road race and, more recently, with the British team at the World Championships.

McLaren's technology has also found its way outside the sporting world altogether, with an orthopedic device using an electronically-controlled damper designed to help speed up recovery from knee injuries. A more developed version of the device is in use with military organisations who use it to allow troops to carry heavier loads and to reduce injuries sustained by special forces using fast landing boats.

GT3 is largely standard, although it runs on the increasingly commonplace McLaren Electronics' TAG-400 ECU, the same unit found in NASCAR and Formula 1. As a result of that we've taken the opportunity to basically reduce the power level of the engine, again based on what we believe we need to do to meet the balance of performance targets. So we've had a range of lower power maps produced by Ricardo. Because they have all the experience of the road car engine, it seemed the logical thing to do.'

VISUALLY DIFFERENT

The bodywork is visually quite different to that of the road car with a new front end, revised ducting and a single plane rear wing in place of the automatically adjusted road car aerofoil.

'All of the work has been done in the virtual world, which obviously has some inherent risk because you never know quite what the exchange rate is going to be,' explains Williams. 'You just have to hope you've done the best job you can [but] you don't know that until you've run the car. We've gone out and run the car and got the exchange rate we expected and believe that to be enough to satisfy the requirements of the balance and the performance level of the car.'

When the GT3 was first rolled out at Silvertsone in early 2011 those present saw the level of engineering and assumed that this was not a GT3 car at all but really a toned down GTE design aimed squarely at the Le Mans 24 Hours. McLaren officially deny any plans to take part in the most famous event in motorsport, but ask at a quiet moment and you'll find the company is, in fact, very keen on the event.

'We'd obviously love to do Le Mans again,' Williams candidly admits. 'The difficulty is, we won Le Mans when the category we were racing in could win the race outright, and that's always the attraction to be able to do that. It will be nice if that happened again, but that's really out of our hands and, at the end of the day, we have to deliver cars that customers want to go and race, in whatever championships they do.'

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Shocks to the system

Three years on from the 'j-damper' story, Penske Racing Shocks announces its hybrid damper / inerter for wider application

"a new, innovative component that has been missing from suspension technology until now"

BY SIMON MCBEATH

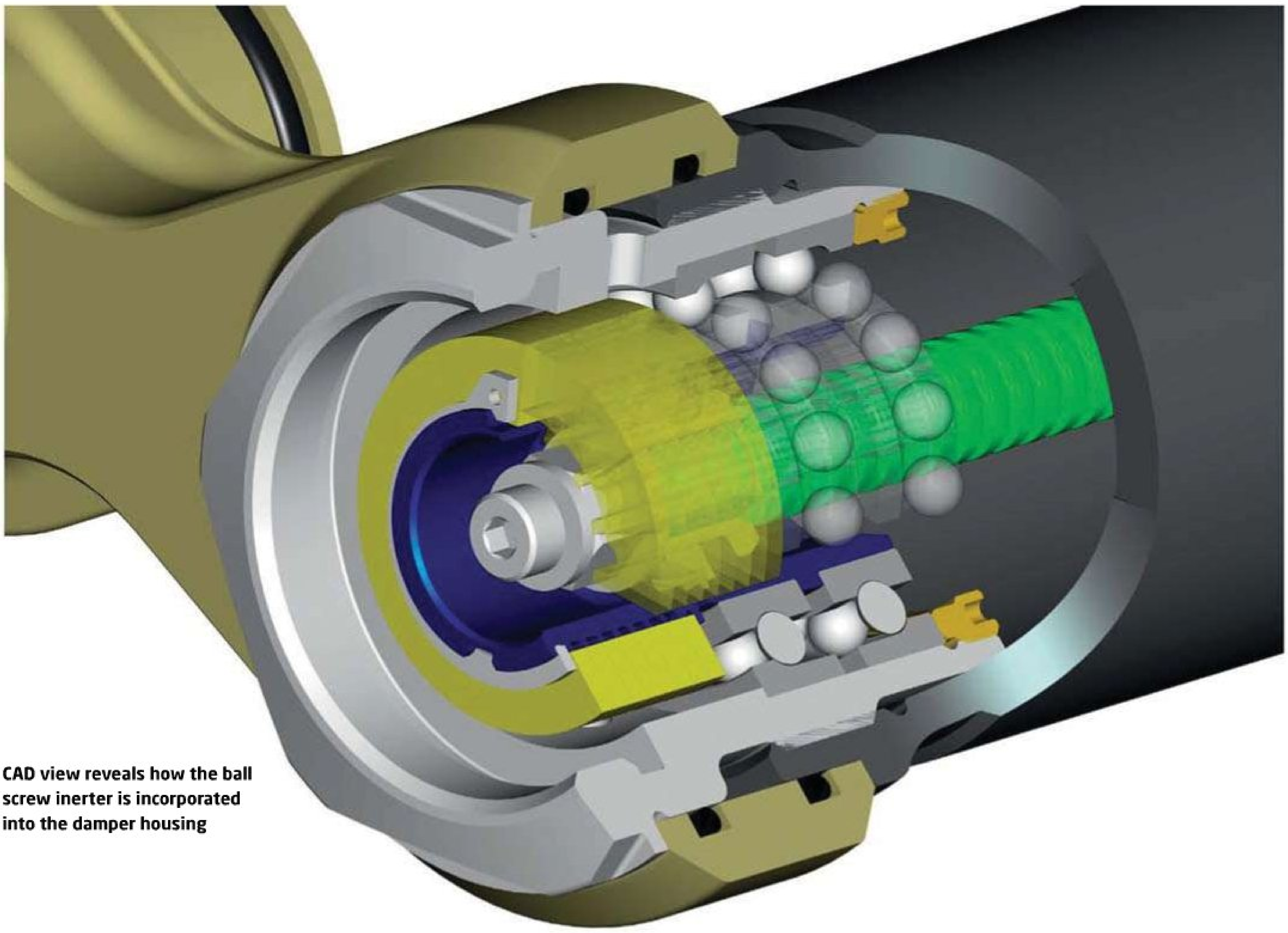
It would be a cynical observer who wasn't impressed with the conception of the inerter, or its application in improving tyre grip. But the simple explanation that it improves mechanical grip by reducing tyre load fluctuations in dynamic situations doesn't do the concept justice. Yet when Professor Malcolm C Smith of Cambridge University in the UK first conceived it in 1997, he admitted to being nervous about talking of it, 'because it seemed so elementary a concept. It was very difficult to believe that nobody had thought of it before, and I presumed that either it had been done already or there was some sort of snag.' But, as we now know, McLaren raced inerters for the first time in 2005, Kimi Raikkonen winning in Spain to give the technology a successful race debut. Since then, inerters have been widely adopted in Formula 1.

As one of the world's leading damper manufacturers, Penske Racing Shocks (PRS) became involved with Cambridge University early on in the development process, during 2003 in fact. Penske's director of research and development, Bill Gartner: 'Some of the earliest Cambridge test arrangements included bits of Penske shocks in order to simulate how inerters and dampers would behave in a suspension system.' Subsequently, in August 2008, PRS entered into a multi-year deal with Cambridge Enterprise, the commercialisation office of the University, to incorporate Cambridge's patented inerter technology into suspension components, primarily in F1. Crucially, the agreement also allowed PRS to design, develop and produce generic and bespoke inerter designs, as well as future applications and improvements.

The deal was a no-brainer for both parties, as technical director at PRS, Jim Arentz, put it at the time the deal was announced: 'Inerter technology is something we feel adds to our portfolio of pioneered applied technologies in professional racing. We are confident that the ingenuity of Cambridge, combined with Penske product quality, performance and customer service will promote greater exposure of the inerter in motorsport.'

USEABLE TECHNOLOGY

That last phrase brings us neatly to the present and, as *Racecar Engineering* can now exclusively



CAD view reveals how the ball screw inerter is incorporated into the damper housing

reveal, to Penske's new hybrid damper / inerter. As Gartner commented, this is a prime example of how F1-specific technology has morphed into real world, useable racecar specification. However, he also admits there were doubts along the way, too...

'We gathered from scraps of information that [early on at least] F1 teams were more likely after settling tyre sidewall oscillations following a kerb strike, as opposed to more general grip gains that a normal racecar would likely be chasing. So we weren't convinced that they would ever find a place outside of F1... But we started to hear increasing rumours that more F1 teams were making use of the technology and, because Formula 1 is an important segment of our business, it was important to keep up to date on any emerging suspension technologies.

'With that in mind, we began to meet with Professor Smith at Cambridge University to discuss his theories, and inerter potential in particular. The concept was interesting, but we weren't sure how beneficial inerters would be for a more traditional suspension layout. Formula 1 suspension systems are in a class of their own because the massive downforce loads require very stiff springs, while the tyres have a very soft and compliant spring rate. During a traditional analysis, this combination shows that inerters should add grip, settle the car much more quickly, and create a more consistent aero platform. However, when a more normal racecar suspension system is analysed using stiffer tyre sidewalls, softer suspension springs and less downforce, the general trend seemed to show minimal gains or even reduced grip. But, as we dug deeper, we found that there are many ways to analyse the grip level that a tyre will provide in different situations, some of which showed significant improvement with inerters. It was time to simply get down to business and try it!'

Then began a fascinating relationship between academics and engineers, something Gartner was keen to expand upon: 'We developed a very interesting dynamic with Professor Smith, who comes from an academic background so adept at the analysis of both mechanical and electrical vibrations, whereas at Penske we use analysis for general guidance, knowing the final key is really the driver's mind... However, inerters were a bit more complex, and needed the right partnership between theoretical and practical. Like a proud father watching his child come of age, he was yearning to see his invention stretch its legs!

> **"a fascinating relationship between academics and engineers"**

'Meanwhile, at Penske we put our heads down on a practical, reliable, easy-to-use design, while Professor Smith got to work analysing many of the common suspension arrangements in racing. His groundwork guided us toward the perfect range of inertance and adjustment levels to begin the development. The use of inerters as central dampers in F1 to settle the overall oscillations of the car had became public knowledge, but we weren't completely sure how drivers would respond to their use in the more traditional corner dampers that drivers rely on to feel the car as they push the limits around a racetrack. In order to solve the mystery, we had to merge the world of analysis, and good old-fashioned R and D.

'For some time now, racing has been pushed more toward computer analysis and racing simulators. Historically, Penske suspension products were geared to the driver's seat-of-the-pants impression, but now our advances need to show

Penske Racing Shocks hybrid damper / inerter disassembled. Look top right for the interesting new bit...

The ball screw and rotating weight arrangement in close up is revealing in respect of the order of mass involved

Removing the inerter weight to change for another is a simple matter of unscrewing the top eye and cap

Close up with top eye only removed

promise to the computers before ever reaching a driver. Even though our approach for many of these changing markets has been adjusted accordingly, in our hearts we still yearn to give the driver what he or she needs to go fast in a racecar. So, in this age of multi-million dollar computer simulations, we decided to buck the trend and spend the time and development dollar to design and prototype an idea...'

PRACTICAL ISSUES

Also there were some fundamental practical issues to tackle, as Gartner explained: 'We wanted to bring inerter technology to the masses, and offer something that normal racing teams could utilise. F1 teams were typically using inerters and dampers separately, and their inerters were usually greased before each race. This required a complete teardown, as the grease would attract carbon dust, or any other particles floating in the air. We knew for a normal racing team to use this technology, we needed to protect the most delicate and important inner workings of the inerter.

'A ball screw is impossible to seal, so we decided we would build a damper around the inerter by telescoping the ball screw directly into the damper shaft, and this is the basis of our own patent pending design. This allowed the ball screw and thrust bearings to operate in the damper oil, keeping things running friction free and well lubricated for a much longer period of time. It also provides some important benefits when compared to normal inerters alone.

'One important feature of any inerter is the elimination of axial free play in the system, without adding running friction to reduce inerter benefits. Highly pre-loaded thrust bearings would easily solve the free play issue, but would quickly eliminate performance gains from the free exchange of energy to and from the spinning weights. There are rumours that some suspension failures that were attributed to inerters were actually [attributable to] other suspension components that couldn't handle the additional high frequency loads from the inerter. One could easily imagine an inerter reaching its natural frequency with some free play in the system, and shaking the suspension system to its breaking point. Even though our hybrid system has a highly accurate shim system to eliminate any backlash, we've also found that coupling an inerter and damper into one complete unit helps to eliminate the negative effects that a normal inerter might exhibit due to free play because any free play is also damped. The damping and inertance can work together in a symbiotic way, with each device assisting the other where it needs help.'

"add grip, settle the car much more quickly, and create a more consistent aero platform"

TRACK-BASED BENEFITS

As Gartner warmed to the topic, he expanded on the key benefits to be had from this new hybrid product: 'While F1 teams generally understand how inerters can be used to

Alternative view of the ball screw and weight inerter assembly

Penske Racing Shocks' dampers are standard fit with the new Dallara IndyCar. The new hybrid inerter / dampers may find their way into the package in the near future

make gains on the track, inerter theory for more standard vehicle suspensions is in its infancy. However, to me, an inerter can be used to accomplish some important goals that can help a car and driver attack the track more effectively. Firstly, an inerter can help to block low-amplitude, high-frequency 'noise' from working its way into the suspension system. I believe the typical racecar suspension can't handle these movements without introducing some lag in response. These types of movements are best handled within the tyre carcass, in order to avoid a delayed response from the suspension that can reduce the tyre contact patch load.

'Another gain that drivers can typically feel is an increase in control over the car, and a sense that the car settles more quickly after road disturbances or aggressive handling manoeuvres. Because the inerter absorbs energy, and then allows that energy to dissipate back into the suspension system, drivers feel as if the car is more controllable, and they are more comfortable accelerating sooner after the car has been upset by the road surface, or simply by driver inputs. Also, we've been finding that inerters allow a bit less damping to be used as each component assists the other, which may also add grip. And in testing, we've been able to actually increase low-speed compression damping without the normal reduction in grip that is common in that situation, giving the driver even greater confidence, and a feeling of stability similar to our work with regressive dampers.'

MOMENT OF TRUTH

After months of design, re-design, dyno testing and calibration, it was finally time for theory and practicality to come together at the racetrack. Gartner: 'To say I was a bit nervous as I watched the car roll down pit lane trying to discern whether the suspension was actually working is an understatement. We really still didn't know what the driver would feel. After some warm-up laps, and then a good number of impressive hot laps, he was finally into the pit for debriefing. The smile on his face told me right away that we were on to something. He raved about grip levels that he never would have expected on used tyres, and a feeling of control at speed that he had never felt before.

'Professor Smith's analysis had pointed us toward the inertance level that was most likely to provide gains, making our first test extremely successful. We found that increasing the inertance by adding weights increased the positive effects until suspension would simply become too harsh. This threshold was dependent on the type of track being raced, the style of the driver and, of course, the car set up. However, because the weights are easy to change, finding the best set up is easier than one might expect. In addition, because the drivers could actually feel the difference as we made changes, it wasn't like we were working in the dark.'

SIMPLICITY OF USE

Part of the re-design work was to make tuning the units as straightforward as possible. Penske moved the bearings and weights up to the very top of the damper to be accessed via a removable cap. Changing weights is now a simple process of de-pressurising the damper, removing the cap and adding or removing weights. The cap is then re-installed with any captured air simply escaping via a bleed screw,

and the damper is re-pressurised and ready to go again.

Interestingly, Gartner commented that 'the only potential obstacles to successfully introducing this new technology to the racing public are misconceptions about what it is, perceptions of complexity, and the belief that inerters had to be extremely expensive because they are used in F1. The inerter itself is actually simple in its operation and, with the help of our friends at Cambridge, we've been able to arrive at various tests with a great baseline set up right away. So far none of our customers have felt overwhelmed or afraid of the technology. And with the concurrent development of our next generation shock, the 8780, which offers a modular approach that can include the hybrid damper / inerter configuration, customers' costs are also controlled.'

There are rumours in some racing circles that inerters may be banned to keep some well-funded teams from going down the F1 route and making expensive one-off units for their own use. 'At Penske we hope to avoid this dilemma,' continued Gartner, 'by providing Cambridge-licensed inerter technology merged into our standard damper product lines, making it accessible to everyone. When Faraday devised his first useful electrical capacitor years ago, the engineering gods didn't devise rules against its use. The capacitor was a new component that advanced the field of electrical engineering. In much the same way, inerters are a new, innovative component that has been missing from suspension technology until now. By banning inerter technology now that their use has been acknowledged, and the gains are apparent, racing formulae would be shelving a very significant new suspension component that was just yearning to be found.

Fittingly, the last word goes to Professor Smith: 'It has been fascinating to see the inerter develop from a mathematical concept in circuit theory through to actual deployment on racecars. From an early stage Penske Racing Shocks forged a close relationship with the Engineering Department at Cambridge University and played an important role in advancing the technology. Penske's latest hybrid damper / inerter, is a further step to its wider use, and the integration of Penske damping technology with an inerter in a single compact package will no doubt prove to be very attractive to customers.'

A BRIEF REMINDER OF INERTER THEORY

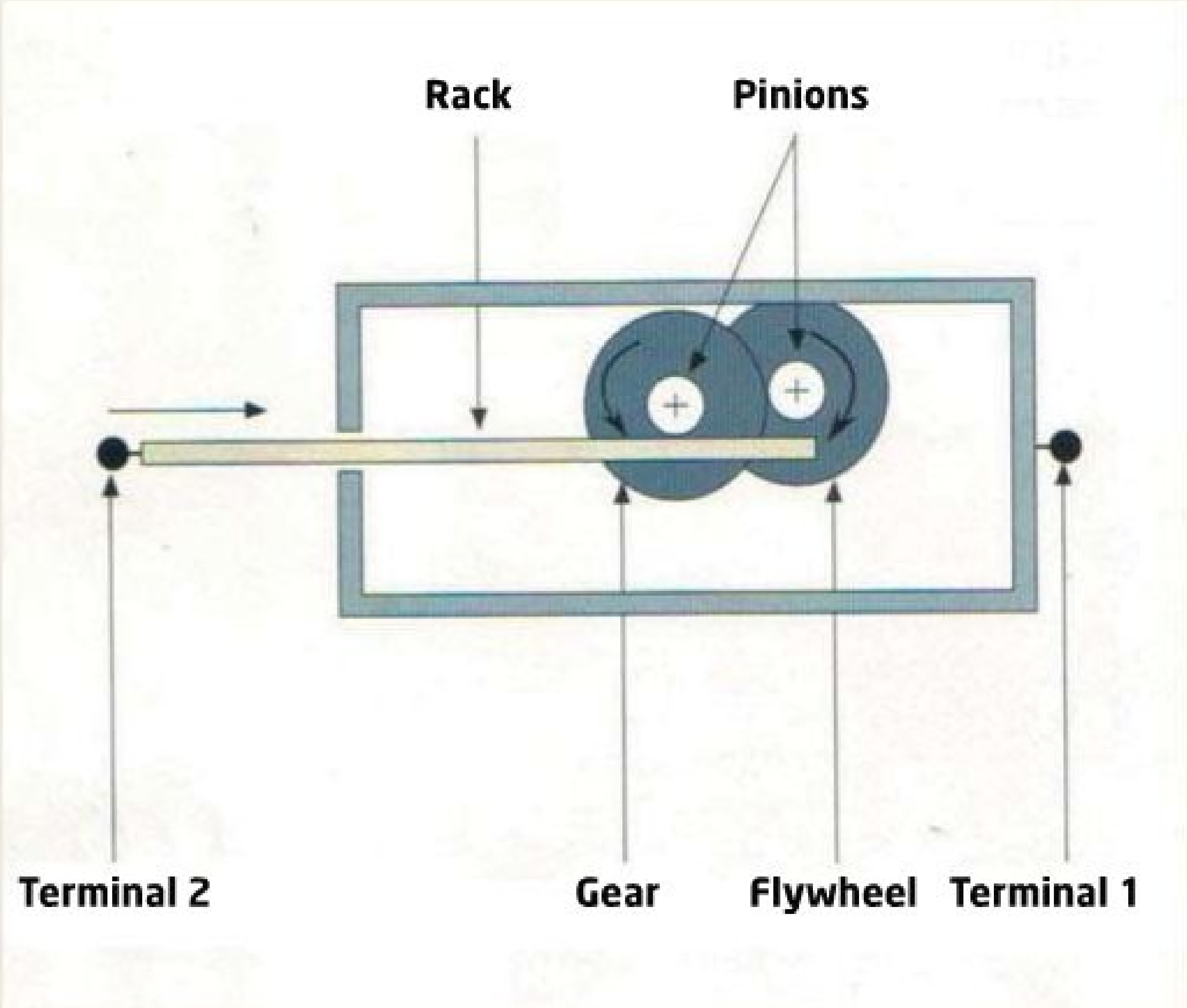
As a professor of control engineering, the inventor of the device (and the word 'inerter'), Malcolm C Smith, was inspired by mechanical analogues to electrical control systems, wherein he related springs and dampers to inductors and resistors, but realised there wasn't a mechanical analogue for the capacitor. What was needed was a new device that had two terminals or attachment points, and which responded with a force that was proportional to the relative acceleration between the two terminals. The inerter is that device. A typical embodiment would see a ball screw and flywheel arrangement, the latter being rotated when there is relative movement between the 'terminals' at either end of the ball screw.

The inerter is therefore an energy storage component, unlike a damper that is an energy dissipater. But, by reacting to acceleration between its terminals, an inerter responds much more rapidly than a velocity-sensitive device like a damper. And by tuning it to operate with the natural frequencies in the tyre and suspension system, load variations at the tyre contact patch can be smoothed out to allow greater mechanical grip to be generated.

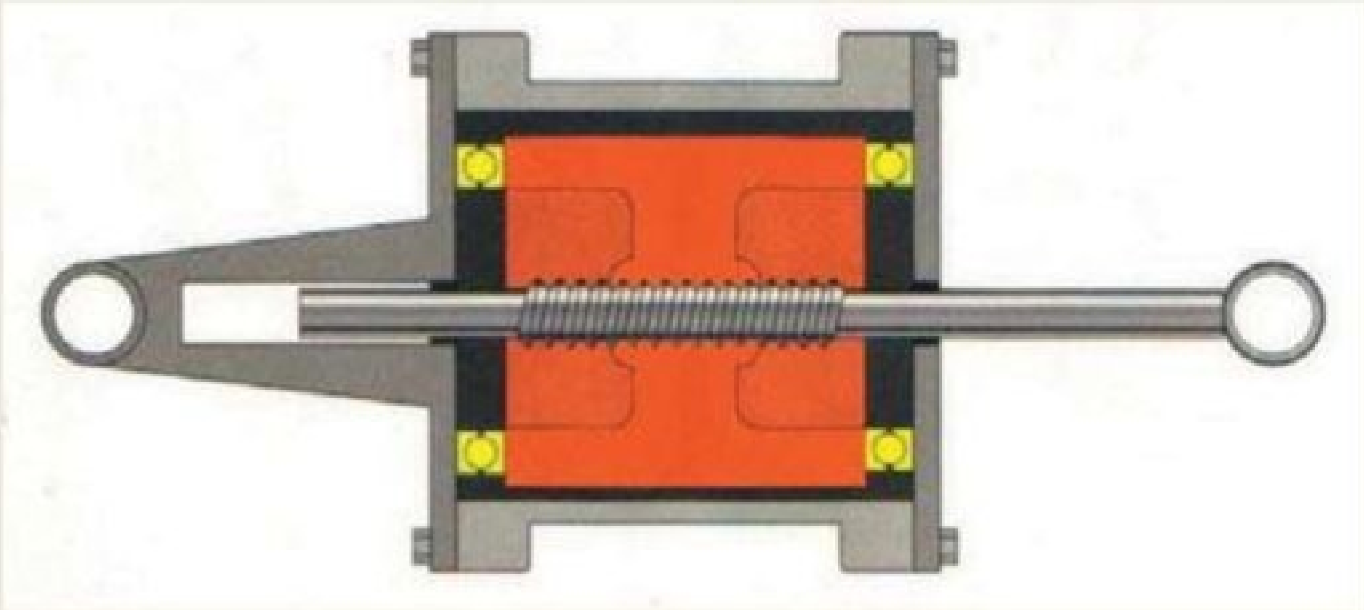
Professor Smith: 'The inerter makes a connection between mechanical design and conceptual modelling, and allows ideas from these two contrasting viewpoints to be combined. Circuit theory can suggest ways of deploying inerters that would not be obvious from a traditional mechanical engineering point of view. On the other hand, intuition from design engineers can merge the inerter into traditional thinking to aid its practical understanding. With racecars, there is naturally a big focus on grip. But the inerter can also be used to optimise other performance measures, such as ride comfort and handling.

How the inerter is used depends in part on the ease with which it can be deployed, hence the advantage of combining the inerter and damper in one single unit.'

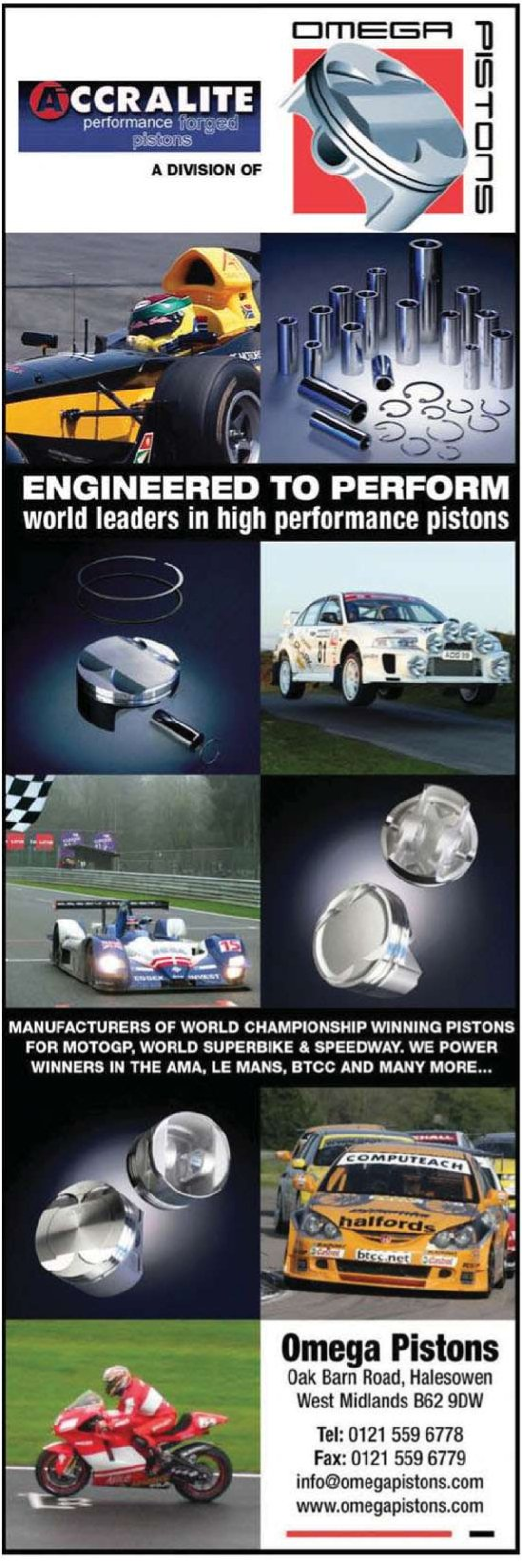
> **[an] inerter is an energy storage component, unlike a damper that is an energy dissipater**



Mechanical interpretation of the principles of the inerter. One terminal is mounted on the casing, the other on a rack that drives a pinion as it moves in and out. The pinion drives a flywheel via a larger gear producing high rotational speeds and capturing large amounts of inertial energy compared to the mass of the whole unit



Cross-section of the j-damper showing the eyes for mounting the casing to one suspension rocker and the threaded rod of the other. The flywheel (red) spins in the bearings (yellow) to absorb and release kinetic energy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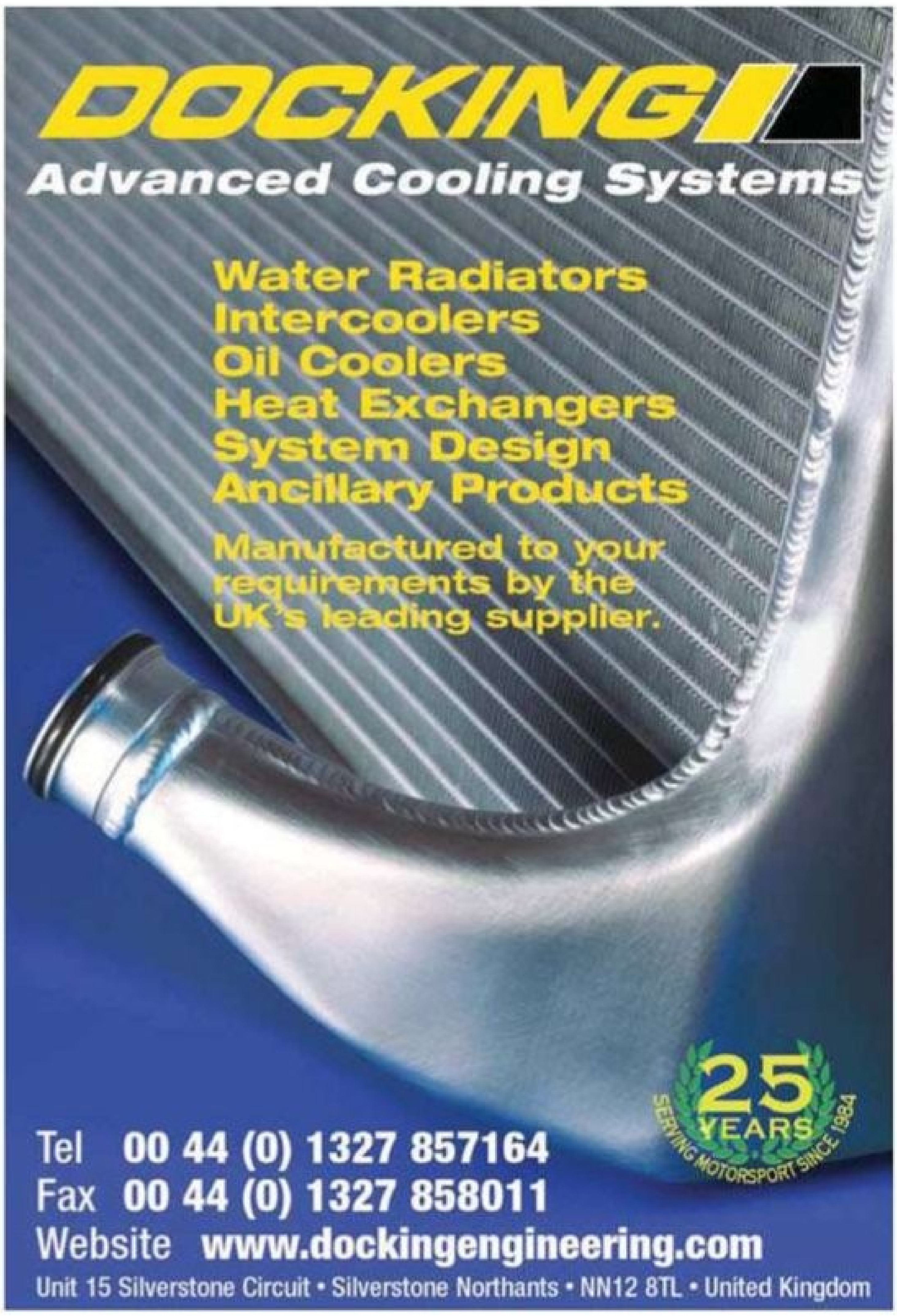
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Looking forward, looking back

Is it time to take another look at active suspension?

BY DANNY NOWLAN

One of the nice things about what I do is the opportunities I am offered to have discussions with people from all walks of life in the motorsport industry. In particular, I recently had a discussion with a colleague of mine involved with the Time Attack category and an ex-Williams F1 aerodynamicist. In the course of that discussion it occurred to me that maybe it is time to re-visit active suspension in motorsport.

For the un-initiated (I realise this may only be about 10 per cent of the readership but bear with me), active suspension started to appear in Formula 1 in the 1980s. By the early 1990s it peaked with cars such as the all-conquering Williams FW-12 and FW-13 that won the F1 World Championship in 1992 and 1993 respectively. So successful was it that the FIA, in its wisdom, decided to ban active suspension for the 1994 season. Ever since then, all of us working in motorsport have been making do with passive suspension systems. On a personal note, I believe this was the most disastrous, knee-jerk decision in the history of motorsport, and I think you'll start to appreciate why as you read this article.

FINE CONTROL

What 'active' brought to the party was it allowed a very fine control of both ride heights and the load distribution as the car cornered. The ride height in particular is of critical importance. To illustrate why, consider the downforce map of a typical F3 car shown in figure 1, overleaf. You can see immediately from this map that the ride height only needs to vary by 15mm and you lose 20 per cent of your downforce. What active offered the race engineer was a very precise way to control this (we'll discuss the significance of load transfer through the corner shortly).

Fast forward to today, and current F1 cars are starting to generate downforce in the same order as the ground effect

days of the early '80s. Now, if you're wondering what this has to with our discussion of active suspension, let's have a look at the numbers, and some typical F1 values are presented in table 1. I don't pretend these numbers are accurate, they are guesstimates at best, and optimistic ones at that, but you'll appreciate their significance as we go on.

For the sake of argument, let's explore the implications of this if the front of the car compresses by, say, 30mm. But let's first calculate the frontal downforce and the combined spring rate that we'll need to make this happen, (see Equation 1).

So, to keep a current F1 car off the deck we need an effective spring rate of 177.2N/mm. To calculate the wheel rate, use Equation 2. From this we know we need a wheel rate of approximately 430N/mm, or 2500lbf/in. This can be mitigated somewhat by using bump rubbers but, by anyone's standards, that's stiff.

Things really start to get interesting though when we look at what proportion of the suspension is being taken by the tyre. Running the numbers on this, we see the results from Equation 3.

What this tells us is that approximately 60 per cent of the movement of the car's body is in the tyre. To illustrate why this is such a telling statistic, let's review the quarter-car model. Looking at the model, the suspension deflection between the body and tyre can be controlled directly with damping rates and spring rates. However, once we have large movements in the tyre we lose direct control over what it is doing. Yes, you can mitigate with wise spring, damper and inerter choices, but at 60 per cent you are in borderline territory.

The other ramification of this is how these high spring rates affect the ability to tune load transfer in the middle of a corner. Recall the equations for simplified load transfer:

rcm = rcf + wdr*(rcr - rcf);

(1)

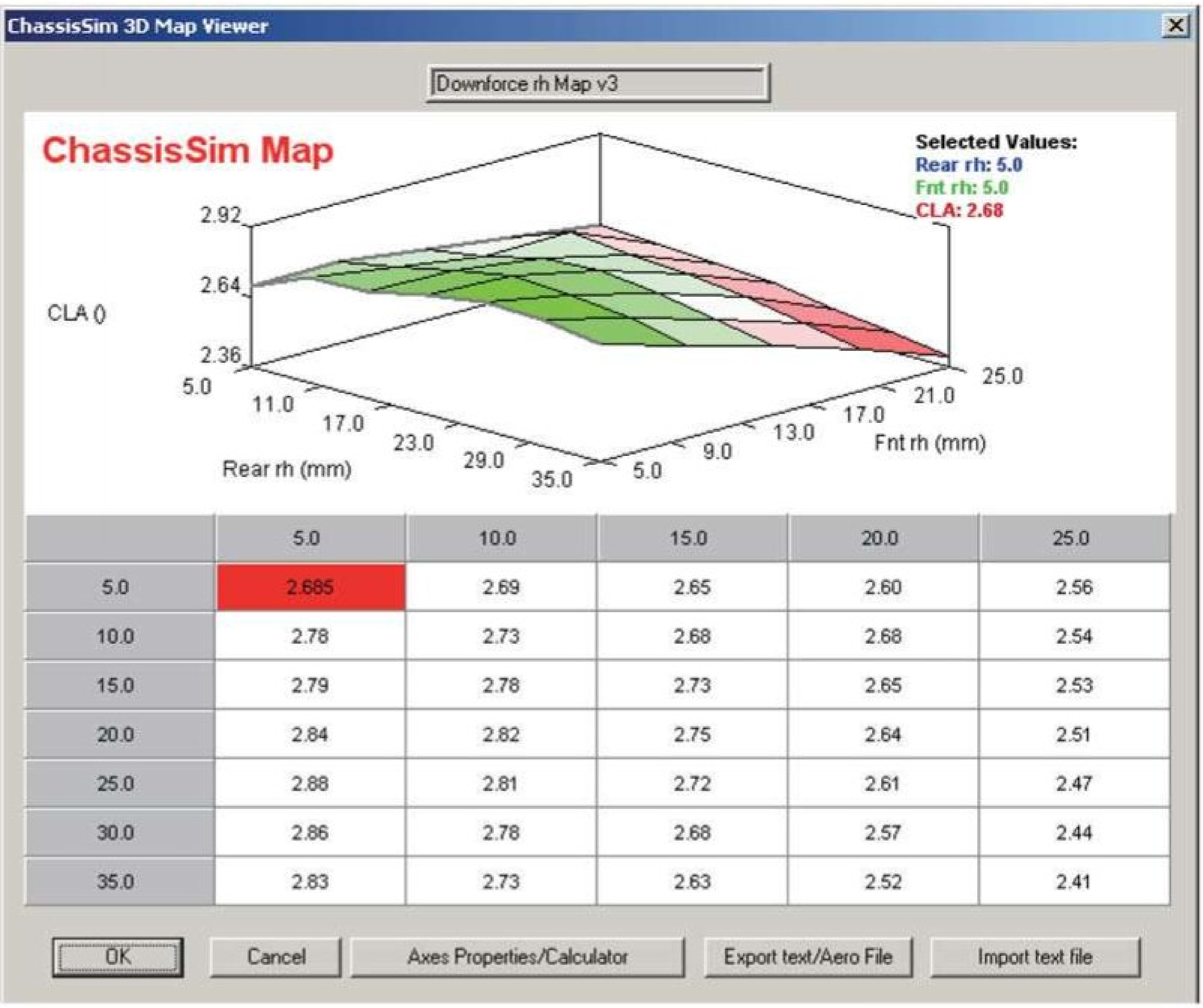
]tm = wdf*tf + (1-wdf)*tr

(2)

h

Table 1: ballpark figures for a current spec F1 car

Parameter	Value
CLA	8
Front ride height / rear ride height	45mm / 65mm
Front weight distribution	45 per cent
Front tyre spring rate	300N/mm
Rear tyre spring rate	300N/mm
Ref speed	250km/h



	5.0	10.0	15.0	20.0	25.0
5.0	2.685	2.69	2.65	2.60	2.56
10.0	2.78	2.73	2.68	2.68	2.54
15.0	2.79	2.78	2.73	2.65	2.53
20.0	2.84	2.82	2.75	2.64	2.51
25.0	2.88	2.81	2.72	2.61	2.47
30.0	2.86	2.78	2.68	2.57	2.44
35.0	2.83	2.73	2.63	2.52	2.41

Figure 1: ride height map of an F3 car. CLA vs front and rear ride height

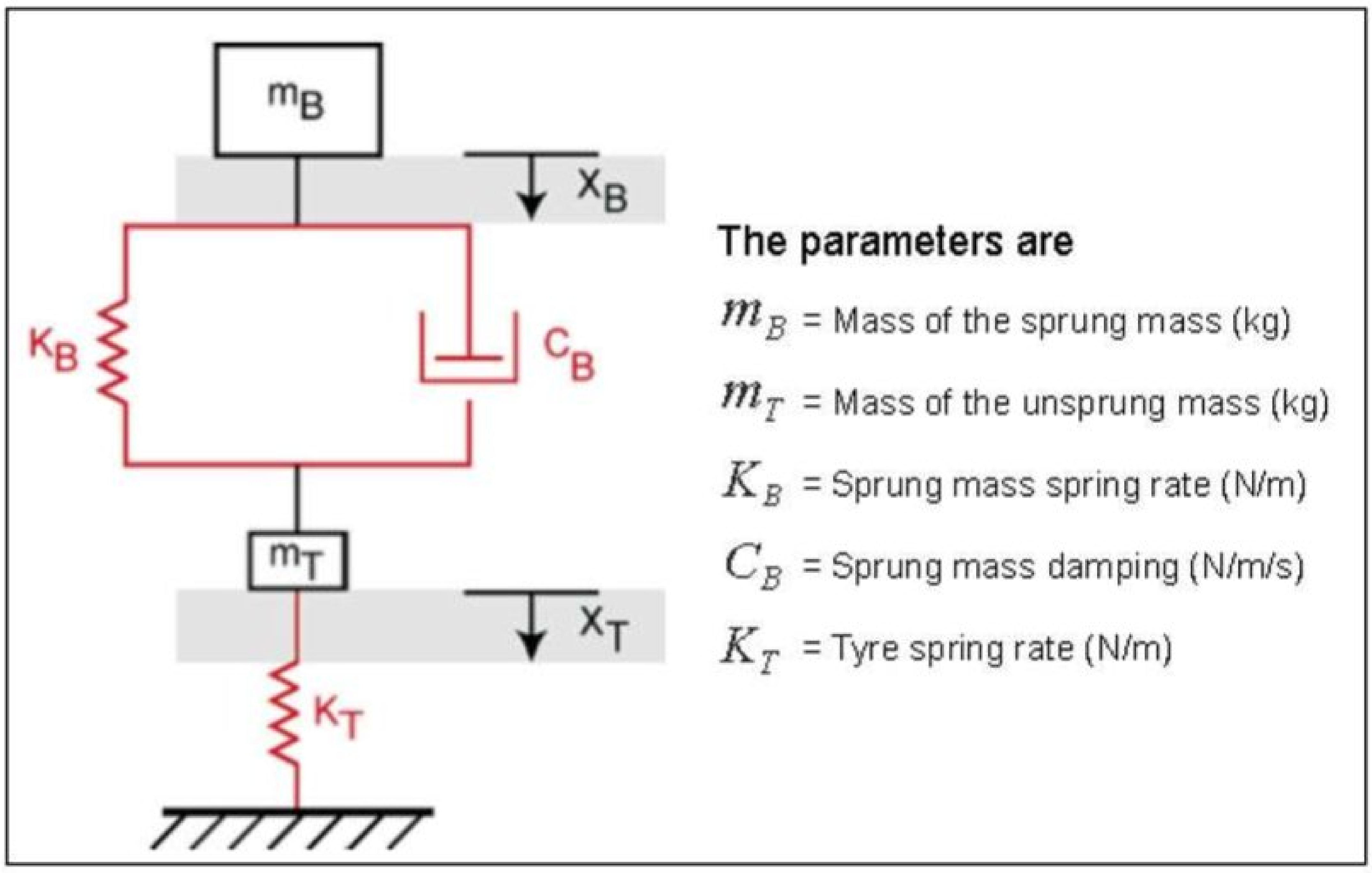
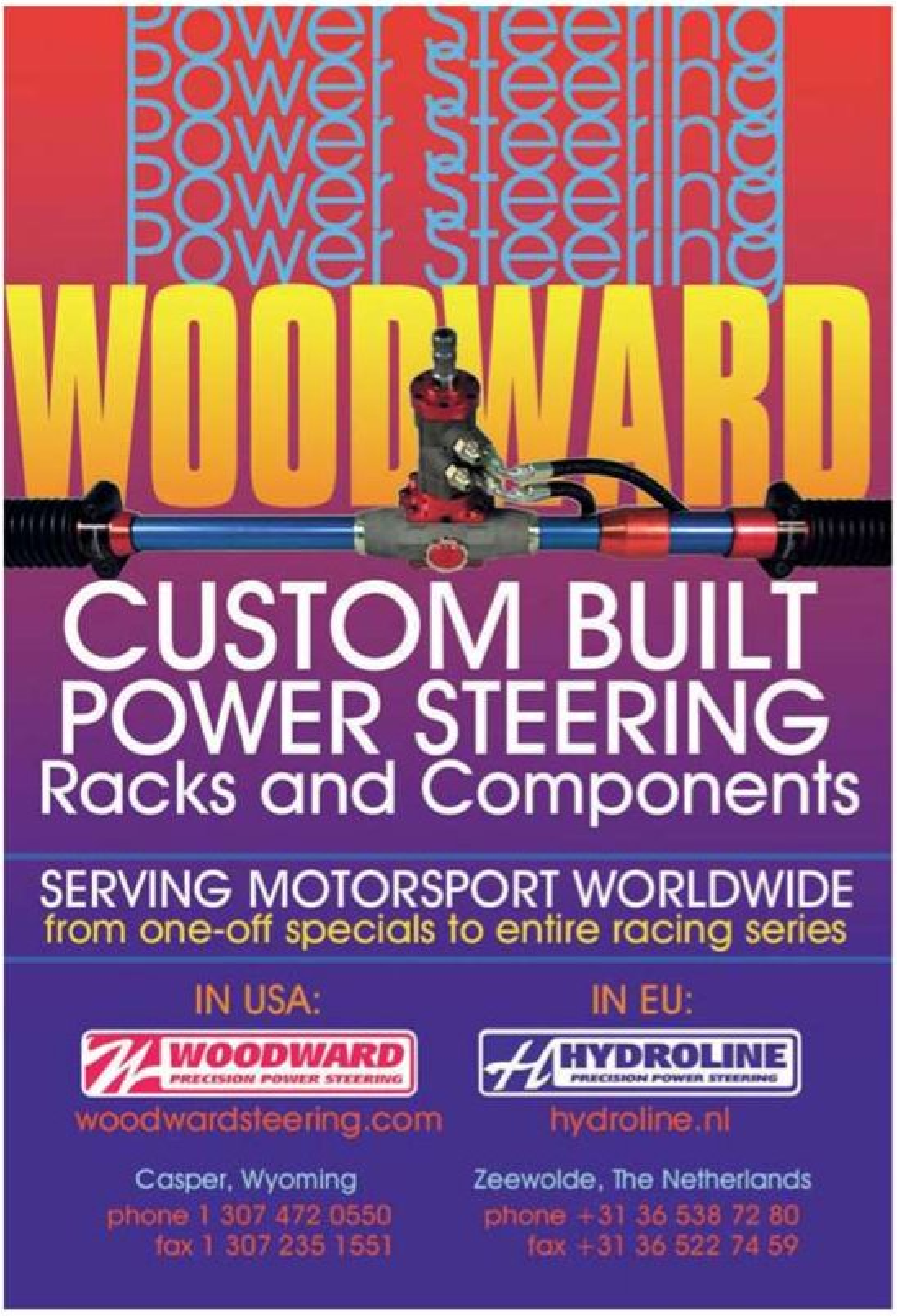


Figure 2: a quarter-car model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EQUATIONS

Equation 1

$$Ft\_Downforce = wdf * C_L A * 0.5 * \rho * V^2$$
$$= 0.45 * 8 * 0.5 * 1.225 * (250/3.6)^2$$
$$= 10633.7N$$
$$k_{EF} = 0.5 * Ft\_Downforce / Ft\_def$$
$$= 0.5 * 10633/(30/1000)$$
$$= 177.2N/mm$$

Equation 2

$$k_S = \frac{k_{EF} \cdot k_t}{k_t - k_{EF}}$$
$$= \frac{177.2 * 300}{300 - 177.2}$$
$$= 432.9N/mm$$

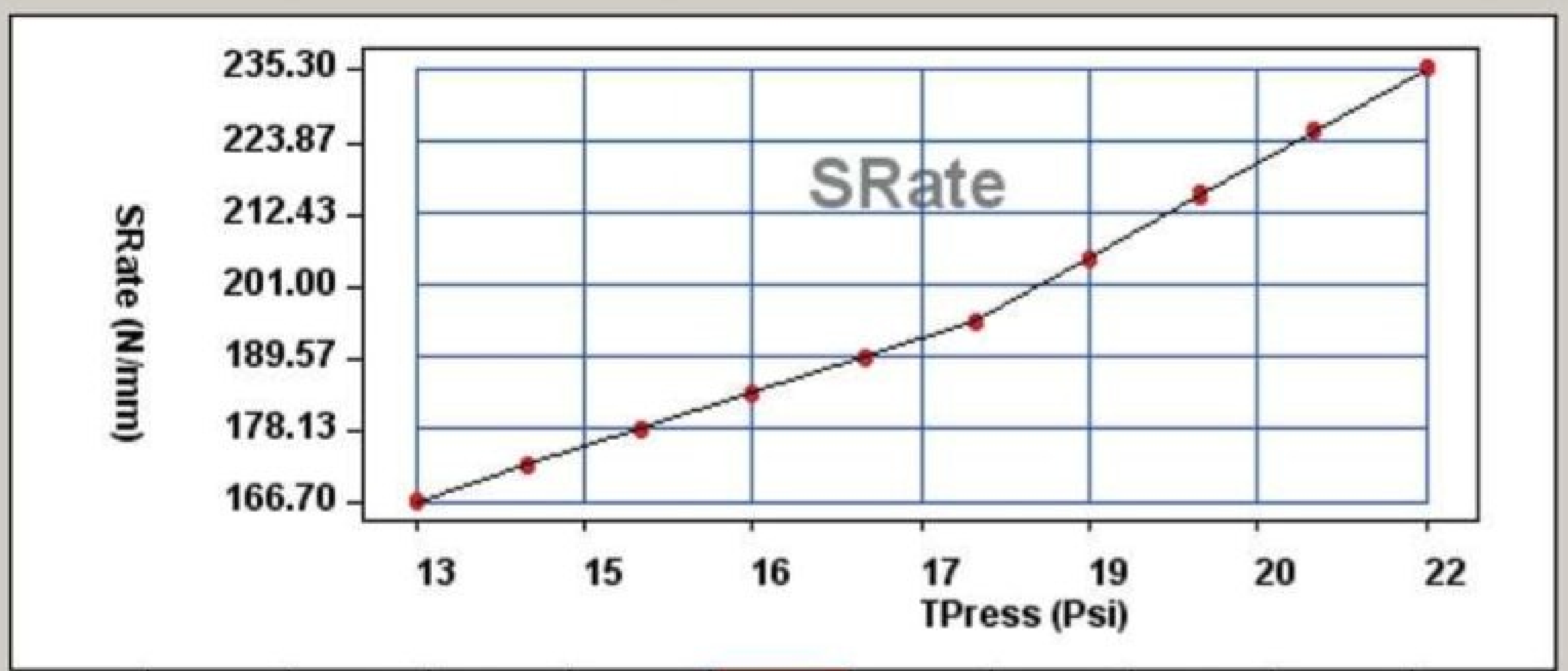
Equation 3

$$\%tyre\_movement = \frac{k_s}{k_s + k_t}$$
$$= \frac{432.9}{300 + 432.9}$$
$$= 59\%$$

Equation 4

$$A_{c.p} = \frac{F_Z}{P_T}$$
$$l_{c.p} = \frac{A_{c.p}}{w_t}$$

where,
Ac.p = contact patch area (m2)
Fz = vertical load on the tyre (N)
wt = width of the tread (m)
lcp = length of the contact patch (m)



TPress	13.05	14.02	14.99	15.95	16.92	17.89	18.86	19.82	20.79	21.76
SRate	166.70	172.38	178.06	183.74	189.42	195.10	205.15	215.20	225.25	235.30

OK Cancel

Figure 3: change in tyre spring rate with air pressure

```
sm = h - rcm;
(3)
rsf = (krbf + kfa)*ktf/( kfa + krbf + ktf);
(4)
rsr = (kfb + krbr)*ktr/(kfb + krbr + ktr);
(5)
prm = tf2*rsf/( tf2*rsr + tr2*rsf);
(6)
prr = (tr/tm)*(wdf*rcf + prm*hsm)/h;
(7)
```

Here the symbols are:
rcm - mean roll centre (m)
rcf - front roll centre height (m)
rcr - rear roll centre height (m)
wdr - weight distribution at the rear of the car
wdf - weight distribution at the front of the car
h - c of g height of the car (m)
rsf - wheel spring rate in roll for the front (N/m)
rsr - wheel spring rate in roll for the rear (N/m)
prm - lateral load transfer of the sprung mass due to forces applied at the mean roll centre (this is determined by the springs and bars)
prr - total lateral load transfer distribution at the front. This includes the effects of the roll centres and the springs and bars
tm - mean track of the vehicle

Looking at equations (1)-(7) you don't have to be a rocket scientist to figure out that if the main spring rates are already large, the anti-roll bar rates you'll need to achieve any desired change will also have to be large (typical high downforce anti-roll bar wheel rates are in the order of 100-1000N/mm). I shudder to think what they are on an F1 car.

What all this means is that a modern F1 car is effectively the ultimate Go Kart on steroids because the tyre is doing so much of the suspension work. Consequently, the tyre spring rates, construction, tyre pressures etc are absolutely critical to getting the set up right. It also implies that tyre pressure adjustments are an absolute go to for a quick mechanical set up change. This arises because tyre spring rates vary with air pressure, as illustrated in figure 3.

However, changes in tyre spring rates also have critical impacts on tyre forces and temperature. To illustrate this, let's consider contact patch length variation as a function of tyre pressure.

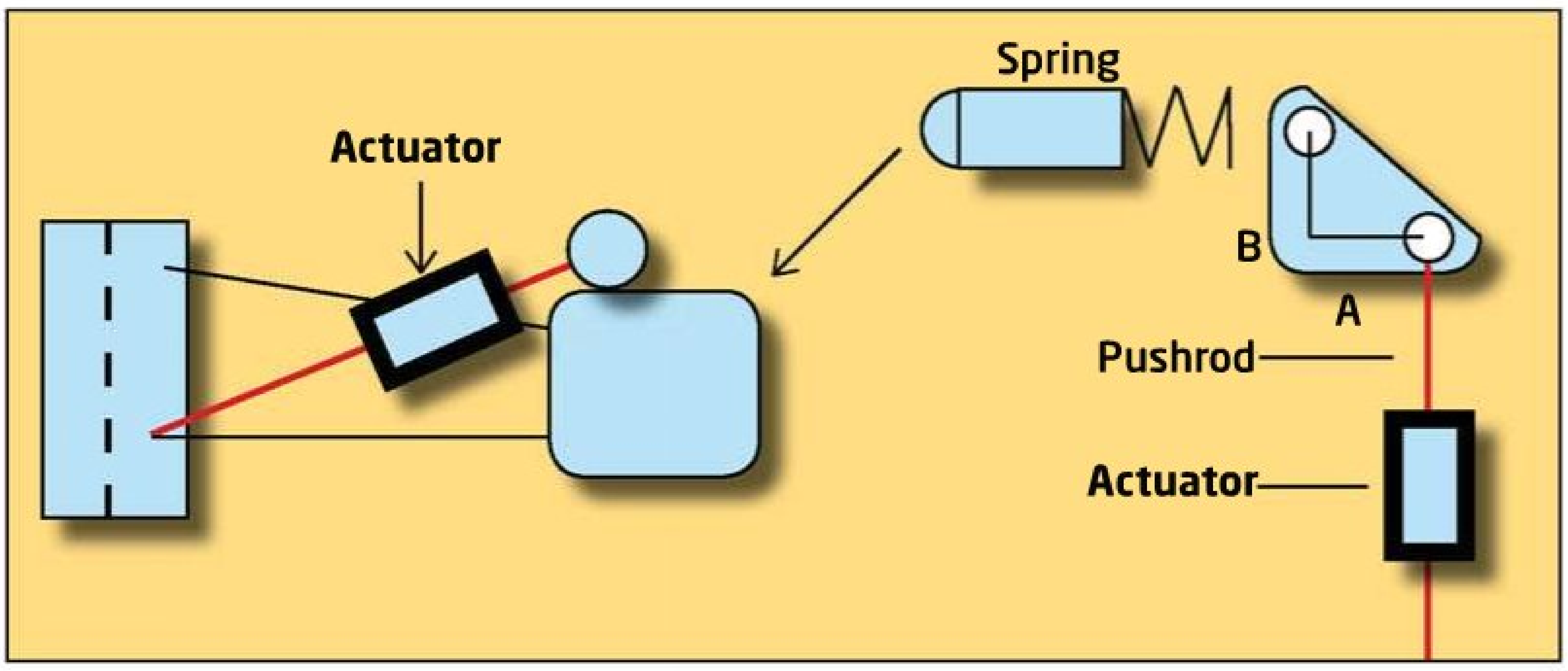


Figure 4: typical active system used in the early '90s

You will no doubt quickly realise the implications of tyre pressure changes on the contact patch length, and what potential effects this has on tyre forces. The other impact tyre pressures have is ultimate tyre temperature. You should by now be starting to appreciate what a minefield this is, and how limiting passive suspension can be.

Furthermore, you will also appreciate this is going to worsen as we add downforce (look at the hand calculations we did earlier). As we add more downforce, the spring rates needed go up and this just adds more deflection on the tyre. In contrast, an active system has at least some hope of keeping up with this, and a schematic of a typical early '90's active system is presented in figure 4, above.

It effectively consisted of an actuator that was tacked on to a passive suspension system. While this isn't perfect (some purists would argue far from it) at least it offered direct control over ride height. Also, by varying the forces in the individual actuators, it was possible to control load transfer distribution precisely throughout the corner. This is absolute gold to a race engineer because it offers you the tools to dial in what's really going on with the car, and a method of fixing it.

THE DRAWBACKS OF ACTIVE

That said, active suspension is not without its drawbacks. In no particular order, these are:

- **The actuation forces you require - particularly as the downforce goes up**
- **Tuning issues to manage tyre warm up and other items of apparel**
- **Reliability of sensors and the appropriate choice of control algorithms**

All of these problems are eminently solvable, of course. And the pay off is greater if you work through these issues. But just imagine the possibilities of being able to dial in load transfer as a function of lateral acceleration, speed and steering, for example.

The primary reason active was banned was because its primary use was to control aerodynamics. As it moved a sprunbg part of the car, it was illegal. It was also expensive, though you can be sure F1 teams will since then have been spending just as much money on non-applicable technology. Today, however,

- **The costs of the sensors has reduced considerably**
- **The processing power of control units has evolved to the point where it is practical**
- **We know a lot more about vehicle dynamics now than we did 20 years ago**
- **Active dampers are now starting to be used in mass production on road cars (eg the MagneRide system developed by Delphi Electronics)**

What has to change is the attitude of some motorsport regulators (not all - I know some are enlightened) who see anything with a circuit board and a computer as the devil incarnate. That preconception is holding the sport, and industry, back.

On the plus side, one series that might see the re-introduction of active suspension is the Time Attack formula.This revolves around taking a standard road car and doing anything you want to it to make it go fast and achieve the fastest lap time around a circuit. While I am unable to give specific details, I know of one project in this arena that will dwarf any current formula in terms of the downforce it produces. When this happens *en masse* it will be a matter of when, not if, active suspension will come back on the radar screen, simply because a passive suspension will not be able to deal with these levels of downforce.

CLOSING THOUGHTS

The numbers clearly indicate that unless serious caps are put on downforce generation, we will arrive at a point where active suspension will *have* to be re-introduced. Let me close with this thought: in 2007 I presented a paper in Stuttgart, Germany that went on to become the basis of my first article for *Racecar Engineering*. I heard all these interesting presentations on active damping and electronic control strategies for road cars, and then something hit me. If you were Toyota, Honda or BMW, why would you pay $500 million a year to run an F1 team and obtain no technical value from it? Three years later, none of those manufacturers were part of Formula One anymore. Racing needs to be relevant.

New age traveller

How Ricardo successfully transferred Formula 1 technology to public transport

BY LAWRENCE BUTCHER

In recent years, those involved in the upper echelons of motorsport, particularly Le Mans and Formula 1, have been at pains to show that racing can still contribute to the advancement of road car technology, while large corporate sponsors and manufacturers with works teams are keen to show that they are 'green', or at least reducing their carbon footprint. Regardless of the politics and spin of the situation (after all, an F1 team's transporters use far more fuel getting to a race than the cars will ever use on track), racing, especially Formula 1, is still viewed by a sector of the public as leading the development of automotive technology. In some areas this is definitely the case – the level of aerodynamic development on a current F1 car, for example, goes way beyond that found in any other automotive sphere. But, and it is a big but, it's not really relevant to road car technology, as it is unlikely that a manufacturer such as Renault will release a version of its Espace model with an exhaust blown diffuser.

The same goes for engine technology. For the power it produces, a Formula 1 engine is exceptionally fuel efficient, but unfortunately the methods used to create these efficiencies are generally at odds with those being adopted by vehicle manufacturers. In fairness to the engineers, regulations and efforts at cost containment often stifle the development of new technologies, with direct injection, variable valve timing and forced induction all currently banned in Formula 1 (although come 2014 this should change).

The result is that many people within the industry claim racing technology has been left behind by the mainstream automotive market, which is certainly true in many areas. Dig below the surface, though, and it becomes clear there are still motorsport companies pushing technological boundaries, with tangible benefits to the wider motoring world. One such operation is Ricardo plc, best known in the racing industry for its transmissions, but with expertise that extends well beyond gearboxes.

THE KINERGY PROJECT

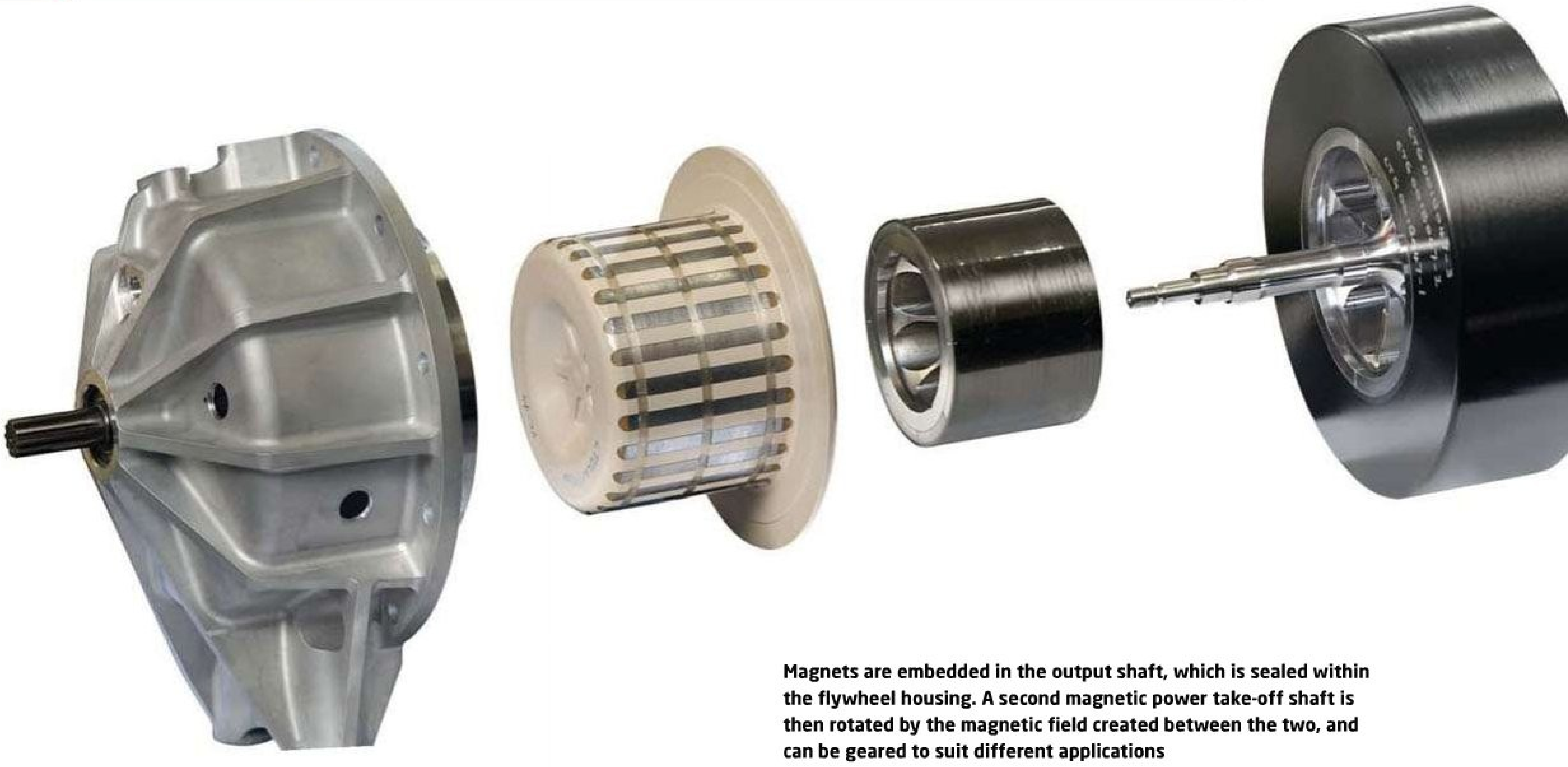
A vast number of the company's projects are not racing specific, but one particular motorsport venture looks set to push forward the development of hybrid vehicle technology.

For many years, Ricardo has produced transmissions for Formula 1 so, when the series first began to look at KERS, the company was in the thick of it. Despite a faltering start in 2009, with most teams choosing not to run their KERS systems due to the weight penalty not being offset by the power available, it marked the beginning of a Ricardo project that would have far broader applications. The company looked at many different methods of storing energy recovered from the drivetrain, including the now familiar battery packs, as well as super capacitors and flywheels.

The system Ricardo settled on was dubbed Kinergy, and consisted of a high speed composite flywheel in a hermetically-sealed housing. At the inception of the project, the

The really clever part of the Ricardo system is the separate output shaft, removing the need for a seal between that and the flywheel

> **"intrinsically different to the other products on the market"**



Magnets are embedded in the output shaft, which is sealed within the flywheel housing. A second magnetic power take-off shaft is then rotated by the magnetic field created between the two, and can be geared to suit different applications

Williams Formula 1 team was also working on a flywheel system, which used the flywheel as a 'battery pack', with the flywheel powering a motor generator unit. Thanks to encouragement from UK Government's Technology Strategy Board, Ricardo and Williams, along with a number of other companies, formed a consortium with a brief to advance the technology and bring it into the wider commercial market. At the time, Ricardo group technology director, Neville Jackson, said: 'The development of highly optimised flywheel-based technology offers the prospect of the effective and low-cost hybridisation of price sensitive vehicle applications with consequent benefits to fuel economy and CO^2 emissions reduction. Ricardo is pleased to be able to lead the KinerStor consortium, which brings together a crucial mass of skills and expertise in this important area of future automotive technology.'

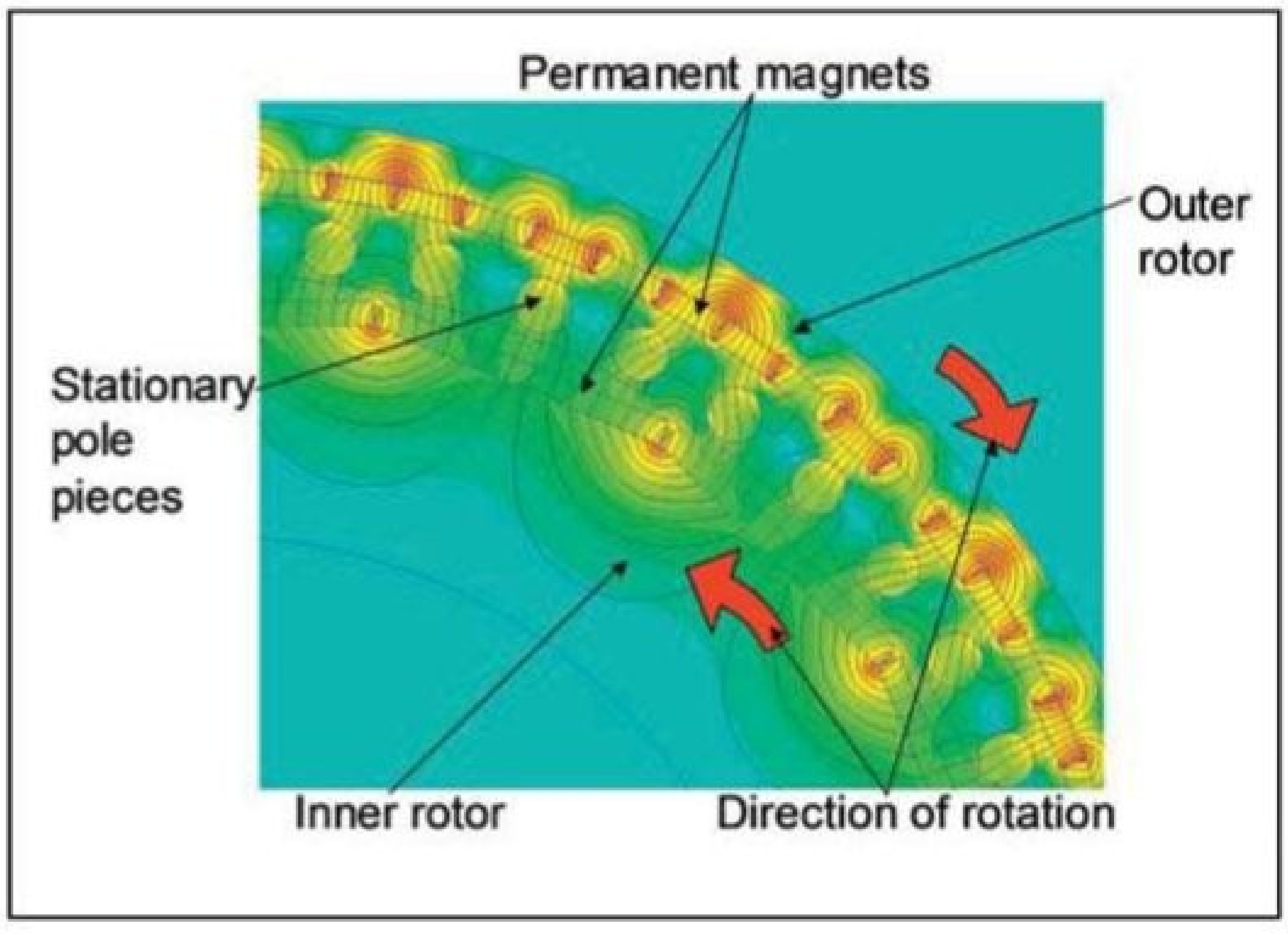
Fast forward a number of years and, despite the fact flywheel hybrids have yet to appear in Formula 1, the wider aims of the project are starting to bear fruit.

Many readers will be familiar with the flywheel hybrids produced by Williams Hybrid Power and British company Flybrid, both of which have already seen competition use – Williams' system in the Porsche 911 GT3 hybrid and Flybrid's in the Hope Racing Le Mans project. Ricardo's system, however, is yet to surface in racing, but is intrinsically different to the other products on the market. Flybrid's system, which has already been covered extensively in *Racecar Engineering*, relies on an output shaft from the flywheel to transmit drive. This creates issues for engineers, notably that in order to achieve sufficient rotational speed (in the region of 60,000rpm) the flywheel housing needs to be hermetically sealed, with the flywheel spinning in a vacuum. If the flywheel was left to spin at normal air pressure, the friction generated would lead to excessively high temperatures and eventual de-lamination of the composites. This makes sealing the output shaft where it exits the vacuum chamber a complex issue, but one that has been overcome in the Flybrid system. Ricardo's solution was more straightforward – remove the output shaft from the equation entirely.

> **"the Kinergy system uses a magnetic gearing and coupling system"**

HOW IT WORKS

Instead, the Kinergy flywheel system uses a magnetic gearing and coupling system, which allows the flywheel housing to be completely sealed. To achieve this, a series of magnets are embedded in the output shaft of the flywheel, which is itself contained within the flywheel housing. Outside the housing sits a second power take-off shaft, which also contains a series of magnets. As the inner shaft rotates, the fields of the two sets of magnets create torque, which causes the power take-off to rotate. Usually this effect could only take place over a distance of less than a millimetre, which would require the flywheel housing to be unfeasibly thin, but the engineers on the project overcame this shortcoming by embedding ferrous pins in the casing itself so the casing wall transmits the magnetic field and the wall effectively disappears, allowing acceptable air gaps to be incorporated within a comfortable



The magnetic field created between the two magnetised shafts creates torque. With no meshing parts, the system is both efficient and robust

Like the other flywheel-based systems on the market, the flywheel itself is contained in a hermetically sealed vacuum and spins at 60,000rpm

The first application of the Kinergy system is in a bus. Combined with Torotrak's CV transmission it offers an efficient, environmentally sound solution in an area where hybrid technology can make a real impact

engineering tolerance. The magnetic drive also removes the need for a reduction gear system to lower the rotational speed of the shaft from 60,000rpm. As the fields of the individual magnets remain distinct from each other, those on the flywheel can be 'meshed' with those on the output shaft, creating a virtual gear ratio. By using a magnet ratio of 10:1 on the output shaft, the speed of the shaft can be reduced to a more useable 6000rpm, with a consequent increase in torque. Additionally, efficiency is extremely high, at more than 99.9 per cent.

The system is robust, too. In the event of a serious torque spike, there are no gears to shear. Instead the magnetic connection will simply slip and can then be quickly re-instated by simply backing off the torque.

As yet, the system has not made it into F1, but the engineering concept is sound and, thanks to the spur of competition, development was undertaken at an accelerated rate. This meant that by the time engineers came to look at the possibility of applications beyond racing, the majority of teething problems had been ironed out. Adaptation of the system for use in other applications was eased thanks to the relatively simple nature of a flywheel as an energy store: they are scalable, modular and have a high power density, meaning they can absorb and release energy very quickly. Unlike battery systems, with their higher energy density but much slower ability to absorb and release it over time, modern flywheel systems are closer to ultra-capacitors in operation, making them ideal for delivering short bursts of power, such as during acceleration. In this way, flywheels can be viewed as a complementary technology to batteries. Equally, when used in a hybrid powertrain, they offer an attractive alternative to ultra-capacitors, out performing them in terms of cost, volume, weight, efficiency and ease of manufacture.

“ efficiency is extremely high, at more than 99.9 per cent ”

PUBLIC TRANSPORT

The new home that Ricardo found for the Kinergy system is about as far from the high-speed world of Formula 1 as it is possible to get – a public transport bus. Working with partner, Torotrak, whose CVT (constantly variable transmission) provided an ideal method of transmitting the drive from the flywheel to the wider drivetrain, Ricardo began work on a scaled-up version of the Kinergy system for mass transport applications. Odd as it may seem, public transport is one of the areas where flywheel hybrid technology can have a real impact on both running costs and environmental impact. John Fuller, product leader for Kinetic Energy Recovery Systems at Torotrak explains: 'The recovery and re-use of kinetic energy during stop-start drive cycles is a priority for bus operators, not just because of the positive impact on emissions but also because it reduces fuel costs and brake wear. Electric hybrid systems are expensive, often doubling the transaction cost of a bus, but initial cost estimates suggest that the Flybus system could be available at a fraction of the cost of an electric hybrid, whilst simulation results indicate fuel savings comfortably in excess of 10 per cent.'

The vehicle chosen for integration with the Ricardo-Torotrak system was the Optare Solo, a UK-produced, medium-sized bus. The idea being that the system could be incorporated into new builds, or be retro fitted to an existing fleet. To this end, the package was designed to fit onto a redundant power take off already incorporated into the Solo's Allison automatic transmission. Extensive simulation undertaken by the design team showed that incorporation into an existing vehicle, even one not originally designed for hybridisation, could provide considerable efficiency gains. 'Simulation work by Torotrak, based on an Optare Solo bus and using the readily available 60kW system with 400kJ of energy storage capacity proposed for this first demonstrator, produced fuel savings of 20 per cent over the official UK bus test cycle,' explains Torotrak engineering director, Roger Stone. 'In this initial project, the CVT and flywheel hybrid system will be applied to the vehicle's driveline through the existing and previously unused power take off facility incorporated within

The Ricardo-Torotrak system is being tested in UK-built Optare Solo buses. The system has been designed for incorporation into new builds or retro-fitting into existing ones and offers significant efficiency gains in both

the standard Allison automatic transmission. Further simulation shows that an optimised system, using a 110kW system with 1MJ energy storage capacity, will produce further significant improvements in fuel savings over the same test cycle.'

TESTING CYCLE

The product is now well into its testing cycle and was unveiled to industry figures at the 2011 Low Carbon Vehicle event at Rockingham, UK. Initial results are encouraging and it is hoped the system will mark the beginning of a new era in efficient mass transport solutions.

> "significant improvements in fuel savings over the same test cycle"

If the Kinergy project proves one thing to those who doubt motorsport's relevance to the wider automotive market it is this: when the rule makers allow it, racing pushes technology development forward at a far higher rate than would usually be the case. This is a view backed up by Jackson: 'I think that technology flow from motorsport to mainstream automotive has provided some important innovations, but the case for this is sometimes overstated, given the differences in mainstream automotive business dynamics and objectives. However, the recent advances in mechanical hybridisation based on high-speed flywheel systems clearly appear to owe much to the FIA's introduction of KERS in Formula 1. This rule change effectively catalysed and focussed research and development in this area. It is very probable that flywheels would have been developed for automotive applications eventually, but the interest from motorsport arguably served to shorten the likely timescales.'

With the introduction of a complete new rule package to Formula 1 in 2014, and the work being undertaken by the ACO to encourage new technology in endurance racing and at Le Mans, hopefully motorsport will once again lead the race in the advancement of mainstream automotive development.

A LIFETIME IN MOTORSPORT

It is not often that you find a motorsport company that has been in existence since man first decided to race automobiles. Beyond manufacturers, the ruthless world of racing makes it challenging for companies to be successful for more than a few years. However, UK-based Ricardo plc is the exception to the rule, being a company that has been successfully involved in motorsport for the past nine decades.

Born in 1885, Harry Ricardo (later Sir Harry Ricardo) was a naturally talented engineer. He designed his first engine at the age of 17 and filed his first patent for an engine in 1906. The company he started, Engine Patents Limited, formed the basis of what is today Ricardo plc.

In 1915, Ricardo set up an engineering company based in the seaside town of Worthing on the south coast of England and found in the British military one of his first customers. Having identified a number of flaws with the Daimler engine used in the first generation of tanks, he designed a new four-stroke engine to meet the war department's requirements.

The 1921 Triumph Ricardo motorcycle represented the company's first foray into racing, but it went on to be involved in the development of racecars such as the Alfa Romeo 162 GP car in the early 1940s. This association with motorsport has continued to this day and still forms a core component of the company's business strategy.

The return of the Lotus Exige

BY SAM COLLINS

When Lotus announced its six 'new era' models at the Paris Motor Show in 2010 it would be polite to say that the response was mixed at best. The new cars were criticised for being too heavy and too tame, and seemed to lack the lightweight, high-performance ethos for which the English car maker was best known. A long running naming dispute with Team Lotus further put people off the brand.

But at the 2011 Frankfurt Motor Show that all changed. With great fanfare, Lotus CEO Dany Bahar, unveiled a new Evora variant, but it was the supporting act that stole the show, when Lotus took the covers off a re-introduced Exige.

Originally conceived in 2004 as a high performance derivative of the Elise, the Lotus Exige has gone on to become a regular sight at amateur races and track days, with variants being built to GT3 and Speed GT regulations. But, more recently, it appeared the car had been dropped from the company line, to the dismay of many.

The new Exige S features Lotus' 'new era' styling and the 3.5-litre Toyota 2GR-FE V6 engine from the Lotus Evora range, now fitted with a Harrop HTV 1320 supercharger, which utilises Eaton's Twin Vortex Series (TVS) technology and helps the V6 kick out 350bhp. This larger powerplant has taken the weight of the Exige S up by a little over 100kg, but increases its already impressive power-to-weight ratio by more than enough to compensate. The end result is a two-wheel drive road car with a better power-to-weight ratio than a modern day World Rally Car.

> **"a two-wheel drive road car with a better power-to-weight ratio than a World Rally Car"**

Of course, Lotus is under no illusion as to where many of these new cars will end up, and consequently it offers the Exige S with an optional race pack. This gives drivers the choice of a fourth mode for the onboard electronic systems. Lotus calls it DPM (Dynamic Performance Management) and it has three settings as standard – Touring, Sport and DPM off. The race pack adds a competition element to

With its dramatic livery and bonnet-mounted spotlights, it's immediately obvious where the English manufacturer wants to take the new Lotus Exige R-GT

TECH SPEC

Lotus Exige S road car

Weight: 1080kg

Chassis: epoxy bonded aluminium alloy extrusion and steel rear subframe

Wheelbase: 2370mm

Dimensions: front - 1453mm; rear - 1499mm; length - 4052mm; width - 1802mm

Engine: mid-mounted, transverse, 3.5-litre, 24-valve V6; Harrop HTV 1320 supercharger; Lotus T6e ECU

Power: 345bhp at 7000rpm

Torque: 400Nm / 295lb.ft at 4500rpm

Transmission: EA60 six-speed transverse manual with open differential

Suspension: unequal length wishbones; Bilstein dampers; Eibach springs, anti-roll bars

Brakes: AP Racing four-piston calipers; 350mm front discs; 332mm rear discs

Tyres: 205/45 x 17 front; 265/45 x 18 rear Pirelli P-Zero

TECH SPEC

Lotus Exige GT-R Rally car

Weight: 1200kg

Chassis: homologated steel rollcage bolted and bonded to aluminium and epoxy bonded chassis

Body modifications: front and rear underbody protection; WRC-style side protection; Lexan windows; roof-mount cockpit air scoop

Engine: 3.5-litre V6; Harrop HTV 1320 supercharger; twin 34mm restrictors

Transmission: six-speed sequential; two homologated final drives; LSD, homologated driveshafts

Suspension: front and rear double wishbones; three-way adjustable dampers

Brakes: upgraded calipers, hydraulic 'fly-off' handbrake; improved air cooling

Wheels: 7 x 17in front; 8 x 18in rear

Tyres: 205/60 x 17 front; 225/65 x 18 rear

this, offering better traction out of corners, different suspension settings and launch control. This will be of particular interest to hillclimbers and those who compete in Solo events. Others will no doubt fit the new Exige S with rollcages (on offer via Lotus Motorsport) and take them racing.

COMPETITION PEDIGREE

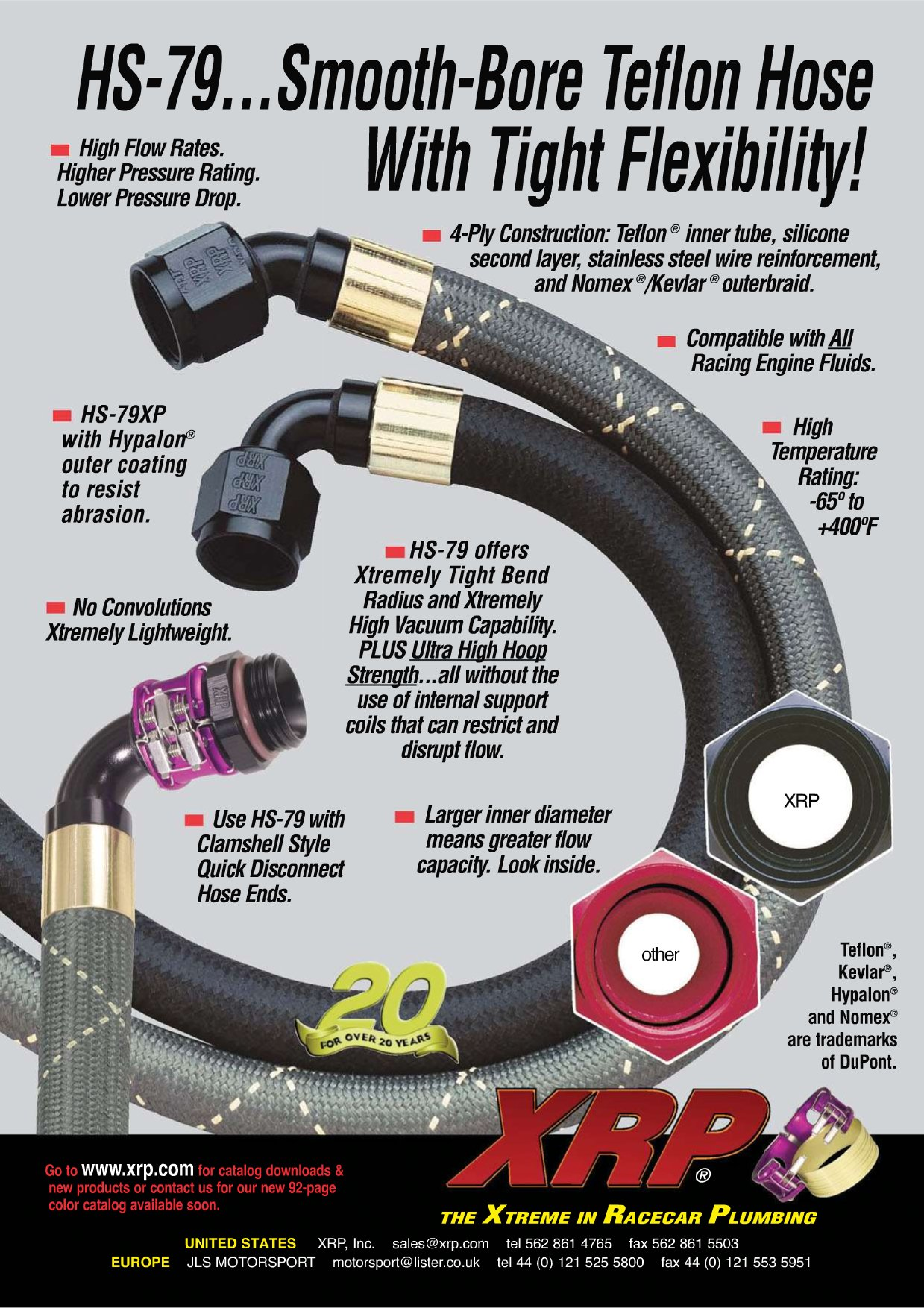
Unsurprisingly, the staff of Lotus Motorsport want to put the new car into competition and the new FIA GT Rally category is where they want to run it. 'My motorsport career started in Rally. In fact, I even took part in the Talbot Sunbeam Lotus' Italian Rally Championship, winning a race in San Marino in 1981, so this is a very nostalgic moment for me,' explained Claudio Berro, head of Lotus Motorsport.

'With the new R-GT rules in Rally, it's a very interesting time for us to return to the sport. Naturally, our approach will be different to when we won the championship with Talbot three decades ago, but I think our philosophy is definitely the same – we want to compete and, ultimately, we want to win.'

The Exige R-GT is the result, and it certainly caught the attention of the assembled press at Frankfurt. Powered by the same 3.5-litre V6 engine as the new roadgoing Exige, significant changes have been made to the gearbox and the restrictors on the engine in order to control the power, which is now down to 302bhp, breathing through twin mandatory 34mm restrictors. The manual gearbox of the Exige S road car has been replaced with a six-speed sequential 'box with a limited slip differential and FIA-homologated halfshafts, while overall weight has been increased to the regulatory minimum of 1200kg.

Developing the race version of the Exige S in parallel with the road car has allowed Lotus' technicians to make rapid advances in terms of safety and reliability. Berro: 'We have learnt a great deal from working with the Evora and creating various race derivatives over the past 18 months, particularly how best to adapt a road car for the track and competitive racing. We were able to put this learning to good use with the Exige [R-GT] project. In my mind, Rally is probably the ultimate motorsport – it combines the excitement of track racing with the specialist skills needed for road racing – [and] we believe it's one of the best ways to demonstrate the capabilities of our products.'

Initially, Lotus will offer the R-GT in asphalt trim, but a gravel spec car will be built in the future. It will make its race debut in the GT class at Rallye Monte Carlo in 2012, with San Remo and the Tour De Corse also on the calendar.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With Tight Flexibility!
High Flow Rates.
Higher Pressure Rating.
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4-Ply Construction: Teflon® inner tube, silicone second layer, stainless steel wire reinforcement, and Nomex®/Kevlar® outerbraid.
Compatible with All Racing Engine Fluids.
HS-79XP with Hypalon® outer coating to resist abrasion.
High Temperature Rating: -65° to +400°F
HS-79 offers Xtremely Tight Bend Radius and Xtremely High Vacuum Capability. PLUS Ultra High Hoop Strength...all without the use of internal support coils that can restrict and disrupt flow.
No Convolutions
Xtremely Lightweight.
Use HS-79 with Clamshell Style Quick Disconnect Hose Ends.
Larger inner diameter means greater flow capacity. Look inside.
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Having signed up to an agreement that will see emissions from production cars dramatically slashed in the next 15 years, the majority of car manufacturers are working on innovative drivetrain solutions, including solar power, hybrid and electric cars. For a while there, it looked as though motorsport was in danger of being left behind, but the electric racecar market has suddenly burst into life. Formula E, Time Attack cars and an assault on the electric lap record at the Nürburgring on the Nordschleife have featured in the news in the last two months.

This month we have taken a good look at the new Formula E regulations, a series that, it is hoped, will speed up the development of electric technology, and the exciting new project from Drayson Racing Technologies.

Danny Nowlan presents a case for the return of active suspension, as used by the Force India team in testing, and which he feels offers a practical production car application. It seemed appropriate in the midst of this technical innovation that we should also feature the Renault R31, possibly the most innovative Formula 1 car on the grid this year. The car has not fulfilled its potential in terms of results but, in terms of showcasing new technology within the tight confines of the regulations, it is a cut above the rest.

The new Formula Ford features the company's latest and most fuel-efficient engine, while the McLaren MP4-12C has the lowest emissions of the current breed of supercar, as the GT World Championship regulations open up to allow it to compete next season.

It is an exciting time in racing, and one that former editor, Graham Jones, would have enjoyed greatly. But early in September, Graham passed away after a long illness. The tributes we have received paint a picture of a well-respected gentleman, who was passionate about his racing and who sought perfection in everything he did. He was a consummate professional in his work, and our sympathies go to his partner, Sheila, and his brother, Trevor.

EDITOR
Andrew Cotton

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FORMULA 1

Red Bull scoops works team status

Dominant F1 team to have input into V6 design

After producing one of the best F1 chassis over the past two seasons, Red Bull Racing will go into future years with even greater technical potential, following a tie-up with Renault that effectively makes Red Bull its works team.

It's believed the new deal, which was signed in mid-September, means the Red Bull team is now obtaining its engines for free. But perhaps more importantly it will also be able to have a major influence on the design of the 1.6-litre V6 turbocharged engine under development at Renault for 2014, with Red Bull chief technical officer, Adrian Newey, now having greater input into the packaging.

Renault said: 'Within the new agreement, a technical joint venture will be set up, in which Red Bull Technology and Renaultsport F1 will collaborate to develop innovative technical solutions for the V6-based power unit that will be introduced from 2014. Red Bull Technology and Renaultsport F1 will contribute their respective know how, experience and specialist personnel to the project to achieve a competitive and reliable powertrain to be used by Red Bull Racing and other customer teams.'

The deal is for five years, and Bernard Rey, president of Renaultsport F1, believes this will give the partnership the stability it will need to succeed: 'We are delighted that the Red Bull Racing-Renault partnership has been extended for a further five years, which will take us to a decade of collaboration [for the past five years Renault has been the Red Bull engine supplier]. Red Bull Racing and Renault share the view that stability is a fundamental condition to perform at the top levels of competition. As well as being a unique opportunity to showcase the performance of the Renault engines at the highest possible level, it is also a fantastic arena to develop the technology and expertise within the Renault-Nissan Alliance.'

Red Bull could also benefit from the KERS expertise of Renault group partner, Nissan (its Infiniti prestige brand is already a Red Bull sponsor), particularly in the area of battery cooling, the Achilles heel on the current RB7.

THE NAME GAME

One curious by-product of the deal is that the team once owned by Renault and which is still known as Renault, is no longer its primary team and, at the time of writing, did not even have an engine deal with Renaultsport F1 in place for 2014.

It is now widely expected that the Renault team, which is sponsored by Group Lotus, will be known as Lotus next season, following a thaw in the long-running legal spat between Renault and Team Lotus on the use of the illustrious name. Reports suggest that the naming row could be resolved by the end of the year, with Team Lotus probably changing its name to Caterham. Tony Fernandes, the boss of Team Lotus, owns the sports car operation and its name already adorns the Lotus racecars, while his GP2 outfit races under the name Caterham Team AirAsia.

That said, it's no easy task for a team to change name in F1, and there are possible complications with the TV monies in particular, so it should be no surprise to see a works Renault Red Bull racing against a Renault Lotus, and a Lotus Renault in 2012.

GT RACING

World GT opts for GT3 spec for 2012

GT3 cars are to form the basis of the revamped FIA GT World Championship for next year, although current GT1 cars will still be allowed to race as long as their performance is equalised.

It had been previously announced that the 2012 championship would involve a performance-balancing formula, allowing GT3, GT2/GTE and GT1 cars to compete. Following a series of meetings with the governing body and team representatives, however, series promoter Stephane Ratel has agreed with the FIA that the championship should adopt uprated GT3 cars as the main category.

From 2013, every GT World car on the grid will be built to GT3 spec

Ratel cited the current economic situation as a major driver in the decision: 'In light of the current economic climate, this GT World specification is the correct solution to secure the future of the FIA GT1 World Championship.'

World championship GT3 cars are to be uprated, while performance-balanced GT1 cars will also be allowed to compete, but only for 2012. There is, however, no place for GT2 / GTE cars in the new World GT vision because, according to SRO, every manufacturer currently in GTE also makes a GT3 model. GT World cars will have carbon brakes, no ABS and 'GT1 noise levels', says SRO.

The main reason for the change is to help attain SRO's ultimate goal of attracting 10 two-car teams, each of which will represent a different manufacturer. By embracing GT3, it has now opened itself up to a number of high profile new cars, such as the McLaren MP4-12C, as well as offerings from BMW, Ford, Mercedes, Audi, Lamborghini, Nissan and Ferrari.

'The meetings have been extremely encouraging, and today we have a clear goal of what we can achieve in 2012,' Ratel said. 'Using regulations adapted from the ultra-successful GT3 category is the correct way to go. It has been agreed with the teams and manufacturers that rather than bringing GT3 cars up to GT1 levels of performance, we will adopt a GT World level, to which the current GT1 cars will adhere, reducing development costs significantly.

'GT3 is the most successful GT category in the world and almost all of the major manufacturers are building cars to these specifications. Using the FIA Balance of Performance, current GT1 cars would be able to race with performance restrictions to bring them into line with the 2012 GT World specification.

'2012 will be a transition year, with the current GT1 cars able to compete alongside the new cars. But in 2013, every car on the grid will be a GT World car, which will reflect the growing demand for GT3 cars in national and international motorsport around the world.'

The 2012 GT World entry announced at Spa in July featured existing GT1 teams All-Inkl Munnich, Marc VDS, Young Driver, JRM and Belgian Racing, plus GT3 squads Vita4one and WRT.

NASCAR

It takes two to tandem...

NASCAR has taken action it hopes will limit the tandem racing that has been a mark of Sprint Cup races at restrictor plate tracks this season.

Tandem racing, where cars have been shown to be quicker running in close proximity, has been a feature of superspeedway events this season, thanks to better track surfaces and the frontal aerodynamics of the current Cup car.

NASCAR initially moved to stamp it out in the run up to the Daytona 500 early in the year, mainly by limiting the grille opening to reduce the cooling effect, thereby hampering cars running in the draft of other cars for long periods. However, this has not been particularly successful.

Now the governing body has decided to allow the cars an extra 7-10bhp when they race at Talladega on October 23, in the hope that this extra power will in some way reduce the reliance on two-car drafting. The power hike is available thanks to bigger openings in the restrictor plates.

NASCAR has also tinkered with the cooling system again, with the relief valve recalibrated to reduce pressure by around 8lb/in^2, which should stop the engines running on the very limit of their temperature ranges. The aim of this move is to force the following car out of the draft more often to prevent it overheating.

NASCAR vice president of competition, Robin Pemberton, said the decision to open up the restrictors came after pressure from drivers: 'After the last few superspeedway races, we've heard many drivers express their desire to open up the size of the restrictor plate some and we thought the time was right to do that. We anticipate these revisions in the rules package for Talladega will help continue to provide competitive and exciting racing for the fans.'

However, it remains to be seen how effective these measures will prove to be. Some drivers have already pointed out that a 10bhp power hike in a 410bhp car might not make much of a difference. Also, previous attempts to restrict cooling were easily countered by drivers, who were able to adapt their drafting technique to cool the cars, while the fact that the race takes place in the autumn also means cooling isn't quite as vital as it was when the Cup last ran at superspeedways in the summer.

Officials at Talladega were happy with the tweaks, though. 'We applaud NASCAR's efforts to continuously monitor the competition at Talladega Superspeedway and be willing to make changes when necessary,' Talladega chairman, Grant Lynch, said. 'Being open to suggestions that improve our sport is beneficial to everyone involved.'

More power and cooling tweaks aim to reduce the advantage gained by drafting

BRIEFLY

Tester zone

Limited in-season Formula 1 testing is to return next year after the teams agreed to drop one of the pre-season tests and replace it with a four-day test at Mugello in early May. This will come just after the first four flyaway races and before the main European season rounds. It will be the first time the F1 teams have run a test during the season since Mugello and Jerez in 2008. Teams will also be allowed to conduct up to eight straight-line test days and eight filming days – the latter of which are run to a 100km maximum. The full test schedule for 2012 is: Jerez (February 7-9), Barcelona (February 21-24 and March 1-4) and Mugello (May 1-4).

New Generation

Honda works outfit, Team Dynamics, is to build an all-new BTCC car to the NGTC (Next Generation Touring Car) regulations for 2012. The car will be based on the new Honda Civic, launched at the Frankfurt Motor Show in September. The team is the first manufacturer-backed outfit to commit to the NGTC rules, which have been introduced this season. Meanwhile, BTCC outfit Triple 8 Engineering has also announced it is to build an NGTC car next year, although it has not yet said what car it will be based on.

FORMULA 1

FOTA prepares to fight for greater share of F1

In what might be seen as a statement of intent, FOTA has hired top corporate financial advisers, DC Advisory Partners, to help in future negotiations for greater control of the sport and a bigger share of F1's income.

Currently, F1 is split three ways between venture capitalist CVC (represented by Bernie Ecclestone's Formula One Management), the FIA and the teams. But FOTA (the Formula One Team's Association), which represents the interests of the teams, has long maintained that more of the profit should be ploughed back into the sport.

At present the teams take 50 per cent of the sport's revenues, with the rest going to CVC, but it's believed FOTA is pushing for up to 75 per cent when the current Concorde Agreement comes to an end next year.

Speaking in the *Independent*, McLaren F1 boss and FOTA chairman, Martin Whitmarsh, said: 'Formula 1 is owned by venture capitalists and one would suspect that they can't hold the sport in their funds *ad infinitum*.'

In a possibly related move, FOTA has also announced the appointment of Oliver Weingarten as its new secretary general. Weingarten comes to FOTA from the Premier League, where he was the in-house lawyer.

Whitmarsh said: 'I'm delighted to welcome Oliver to FOTA, where his experience... together with his commercial, legal and public policy expertise, will be extremely valuable.

'The next few years will be a crucial time for the sport of Formula 1, and, working in close collaboration with the FIA and FOM, FOTA will play a very important role in shaping the future of our great sport.'

Meanwhile, it has emerged that Formula 1's income should not be hit by the much publicised cancelation of this year's Bahrain GP because, remarkably, the race organisers still paid the fee for staging the race, said to be around £25m.

• MORE NEWS ONLINE AT WWW. RACECAR-ENGINEERING.COM

DRIVETRAIN

COSWORTH IN A CRATE

Renowned engine manufacturer, Cosworth, is continuing its long association with the Blue Oval, thanks to a new range of crate Duratec engines. The engines are suitable for a range of applications up to and including all out race and rally cars. Cosworth start with all the individual parts direct from Ford, add their own tuning components such as forged pistons and connecting rods, high performance bearings, cams, modified cylinder heads, barrel throttles and air filters. Engines are available as short or long blocks in 2.0 and 2.3-litre capacities and states of tune from 205bhp (standard was 145bhp) to 280bhp (or 300bhp on some specially built race engines). A number of options can also be included, such as dry sumps and roller barrel throttle bodies. Cosworth Duratec crate engines start at £5499 ($8550), but each one is built to order and price will be according to spec.
For further information visit www.cosworth.com

HARDWARE

GT-K TURBOS

Forced induction specialist, Owen Developments, is now able to supply the new Turbonetics GT-K range of turbochargers. The units cover power outputs ranging from 350bhp to over 1000bhp, with A/R ratios from 0.48 to 0.96. All are compatible with a Garrett T3 or T4 mounting flange so will suit many popular vehicle platforms and are suitable for street, strip and circuit use. Equipped with the company's latest HP compressor wheels and F1 turbine wheels, the GT-K turbos are designed to optimise efficiency at high boost pressures and capture the maximum exhaust gas energy to produce unrivalled performance. The inlets feature machined slots, designed to limit the effects of surge and flow in large volumes of air at high boost pressures, while still delivering a cool, efficient intake charge. Known as 'map enhancement porting' this feature allows the GT-K's compressor wheel to operate at maximum efficiency across a broad rpm range, and combined with ceramic bearings provides excellent response during spool up and transient throttle periods.
For further information visit www.owendevelopments.co.uk

MEASUREMENT

HANDY PROBE

3D measurement specialist, Creaform, recently unveiled its new HandyProbe arm-free CMM system. The system features the company's TRUaccuracy technology, which generates accurate measurements down to 22μm (0.001in). The compact and sturdy device has shed 0.5kg over its predecessor, weighing in at just 450g, and is capable of measuring up to 30 points per second.

Its highly portable nature makes it ideal for tasks such as reverse engineering components outside of a factory environment, allowing rapid development of CAD models.
For more information visit www.creaform3d.com

ANCILLARIES

TIME FOR TS

UK-based hose and plumbing specialist, Viper Performance, has launched a new range of alloy T-pieces for coolant or induction applications.

The components are made from 6063 T6 aerospace grade aluminium so can be welded easily if required. The main pipes are 100mm (4in) long and have a wall thickness of 5mm, with CNC machined and TIG-welded take offs. Additionally, the fixtures feature bevelled ends for secure hose clamping, with various diameters from 38-76mm available for main pipes and 16-25mm for the take off.
For more information visit www.viperperformance.co.uk

cruden

We don’t need to tell motorsport professionals that simulators can help racing drivers learn new tracks...

...but did you know that the latest **generation simulators from Cruden** can be used to evaluate new components and race set-ups?

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The rivals

Putting two teams of designers on the same project in one team produced some friendly competition, and this season's most innovative F1 car

BY SAM COLLINS

Adrian Newey is known for taking a good look at the designs of rival teams, so it is interesting to note that he cites the Renault R31 as the most interesting grand prix car of 2011. The car is the 30th to be constructed by the team now known as Lotus Renault Grand Prix (LRGP), but which in the past has been known as Toleman and Benetton.

The team is in something of a new era. Backing from the French car manufacturer has been reduced substantially and the team is owned now by Genii Capital. Eric Boullier, the man in charge, offered the engineers a new challenge with the R31: 'I gave the engineers *carte blanche* to be innovative and to come up with some crazy ideas. I though the time was right,' reveals Boullier. 'And it worked very well. The concept we had was funny because we have a way where we develop the car in two different teams and it created a competition between them. It was funny to see how competitive they became.'

The result, though, was a car which had been re-thought and re-designed in every area, but with a simple underlying approach, as laid down by Boullier himself: to do better, to make a lighter, more rigid car, to find more speed and to be more inventive.

At the launch of the R31 in Valencia, most people admired the retro Gold Leaf-inspired livery (a reference to the title sponsor), and looked over what seemed to be a conventional Formula 1 car. But, as people started to pour over the detail images, something unusual became apparent – it had no exhausts!

SOMETHING STRANGE

'At the launch we had a good laugh as we had this idea that we did not want to show it to the press straight away, we wanted them to find it for themselves. We knew there was a media leak about something strange on the car so we designed some special covers so when the car was unveiled nobody could see the exhausts,' laughs the Frenchman.

What they came up with was a rear bodywork section that was continuous, aside from the exit duct for the gearbox oil cooler. The exhaust exits instead were to be found at the front of the sidepods, just below the radiator ducts, something that shocked the whole paddock. Renault technical director, James Allison, alluded to the benefits of the layout during the launch: 'It represents our attempt to extract the absolute maximum aerodynamic performance from the regulations, which have changed quite significantly for this year, and to further develop the concept of using the exhausts to blow the floor.'

What Allison was doing was using the hot exhaust gasses to drive underbody aerodynamics in a more extreme way than any other team in the paddock. It meant that the Renault engineers had to route the exhaust pipes forward, rather than rearward, from the conventionally located engine and exhaust manifold, along the side of the tub and out through the sidepod. It is clearly something

“ an attempt to extract the absolute maximum aerodynamic performance from the regulations ”

of a thermal management nightmare, and the pictures here show just how complex the layout is, with the tailpipe wrapping around the lower impact structure of the monococque.

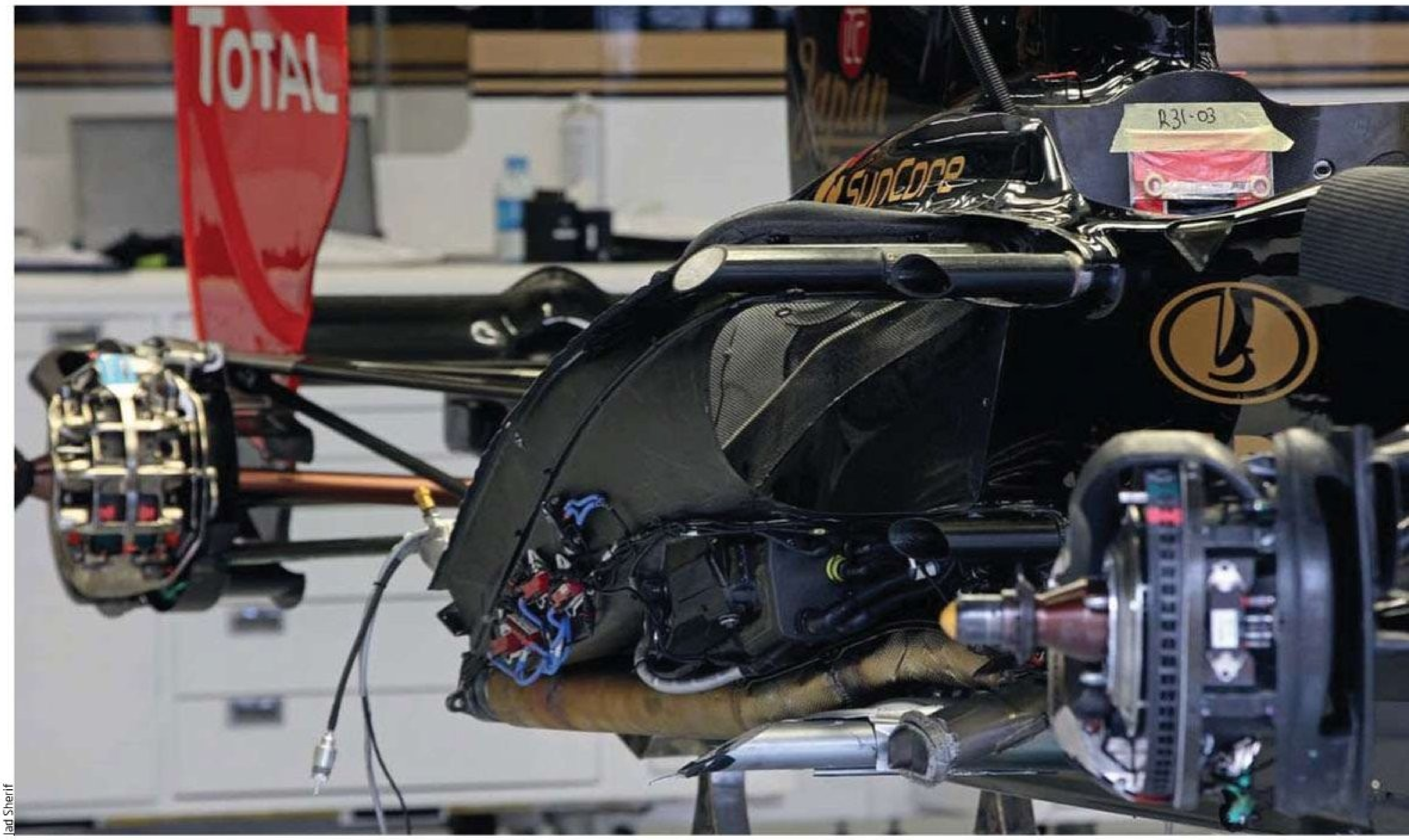
'I remember when James first came to me and proposed the front exhausts and I just looked at him and said 'why?' He took a piece of paper, sketched the basic layout and explained it to me,' recalls Boullier. 'I said to him, 'well, let's go first to the wind tunnel and, if it works like it's supposed to and it looks promising, go ahead.' I'm not entirely sure whose idea it was in the first place but I pay tribute to that person. It works very well. Actually, to be honest, it works brilliantly.'

TORQUE SWITCH

The exhaust layout took advantage of one of the characteristics of the Renault RS27 V8 engine, which is thought to be the best in grand prix racing for off-throttle blowing. At its most basic level, this allows the engine to run at 100 per cent throttle 100 per cent of the time, with the drivers' pedal acting as a torque switch. The reality, of course, is far more complicated, as Rob White, Renault Sport F1's head of engine operations, reveals: 'Independent of exhaust blowing, matching the torque delivered by the engine to the torque required by the driver and accepted by the car is a big juggling act for many reasons. The type of engines we have are quite tricky to control – an engine that will pull cleanly from 3000rpm to 18,000rpm is hard to do without spitting, backfiring, popping and farting. They do need to be in that range too, as the hairpin at Monaco is a bit over 4000rpm.

'The precision with which we need to deliver the torque required by the driver is extremely fine, and the precision with which the torque needs to be delivered to deal with the miracle of choreography that is the seamless gearshift, is a big ask. But getting the engine torque to respond in milliseconds in order to satisfy both requirements really is a tall order.

'Opening the throttle a long way and firing a small number of cylinders is widespread road car practice. Cylinder disabling is very common too, and overall it's more efficient to use the small number of cylinders with the throttle wide open than all of the cylinders with the throttle almost closed. It is this phenomenon that has been exploited because one can use the energy in the exhaust stream exiting the tailpipe as a kind of fluid amplifier to generate downforce. The exhaust blowing strategies are a further use of something that exists for other reasons, and with all of these things there are trade offs. For example, it takes less fuel to use four cylinders instead of eight cylinders but, because you have the number of cylinders coming back again you have a driveability trade off. Plus there is the risk of a hesitation as the other cylinders come back or drop out that some drivers don't like. If our mapping is not absolutely spot on, it will not be acceptable to the driver, and mapping activity is an integral part of the track support we give to LRGP.'



Jad Sherif

The radical exhaust system on the R31 works its way forward from the engine bay, under the radiator housing, though the sidepod and exits just forward of the lower impact structure, visible here in silver (the exhaust outlet is the duller pipe with the D-shaped exit). The exhaust layout could not be fully simulated in the wind tunnel, particularly at low speeds, and that hurt the R31, but it came into its own at higher speeds

One of the key challenges of the new exhaust system was cooling, but the team was determined to find workable solutions. It was not all plain sailing. Two major fires caused by issues related to the exhaust concept caused substantial damage, the second instigated by a driver over revving the car during a pit stop, leading to a nitrogen bottle exploding in spectacular fashion at the Hungarian Grand Prix. But changes were made to the car (and the driver line up) to prevent that issue re-occurring.

FIA INVESTIGATION

The biggest challenge facing the team, though, was when the concept was banned mid-season. Being such an integral part of the car's design, dropping the forward exhausts would be no simple task. 'When we heard in Monaco that the FIA was investigating the system, and that they were very serious about the hot blowing being banned,' says Boullier. 'We were a little bit nervous because our whole concept was based on hot blowing,' reveals Boullier. 'So we had to dedicate some resources to rear-facing exhausts because we believed our solution would be banned. During those weeks we didn't develop much on the forward exhausts, but then we found out it wasn't going to be banned after all, so we had to switch back all our efforts onto the original concept. It was lucky that they were not banned as we were not convinced that we could manage the rearward exhaust properly. It would have been a disaster for us if it had been banned, but we still probably lost six weeks of development time due to that.'

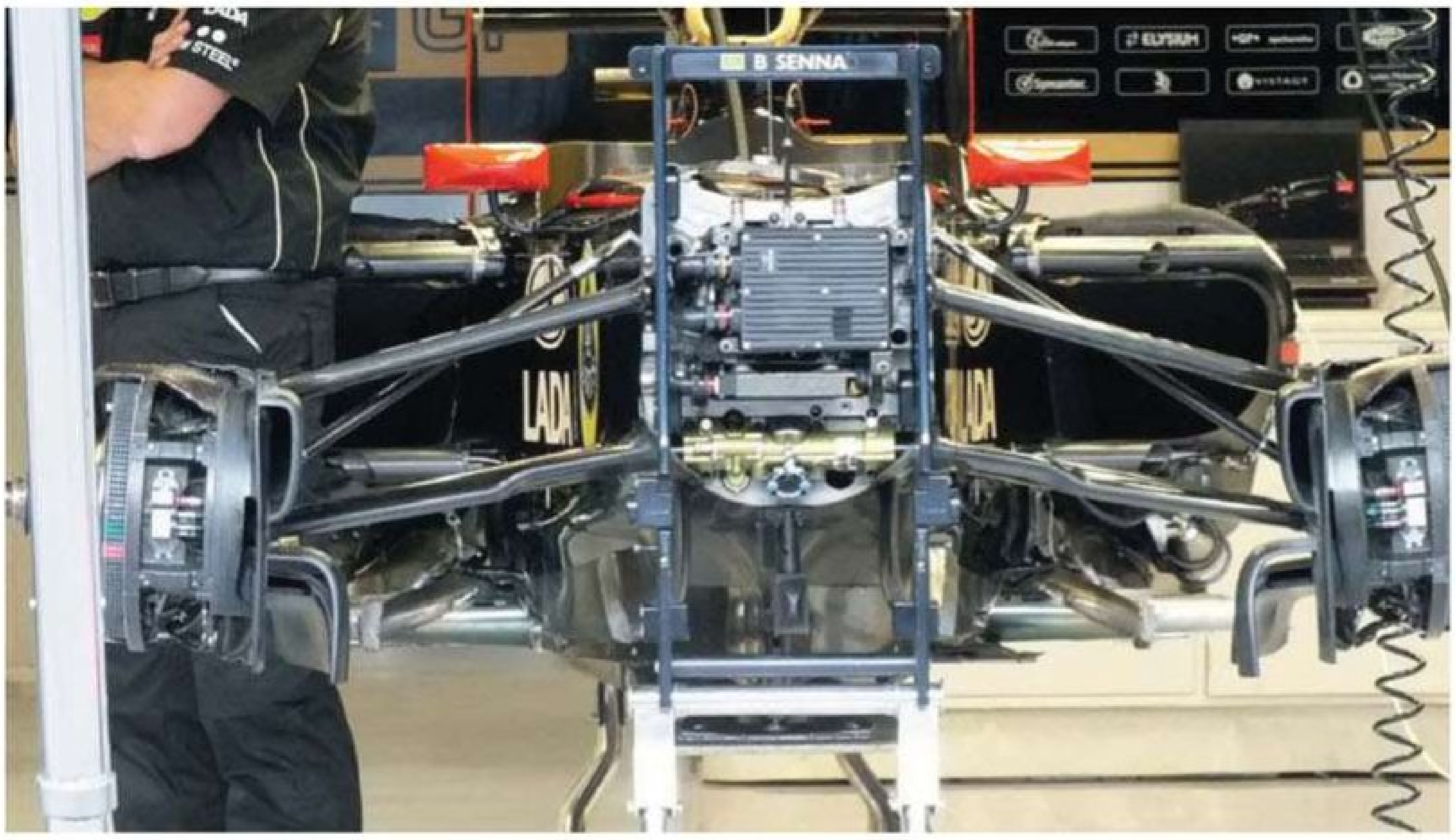
> Boullier's mantra of 'be daring, try to innovate, take risks'

The rest of the R31 did indeed follow Boullier's mantra of 'be daring, try to innovate, take risks'. 'Words like 'aggressive' and 'innovative' are very much *en vogue* in Formula 1 at the moment, but where the R31 is concerned we feel that those adjectives are appropriate. It's true to say that the car has been designed in an ambitious manner, and a quick glance at the layout will confirm that its entire concept differs considerably, not just from last year's car, but from any car this team has ever produced,' says Allison, with a hint of pride. 'It is very difficult to compare the R31 to the R30 in any meaningful way. 2011 is a different year with a new set of regulations and that's why the R31 is a very different car. For example, KERS came back this year and the car concept was completely re-engineered to accommodate that system in an efficient way. We set out to try and conceive a car that wasn't just smaller, lighter, stiffer etc, but one built to what are quite a different set of regulations this year. That was going to give us the best chance to jump up the grid. The guys up top said they were okay with us taking some risks, and to have a go at something that was different that will hopefully bring us an advantage. The risk is that the layout of a Formula 1 car has been settled for some while, and it's quite tricky to package all of the stuff you need into the space that is available. You make much of a change to that and you are in virgin territory, where you find out as you go along what happens. We have gone with a layout that is different - different to last year, different to any year I can remember.

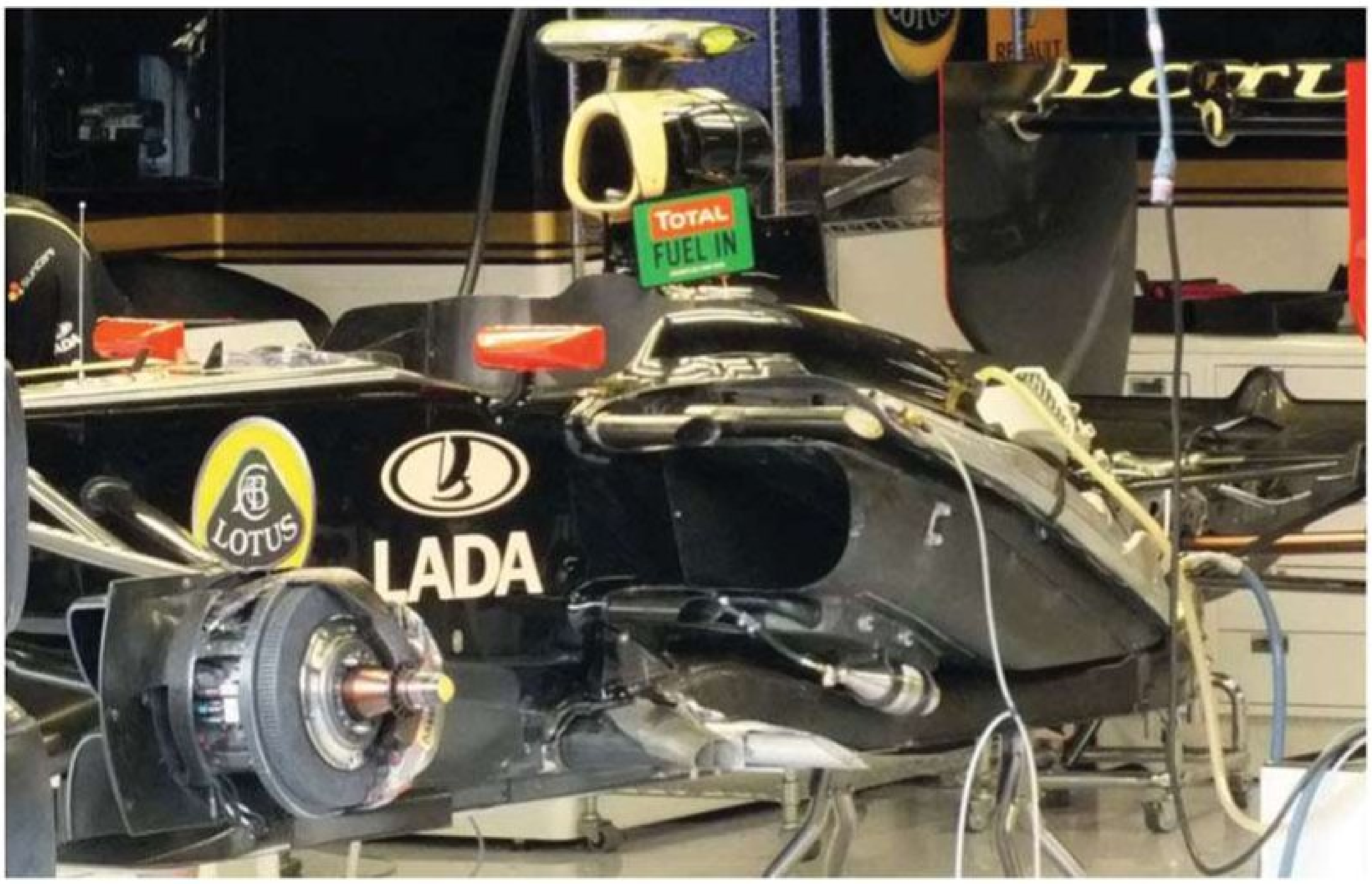
INTEGRATING KERS

'The only real difficulty with KERS was that although we ran it in 2009, we didn't have a great experience doing so. You had to be mindful, though, that the rules are now very different. There were a number of things that make KERS a more attractive proposition than it was in '09, so it was relatively easy to decide that we needed to have KERS

Jad Sherif



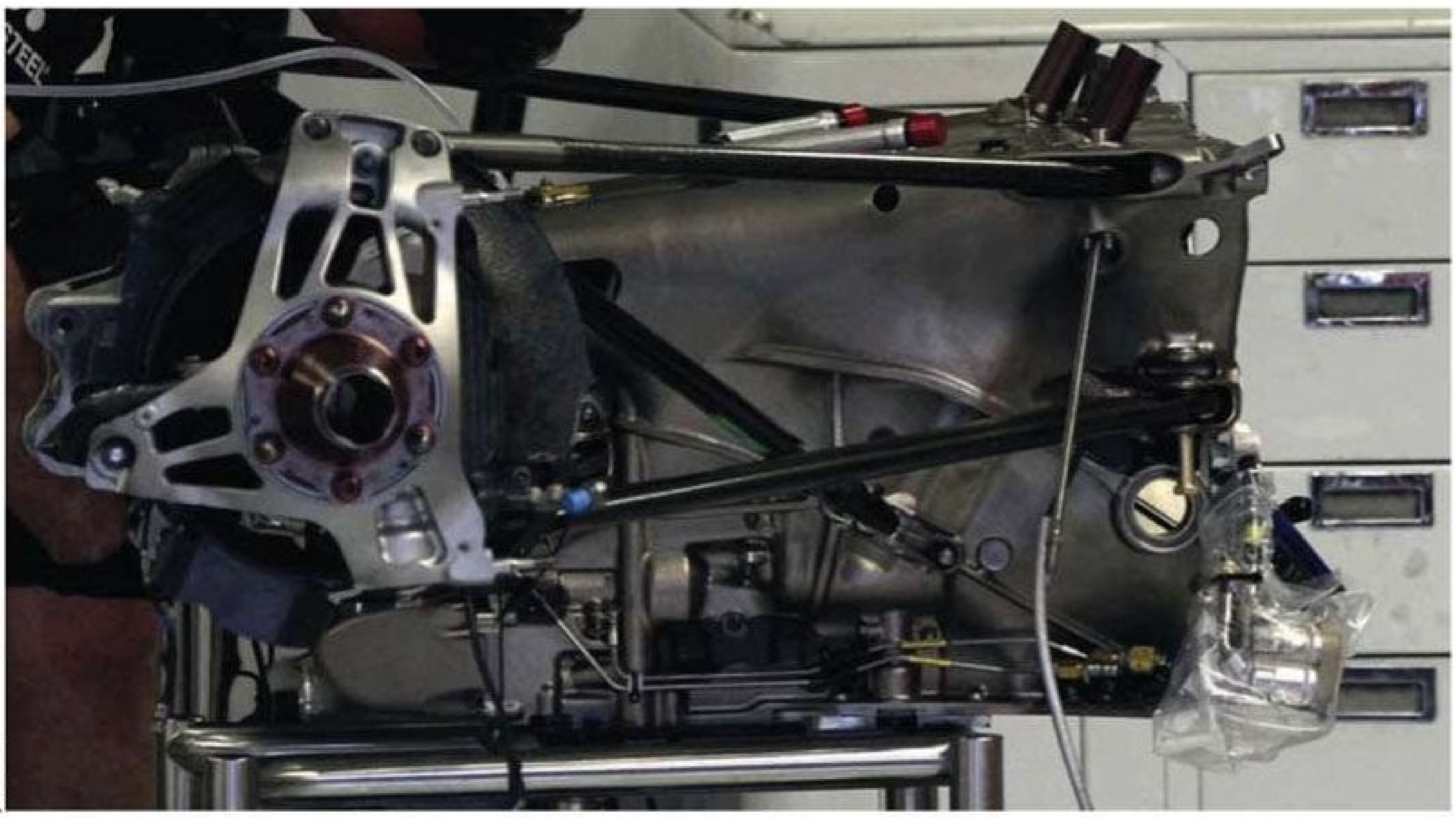
LAT



Top: experiments with a conventional exhaust showed that it produced more downforce at the rear, particularly with the high rear ride heights used at slow circuits like Singapore. At low speeds the R31 was found to be very sensitive to geometry changes – another factor in the team's poor form at some tracks

Middle: the front suspension and bulkhead is fairly conventional, with the McLaren ECU mounted at the front of the chassis

Bottom: after the Hungarian explosion, the composite nitrogen bottle was replaced with the metal unit seen here in place at Monza



Jad Sherif

For the R31, LRGP adopted a pull rod rear suspension layout, although James Allison claims that in aerodynamic terms there is not much to choose between this concept and a more conventional push rod set up

Jean-Francois Galeron

In Montreal the car was tested with this ultra swoopy rear wing in an attempt to reduce drag. It is identical in concept to a similar wing trialled, but not raced, on the R30 of 2010. This is one of the very few carry-over items

as part of the car. We needed to make a better job of it than the first time round, though, and make it have less impact on the car as a whole in packaging terms. And make it much, much lighter.'

The R31 KERS is based on the Magneti Marelli system, which debuted in 2009 and was used by Toyota, Red Bull and Ferrari, and the KCU and battery cells are located in the fuel cell area.

The rear of the car was one area where the changes were instantly noticed at the car's launch, and not just the missing tailpipes. The R31 also had a different suspension concept. 'We chose to change the layout of our rear suspension by opting for a pull-rod system for the first time in decades,' Allison continues. 'And, as I said before, anyone can see that the treatment we have given to some specific areas is completely new compared with anything we have done previously. All of those things are aimed at trying to maximise the R31 under the 2011 rules.

REAR SUSPENSION

'There is a lot of discussion over the rear suspension. It's not surprising really, as the fastest car of last year, the Red Bull RB6, had a pull rod, so I would imagine every team in the pit lane would have seriously evaluated the idea. Eventually, we came to the conclusion that in aero terms there wasn't a lot in it.'

Like all the 2011 F1 cars, weight distribution is largely fixed by the regulations, with only a tiny amount of scope for adjustment, but this was not something that worried Allison's team too much: 'It removed one of the main degrees of freedom the engineer has in his set-up arsenal, but it applies to everybody equally, so it just means you have to fall back on the other tools available. I don't think it is much of an issue, after all it is not the only thing that will impact the balance of the car. The challenge for us as teams is that aside from the one per cent of the weight distribution we can move around, we use all the other degrees of freedom on the car to get the most out of it.'

TECH SPEC

Lotus Renault GP R31

Chassis
Moulded carbon fibre and aluminium honeycomb composite monocoque, manufactured by Lotus Renault GP. RS27-2011 V8 engine installed as a fully stressed member

Front suspension
Carbon fibre top and bottom wishbones operate an inboard rocker via a pushrod system. This is connected to a torsion bar and damper units that are mounted inside the front of the monocoque; aluminium uprights and OZ magnesium wheels

Rear suspension
Carbon fibre top and bottom wishbones with pull rod-operated torsion springs and transverse-mounted damper units located in the top of the gearbox casing; aluminium uprights and OZ magnesium wheels

Transmission
Seven-speed, semi-automatic titanium gearbox with reverse gear; 'Quickshift' system to maximise speed of gearshifts

Fuel system
Kevlar-reinforced rubber fuel cell by ATL

Cooling system
Separate oil and water radiators located in the car's sidepods, cooled using airflow from the car's forward motion

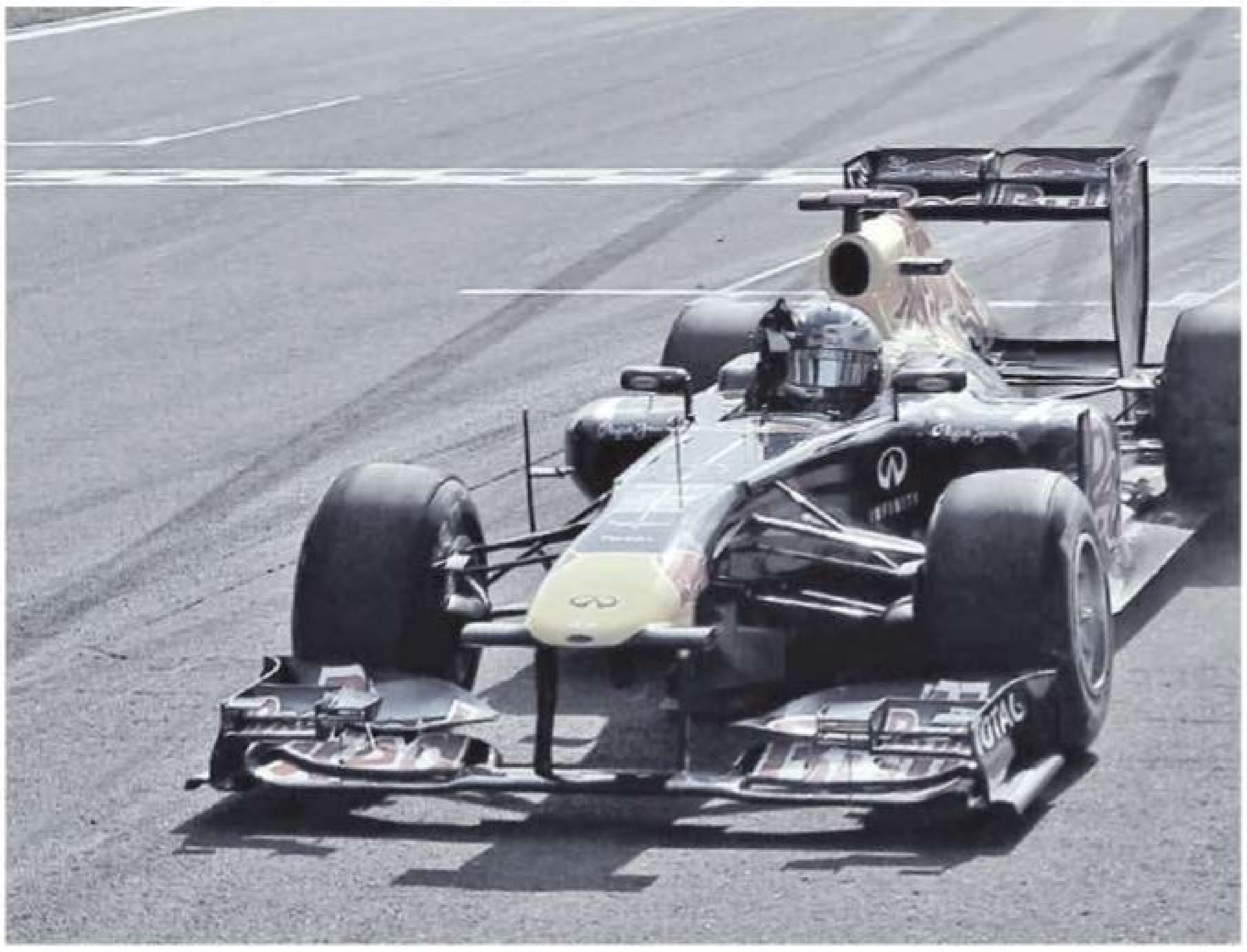
Electrical
MES – Microsoft standard electronic control unit

Braking system
Carbon discs and pads; AP Racing calipers; master cylinders by AP Racing and Brembo

Cockpit
Removable driver's seat made of anatomically formed carbon composite; six-point OMP racing harness; steering wheel with integrated gearshft system and clutch paddles; rear wing adjuster

Dimensions
Front track – 1450mm
Rear track – 1400mm
Length – 510mm
Height – 950mm
Width – 180mm

KERS
Motor generator unit driving into front of engine with batteries as an energy store; motor generator supplied by Renault Sport F1; electronic control unit by Magneti Marelli



According to Boullier, innovation on the R31 is not limited purely to the unusual exhaust layout, but he refuses to be drawn on some of the other features of the design. 'There are some other very innovative things on this car that are hidden, and I will leave them that way!'

In pure results terms, it is probably fair to say that the R31 has so far under performed. With only two podiums in the book, and a smattering of other points finishes, Lotus Renault Grand Prix is, at the time of writing, in a disappointing fifth place in the Constructors' Championship. It didn't help that, shortly after setting the fastest time in the final day of the opening pre-season test, driver, Robert Kubica, was badly injured during a stage rally. The loss of its lead driver really set the team back, as Boullier admits: 'It is difficult to assess the amount of loss that situation caused us. When a driver is pushing your team to deliver, and helping your team to deliver, losing him is a big blow. We could be fighting for the first position in the championship today, definitely we could be third if we had not lost Robert.'

The R31's development has slowed down now, with focus turning to 2012's R32, and once again Boullier has given his engineers the chance to be innovative. 'The car will be more conventional because of the regulations, but we still have some things to play with...'

Ultimately, like all team principals, Boullier is tasked with winning the World Championship and, in a couple of years, it may be hard to bet against them.

RENAULT RS27 V8

The Renault RS27 that powers the R31 has its roots in the RS26 engine of 2006. Rob White, deputy managing director engine at Lotus Renault Grand Prix, explains how the engine has evolved over the years: '2007 was the first year of the homologation process so all [current] engines have their roots in an RS26 engine we supplied to the FIA around October 2006.

'After that we were allowed to make a certain number of modifications – some for installation reasons and some minor re-workings for the first rev limit that we had, which was 19,000rpm. At that point the homologation only applied to the fundamental engine architecture, not to the pumps and ancillaries or the inlet.

'At the beginning of the 2007 season we provided another engine and drawings to the FIA, knowing that once we had done so, all of the rest of it it would be fixed up until the end to 2010. That was the rule framework as it stood on that day.

'Leading into that 2007 engine there was a big development effort going on as at that time we were in the middle of trying to win the World Championship. That took priority.

'In a completely unconstrained environment we probably would have done some more development on the RS27. Subsequently, through 2007 we were able to work on the auxiliaries and the inlet system, but then in 2008 the FIA homologation perimeter was extended to include all of the peripheral stuff as well.

'But over the years we have made a lot of detail changes for the installation of the engine in different cars. We also made changes to accompany all of the other rule changes that came along. The engine life example is a good one – today we validate engines to 3000kms on the dyno, whereas the RS26 and the first RS27s were validated to half of that.

'You are not allowed to make a change just because it makes the engine go better, or because you've discovered a new magic coating, or whatever, but that's not a particularly frustrating situation because there's not a bandana of silver bullets rushing around that nobody had thought of before the homologation process arrived.

'Over the years we have gained a fantastic understanding of the control of the operation of our engines. There is a much smaller spread in performance between the engines that we produce now and we have a much smaller deterioration of the performance in its lifespan than we did before.

'The spread in the pit lane over the life of the engine is between one and three per cent, and that's up to about 20bhp at the end of the life of the engine. I'd like to think that we are at the happy end of that spectrum.

'The sum of all the small changes, though, is a big development programme. You shouldn't underestimate how finely optimised these engines are, or how close to the edge they are. It's all about how to extract the smallest element of performance we can, even if we're not able to make any mechanical change. We will seek to make best use of how we operate the engine, the fuel and the temperatures. Even the oil is specially developed by Total for our engines.

'The biggest, baddest example of changes in operating conditions for the engine is the hot blown diffuser, which came around in the past 18 months, and now most of the cars on the grid have it. Both LRGP and Red Bull are particularly sophisticated users of that concept and we've used it to help exploit the potential of the engine and of the car.'

Jad Sherif

A long development process has resulted in a highly optimised engine, but one which is essentially the same as the 2006 RS26 it is based upon

TECH SPEC

Renault F1 RS27-2011 engine

Capacity	2.4-litre
Architecture	90-degree V8
Weight	95kg
Max rpm	18,000rpm
ECU	MES SECU
Fuel	Total
Oil	Elf (a brand of Total)
Battery	Lotus Renault GP

FIRST PRINCIPLES

Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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The perfect compromise

Achieving that all-important balance

With any racecar, the opening 'baseline' run achieved on the first visit to the wind tunnel generally dictates the path the rest of the session must follow. However well prepared a team might be, that first run will objectively show what the front-to-rear downforce balance of the car actually is. So we continue reporting this month on a session with two very different and distinctive sports racers – CTR Developments' Arachnid closed coupé and the Force LM of Force Racing Cars.

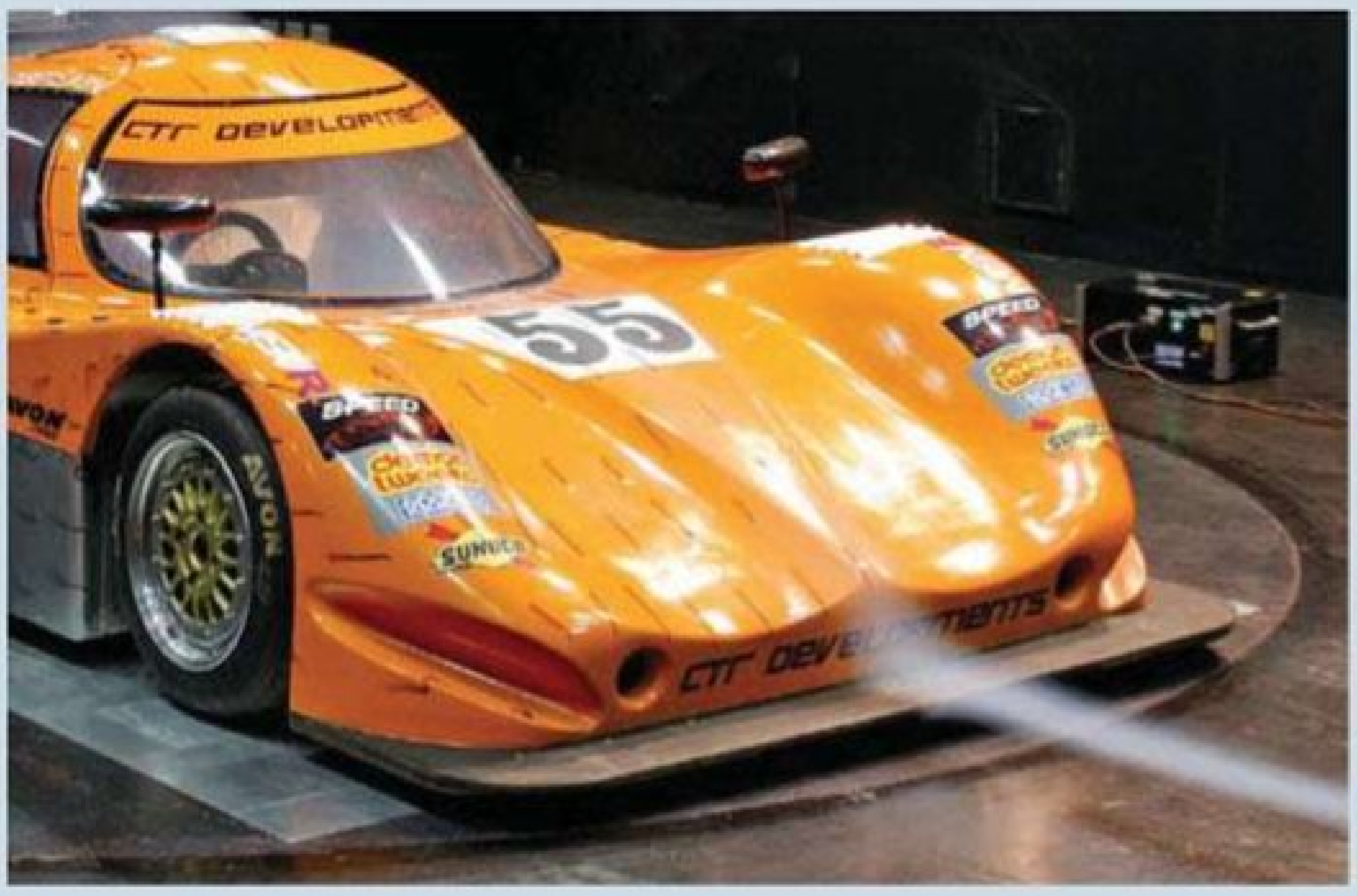
The aim, as usual, was to achieve an aerodynamic balance that approximated the front-to-rear static weight distribution with driver and half fuel aboard, hopefully providing an unchanged handling balance throughout the speed range encountered on track. It's a simplistic approach, taking no account of dynamic changes of ride height, pitch, roll or yaw, but it usually provides a better balanced steady-state set up in the right ballpark, which can then be refined on track. As always, we must remind ourselves that the MIRA wind tunnel has a fixed floor, albeit with a boundary layer control fence in place, and that the racecars' wheels do not rotate during testing, both of which affect the absolute downforce numbers obtained. The fixed wind tunnel floor tends to reduce the downforce generated by low-mounted front wings, splitters and underbodies, so if anything it is better to aim for a slightly lower front downforce percentage, as measured in the tunnel, than static front weight percentage.

Let's take another look at the baseline numbers found on the first runs with these two cars, as shown in table 1, below.

Clearly, the starting balances of the two cars, as given by the '% front' value, were completely different and, as such, the subsequent test programme implemented on each was tailored accordingly. We'll look this month at the Arachnid's session.

VALIDATING EXPECTATIONS

It was expected from prior track use that the Arachnid would be short of front downforce at the outset, and the wind tunnel validated that expectation, showing just 10.6 per cent of the car's total downforce to be acting on the front wheels, compared to a front static weight percentage of about 45 per cent. Initially, it was felt best to add downforce at the front rather than reduce it at the rear, so the first adjustment saw the front ride height lowered from 66mm to 51mm. Although CTR Developments' Richard and Matthew Chamberlain thought this to be an impractically large adjustment, they were keen to see the magnitude of the effect. The changes are expressed in table 2 in counts, where a



The Arachnid featured a non-adjustable splitter beneath a bluff 'air dam'

Lowering front ride height shifted the aerodynamic balance significantly

Table 1: starting coefficients on the Arachnid and Force LM at 80mph

	CD	-CL	-CLfront	CLrear	%front	-L/D
Arachnid	0.534	1.084	0.115	0.969	10.6%	2.030
Force LM001	0.676	1.263	0.725	0.539	57.4%	1.868

Table 2: the effects of dropping front ride height by 15mm

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
FRH down 15mm	-4	+81.5	+94.5	-12.5	+7.37	+166.0

Table 3: the effects of fitting small dive planes, in counts

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Add front dive planes	+26.5	+152.5	+148.5	+3.5	+9.195	+169.5

These small dive planes were surprisingly efficient

Reducing the rear wing angle overall shifted the balance

Dropping the rear flap angle shifted yet more balance

Table 4: the effects of reducing overall wing angle

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Reduce wing angle	-42.5	-107.5	+32.0	-139.0	+5.055	-13.5

Table 5: the effects of reducing flap angle to minimum

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
Reduce flap angle	-64.5	-239.0	+67.0	-431.5	+14.825	-194.0

Table 6: the effects of raising ride height to 61mm

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ% front	-L/D
FRH up 10mm	-1.0	-56.0	-46.5	+9.0	-2.21	-120.0

Table 7: the baseline and the 'balanced' numbers, with the changes in counts

	CD	-CL	-CLfront	-CLrear	% front	-L/D
Baseline	0.534	1.084	0.115	0.969	10.57%	2.030
Balanced	0.449	0.915	0.410	0.505	44.81%	2.038
Change, counts	-85.0	-169.0	+295.0	-460.0	+34.24	+8.0

coefficient change of 0.100 = 100 counts. The Greek letter Δ (delta) represents the change to each parameter as a result of the configuration adjustments.

As expected, this substantial front ride height change had a large effect on total downforce and distribution by adding a significant increment of front downforce. The effect on drag was minimal, so the efficiency (-L/D) also increased.

As is often the case with sports racers, there was no provision for splitter length adjustment on the Arachnid, which may well have been another efficient means of gaining more front downforce. Having said that, the car already carried quite a long splitter, so the downforce gains from further lengthening this might not have been all that significant. So the next adjustment was to add small front dive planes (see table 3).

EFFICIENT GAINS

Compared to changes effected by dive planes we have previously seen in Aerobytes, these produced very efficient gains. There was a small increase in drag, but a 5.75:1 downforce-to-drag gain, with nearly all the extra downforce at the front end, produced another useful forward shift in the aerodynamic balance, and another gain in efficiency.

The next changes involved reducing rear downforce, with the first adjustment being to reduce the overall wing angle by two degrees, as shown in table 4.

Once again, the balance shift here was substantial, so this was deemed another step in the right direction. However, total downforce and efficiency had now reduced in the quest for aerodynamic balance, indicating where the priority was placed.

The rear wing flap angle was decreased next, from its middle setting down to its minimum setting, corresponding to a three degree overall angle reduction, as seen in table 5. This produced an even bigger change than the previous wing angle adjustment, overshooting the desired balance by a couple of percentage points. Clearly, significant downforce had been sacrificed and, although drag reduced, efficiency dropped, too.

Rather than adjust the rear flap angle up by a small amount to recover the balance, it was decided to raise the front ride height again to a level that was just 5mm lower than the baseline setting, this being the setting that could be accommodated without regular front end bottoming. See table 6 for the effects.

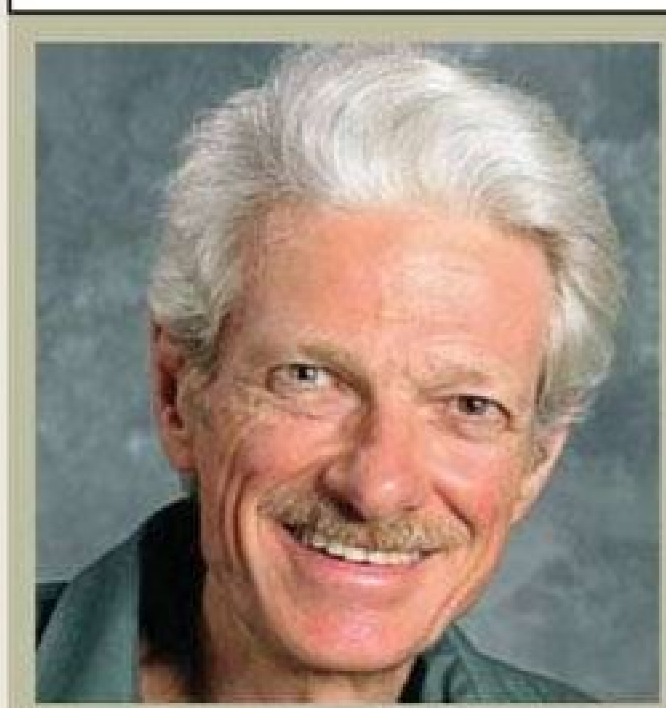
This took the proportion of front downforce to 44.8 per cent, a fraction under the static front weight percentage, and in the aerodynamically balanced ballpark. Finally, the coefficients at the end of this part of the exercise are shown in table 7, along with the starting numbers again for comparison.

SUGGESTIONS TO IMPROVE

So balancing the Arachnid produced lower downforce and lower drag, which saw the efficiency almost unchanged. The improved balance would almost certainly enable the car to be driven quicker, despite the 15.5 per cent loss of total downforce. That loss of downforce might best be addressed with a more aggressive rear diffuser, and possibly driving that diffuser harder by lowering the rear wing (as we saw on the ADR in our August issue) in order to retain or improve the car's efficiency.

Next month we'll compare the balancing process implemented on the Force LM.

Thanks to CTR Developments, Force Racing Cars and Graham Wynn for their assistance



FIRST PRINCIPLES

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European Formula Vees are, it seems, very different animals to their US counterparts

Rolling with the Vees

The question of anti-roll bars on Formula Vees revisited

It has been brought to my attention that Formula Vees as raced in Europe, including the UK and Ireland, *do* use anti-roll bars at the rear. In my previous communication on this subject, I was responding to a questioner who wondered why we use anti-roll bars at all. I said that when there is ample geometric roll resistance, and a problem with jacking (as in the swing axle suspension at the rear of a Formula Vee), an anti-roll bar is undesirable. However, European-style Formula Vees it seems have both front and rear anti-roll bars, as well as rear coilover dampers arranged to act in both ride and roll. This is similar to the system used on older, US-spec Vees.

On current Vees in the US, though, one never sees this set up. Modern ones all have rear springing that acts only in ride and, unlike the European Vees with their external front anti-roll bars, one of the multi-leaf torsion bars at the front is replaced with a solid anti-roll bar, still inside the tube. The reason for the confusion is that I was under the impression that external bars at the front were illegal in SCCA. It turns out that that's not quite the case. Here's what the 2011 General Competition Rules say:

9.1.1.C.3 Suspension

A. The front suspension and steering shall be standard VW Sedan as defined herein, or an exact replica of the same material and dimensionally identical. The following modifications are allowed:

1. Removal or modification of spring packs, including the use of ride height adjusters incorporated into the front beam, provided they are not adjustable from the cockpit. At least one spring pack shall be retained as the primary spring media for the front suspension.

2. The use of any anti-sway bar(s), mounting hardware, and trailing arm spacers.

3. The use of any direct acting, tube-type shock absorber(s) mounted in a longitudinal, vertical plane and acting through the standard mounting points. Spring shocks and linkage activated shocks are prohibited.

9. Caster, camber, and toe in / out settings are unrestricted. Clearancing of carrier or trailing arm to eliminate binding is permitted. Offset suspension bushings and alternate locating spacers are permitted.

> **"I was under the impression that external bars at the front were illegal in SCCA..."**

There is a front track limit of 52.5in (133.35cm) maximum. Track is defined as the distance between rim centres. No height is specified, so this would have to mean the centre vertically and longitudinally, as well as laterally. That would appear to mean that the front wheels can have considerable negative camber without running afoul of the track width rule by being too far apart at ground level.

So it actually would be legal to add an external front bar, and make it adjustable as well, if desired. The front bar on the European-spec car in the illustration is non-adjustable, as far as I can see in the photos. The rear one, however, is adjustable, via a series of holes for the drop links to attach to.

The rear bar on the European Vee is very slender and willowy, with fairly long arms, so serves as a fine-tuning device only. The front bar is visibly thicker, with shorter arms, and therefore inevitably higher in rate.

The European Vee is also visibly longer than a US-spec Vee, and has rack and pinion steering, as well as pushrod and rocker-actuated front dampers. Those would be illegal in US Formula Vee, and there would be no room for inboard dampers anyway. SCCA rules call for an 81.5in (207cm) minimum and an 83.5in (212.1cm) maximum wheelbase. The European Vee driver also still sits back near the engine, so the longer wheelbase implies less front percentage, and the tyres are different to the US-spec car. In dry to moderately wet conditions, it runs on treaded radials, the same size front and rear, whereas US cars run on bias-ply slicks with the rears wider than the fronts.

This means the US car has more rear tyre relative to front, and more front weight relative to rear, compared with the European Vee. That would explain why the latter needs some extra front bar. If the rules allow the front bar to be adjustable, it's hard to see the need for the rear bar but, if the front bar has to be non-adjustable, it starts to make sense to have a soft rear bar that is adjustable.

The European Vee also has a rear z-bar, and it is apparently stiffer than the anti-roll bar. The z-bar runs inside a frame tube, so it is impossible to see how fat it is, but the arms are short compared to those of the anti-roll bar, and that is really slim. The car therefore has three rear springing systems: a stiff one that acts in ride only, a soft one that acts in roll only and a soft one that acts in both ride and roll. Really, a car only needs two of those systems, or so one would think. It doesn't appear that there is any significant non-linearity designed into any of the three systems.

Would that combination be legal in SCCA? As I read the rules, no. Here's the wording:

B. The rear axle assembly shall be standard VW sedan as defined herein with axle location provided by a single locating arm on each axle.

Rear anti-roll bars on European Formula Vees are soft, and adjustable, so are used as a fine tuning device, in combination with the fixed front bar

These are commonly used in Europe because the cars are longer and have less front percentage than their US counterparts

1. The rear axle tube may be rotated about its axis.
2. Coil spring(s) shall provide the primary springing medium, with telescopic shock absorber(s) mounted inside the spring(s). Cables, straps, or other positive stops may be used to limit positive camber. An anti-roll bar or camber control device may also be used. When said anti-roll bar or camber control device is removed, the required coil springs shall continue to perform functionally.
3. The shock absorber mounts may be modified.

A 'camber control device' is a simple device that limits jacking by increasing wheel rate in ride without increasing wheel rate in roll. A z-bar qualifies as such a device. I have seen Formula Vee rear suspensions where a torsional z-bar was the only springing device, but apparently that is no longer legal. There now has to be at least one coil spring that has to hold the car up and have a shock concentric with it. But there can be just one. I have seen a Formula Vee rear suspension with two additional shocks to damp, but not spring. Apparently, that is legal, too.

"a set up with lots of roll stiffness will have more overall grip"

So you can have a single rear ride spring, which gives you the same effect as a camber compensator, except it's not one, legally, because it's the required coilover that holds the car up. You can then add a camber control device *or* an anti-roll bar, but not both. You cannot therefore have the same combination as a European Vee on a US Vee, but you can have a coilover that acts only in ride, additional shocks that act only in roll, and an additional torsion bar that acts only in roll.

Under what conditions would the anti-roll bar be desirable? When it is possible to put enough elastic roll resistance on the front to make the car understeer. Current US-spec Vees corner reasonably neutrally, but their front camber is not optimal. The front grip would benefit from more static negative camber, and / or less roll. The trailing arm front suspension has zero camber recovery in roll. If the outside front tyre can be kept more upright, more load transfer at the front can be allowed. That gives us less load transfer at the rear, and therefore more cornering power at the rear as well. If we encounter either inside front wheel lifting, or more understeer than we want, we then might benefit from a rear anti-roll bar.

The objective should be to run the front wheels at optimal camber, not degrade their cornering power with poor static camber. You also want to minimise roll to minimise front camber loss due to roll, then add rear roll resistance to keep the inside front wheel at the point of incipient lift most of the time, or as close to that as front grip will allow without excessive understeer. At least on smooth surfaces, a set up with lots of roll stiffness will have more overall grip due to improved front camber, and some of the front grip can then be traded as needed to improve rear grip.

However, even though such a set up might involve using a rear anti-roll bar, the rear suspension will still have a greater wheel rate in ride than in roll, unlike other independent suspensions with anti-roll bars.

HXDB AKK
SPEED DEMON
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IMPALA
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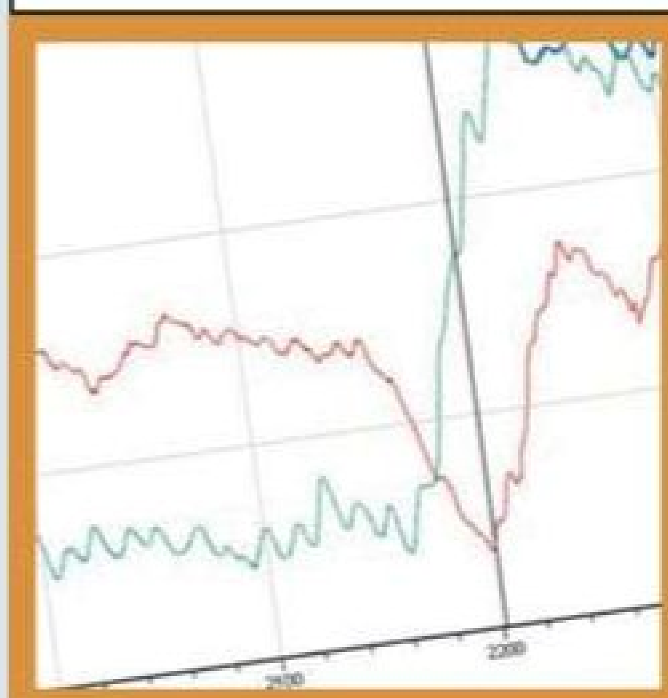


FIRST PRINCIPLES

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

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

Compare and contrast

Using variables to create miniature programmes within programmes

The subject of maths channels is a recurring theme in analysing racecar behaviour, and there are many helpful things that can be calculated using them in most software packages. However, only the best tools allow you to create small programmes that can, for example, count or compare different samples.

In the Databytes challenges last month, the question of how to calculate the number of gear changes was raised. The answer to this challenge will be used as a basis to introduce registers or variables in maths channels, which enable us to do some fairly complex calculations and effectively create miniature programmes.

For those that understand programming languages, the concept of variables will be well known. These can hold values that are later used in calculations, but the values can also be changed by the programme itself, should the need arise. The gear counter challenge has a number of different solutions but, in this article, the focus will be on one type of solution that will work even if the gear position is calculated, rather than coming from a specific sensor.

The idea is to compare the current gear position channel value to the one in the previous sample. This means that a register is needed to hold the value of the gear position for one sample. The maths channel will then start counting if the gear position has changed and stop in the next sample unless the gear has been changed again. This means that the channel will only increment once for each gear position change. In order to achieve this it is important to set the maths channel calculation, or logging rate, to the same value as that of the gear position (see figure 1).

Figure 1: the maths channel could look something like this in code form:

```
register @A; // holds the value of the gear position in the previous sample
register @B; //holds the value of the number of gearshifts so far

@B = choose( floor([Gear]) != @A, @B+1, @B); //increments the gearshift register @B of the current
gear number is different from the one in the last sample

@A = [Gear];

@B //returns the value of the maths channel
```

INTO THE SYNTAX

In this case, the syntax requires an @ symbol to identify registers. The 'choose' function is an if-else statement, where the gear channel is compared with the value of register A and, if it is not the same as register B, is incremented. If it is the same then register B remains unchanged. The != is, in this case, used as a not equal.

The flow through this maths channel might not be obvious at first glance, but the sequence of it is very important in order to achieve the comparison between the current and previous sample. If the 'second' register (@B) is not calculated first, then the maths channel will not work. The 'floor' function is used to make sure that the gear position channel switches only between whole numbers. Even if the gear position comes from a sensor it sometimes

Figure 1: gear position and gear counter channels. The gear counter can be seen to increment both when going up and down the gearbox. At the top, the statistics of the gear counter can be seen as number of shifts per lap in the outing

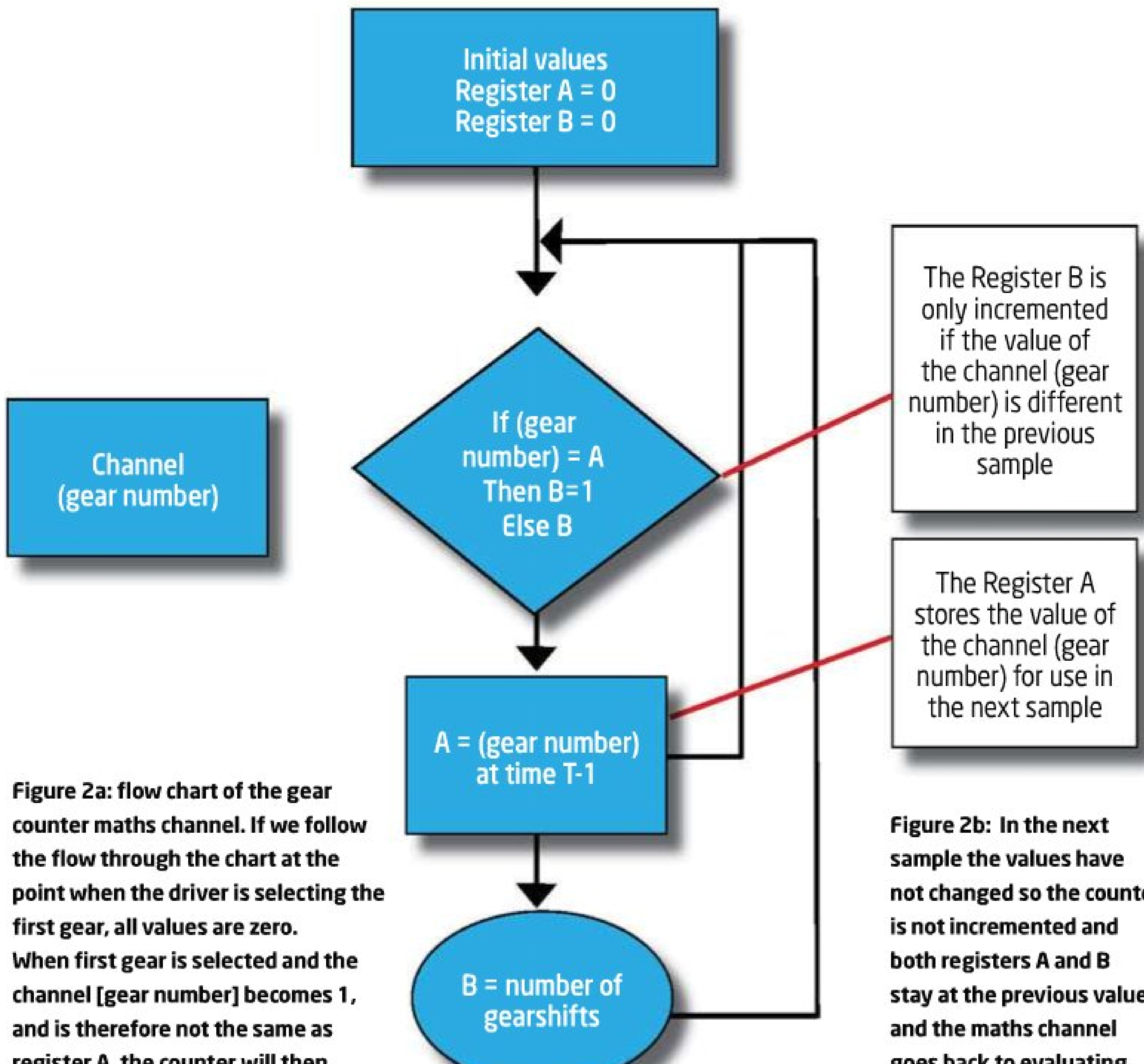


Figure 2a: flow chart of the gear counter maths channel. If we follow the flow through the chart at the point when the driver is selecting the first gear, all values are zero. When first gear is selected and the channel [gear number] becomes 1, and is therefore not the same as register A, the counter will then increment and set register B to 1.

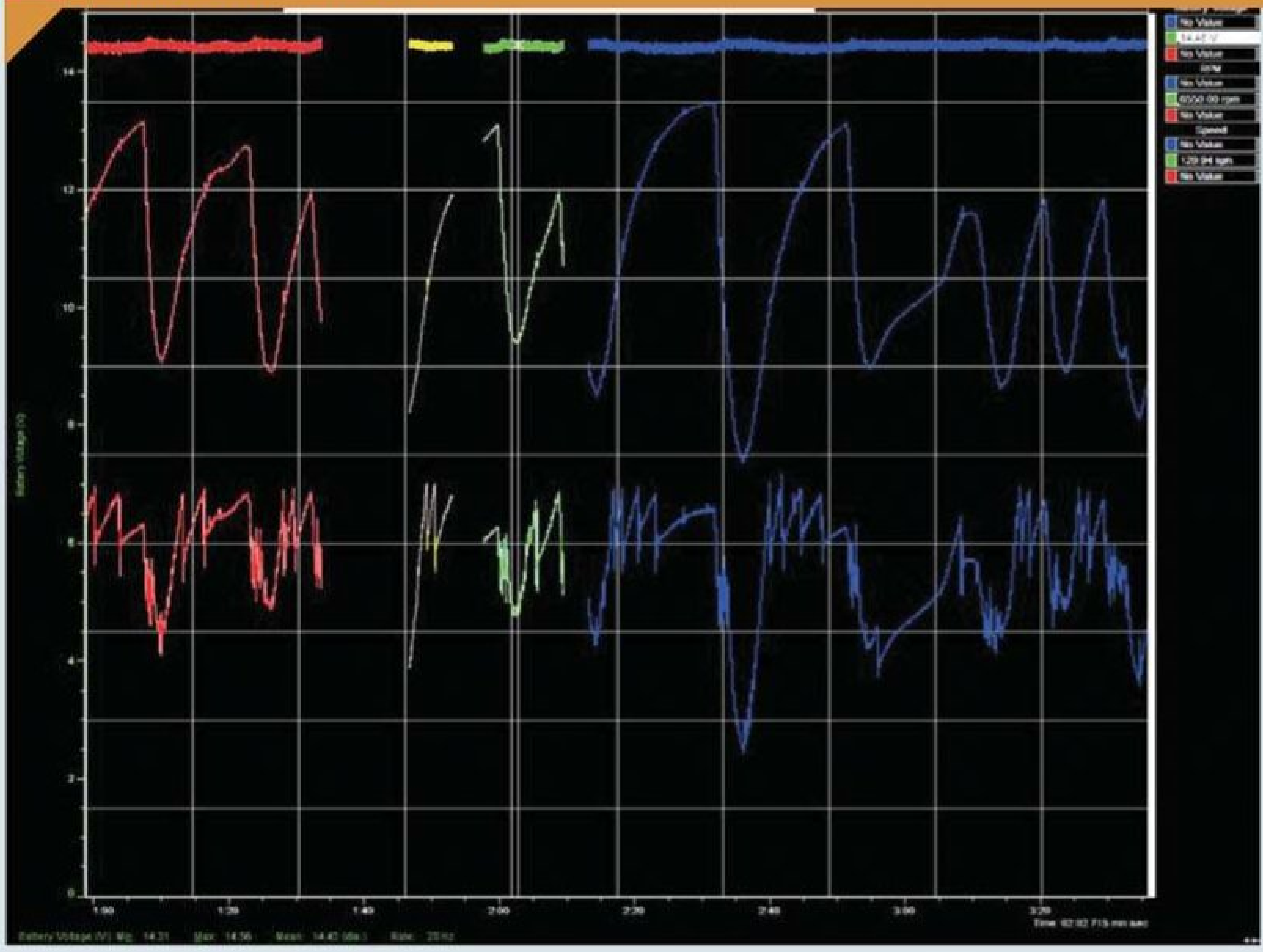
Figure 2b: In the next sample the values have not changed so the counter is not incremented and both registers A and B stay at the previous value and the maths channel goes back to evaluating its initial conditions

does not just jump between whole numbers but increments, which can cause the gear number calculation to trigger more than once for a single gear shift.

The gear counter can then be used as any other channel in the data set and the most useful feature will be a comparison of how many shifts a driver does in a lap. In most cases, that would be best presented in a tabular outing report, along with other statistical information.

When it comes to maths channels and programming in general, there are of course many ways to skin the cat and that is the case here with the gear counter. In the original challenge, channels that switched states when a shift paddle was pulled were shown – one channel for up-shifts and another for downshifts. This information can also be used to count the gears, but the ability to be able to detect when a channel switches states can also be used for various other things, such as re-setting a channel when a new lap begins. The possibilities are endless, it is up to you to make the most of what they are capable of to suit your particular application.

CHALLENGE



Question

A data logger recorded the data shown left in a single run. However, several data files were created and they appear to have a gap between them. What could explain this behaviour and how can we better understand what is occuring in the gaps?

COSWORTH

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Bright sparks

There is no doubt electric cars are coming, but plausible race series that cater for them are few and far between. Could Formula E offer the answer?

BY SAM COLLINS

Even before Formula E was officially announced, two technology demonstrators were already on track – the Mercedes Grand Prix-built Formulec (opening shot) was the first, followed by Toyota Motorsport's Radical-based powertrain showcase (above), which broke the EV lap record at the Nürburgring. Other projects such as the one from Fondtech (top) are aimed specifically at the new-for-2013 championship

Motorsport is not future proof. Whilst the transport world is moving rapidly towards alternative propulsion, its sporting side has barely reacted. The implementation at the top level has been restricted to the rather stumbling introduction of KERS in Formula 1.

But all this looks set to change with the announcement by the FIA of a new championship for high performance electric vehicles, called Formula E.

At its most basic, the proposed series ticks the ever more fashionable corporate social responsibility box for the FIA. But when you scratch the surface you find there is great interest in such a championship, and some very well-known names have already announced projects.

The basic car concept has been laid down by the FIA in its invitation to tender. All cars should be fully electric single seaters capable of running for around 15 minutes between charges at roughly Formula 3 pace, and weighing no less than 780kg. With electric vehicle (EV) technology where it sits currently, this sort of performance can only realistically be achieved with low-drag bodywork.

Three serious contenders have already shown their hands and proposed design concepts, and there are almost certainly more waiting in the wings. But in a situation not dissimilar to the one faced by IndyCar's ICONIC committee last year, the FIA will have to decide which approach to take, whether it be a spec racer or a fully open race series.

The technical part of the new series appears not to be decided at the moment, but there are three possible scenarios. The series would be fully competitive with multiple designs from the

FORMULEC

The Formulec programme started as a direct response to the celebrations of 100 years of grand prix racing and was championed by Eric Barbaroux, the former promoter of the French Grand Prix.

'It became clear that we had to start a new history with cars using the new energies. It took us a little while to define it but we realised that it had to be pure electric and not a hybrid,' the Frenchman explains. 'We identified a team from Matra Segula Technologies who have a lot of experience in EV powertrains, and for the chassis we worked with Mercedes Grand Prix because we knew some of the guys there from our days together at Ligier.'

Despite positive reaction to its prototype, Formulec is currently working on an all-new car

Very conventional in its appearance, the Formulec chassis and bodywork was developed by a team under the guidance of Loïc Bigois: 'It goes back to Brawn GP in 2009 where their future was somewhat uncertain and they were taking on some other work. We had good relationships with the engineers there and, when Mercedes came in, they saw what was going on and let it continue. The chassis is approximately built to Formula 3 specifications as we though that was a reasonable level.'

Together with Matra Segula Technologies, Barbaroux's team selected SAFT batteries and an experimental electric motor from Siemens. 'We chose to work with SAFT because this company has a lot of experience with defence technology and are used to the safety procedures required. For motors we chose to go with Siemens because they developed a high-power motor that had originally come from a bus, but with a lot of modifications.'

POSITIVE RESPONSE

But despite the very positive response to the first Formulec concept car, the team has decided to develop an all-new car. 'One of the first things we realised was that we had to cut the cost. So we have to build another car with cost as a design objective. We also have to reduce the weight. When you build a prototype like this, every single one of your partners wants to make sure their product works and doesn't fail, so everything is perhaps a little bit too heavy. Finally, we have to also increase reliability.'

The original Formulec car is still on a publicity tour, which has taken in, amongst other places, the Le Mans 24 Hours and the Frankfurt Motor Show.

TECH SPEC

Formulec EF01

Class: EV demonstrator

Chassis: Mercedes Grand Prix carbon fibre monocoque

Powertrain: Matra Segula

Battery: SAFT lithium cells

Motors: Siemens twin prototype BLDC

Transmission: bespoke two-speed Hewland gearbox

Performance: 0-100km/h sub three seconds; maximum speed 250km/h; range 20-25 minutes.

Data: 2D, ECU and CAN from FAAR Industry

Weight: not disclosed

Cost: €3m

Number built: one, but new-for-2012 EF02 is aiming at larger volumes

beginning. In that scenario, key suppliers like Bosch and Valeo could join manufacturers in entering cars, but that is probably not very realistic and it is unlikely there would be 20 different cars on the grid. The alternative is to have a single-make car that teams will run. That is more realistic, technically, but is a little bit poor in terms of the fact there will only be one car, and it would not appeal to a car maker developing its technology. The third option is we have a series of perhaps three or four car designs, with three or four teams running a grid of them.

According to Eric Barbaroux, who masterminded the Formulec project (see panel above), there are a number of key concerns that he believes should force the FIA to go the spec racer route.

'We are keen on a single-make series because then you can reduce your R and D expenses because you're providing 20 cars. It cuts the cost of each car. If you have an open championship full of prototypes, it becomes more expensive for everybody. Our prototype cost us more than €3 million. Also, you have to think about the safety of cars like this because when you have 800v in the car you have to be very, very careful. If you have many different technologies there is no way that anybody is going to be able to regulate it. No technical delegate and no marshal will be able to understand how all of the different cars should be handled and it will simply be dangerous. Plus scrutineering will be impossible. If you have just one type of car you can educate everybody at the track – not just the marshals, but the drivers and the technical staff, too. It is important we do not end up with something you can't control.'

Jean Claude Migeot, however, who has developed a Formula E concept at Fondtech in Italy, disagrees, feeling a spec series would be a waste of time: 'The long-term solution looks clear – set free the best engineers' creativity, because time is running out. Formula E should be an open formula because it is the start of a new era and not a market product. Having said that, what is the best way to reach that point in a short space of time when today we effectively start from zero? I think the FIA wants to be pragmatic and explore any other options on the table. But are there any?'

FONDTECH E-11

Jean Claude Migeot's latest racecar took many by surprise when it was revealed in late August this year. The car, which is squarely aimed at Formula E, was entirely developed by Fondtech in Bologna, Italy.

The project can be traced back to computer simulations carried out in 2009 before the project was officially signed off in May 2010. Since then, CFD research has continued, a 60 per cent scale wind tunnel model developed and the chosen motor / gearbox assembly bench tested. Chassis manufacture has also begun, ahead of the car's first track test, scheduled for January 2012.

The four-wheel drive powertrain features energy recovery to extend the range and, unusually, has all of the major electronic components mounted underneath the driver in the safety cell. To answer any doubters, its designers say they will crash test the chassis to weight balanced F3 standards.

'As an engineer it is extremely liberating to work without the usual boundaries and principles that often stifle progress in motorsport,' comments Luc Gasparini, the project's head of engineering. 'With the E-11 it is the level of a technology outside of our control that has proven most prohibitive, so we have had to work hard to overcome a lot of potential pitfalls. Sitting the driver on top of the batteries is controversial, but a deliberate choice to make our technology demonstrator simple but radical at the same time. Our firm decision of having them within the structural chassis and below the driver's seat gives the car its peculiar 'double-decker' look. It is our opinion that this will ensure maximum safety for both the driver, whose cockpit is completely separated from the battery compartment with no possibility of fluid leaks, and those outside the car, since the compartment is conceived to contain the batteries' debris in the event of an accident.'

TECH SPEC

Fondtech E-11

Class: Formula E (proposed)

Chassis: split-level, custom design, carbon fibre monocoque

Powertrain: Fondtech / various

Battery: lithium-ion cells

Motors: 300kW BLDC with energy recovery

Transmission: four-wheel drive; one motor per wheel with reduction gears

Performance: 0-100km/h sub 3.2 seconds; maximum speed 260km/h; range 50km / 20 mins

Data: TBC

Weight: 800kg

Cost: not disclosed

Number built: zero, first car due to be completed in early 2012

LIKELY COMPROMISE

Taking these opinions into account, it seems that the best compromise, and the most likely outcome, would be to have a semi-spec category with perhaps two or three chassis suppliers, as suggested by Vasselon. A pure spec category would be unlikely to impress spectators, and that is key to the success of the project.

The FIA sees the new championship as something of a trailblazer, with the invitation to tender stating, 'It should have the ambition to open a new area of motorsport in the way it is organised and promoted, and the initial view is therefore that it should not necessarily look like "traditional" motorsport. The venues, the format of the races, the relationship with the public and the other main parameters of events need to be considered with an open mindset in order to meet the objective of attracting a new audience. For example, the X Games could be used as a more relevant benchmark for the championship than traditional motorsport, making the competition cutting edge.'

The intention is that the events would be held in urban areas, with courses built in the centres of major cities. Critically, the courses should not feature any long straights, as these do not really suit EVs. Urban racing is a well-proven concept, but it can be vastly expensive, and that could force Formula E into less ideal locations such as parkland.

COOLING CHALLENGE

In terms of its geographical spread, the FIA hopes that Formula E will be global, and that means the cars will have to be able to cope with weather conditions ranging from a cold and wet afternoon in London to a sweltering hot day in the San Francisco Bay area. This alone provides a real technical challenge for the cars, says Vasselon: 'Cooling is critical. There is always a temperature range with batteries. The window is really quite narrow. A battery needs to be reasonably hot to achieve good efficiency. Yes, you could run it at zero degrees but, realistically, you have to heat the battery on a cold day. Alternatively, the battery can also get too hot. On a Formula 1 KERS system a significant proportion of the weight is its cooling system, and still on hot days like at Monza or Singapore you see some cars having issues.'

It may be for this reason that the FIA's preferred format is for short races. Over the duration of TMG's Nürburgring lap record run, for example, battery temperature was not a major issue. Indeed, it was the electric motors that required more cooling than the batteries.

CHANGE OF PACE

Not everybody sees the short race format as a problem, and the Formula E tender states that this could be an opportunity to revise the rhythm of the typical motorsport event, looking to create an action-packed day of competition and entertainment.

'Okay, so we can't do a two-hour race or 300kms with these cars, but why should we be copying Formula 1?' says Barbaroux. 'I would do something different. The 100m is over in just 10 seconds at the Olympic Games, you run 24 hours at Le Mans and the Tour de France takes four weeks, so is not the length of the race that brings interest, it's the way you sell it.'

But with cars like the Formulec capable of running for

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TOYOTA

Toyota Motorsport took a different approach to its electric racecar programme. With its chassis design and manufacturing capabilities well known through its Formula 1 and Le Mans programmes, it needed to prove that it had EV powertrain capabilities, too. So it went out to break the electric vehicle lap record at the Nürburgring, and succeeded. 'It worked on a bigger scale than expected. We had a lot of positive response. We were doing some EV activity and we wanted people to know about it,' explains Pascal Vasselon. 'It started from work in Formula 1 with KERS in 2009. We were the first to run a system and came to the conclusion that the performance was not there, but we had a very good understanding of it and made some serious development around it. During that programme we developed a very good understanding of batteries, battery cooling, management systems, inverters motors, that kind of thing. So when our F1 programme stopped, we decided to start an EV project. With the record car, we assembled some off-the-shelf components, together with our own technology, as an integration project.'

TMG is working on chassis designs for a Formula E car but is also keen to offer its powertrain as an off-the-shelf solution.

It has also developed extensive testing facilities for both EVs and hybrids during the course of the programme.

TECH SPEC

Toyota EV P001

Class: demonstrator

Chassis: Radical SR, tubular steel frame

Powertrain: Toyota Motorsport / Rational Motion

Battery: lithium-ceramic cells

Motors: 280kW 520v twin Evo-Electric motors; 800Nm torque

Transmission: electronic differential

Performance: 0-100km/h sub 3.9 seconds, maximum speed 260kph, range 50km / 20 min

Data: TBC

Weight: 970kg

Cost: not disclosed

Number built: one demonstrator only

15-25 minutes only, and recharge times as long as six hours, the show would have to involve battery swaps (not especially green or easy) or significantly shorter charging times.

Lord Drayson, the former British Government peer and Sportscar racer, is developing his own EV project with Lola cars. But whilst supportive of Formula E, he will not be involved as his project is based around LMP1 lap times and performance over a single lap. However, his project is taking steps to deals with the charging time issue: '[you have to] accept the physics that the energy density of petrol is enormous. The metallurgy and chemistry of batteries is going to improve over the next 20 years, but it is not going to be as good as petrol. The solution is to use dynamic induction charging,' he explains. 'We are working with a group called Halo IPT on this.'

Halo IPT offers a contactless charging system based on inductive power transfer, which uses strongly coupled magnetic resonance to transfer power from a transmitting pad on the ground to a receiving pad on the car.

'You can go to a circuit like Rockingham and have a 12-hour electric race because in the track are imbedded induction coils and the cars re-charge as they go round. You don't need the weight of the batteries and you can change the whole power-to-weight ratio of the car. These cars are going to scream around the track. It is relevant for the road too, because we increasingly spend a lot of time going short distances on congested roads. I think what we are using here as a racing laboratory can show governments and car manufacturers that this can work. The next time they are digging up a road, put in the induction coils and then, when they design the next generation of electric cars, they can put an induction pad in the car.'

THE SOUND OF SILENCE

The show is clearly a critical element for Formula E events and the invitation to tender suggests there should be support events featuring other types of electric vehicles (dragsters are one cited example). But another element often discussed about electric vehicles is the sound. Racing purists crave the sound of a Chevy V8 or an Aston Martin V12. Indeed, Bernie Ecclestone has been insistent that the 2014 F1 cars have to sound good and is trying to get the regulations in that series to ensure that happens. Formula E is no different. The tender insists that the 'noise' environment of the events is seen as fundamental to their success. This could include some musical background, but also some work on the noise that the cars might produce (aerodynamic, rolling noise etc).

'We need to make Formula E events that young people really want to attend. Have *Green Day* playing or something, that would work,' suggests Drayson. 'Who cares about the noise anyway? If you had a 200mph, high-revving electric car it will make a noise. Not like a V8 or anything, but then there is no point pretending it is.'

Interestingly, the team behind the Formulec have gone back to the drawing board to re-develop their concept, and one of the reasons is to improve the sound it makes. 'The car does actually make 83dB when it's running, but we have to provide more. The noise we have is due to the shape of the car, but 83dB is not ridiculous. If we had 16 cars on the track in a city centre, you can certainly make some kind of show,' says Barbaroux.

Lotus, in conjunction with in-car audio specialist, Harman, are working on an alternative approach, dubbed Halosonic. The core of the technology is a software algorithm originally emerged from the Active Noise Control programme. Using inputs from throttle position and vehicle speed, a central processor generates an authentic engine-like sound that is played back through a speaker in the front bumper and through the car's conventional audio system. 'Our system is about generating a sound, not making unwanted noise,' says Harman's director of active noise control, Jon Lane. 'The ruggedised external speaker is placed at the front of the car so it can be heard from further away, but also so that the sound decays much quicker when the vehicle has passed. You don't get that with an internal combustion engine.'

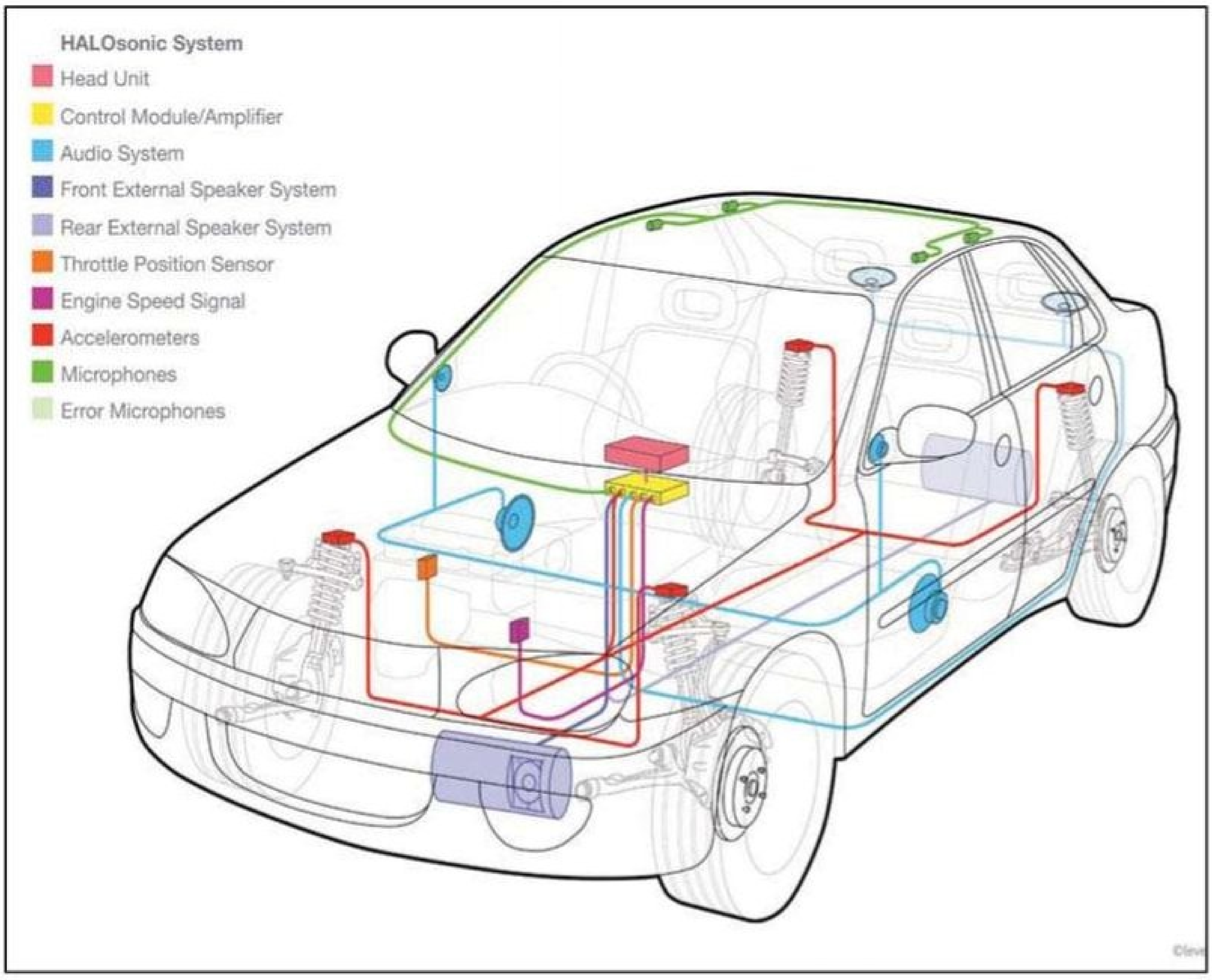
The sound processor mimics the petrol engine's pitch and frequency, initially so pedestrians can identify the vehicle's speed, direction and distance, but when applied to Formula E it could really spice up the show. The cars could be made to sound like a V8 Stock Car, a Rolls Royce Merlin-powered Spitfire or even a Cylon Raider from *Battlestar Galactica*!

Vehicle appearance, of course, is another critical part of the show, with everyone involved keen to move away from the conventional open-wheel / Prototype look.

'Another reason we are re-working our design is because it is a classic Formula 1 design,' continues Barbaroux. 'A car that looks like a Formula 1 car is not the future. Just look at the things they did in IndyCar with the Swift and the Deltawing – we just want something original.'

Finally, the FIA states in its tender one of the hardest elements of all for the engineers to deal with – environmental credibility: 'The championship should strive to be credible and trend-setting in terms of sustainability, efficient use of resources, sustainable logistics, supply chain management etc.' This could challenge those groups insistent on using composite chassis and raises real questions about the battery chemistry. It is already well known that F1 KERS batteries are rarely recycled and it may be suggested that Formula E will worsen this situation.

Throughout 2012, the Formula E regulations will take shape, along with the cars set to take part in it, while the first event will be staged in 2013. However it turns out, it is sure to provide a fresh and exciting challenge, and that can only be a good thing for the engineers involved.

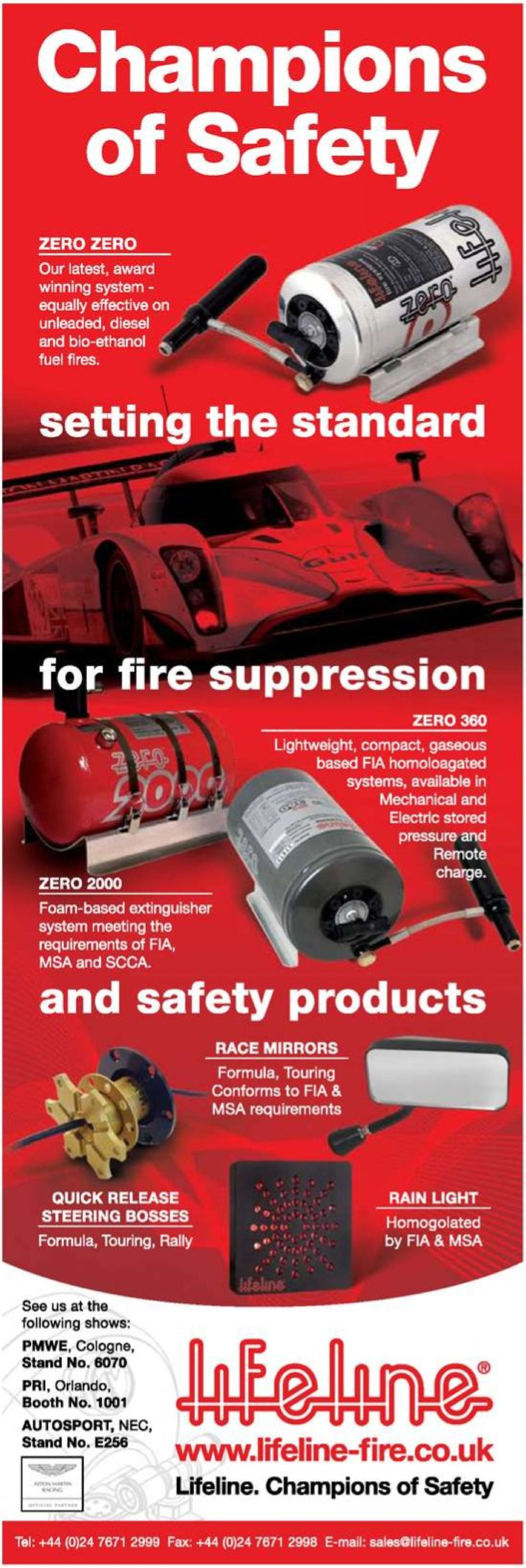


Developed jointly by Lotus Engineering and Harman HALOsonic, this could be the answer to making Formula E cars sound the way the FIA want. Lotus is certain that the system could be fitted to an open-wheel car

OPINION SSC

It seems to me that in some ways Formula E has missed a trick because there are many burgeoning and developing EV projects around, though most are destined for the road. Motor racing is funded by two major groups – manufacturers (be it of cars or energy drinks) and drivers. In reality, the latter group provides the wealth of funding, right up to and including Formula 1. Formula E will probably cost more than F3 to contest, so the drivers will likely not be interested, leaving a very small number of works-backed entries. Take the Delta E4 Coupé (shown below) for example. I drove this car at Silverstone and Crystal Palace this year and was blown away by its handling and acceleration. It is already road legal and, if put into full production, could easily be turned into a very affordable competition car. Tesla, and other similar cars, would slot straight into such a category, too. There could even be a class for the many budge 'city cars' out there. This was part of the two proposed EV championships that surfaced during the winter, but neither of those had the full support of the FIA. I think perhaps any promoter needs to realise that it is highly likely that spectators will associate more with roadgoing EVs than futuristic open wheelers.

The Formula E race format also only serves to reinforce the number one issue with EVs, that of range anxiety. Halo IPT is a fantastic example of what can be done to overcome that, but it will likely play no part in this new series. More's the pity.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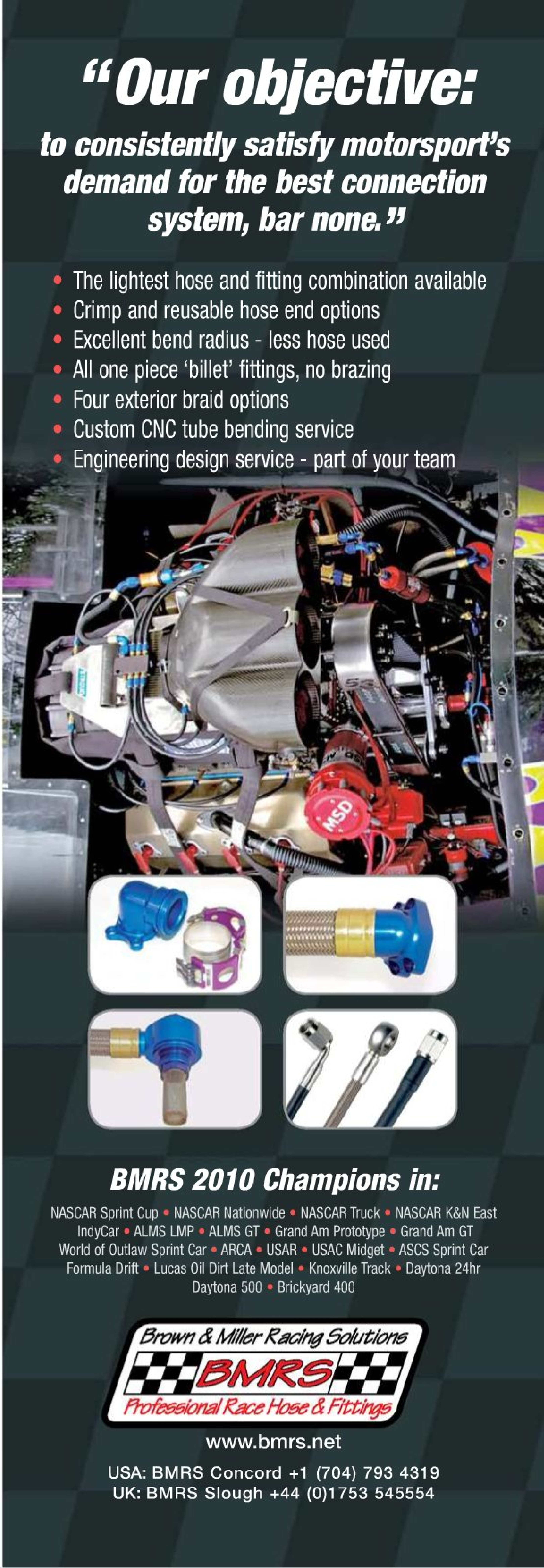
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Controlling freedom

Another new engine, but with a sequential transmission and the restrictions on aerodynamics lifted, this time it's a step change for the popular feeder series

BY SAM COLLINS

For more than four decades, one open-wheel formula above all others has dominated the national open-wheel scene, and it is about to undergo some radical changes. Again. Over the years Formula Ford has gone through a range of incarnations, from its 1.6-litre Kent engine roots through to its current Duratec form and even at one point a Honda engine! But, at the Frankfurt Motor Show, Ford revealed the formula's latest incarnation, along with a renewed commitment to the series.

At first glance, the big change is to move away from normally-aspirated engines for the first time in the class' history. Ford's new turbocharged Eco-Boost in-line four will be found in the back of the new cars in its 1.6-litre guise. But this is just one change in a raft of new features for this well-known formula.

'Our last big change was six years ago with the introduction of the Duratec, and we are just keeping up with modern technology,' explains Mike Norton, Ford's motorsport manager. 'So all of the changes are done under the auspices of keeping the formula up to date, and in keeping with the environmental pressures of today. It's a very lean burn, petrol, direct injection engine. It helps keep the formula in touch with the new technologies in our road cars.'

> "it helps keep the formula in touch with the new technologies in our road cars"

Unsurprisingly, given the current climate, much of the standard production engine has been carried over to the racing version in an attempt to keep costs under control: 'It is almost completely standard,' says Norton. 'The only big thing we changed was [to go] from a wet sump to a dry sump. It retains the standard inlet manifold, the fly-by-wire throttle, the exhaust manifold, turbocharger and the standard control systems in terms of sensors and so on. We will run our own motorsport ECU and wiring harness, mainly because the security systems on road cars do not really allow us to run the engine in the way we want. Also, a road car ECU doesn't have all

TECH SPEC

Formula Ford 2012 concept

Engine: 1.6 Ford Eco-Boost turbocharged in-line four

Electronics: Life Racing ECU

Chassis: tubular steel frame, open to any design

Suspension: free

Gearbox: six-speed sequential transmission open to any design within the regulations

Wheels: single design from Rimstock

Bodywork: spec radiator ducts, cockpit surround and roll hoop shrould

The launch car is Ford's own interpretaton of how the new car will look and is based on the Mygale tubular steel chassis that will remain in use. Body design and manufacture will be free but with certain fixed parameters such as the sidepod inlets, front and rear impact structures and a flat floor

the data logging capability that we need. Everyone will have to run the same LIFE Racing ECU, and they will have certain access to the logging functions, but they have no access to any of the maps at all. This does not end things for the engine builders, who can continue to strip the units down and hone them, and all the things they like to do. From that perspective it is no different to the Duratec.'

The car shown at Frankfurt and pictured in these pages is Ford's interpretation of the new look class, built around a current spec Mygale chassis. According to Norton, Ford will make the data to build the bodies available to anyone who wants it.

Garish Rimstock wheels look more like aftermarket road car alloys but are a further spec part designed to keep costs down. Wheel tethers are also used

TUBULAR BELLES

It may surprise many that Ford has shunned the more usual approach of a single specification carbon fibre monocoque chassis, but Norton believes the tubular steel chassis is as safe as it needs to be: 'The chassis has not really changed in reality, because when we crash tested it and subjected it to quasi-static load tests in 2007 it met the 2008 Formula 3 standards. We did not really see the need to change things there.

'We worked quite closely with the FIA Safety Institute and Andy Mellor for about two and half years. Article 277 of Appendix J had a set of safety regulations for tubular cars but nothing existed in terms of a really detailed criteria. There was no strength stated for the roll hoop, and no real crash testing criteria, so we have been developing those with the FIA and MSA and the new rules are the result of that work.'

Front and rear impact structures have been fitted to the car and these will be control parts for all manufacturers. The front structure is mounted on a square 300 x 300mm bulkhead, which all cars will have to run, and it is around 550mm in length. It will be up to the car designers to accommodate it in the nosecone.

The cockpit aperture is also a spec area, with all cars having to run a Formula 1-style head restraint and a removable seat. Further driver protection comes in the form of wheel tethers and anti-intrusion panels running along the cockpit sides.

The safety components will not be the only parts of the car that everyone has to use. The flat floor, roll hoop shroud and sidepod inlets are all fixed shapes, which all chassis will have to use. Even the wheels are a spec design from Rimstock.

AERODYNAMIC INFLUENCE

'You'll notice with the current cars they have these very low and square sidepods in a very basic shape. That's what the regulations dictated, and they also stipulated that anything that has an aerodynamic influence is not allowed. Clearly that was a nonsense because the entire car has aerodynamic influence and it's just about impossible to police. We have opened up the regulations to allow people to do a lot more sculpting, with undercuts and complex curves all allowed now. Just nothing that obviously constitutes an


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The cockpit aperture is a spec part and includes an F1-style head restraint, removable seat and anti-intrusion bars

Gone are the nonsensical limits on 'anything that has an aerodynamic influence', so expect to see teams coming up with novel solutions and developments to squeeze every last bit of performance out of the 1.6-litre turbo engines

aerofoil. As a result of the control components – our kinetic design elements – the frontal area of all of the cars will be roughly similar, so the aerodynamic effect of the cars will be roughly the same. There is a lot of scope for teams and manufacturers – just look at the nose. As long as it fits the attenuator then it's okay.'

Uniquely for a manufacturer-backed series, Formula Ford will continue to let anyone build chassis, whereas all of the other similar formulae, such as Formula Renault or Star Mazda, require everyone to race identical cars. It is something Norton believes is part of the core ethos of what has made the class a success over the years. 'We don't have wings or DRS to make the racing exciting. Formula Ford is for people coming out of karting and learning to set the car up to get the best mechanical grip. It is not just for drivers either. The engineers, team managers and technicians will want to progress their careers and learn, too. Understand the engineering in full in this class is still a crucial step for everybody, and that is one of the fundamental thrusts of Formula Ford.'

SEQUENTIAL TRANSMISSIONS

For the drivers, the new cars will have one major change – the adoption of sequential transmissions. It means that on the traditional ladder of progression to Formula 1, drivers will not have ever had to race a car with an H-pattern gearbox. This, though, may not be a bad thing, as the likes of Lewis Hamilton and Bruno Senna (both of whom skipped Formula Ford) have proved. The show car was fitted with the well-proven Hewland FTR transmission, but Norton reveals that anyone can offer a transmission, as long as it meets the regulations. 'We wrote the rules based on the FTR / JFR concept, but it is open to anybody, [though] of course you have to fit the rear crash 'box and it has to be a six-speed sequential. We do not want a gearbox war so we have mandated things like the gear weights. Again it was part of bringing the formula up to date. The old LD200 was getting harder to get spares for and it was struggling to deal with the higher output of the engines.'

The suspension concept on the new car is largely unchanged, though the adoption of the FTR transmission will see most chassis manufacturers utilise the rear suspension pick-up points found on the Hewland casing.

EMERGING MARKETS

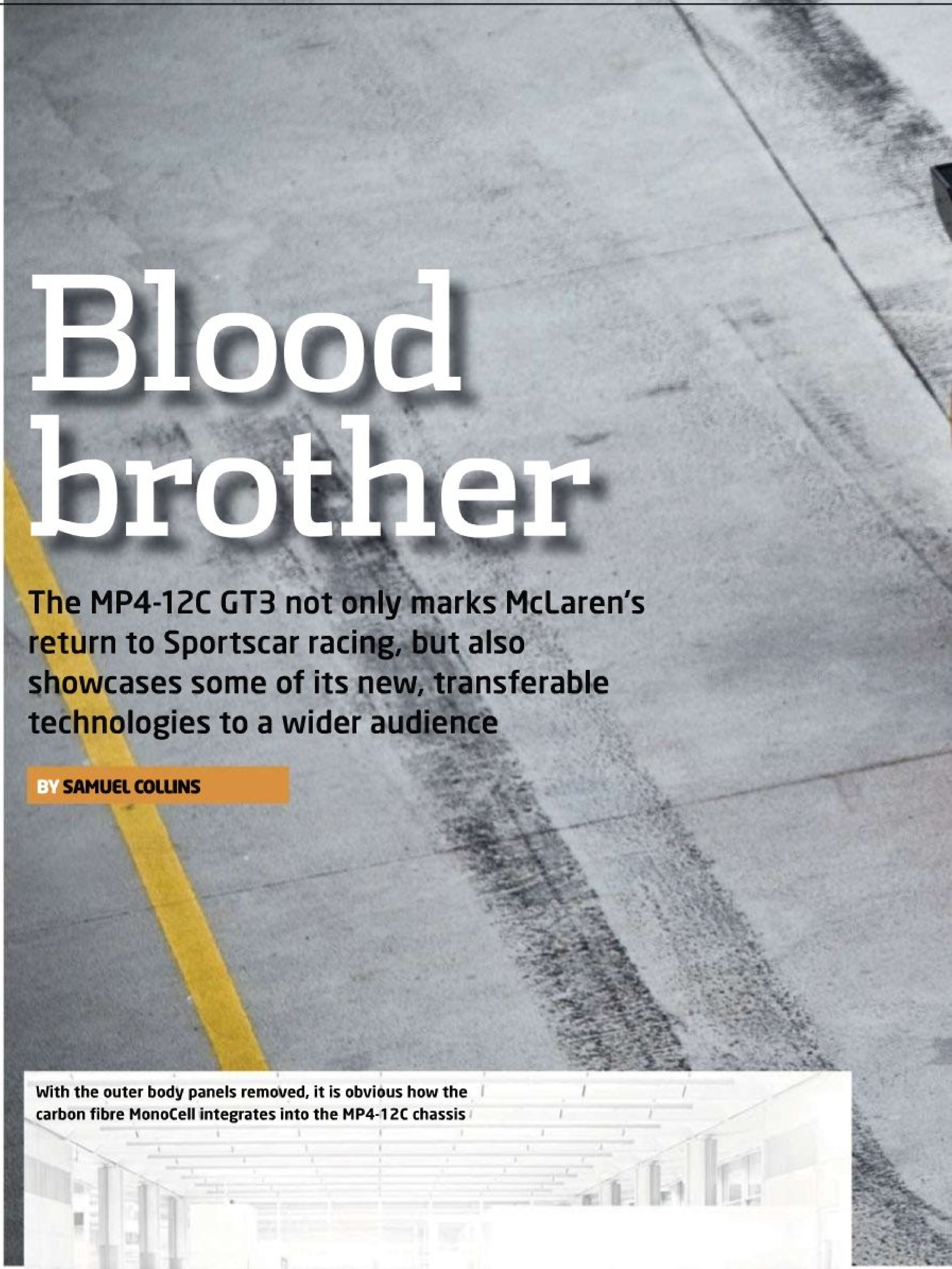
Ford is clearly hoping that the new regulations will revitalise its formula and open up the doors to new markets. Indeed, launching the concept car at the high profile Frankfurt Motor Show was all about that, as Norton explains: 'We want to get Formula Ford back into markets we have lost over the years, and into new markets. We have had discussions with places like the USA, Russia and even the Philippines. There are many markets that are trying to grow right now, and there are a lot of these going to the FIA and asking them how to do that. We feel that we are right there on hand with the perfect development formula. Formula Ford is cost-effective and,

> "the perfect development formula"

because we used a tubular steel chassis, they can be licence built in those markets and repaired there. Ninety per cent of the time a carbon chassis would have to go back to the manufacturer for repair, or even destruction, but in pretty much every country in the world you can find someone who can weld steel chassis to a good standard and you know when it is bent or broken. That means it keeps those emerging markets safe and long lasting.'

The new Formula Fords will cost more than the current Duratec-powered breed, due largely to the higher specification transmission and increased safety equipment, and estimates suggest that this increase will be in the region of 4000-6000 euros (£3500-£5200 / $5400-$8100).

The new cars will make their race debuts at the start of the 2012 season.



Blood brother

The MP4-12C GT3 not only marks McLaren's return to Sportscar racing, but also showcases some of its new, transferable technologies to a wider audience

BY **SAMUEL COLLINS**

McLaren has never really been 'just' a Formula 1 team. The first car to bear the M1A name was a sports racer built by Elva. Elvis Presley took to the wheel of it in the Hollywood film *Spinout* where he was told that 'it took some imagination to build the car'. Well, over the years McLaren has used that imagination to build a range of sports cars, peaking with its Le Mans-winning F1 GTR in 1995.

In 2011, the McLaren name returned to Sportscar racing with its MP4-12C GT3, a project that draws heavily on the wide resources of the McLaren group.

The new racecar is based on the MP4-12C road car, the first of a new range of products from McLaren Automotive that follow the ethos of being highly efficient, high quality, lightweight, practical, dynamic, safe, comfortable and visually arresting. 'McLaren has racing in its blood, and it was a natural step to take our MP4-12C road car and turn it into the most reliable, efficient and easy to drive GT3 car,' explains McLaren CEO, Martin Whitmarsh. 'Every car on the grid is performance balanced by race rules, meaning our objective must be to select a technical specification that ensures any driver is able to access the 12C GT3's performance limit with ease.'

Weighing just 75kg (165lb), the 12C's carbon chassis, or 'MonoCell' as its makers call it, was designed and developed by the McLaren Automotive Body Structures team at the company's headquarters in Woking, UK. The chassis composition and construction process were defined over a three-year period as the first, and vital, step in McLaren Automotive's launch as a fully-fledged sports car company.

'It is light, which helps reduce the 12C's CO^2 emissions to


With the outer body panels removed, it is obvious how the carbon fibre MonoCell integrates into the MP4-12C chassis

unprecedented levels for high-performance sports cars. It is also incredibly strong and predictable in form and behaviour, providing a great foundation to world-beating performance. Acceleration, braking, changes of direction and vehicle stability are all significantly better than on any car with an aluminium chassis that I have ever known,' explains Claudio Santoni, function group manager for body structures at McLaren Automotive. 'This is because using a carbon composite means we can manufacture the MonoCell with aerospace industry levels of precision, which is fundamental to accurate dynamic suspension geometry control.'

McLaren Automotive contracted composite experts, CarboTech, to refine the production process and bring to market McLaren's ambitions. Presented with a working concept based on 50 McLaren-made chassis, the Austrian company was challenged to help revolutionise carbon chassis manufacturing.

The chassis is produced in one piece through the Resin Transfer Moulding (RTM) process that, for the first time, uses robots and production lines during its manufacture, systems that these days are commonplace in most car factories.

The production process begins by loading dry carbon fibre into a complex, 35 tonne steel tool before it is pressed together, heated and then injected with epoxy resin. Using a steel tool is also new to the manufacturing process as, historically, carbon chassis have been formed in 'soft' tooling, made of composite materials, which adds production costs and time. The subsequent post-curing process hardens the resin, and the MonoCell then enters a booth where key surfaces are precision machined in preparation for vehicle assembly. The process between forming and curing produces the MonoCell as a hollow structure, and is the

MonoCell, as developed by Carbo Tech and, unusually, for a carbon fibre product, manufactured by robots

key to the chassis' combination of strength and light weight.

'I see no reason why the benefits of carbon should not cascade into more and more automotive product lines,' continues Santoni, 'but it will take a little while. McLaren took three years to develop the MonoCell and its production process. We also had the benefit of no industrial legacy, such as investment in aluminium plants or tooling. Nor do we have existing cars and after-sales processes based on aluminium structures and repair constraints. This gives us a competitive advantage that we will, of course, maintain as we launch our range of sports cars. But I hope that we have proven the benefits of carbon and that inspires both our competition and the car industry as a whole.'

CUSTOMER RELATIONS

One of the frequently-voiced concerns about composite structures, despite their inherent safety, is the difficulty of repairing them in the aftermath of a crash – something that is likely to happen in the rough and tumble world of GT3 – but McLaren Racing's head of vehicle engineering, Mark Williams, is unconcerned: 'The nice thing about that is, say for example you have an off, and you do damage some part of the car, unless it's a very large accident, the MonoCell stays intact, so you can just take that as a given, and then just do your normal checks to make sure there's no delamination or anything happening. You can then say 'right, that's good, I don't need to put it back in the jig, what could be wrong with it?' So from that perspective, you then only have to start replacing the crash structures that are built into the road car and off you go again. So I think, maintenance-wise, it should be very good. At the end of the day, in the event of a big crash they probably have to come back to us anyway. If it's significant, you have to assess how much damage has been done, and that's all going to be part of managing the customer relationship.'

A single plane rear wing is used on the racecar version in place of the road car's automatically-adjusted aerofoil. Ducting has also been revised

> "I hope we have proven the benefits of carbon and that inspires both our competition and the car industry as a whole"

RACING MODIFICATIONS

One of the key differences between the GT3 car and the road car is the extra grip provided by the competition tyres. This has moved the balance of the car further forward and called for some fairly major mechanical changes. 'We'd like to move weight further forward, but what are you going to move? There isn't anything to move and anything you do makes it very different from the original road car, and that's not the concept of the GT3. All we could do was to reduce weight at the rear,' explains Williams.

'A six-speed sequential shift gearbox by Ricardo was selected because a race-specific transmission is 80kg lighter than the seamless shift, seven-speed gearbox used in the road car. All the internal components have been proven in other racing series. We then challenged Ricardo to reduce weight further, meaning the unit has a bespoke casing design. The nice thing is, it's a very low c of g gearbox, too.

'We also had to move the oil tank from its road car location as it sits in the space we needed for the fuel cell volume. But, when you look at the packaging of the car, we had no option but to move it rearward. When you open the engine compartment, there's the engine, there's the exhaust and turbos, there's just no room there, and we didn't want it to go far from the engine, so it's now alongside the gearbox. It did mean we could do a little bit of work on the oil tank, though, and try and make it a bit smaller.'

Despite having a revised c of g, the GT3 largely retains the suspension geometry of the roadgoing MP4-12C. 'We've had to do our own front lower wishbone, but that's really based around packaging and just making that design work. Other than that, we've tried to keep as many standard components as possible.' The car does, however, use Mulitimatic DSSV dampers, while outboard you will find full race Akebono brakes with purpose-designed pads and friction materials – a nod to technical partners of the McLaren's grand prix team. 'We went to those suppliers because we have a good working relationship with them and we could use the same proven technology we've been developing for the F1 car.'

The engine on the MP4-12C

TECH SPEC

McLaren MP4-12C GT3	
Width	1995mm
Height	1145mm
Wheelbase	2670mm
Fuel tank capacity	120 litres

Chassis / body
McLaren carbon fibre MonoCell with aluminium front and rear frames and bespoke carbon body panels

Aerodynamics
Front and rear diffuser, front splitter, dive planes, adjustable rear wing

Transmission
six-speed sequential with steering wheel-mounted paddles; limited slip differential; sintered clutch; driveshafts with tripod joints

Engine
3.8-litre, 32-valve, twin turbo McLaren M838T V8; cast aluminium block, 90-deg v; flat plane crank; cast aluminium cylinder heads; variable cam timing; two water / air charge coolers; plastic composite plenum; cast stainless exhaust manifold; MHI fixed geometry turbochargers

Engine management
MESL TAG400 ECU and CIU 100 interfacing with Bosch ABS and Shiftec control units

Suspension
Double wishbone all round, adjustable for ride height camber and toe

Dampers
Multimatic coilover dampers with DSSV technology and independent bump and rebound adjustment

Front brake
Akebono six-piston monoblock calipers; 378 x 36mm iron ventilated discs

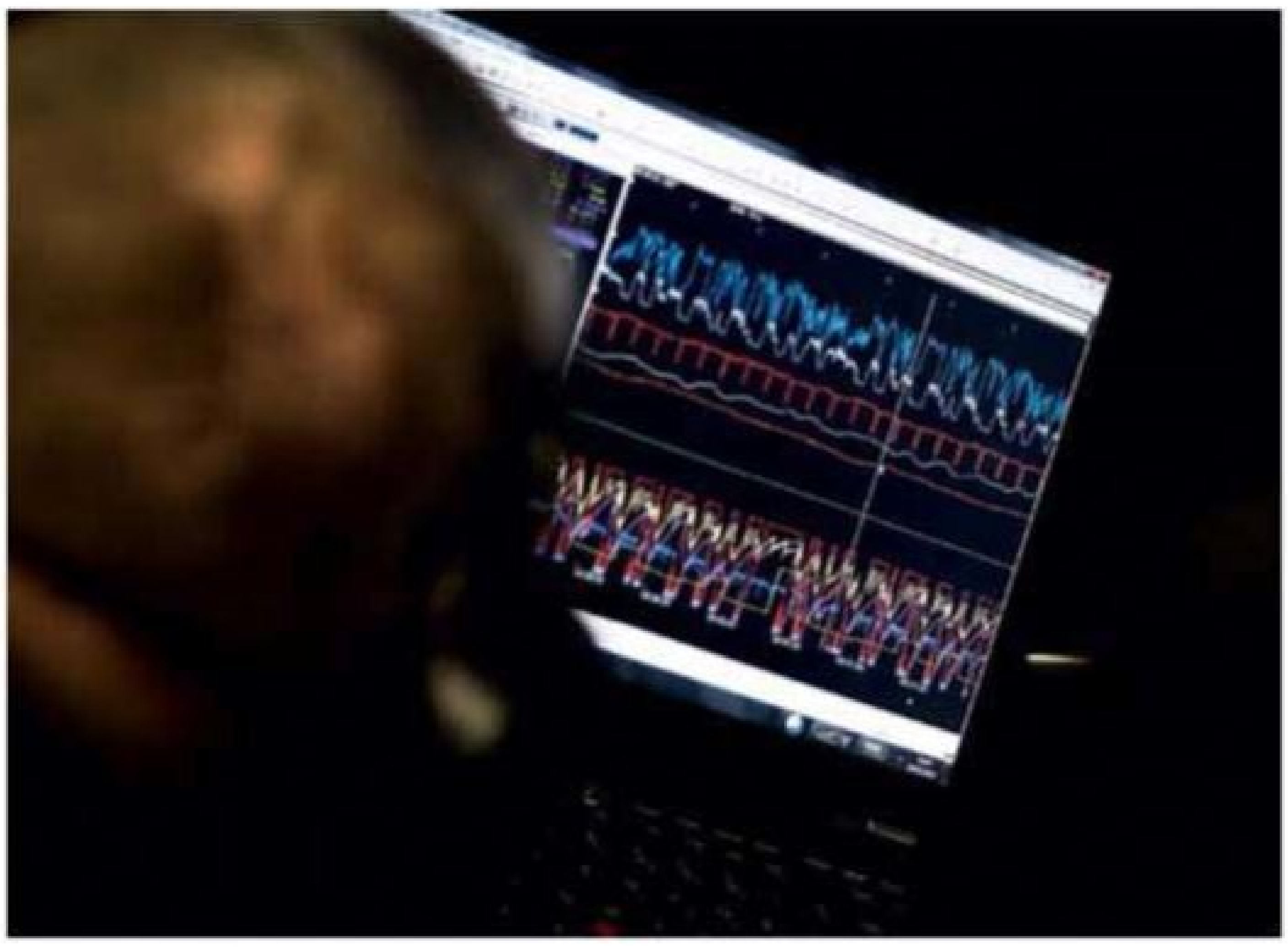
Rear brakes
Akebono four-piston monoblock calipers; 355 x 32mm iron ventilated discs

Steering
Electro-hydraulic PAS

Wheels
Forged aluminium
Front – 12 x 18in
Rear – 13 x 18in
MESL TPS system compatible

Cockpit electronics
Multi-function steering wheel with integrated driver display; central switch panel with systems display screen

Steering wheel
Derived from MP4-24 Formula 1 wheel, retaining integrated driver display, paddle shift and switches



According to McLaren, the integral data logging is designed for ease of use, enabling any team, or driver, to explore the maximum potential of the car

APPLIED TECHNOLOGY

McLaren is no longer just a small English racing team named after a Kiwi racing driver, it is a major force in manufacturing in the UK, with a stock market floatation rumoured for 2015.

Much of the advanced technology found in McLaren's racing projects can increasingly be found in other markets – most famously the Green Jersey competition of the Tour De France, which was won on a McLaren-developed bike called the S-Works Venge. Cycle maker, Specialized, turned to McLaren Applied Technologies to help create the low-drag, ultra-stiff design. Using FEA and the composite process usually applied to Formula 1 car projects, the frame weight was cut to just 950g. It was one of the key factors in the incredibly strong performances of sprinter, Mark Cavendish, on the classic road race and, more recently, with the British team at the World Championships.

McLaren's technology has also found its way outside the sporting world altogether, with an orthopedic device using an electronically-controlled damper designed to help speed up recovery from knee injuries. A more developed version of the device is in use with military organisations who use it to allow troops to carry heavier loads and to reduce injuries sustained by special forces using fast landing boats.

GT3 is largely standard, although it runs on the increasingly commonplace McLaren Electronics' TAG-400 ECU, the same unit found in NASCAR and Formula 1. As a result of that we've taken the opportunity to basically reduce the power level of the engine, again based on what we believe we need to do to meet the balance of performance targets. So we've had a range of lower power maps produced by Ricardo. Because they have all the experience of the road car engine, it seemed the logical thing to do.'

VISUALLY DIFFERENT

The bodywork is visually quite different to that of the road car with a new front end, revised ducting and a single plane rear wing in place of the automatically adjusted road car aerofoil.

'All of the work has been done in the virtual world, which obviously has some inherent risk because you never know quite what the exchange rate is going to be,' explains Williams. 'You just have to hope you've done the best job you can [but] you don't know that until you've run the car. We've gone out and run the car and got the exchange rate we expected and believe that to be enough to satisfy the requirements of the balance and the performance level of the car.'

When the GT3 was first rolled out at Silvertsone in early 2011 those present saw the level of engineering and assumed that this was not a GT3 car at all but really a toned down GTE design aimed squarely at the Le Mans 24 Hours. McLaren officially deny any plans to take part in the most famous event in motorsport, but ask at a quiet moment and you'll find the company is, in fact, very keen on the event.

'We'd obviously love to do Le Mans again,' Williams candidly admits. 'The difficulty is, we won Le Mans when the category we were racing in could win the race outright, and that's always the attraction to be able to do that. It will be nice if that happened again, but that's really out of our hands and, at the end of the day, we have to deliver cars that customers want to go and race, in whatever championships they do.'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Shocks to the system

Three years on from the 'j-damper' story, Penske Racing Shocks announces its hybrid damper / inerter for wider application

"a new, innovative component that has been missing from suspension technology until now"

BY SIMON MCBEATH

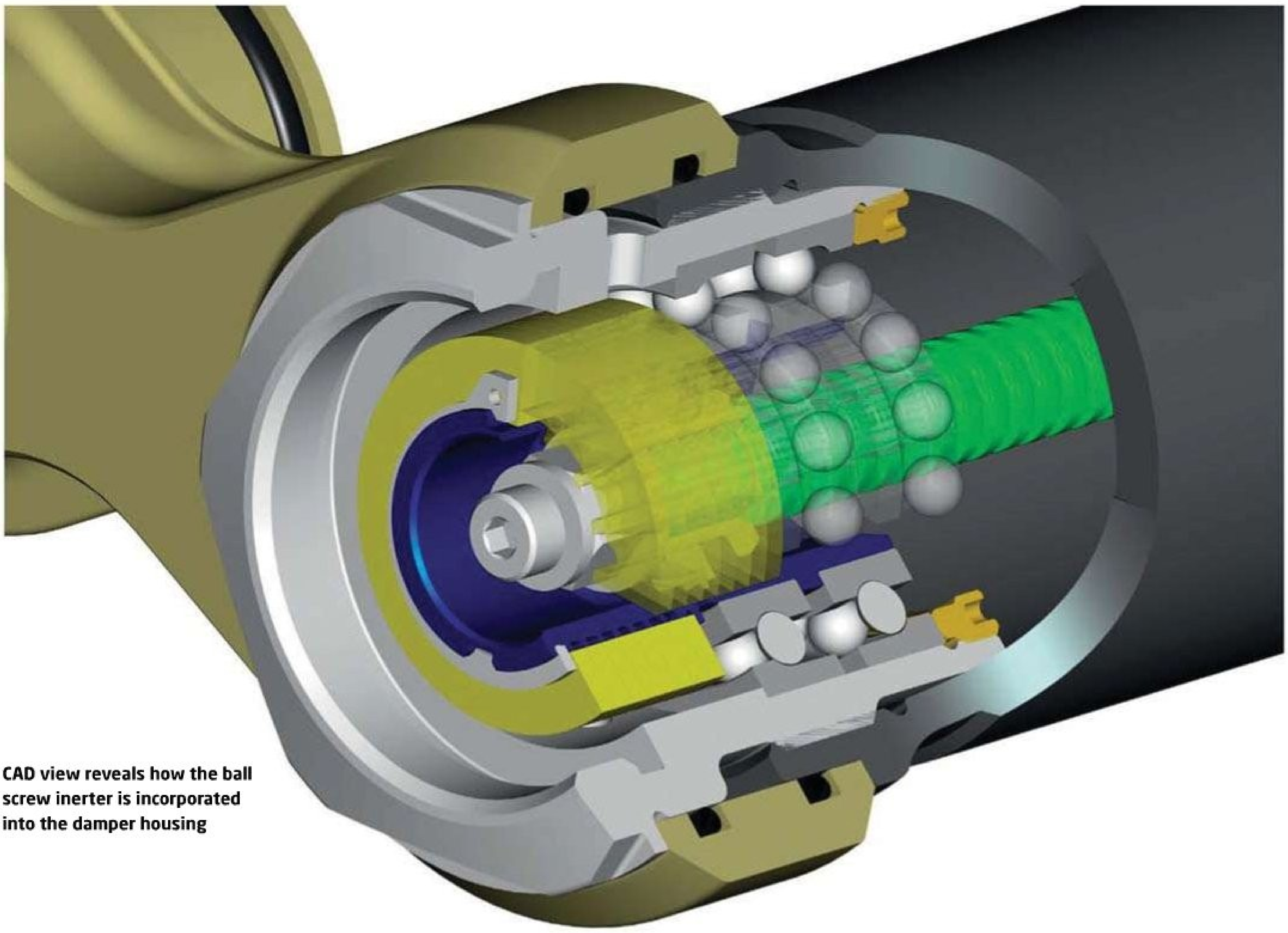
It would be a cynical observer who wasn't impressed with the conception of the inerter, or its application in improving tyre grip. But the simple explanation that it improves mechanical grip by reducing tyre load fluctuations in dynamic situations doesn't do the concept justice. Yet when Professor Malcolm C Smith of Cambridge University in the UK first conceived it in 1997, he admitted to being nervous about talking of it, 'because it seemed so elementary a concept. It was very difficult to believe that nobody had thought of it before, and I presumed that either it had been done already or there was some sort of snag.' But, as we now know, McLaren raced inerters for the first time in 2005, Kimi Raikkonen winning in Spain to give the technology a successful race debut. Since then, inerters have been widely adopted in Formula 1.

As one of the world's leading damper manufacturers, Penske Racing Shocks (PRS) became involved with Cambridge University early on in the development process, during 2003 in fact. Penske's director of research and development, Bill Gartner: 'Some of the earliest Cambridge test arrangements included bits of Penske shocks in order to simulate how inerters and dampers would behave in a suspension system.' Subsequently, in August 2008, PRS entered into a multi-year deal with Cambridge Enterprise, the commercialisation office of the University, to incorporate Cambridge's patented inerter technology into suspension components, primarily in F1. Crucially, the agreement also allowed PRS to design, develop and produce generic and bespoke inerter designs, as well as future applications and improvements.

The deal was a no-brainer for both parties, as technical director at PRS, Jim Arentz, put it at the time the deal was announced: 'Inerter technology is something we feel adds to our portfolio of pioneered applied technologies in professional racing. We are confident that the ingenuity of Cambridge, combined with Penske product quality, performance and customer service will promote greater exposure of the inerter in motorsport.'

USEABLE TECHNOLOGY

That last phrase brings us neatly to the present and, as *Racecar Engineering* can now exclusively



CAD view reveals how the ball screw inerter is incorporated into the damper housing

reveal, to Penske's new hybrid damper / inerter. As Gartner commented, this is a prime example of how F1-specific technology has morphed into real world, useable racecar specification. However, he also admits there were doubts along the way, too...

'We gathered from scraps of information that [early on at least] F1 teams were more likely after settling tyre sidewall oscillations following a kerb strike, as opposed to more general grip gains that a normal racecar would likely be chasing. So we weren't convinced that they would ever find a place outside of F1... But we started to hear increasing rumours that more F1 teams were making use of the technology and, because Formula 1 is an important segment of our business, it was important to keep up to date on any emerging suspension technologies.

'With that in mind, we began to meet with Professor Smith at Cambridge University to discuss his theories, and inerter potential in particular. The concept was interesting, but we weren't sure how beneficial inerters would be for a more traditional suspension layout. Formula 1 suspension systems are in a class of their own because the massive downforce loads require very stiff springs, while the tyres have a very soft and compliant spring rate. During a traditional analysis, this combination shows that inerters should add grip, settle the car much more quickly, and create a more consistent aero platform. However, when a more normal racecar suspension system is analysed using stiffer tyre sidewalls, softer suspension springs and less downforce, the general trend seemed to show minimal gains or even reduced grip. But, as we dug deeper, we found that there are many ways to analyse the grip level that a tyre will provide in different situations, some of which showed significant improvement with inerters. It was time to simply get down to business and try it!'

Then began a fascinating relationship between academics and engineers, something Gartner was keen to expand upon: 'We developed a very interesting dynamic with Professor Smith, who comes from an academic background so adept at the analysis of both mechanical and electrical vibrations, whereas at Penske we use analysis for general guidance, knowing the final key is really the driver's mind... However, inerters were a bit more complex, and needed the right partnership between theoretical and practical. Like a proud father watching his child come of age, he was yearning to see his invention stretch its legs!

> **"a fascinating relationship between academics and engineers"**

'Meanwhile, at Penske we put our heads down on a practical, reliable, easy-to-use design, while Professor Smith got to work analysing many of the common suspension arrangements in racing. His groundwork guided us toward the perfect range of inertance and adjustment levels to begin the development. The use of inerters as central dampers in F1 to settle the overall oscillations of the car had became public knowledge, but we weren't completely sure how drivers would respond to their use in the more traditional corner dampers that drivers rely on to feel the car as they push the limits around a racetrack. In order to solve the mystery, we had to merge the world of analysis, and good old-fashioned R and D.

'For some time now, racing has been pushed more toward computer analysis and racing simulators. Historically, Penske suspension products were geared to the driver's seat-of-the-pants impression, but now our advances need to show

Penske Racing Shocks hybrid damper / inerter disassembled. Look top right for the interesting new bit...

The ball screw and rotating weight arrangement in close up is revealing in respect of the order of mass involved

Removing the inerter weight to change for another is a simple matter of unscrewing the top eye and cap

Close up with top eye only removed

promise to the computers before ever reaching a driver. Even though our approach for many of these changing markets has been adjusted accordingly, in our hearts we still yearn to give the driver what he or she needs to go fast in a racecar. So, in this age of multi-million dollar computer simulations, we decided to buck the trend and spend the time and development dollar to design and prototype an idea...'

> “add grip, settle the car much more quickly, and create a more consistent aero platform”

PRACTICAL ISSUES

Also there were some fundamental practical issues to tackle, as Gartner explained: 'We wanted to bring inerter technology to the masses, and offer something that normal racing teams could utilise. F1 teams were typically using inerters and dampers separately, and their inerters were usually greased before each race. This required a complete teardown, as the grease would attract carbon dust, or any other particles floating in the air. We knew for a normal racing team to use this technology, we needed to protect the most delicate and important inner workings of the inerter.

'A ball screw is impossible to seal, so we decided we would build a damper around the inerter by telescoping the ball screw directly into the damper shaft, and this is the basis of our own patent pending design. This allowed the ball screw and thrust bearings to operate in the damper oil, keeping things running friction free and well lubricated for a much longer period of time. It also provides some important benefits when compared to normal inerters alone.

'One important feature of any inerter is the elimination of axial free play in the system, without adding running friction to reduce inerter benefits. Highly pre-loaded thrust bearings would easily solve the free play issue, but would quickly eliminate performance gains from the free exchange of energy to and from the spinning weights. There are rumours that some suspension failures that were attributed to inerters were actually [attributable to] other suspension components that couldn't handle the additional high frequency loads from the inerter. One could easily imagine an inerter reaching its natural frequency with some free play in the system, and shaking the suspension system to its breaking point. Even though our hybrid system has a highly accurate shim system to eliminate any backlash, we've also found that coupling an inerter and damper into one complete unit helps to eliminate the negative effects that a normal inerter might exhibit due to free play because any free play is also damped. The damping and inertance can work together in a symbiotic way, with each device assisting the other where it needs help.'

TRACK-BASED BENEFITS

As Gartner warmed to the topic, he expanded on the key benefits to be had from this new hybrid product: 'While F1 teams generally understand how inerters can be used to

Alternative view of the ball screw and weight inerter assembly

Penske Racing Shocks' dampers are standard fit with the new Dallara IndyCar. The new hybrid inerter / dampers may find their way into the package in the near future

make gains on the track, inerter theory for more standard vehicle suspensions is in its infancy. However, to me, an inerter can be used to accomplish some important goals that can help a car and driver attack the track more effectively. Firstly, an inerter can help to block low-amplitude, high-frequency 'noise' from working its way into the suspension system. I believe the typical racecar suspension can't handle these movements without introducing some lag in response. These types of movements are best handled within the tyre carcass, in order to avoid a delayed response from the suspension that can reduce the tyre contact patch load.

'Another gain that drivers can typically feel is an increase in control over the car, and a sense that the car settles more quickly after road disturbances or aggressive handling manoeuvres. Because the inerter absorbs energy, and then allows that energy to dissipate back into the suspension system, drivers feel as if the car is more controllable, and they are more comfortable accelerating sooner after the car has been upset by the road surface, or simply by driver inputs. Also, we've been finding that inerters allow a bit less damping to be used as each component assists the other, which may also add grip. And in testing, we've been able to actually increase low-speed compression damping without the normal reduction in grip that is common in that situation, giving the driver even greater confidence, and a feeling of stability similar to our work with regressive dampers.'

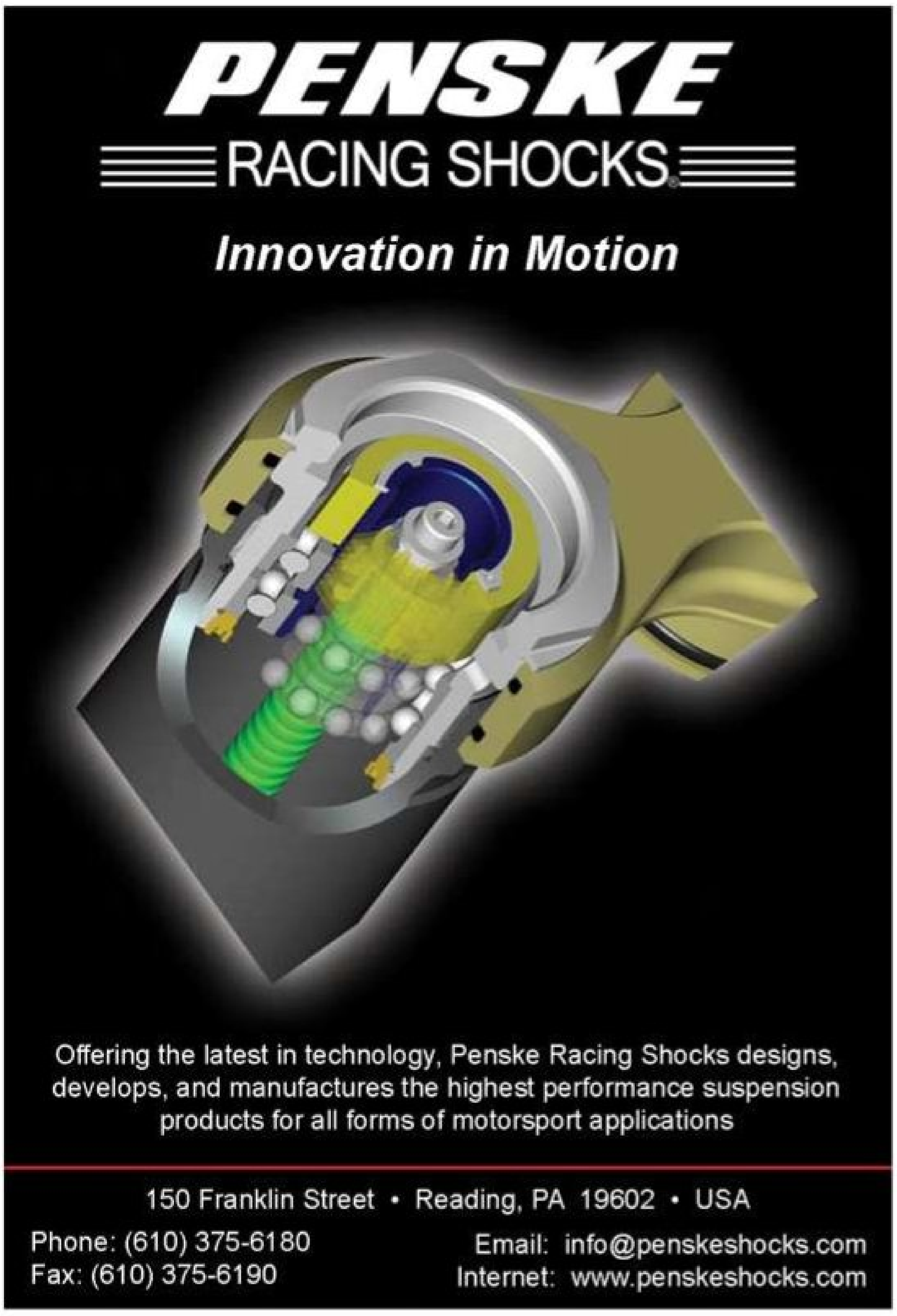
MOMENT OF TRUTH

After months of design, re-design, dyno testing and calibration, it was finally time for theory and practicality to come together at the racetrack. Gartner: 'To say I was a bit nervous as I watched the car roll down pit lane trying to discern whether the suspension was actually working is an understatement. We really still didn't know what the driver would feel. After some warm-up laps, and then a good number of impressive hot laps, he was finally into the pit for debriefing. The smile on his face told me right away that we were on to something. He raved about grip levels that he never would have expected on used tyres, and a feeling of control at speed that he had never felt before.

'Professor Smith's analysis had pointed us toward the inertance level that was most likely to provide gains, making our first test extremely successful. We found that increasing the inertance by adding weights increased the positive effects until suspension would simply become too harsh. This threshold was dependent on the type of track being raced, the style of the driver and, of course, the car set up. However, because the weights are easy to change, finding the best set up is easier than one might expect. In addition, because the drivers could actually feel the difference as we made changes, it wasn't like we were working in the dark.'

SIMPLICITY OF USE

Part of the re-design work was to make tuning the units as straightforward as possible. Penske moved the bearings and weights up to the very top of the damper to be accessed via a removable cap. Changing weights is now a simple process of de-pressurising the damper, removing the cap and adding or removing weights. The cap is then re-installed with any captured air simply escaping via a bleed screw,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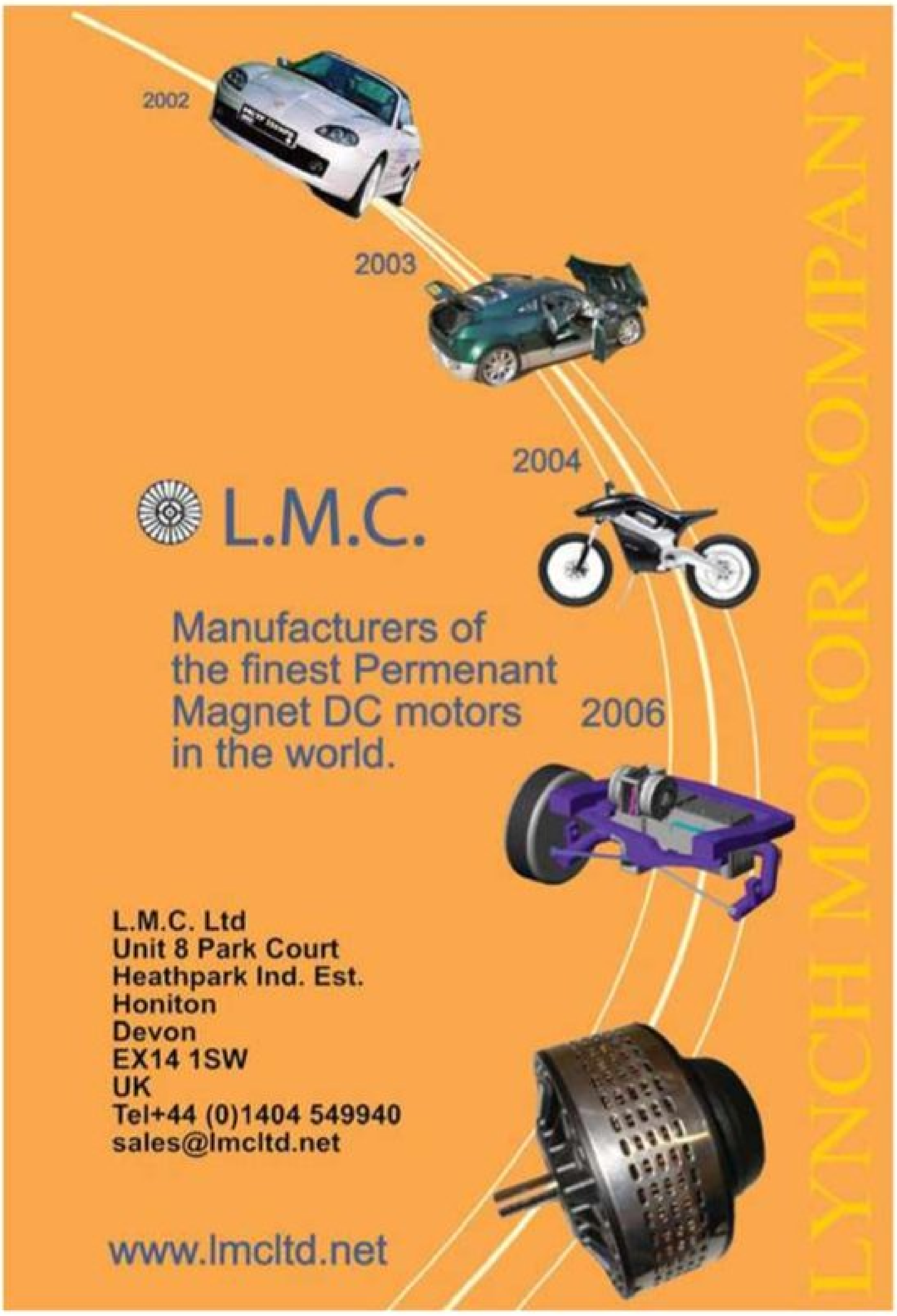
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and the damper is re-pressurised and ready to go again.

Interestingly, Gartner commented that 'the only potential obstacles to successfully introducing this new technology to the racing public are misconceptions about what it is, perceptions of complexity, and the belief that inerters had to be extremely expensive because they are used in F1. The inerter itself is actually simple in its operation and, with the help of our friends at Cambridge, we've been able to arrive at various tests with a great baseline set up right away. So far none of our customers have felt overwhelmed or afraid of the technology. And with the concurrent development of our next generation shock, the 8780, which offers a modular approach that can include the hybrid damper / inerter configuration, customers' costs are also controlled.'

There are rumours in some racing circles that inerters may be banned to keep some well-funded teams from going down the F1 route and making expensive one-off units for their own use. 'At Penske we hope to avoid this dilemma,' continued Gartner, 'by providing Cambridge-licensed inerter technology merged into our standard damper product lines, making it accessible to everyone. When Faraday devised his first useful electrical capacitor years ago, the engineering gods didn't devise rules against its use. The capacitor was a new component that advanced the field of electrical engineering. In much the same way, inerters are a new, innovative component that has been missing from suspension technology until now. By banning inerter technology now that their use has been acknowledged, and the gains are apparent, racing formulae would be shelving a very significant new suspension component that was just yearning to be found.

Fittingly, the last word goes to Professor Smith: 'It has been fascinating to see the inerter develop from a mathematical concept in circuit theory through to actual deployment on racecars. From an early stage Penske Racing Shocks forged a close relationship with the Engineering Department at Cambridge University and played an important role in advancing the technology. Penske's latest hybrid damper / inerter, is a further step to its wider use, and the integration of Penske damping technology with an inerter in a single compact package will no doubt prove to be very attractive to customers.'

A BRIEF REMINDER OF INERTER THEORY

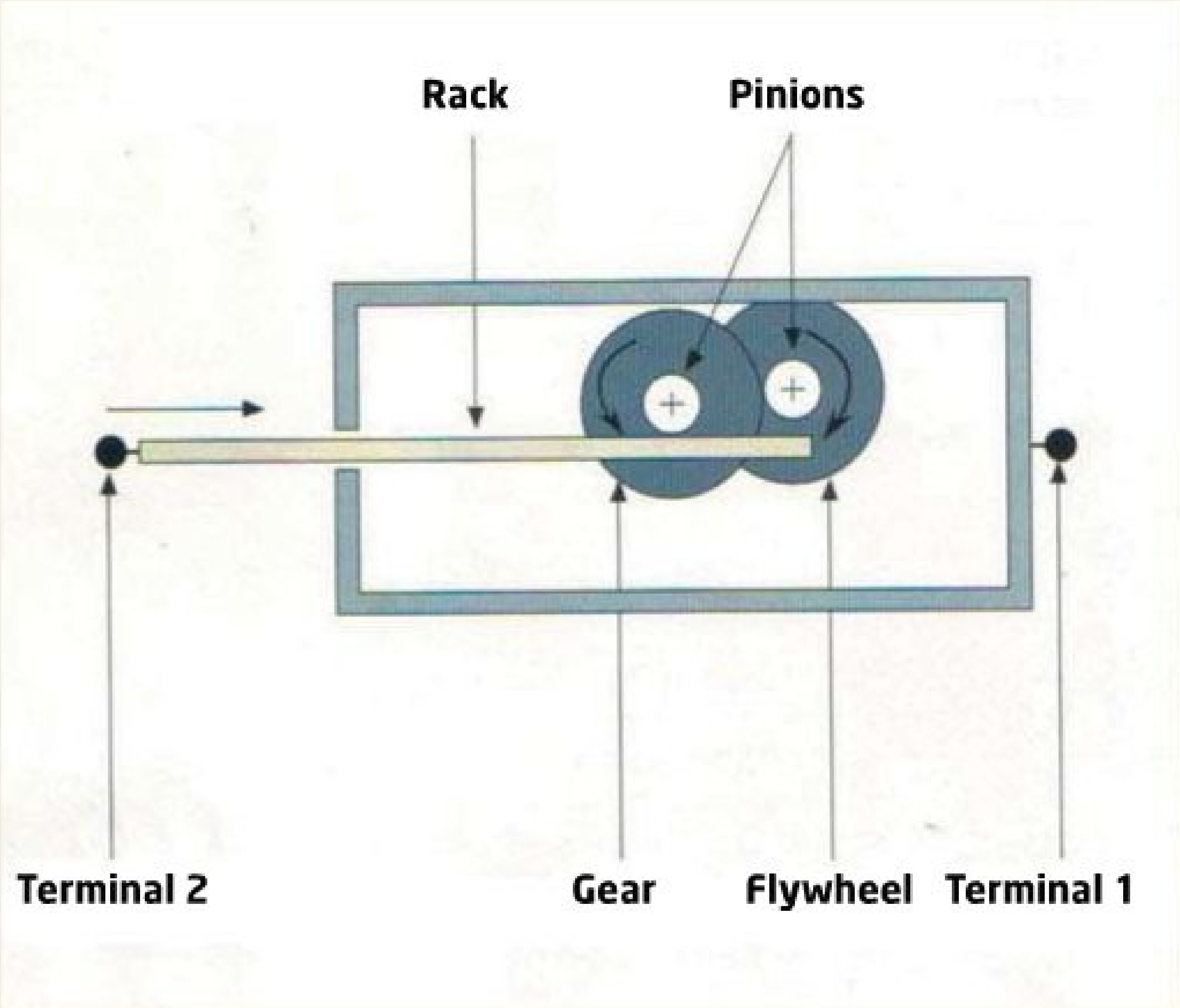
As a professor of control engineering, the inventor of the device (and the word 'inerter'), Malcolm C Smith, was inspired by mechanical analogues to electrical control systems, wherein he related springs and dampers to inductors and resistors, but realised there wasn't a mechanical analogue for the capacitor. What was needed was a new device that had two terminals or attachment points, and which responded with a force that was proportional to the relative acceleration between the two terminals. The inerter is that device. A typical embodiment would see a ball screw and flywheel arrangement, the latter being rotated when there is relative movement between the 'terminals' at either end of the ball screw.

The inerter is therefore an energy storage component, unlike a damper that is an energy dissipater. But, by reacting to acceleration between its terminals, an inerter responds much more rapidly than a velocity-sensitive device like a damper. And by tuning it to operate with the natural frequencies in the tyre and suspension system, load variations at the tyre contact patch can be smoothed out to allow greater mechanical grip to be generated.

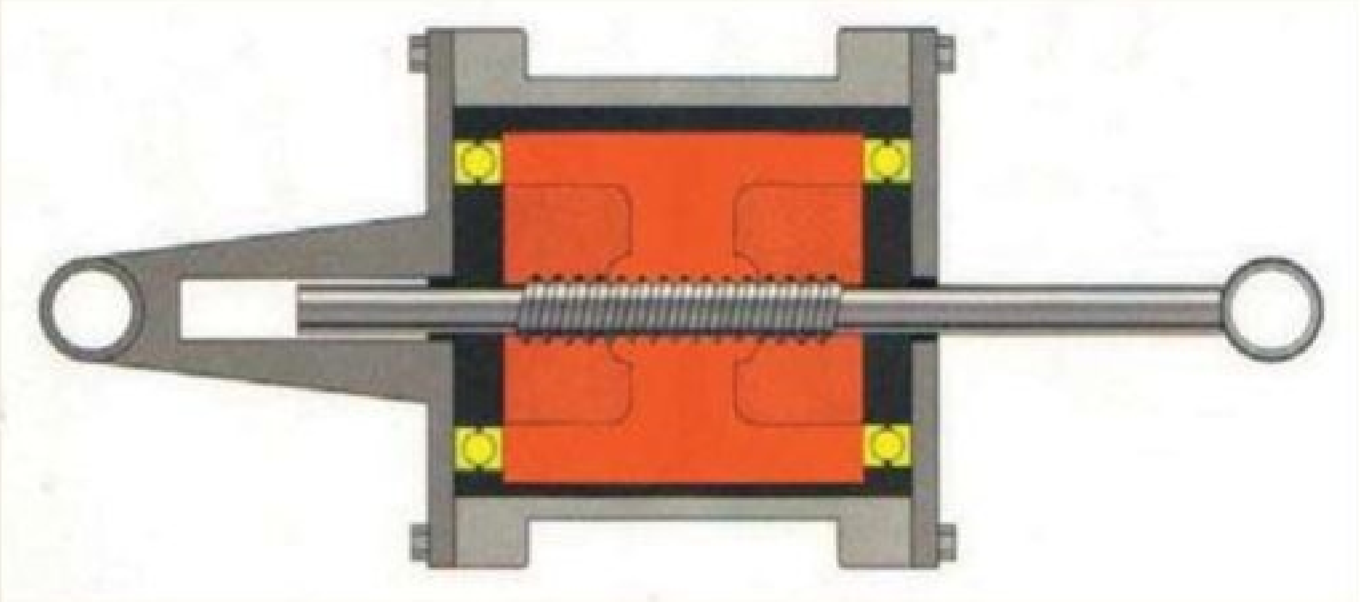
Professor Smith: 'The inerter makes a connection between mechanical design and conceptual modelling, and allows ideas from these two contrasting viewpoints to be combined. Circuit theory can suggest ways of deploying inerters that would not be obvious from a traditional mechanical engineering point of view. On the other hand, intuition from design engineers can merge the inerter into traditional thinking to aid its practical understanding. With racecars, there is naturally a big focus on grip. But the inerter can also be used to optimise other performance measures, such as ride comfort and handling.

How the inerter is used depends in part on the ease with which it can be deployed, hence the advantage of combining the inerter and damper in one single unit.'

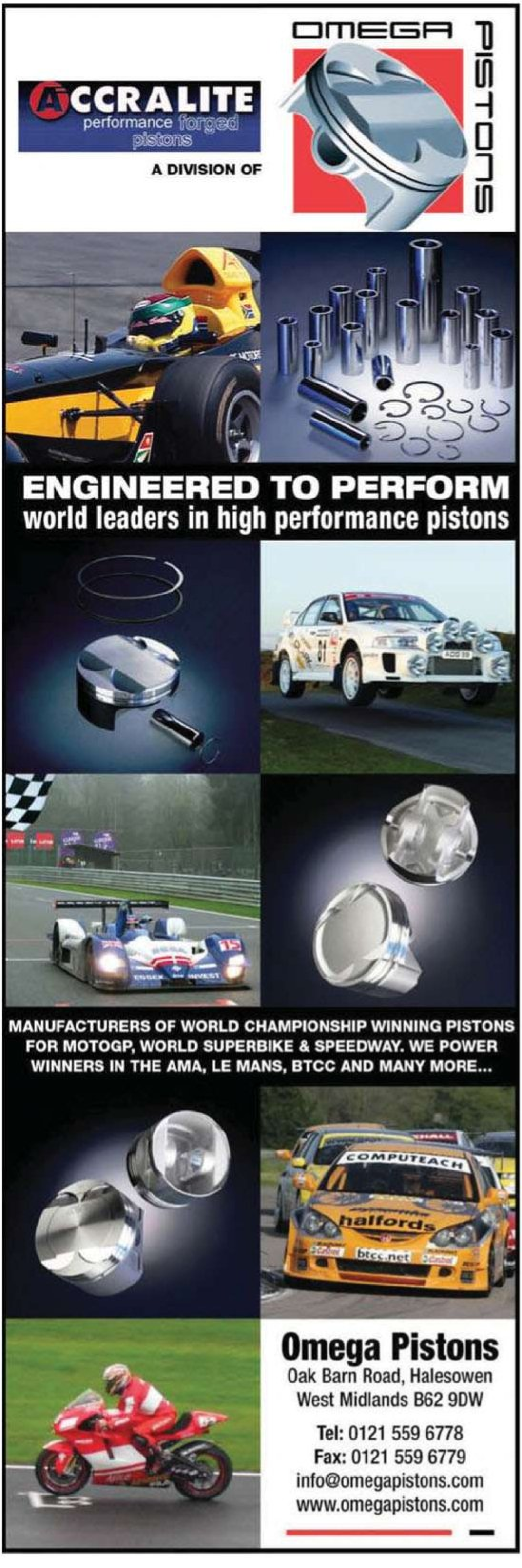
> **"[an] inerter is an energy storage component, unlike a damper that is an energy dissipater"**



Mechanical interpretation of the principles of the inerter. One terminal is mounted on the casing, the other on a rack that drives a pinion as it moves in and out. The pinion drives a flywheel via a larger gear producing high rotational speeds and capturing large amounts of inertial energy compared to the mass of the whole unit



Cross-section of the j-damper showing the eyes for mounting the casing to one suspension rocker and the threaded rod of the other. The flywheel (red) spins in the bearings (yellow) to absorb and release kinetic energy



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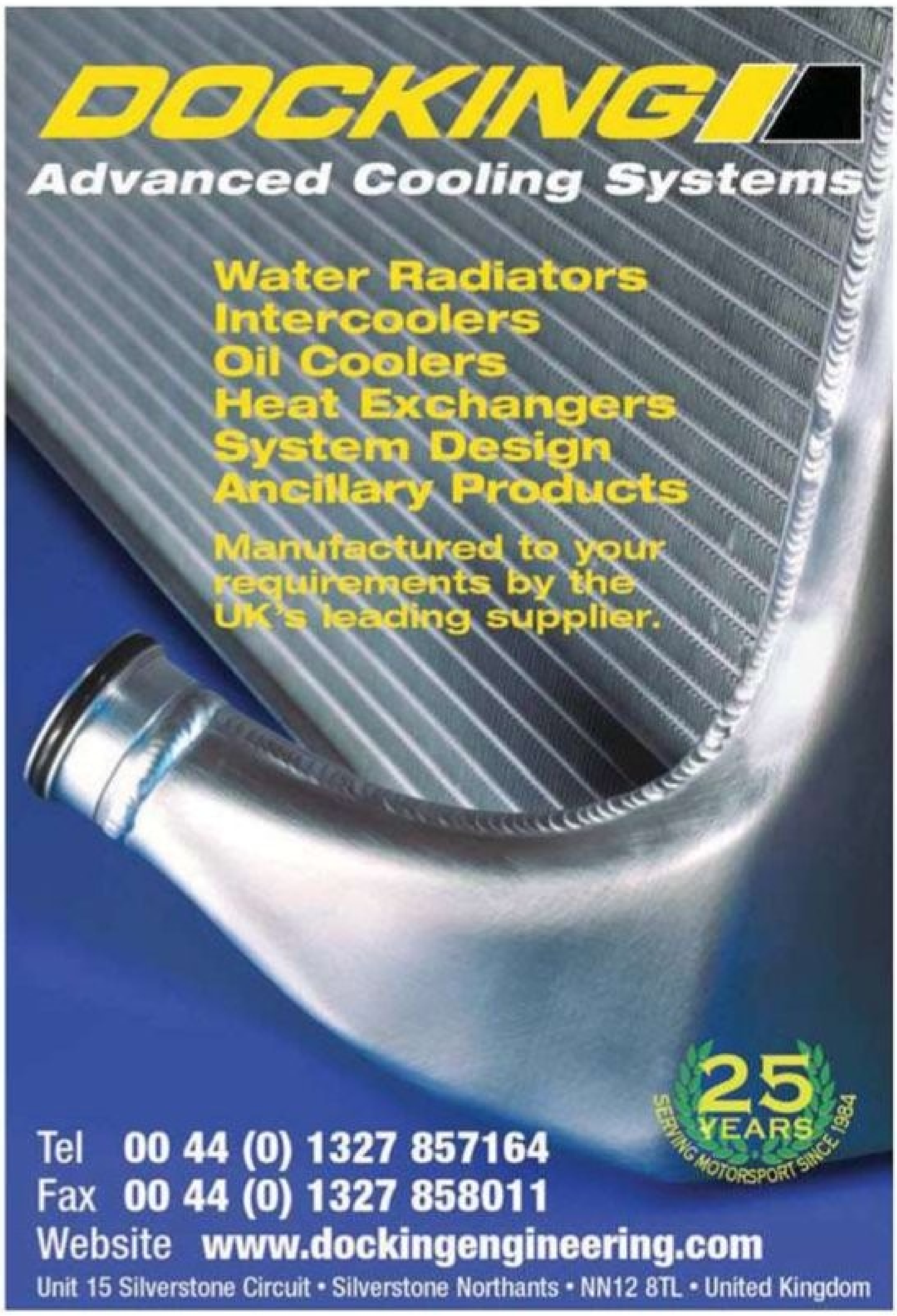
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Looking forward, looking back

Is it time to take another look at active suspension?

BY DANNY NOWLAN

One of the nice things about what I do is the opportunities I am offered to have discussions with people from all walks of life in the motorsport industry. In particular, I recently had a discussion with a colleague of mine involved with the Time Attack category and an ex-Williams F1 aerodynamicist. In the course of that discussion it occurred to me that maybe it is time to re-visit active suspension in motorsport.

For the un-initiated (I realise this may only be about 10 per cent of the readership but bear with me), active suspension started to appear in Formula 1 in the 1980s. By the early 1990s it peaked with cars such as the all-conquering Williams FW-12 and FW-13 that won the F1 World Championship in 1992 and 1993 respectively. So successful was it that the FIA, in its wisdom, decided to ban active suspension for the 1994 season. Ever since then, all of us working in motorsport have been making do with passive suspension systems. On a personal note, I believe this was the most disastrous, knee-jerk decision in the history of motorsport, and I think you'll start to appreciate why as you read this article.

FINE CONTROL

What 'active' brought to the party was it allowed a very fine control of both ride heights and the load distribution as the car cornered. The ride height in particular is of critical importance. To illustrate why, consider the downforce map of a typical F3 car shown in figure 1, overleaf. You can see immediately from this map that the ride height only needs to vary by 15mm and you lose 20 per cent of your downforce. What active offered the race engineer was a very precise way to control this (we'll discuss the significance of load transfer through the corner shortly).

Fast forward to today, and current F1 cars are starting to generate downforce in the same order as the ground effect

days of the early '80s. Now, if you're wondering what this has to with our discussion of active suspension, let's have a look at the numbers, and some typical F1 values are presented in table 1. I don't pretend these numbers are accurate, they are guesstimates at best, and optimistic ones at that, but you'll appreciate their significance as we go on.

For the sake of argument, let's explore the implications of this if the front of the car compresses by, say, 30mm. But let's first calculate the frontal downforce and the combined spring rate that we'll need to make this happen, (see Equation 1).

So, to keep a current F1 car off the deck we need an effective spring rate of 177.2N/mm. To calculate the wheel rate, use Equation 2. From this we know we need a wheel rate of approximately 430N/mm, or 2500lbf/in. This can be mitigated somewhat by using bump rubbers but, by anyone's standards, that's stiff.

Things really start to get interesting though when we look at what proportion of the suspension is being taken by the tyre. Running the numbers on this, we see the results from Equation 3.

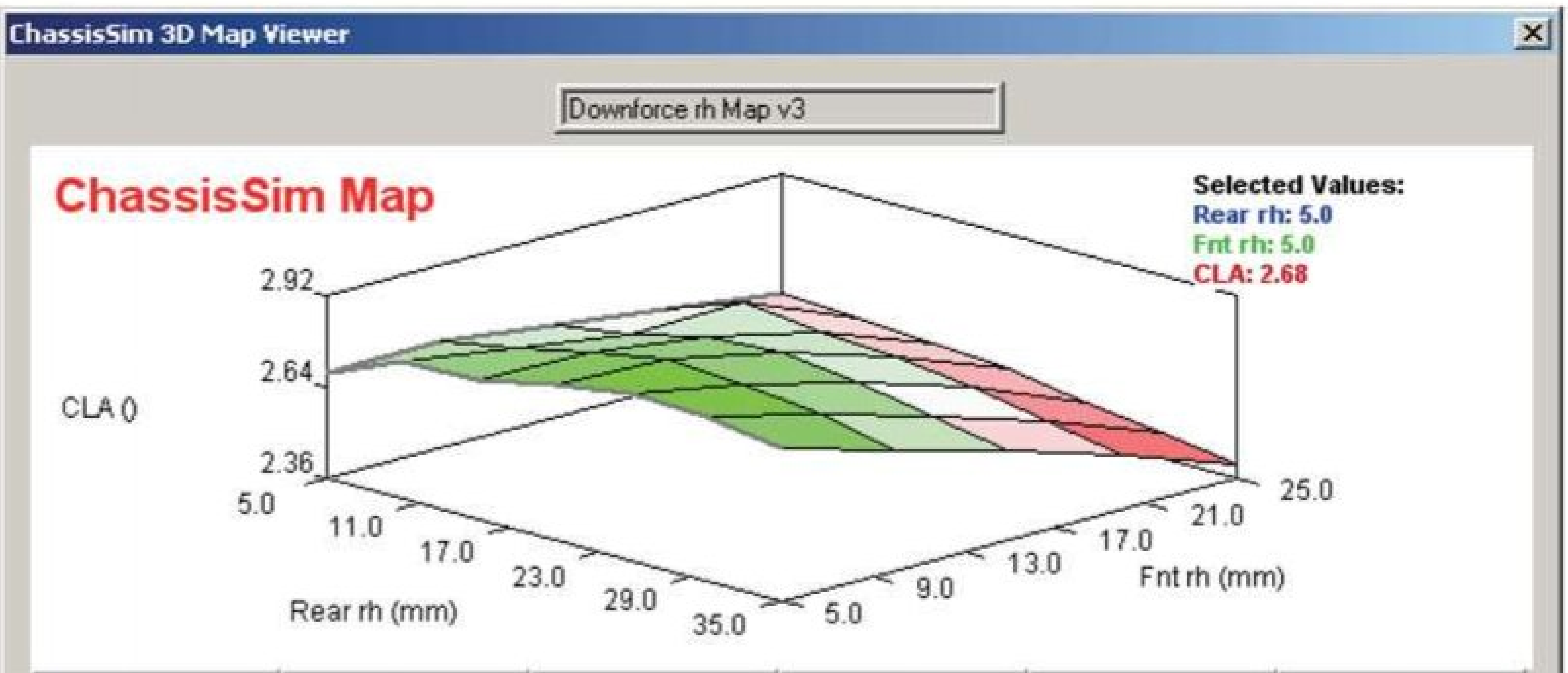
What this tells us is that approximately 60 per cent of the movement of the car's body is in the tyre. To illustrate why this is such a telling statistic, let's review the quarter-car model. Looking at the model, the suspension deflection between the body and tyre can be controlled directly with damping rates and spring rates. However, once we have large movements in the tyre we lose direct control over what it is doing. Yes, you can mitigate with wise spring, damper and inerter choices, but at 60 per cent you are in borderline territory.

The other ramification of this is how these high spring rates affect the ability to tune load transfer in the middle of a corner. Recall the equations for simplified load transfer:

rcm = rcf + wdr*(rcr - rcf);
(1)
]tm = wdf*tf + (1-wdf)*tr
(2)
h

Table 1: ballpark figures for a current spec F1 car

Parameter	Value
CLA	8
Front ride height / rear ride height	45mm / 65mm
Front weight distribution	45 per cent
Front tyre spring rate	300N/mm
Rear tyre spring rate	300N/mm
Ref speed	250km/h



	5.0	10.0	15.0	20.0	25.0
5.0	2.685	2.69	2.65	2.60	2.56
10.0	2.78	2.73	2.68	2.68	2.54
15.0	2.79	2.78	2.73	2.65	2.53
20.0	2.84	2.82	2.75	2.64	2.51
25.0	2.88	2.81	2.72	2.61	2.47
30.0	2.86	2.78	2.68	2.57	2.44
35.0	2.83	2.73	2.63	2.52	2.41

Figure 1: ride height map of an F3 car. CLA vs front and rear ride height

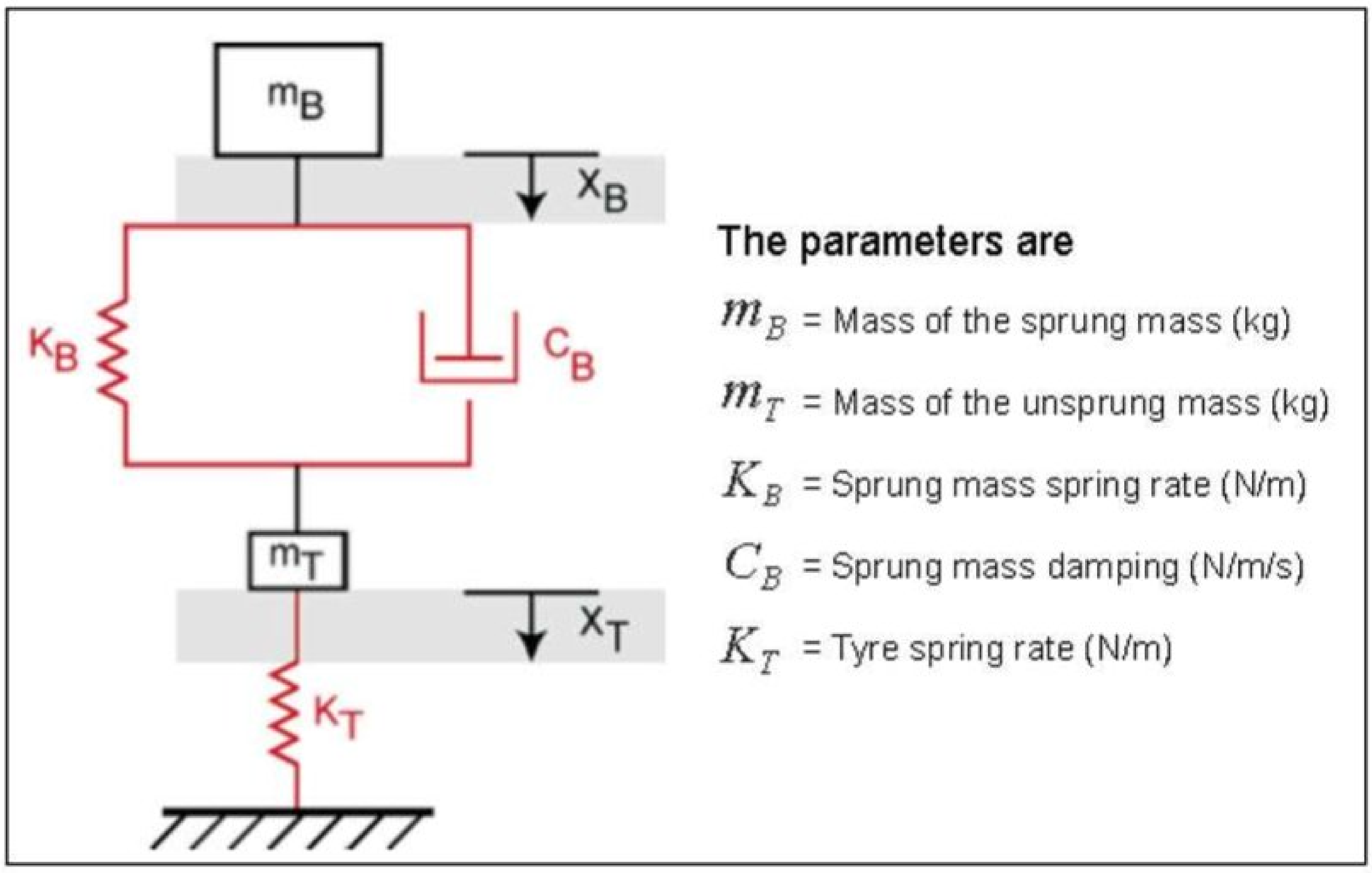
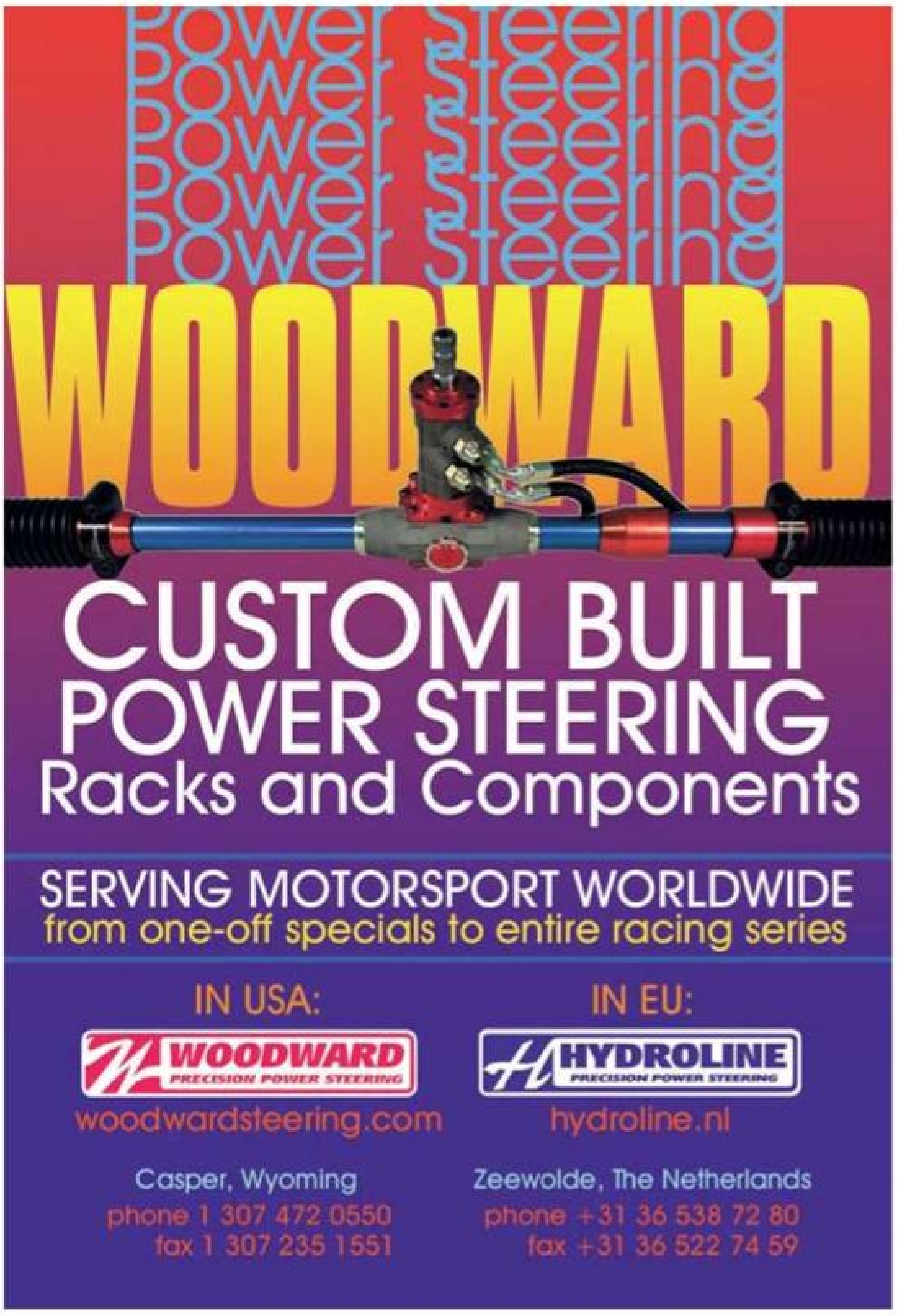


Figure 2: a quarter-car model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EQUATIONS

Equation 1

$$Ft\_Downforce = wdf * C_L A * 0.5 * \rho * V^2$$
$$= 0.45 * 8 * 0.5 * 1.225 * (250/3.6)^2$$
$$= 10633.7N$$
$$k_{EF} = 0.5 * Ft\_Downforce / Ft\_def$$
$$= 0.5 * 10633/(30/1000)$$
$$= 177.2N/mm$$

Equation 2

$$k_S = \frac{k_{EF} \cdot k_t}{k_t - k_{EF}}$$
$$= \frac{177.2 * 300}{300 - 177.2}$$
$$= 432.9N/mm$$

Equation 3

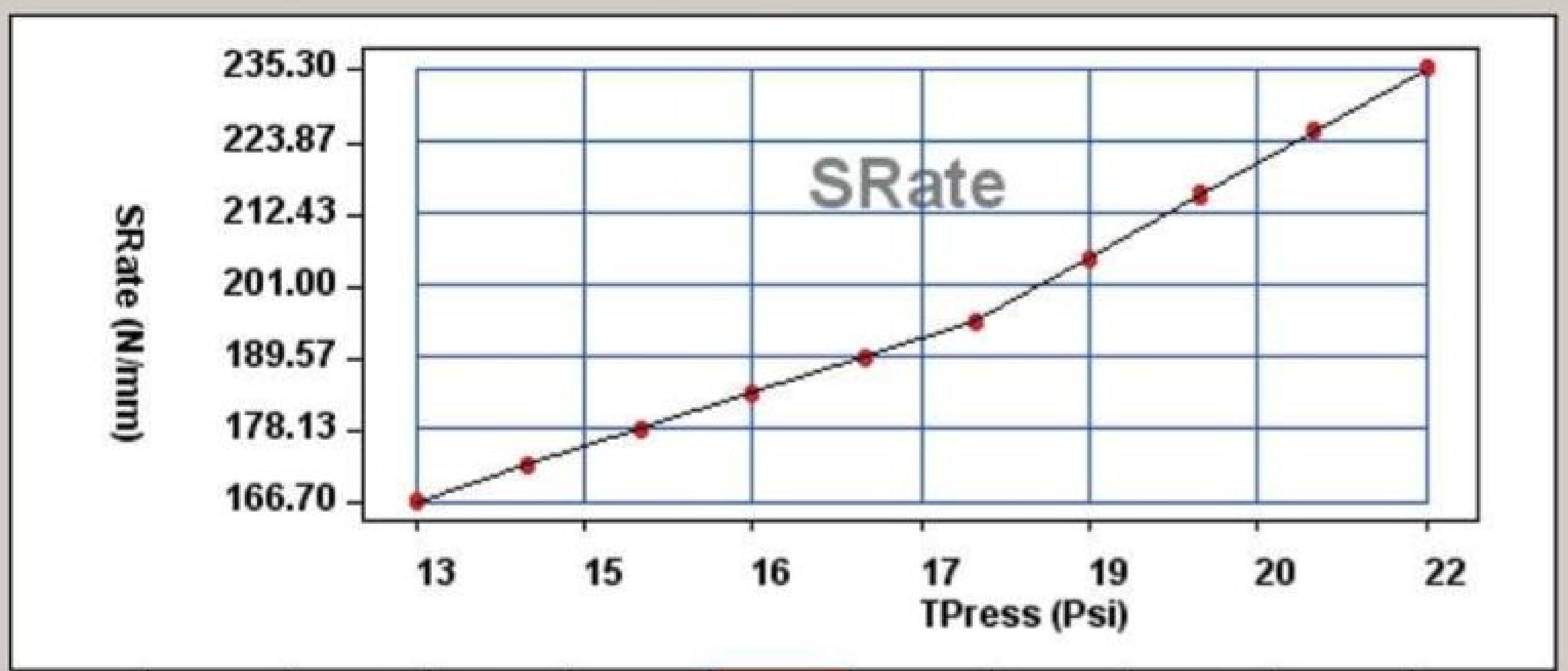
$$\%tyre\_movement = \frac{k_s}{k_s + k_t}$$
$$= \frac{432.9}{300 + 432.9}$$
$$= 59\%$$

Equation 4

$$A_{c.p} = \frac{F_Z}{P_T}$$
$$l_{c.p} = \frac{A_{c.p}}{w_t}$$

where,
Ac.p = contact patch area (m2)
Fz = vertical load on the tyre (N)
wt = width of the tread (m)
lcp = length of the contact patch (m)

Tyre Spring rate as a function of Pressure



TPress	13.05	14.02	14.99	15.95	16.92	17.89	18.86	19.82	20.79	21.76
SRate	166.70	172.38	178.06	183.74	189.42	195.10	205.15	215.20	225.25	235.30

OK Cancel

Figure 3: change in tyre spring rate with air pressure

sm = h - rcm;
(3)
rsf = (krbf + kfa)*ktf/(kfa + krbf + ktf);
(4)
rsr = (kfb + krbr)*ktr/(kfb + krbr + ktr);
(5)
prm = tf2*rsf/(tf2*rsr + tr2*rsf);
(6)
prr = (tr/tm)*(wdf*rcf + prm*hsm)/h;
(7)

Here the symbols are:
rcm - mean roll centre (m)
rcf - front roll centre height (m)
rcr - rear roll centre height (m)
wdr - weight distribution at the rear of the car
wdf - weight distribution at the front of the car
h - c of g height of the car (m)
rsf - wheel spring rate in roll for the front (N/m)
rsr - wheel spring rate in roll for the rear (N/m)
prm - lateral load transfer of the sprung mass due to forces applied at the mean roll centre (this is determined by the springs and bars)
prr - total lateral load transfer distribution at the front. This includes the effects of the roll centres and the springs and bars
tm - mean track of the vehicle

Looking at equations (1)-(7) you don't have to be a rocket scientist to figure out that if the main spring rates are already large, the anti-roll bar rates you'll need to achieve any desired change will also have to be large (typical high downforce anti-roll bar wheel rates are in the order of 100-1000N/mm). I shudder to think what they are on an F1 car.

What all this means is that a modern F1 car is effectively the ultimate Go Kart on steroids because the tyre is doing so much of the suspension work. Consequently, the tyre spring rates, construction, tyre pressures etc are absolutely critical to getting the set up right. It also implies that tyre pressure adjustments are an absolute go to for a quick mechanical set up change. This arises because tyre spring rates vary with air pressure, as illustrated in figure 3.

However, changes in tyre spring rates also have critical impacts on tyre forces and temperature. To illustrate this, let's consider contact patch length variation as a function of tyre pressure.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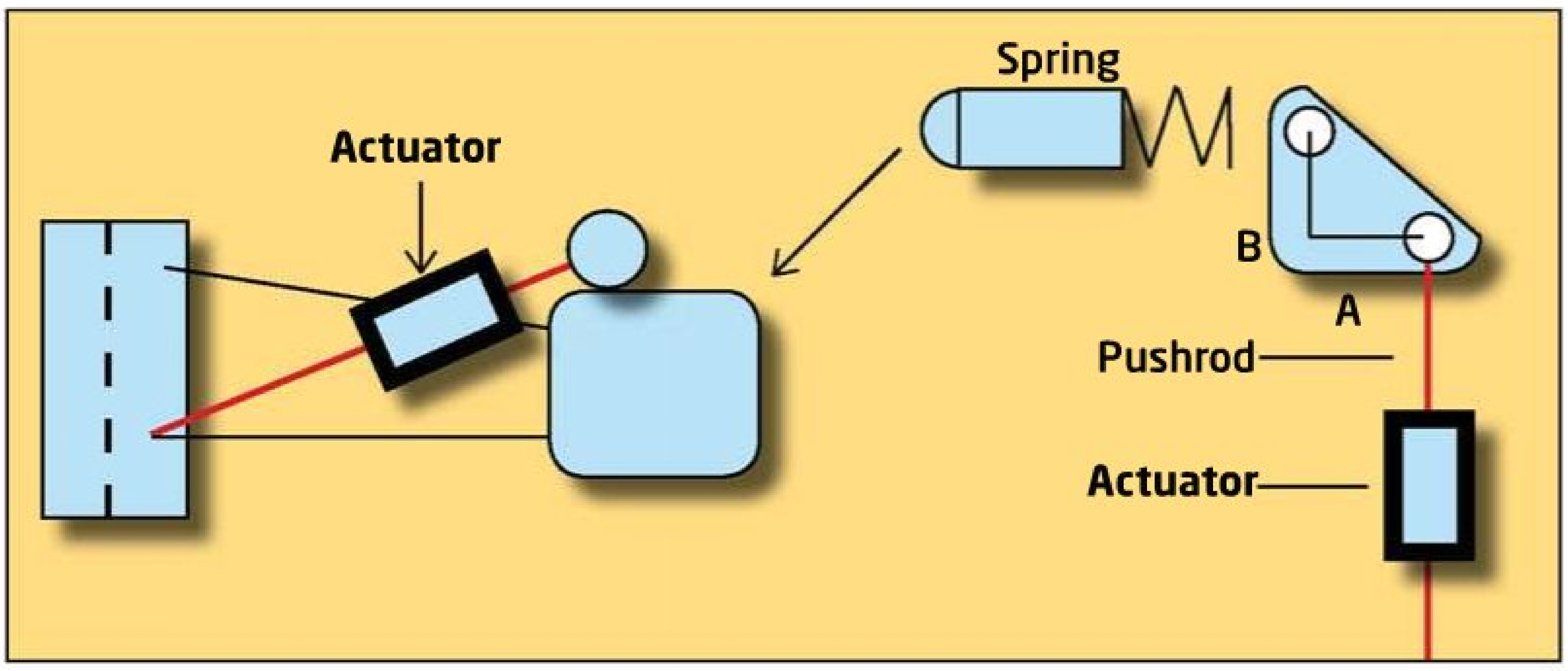

Figure 4: typical active system used in the early '90s

You will no doubt quickly realise the implications of tyre pressure changes on the contact patch length, and what potential effects this has on tyre forces. The other impact tyre pressures have is ultimate tyre temperature. You should by now be starting to appreciate what a minefield this is, and how limiting passive suspension can be.

Furthermore, you will also appreciate this is going to worsen as we add downforce (look at the hand calculations we did earlier). As we add more downforce, the spring rates needed go up and this just adds more deflection on the tyre. In contrast, an active system has at least some hope of keeping up with this, and a schematic of a typical early '90's active system is presented in figure 4, above.

It effectively consisted of an actuator that was tacked on to a passive suspension system. While this isn't perfect (some purists would argue far from it) at least it offered direct control over ride height. Also, by varying the forces in the individual actuators, it was possible to control load transfer distribution precisely throughout the corner. This is absolute gold to a race engineer because it offers you the tools to dial in what's really going on with the car, and a method of fixing it.

THE DRAWBACKS OF ACTIVE

That said, active suspension is not without its drawbacks. In no particular order, these are:

- **The actuation forces you require - particularly as the downforce goes up**
- **Tuning issues to manage tyre warm up and other items of apparel**
- **Reliability of sensors and the appropriate choice of control algorithms**

All of these problems are eminently solvable, of course. And the pay off is greater if you work through these issues. But just imagine the possibilities of being able to dial in load transfer as a function of lateral acceleration, speed and steering, for example.

The primary reason active was banned was because its primary use was to control aerodynamics. As it moved a sprunbg part of the car, it was illegal. It was also expensive, though you can be sure F1 teams will since then have been spending just as much money on non-applicable technology. Today, however,

- **The costs of the sensors has reduced considerably**
- **The processing power of control units has evolved to the point where it is practical**
- **We know a lot more about vehicle dynamics now than we did 20 years ago**
- **Active dampers are now starting to be used in mass production on road cars (eg the MagneRide system developed by Delphi Electronics)**

What has to change is the attitude of some motorsport regulators (not all - I know some are enlightened) who see anything with a circuit board and a computer as the devil incarnate. That preconception is holding the sport, and industry, back.

On the plus side, one series that might see the re-introduction of active suspension is the Time Attack formula.This revolves around taking a standard road car and doing anything you want to it to make it go fast and achieve the fastest lap time around a circuit. While I am unable to give specific details, I know of one project in this arena that will dwarf any current formula in terms of the downforce it produces. When this happens *en masse* it will be a matter of when, not if, active suspension will come back on the radar screen, simply because a passive suspension will not be able to deal with these levels of downforce.

CLOSING THOUGHTS

The numbers clearly indicate that unless serious caps are put on downforce generation, we will arrive at a point where active suspension will *have* to be re-introduced. Let me close with this thought: in 2007 I presented a paper in Stuttgart, Germany that went on to become the basis of my first article for *Racecar Engineering*. I heard all these interesting presentations on active damping and electronic control strategies for road cars, and then something hit me. If you were Toyota, Honda or BMW, why would you pay $500 million a year to run an F1 team and obtain no technical value from it? Three years later, none of those manufacturers were part of Formula One anymore. Racing needs to be relevant.


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New age traveller

How Ricardo successfully transferred Formula 1 technology to public transport

BY LAWRENCE BUTCHER

In recent years, those involved in the upper echelons of motorsport, particularly Le Mans and Formula 1, have been at pains to show that racing can still contribute to the advancement of road car technology, while large corporate sponsors and manufacturers with works teams are keen to show that they are 'green', or at least reducing their carbon footprint. Regardless of the politics and spin of the situation (after all, an F1 team's transporters use far more fuel getting to a race than the cars will ever use on track), racing, especially Formula 1, is still viewed by a sector of the public as leading the development of automotive technology. In some areas this is definitely the case – the level of aerodynamic development on a current F1 car, for example, goes way beyond that found in any other automotive sphere. But, and it is a big but, it's not really relevant to road car technology, as it is unlikely that a manufacturer such as Renault will release a version of its Espace model with an exhaust blown diffuser.

The same goes for engine technology. For the power it produces, a Formula 1 engine is exceptionally fuel efficient, but unfortunately the methods used to create these efficiencies are generally at odds with those being adopted by vehicle manufacturers. In fairness to the engineers, regulations and efforts at cost containment often stifle the development of new technologies, with direct injection, variable valve timing and forced induction all currently banned in Formula 1 (although come 2014 this should change).

The result is that many people within the industry claim racing technology has been left behind by the mainstream automotive market, which is certainly true in many areas. Dig below the surface, though, and it becomes clear there are still motorsport companies pushing technological boundaries, with tangible benefits to the wider motoring world. One such operation is Ricardo plc, best known in the racing industry for its transmissions, but with expertise that extends well beyond gearboxes.

THE KINERGY PROJECT

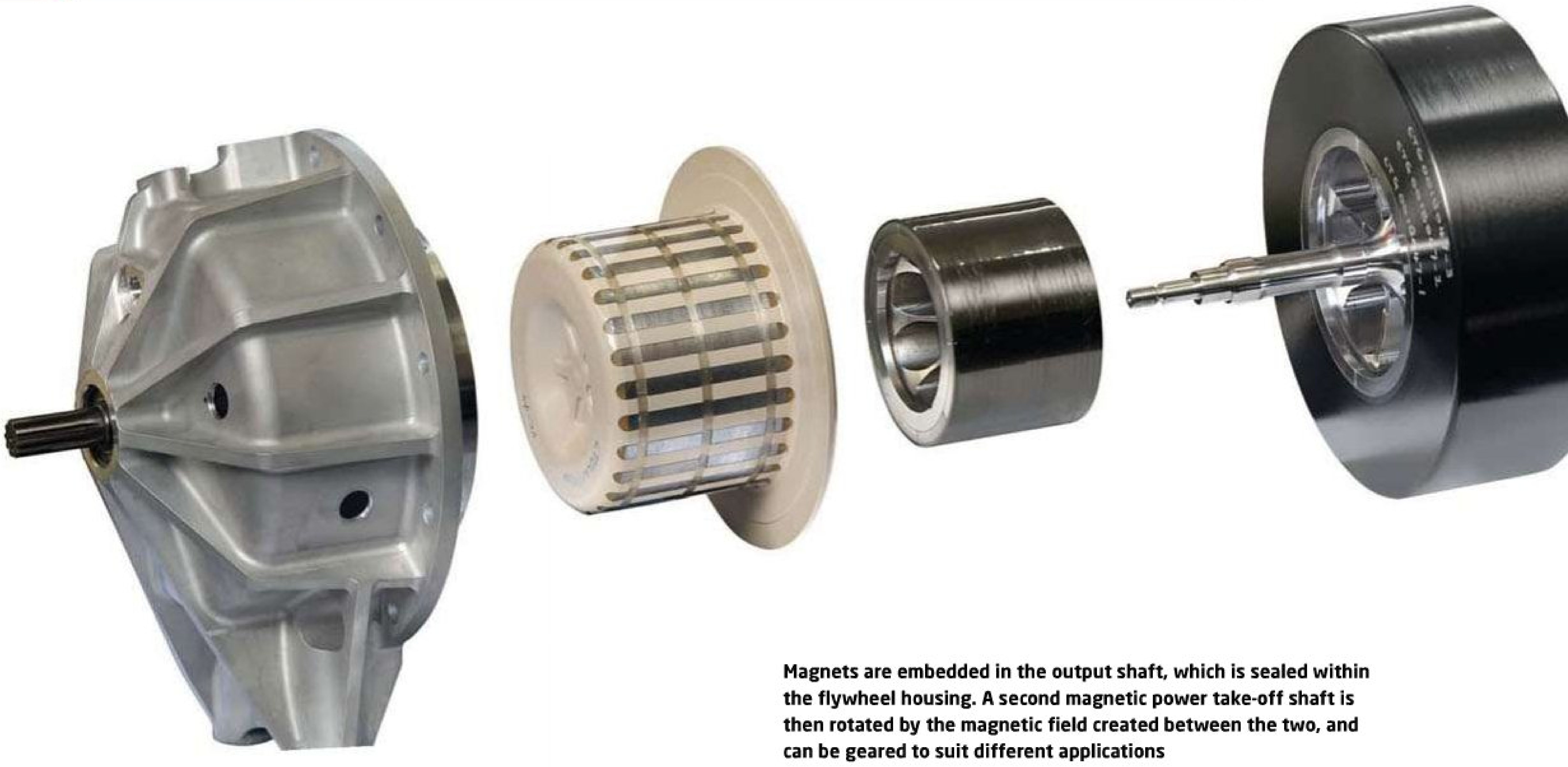
A vast number of the company's projects are not racing specific, but one particular motorsport venture looks set to push forward the development of hybrid vehicle technology.

For many years, Ricardo has produced transmissions for Formula 1 so, when the series first began to look at KERS, the company was in the thick of it. Despite a faltering start in 2009, with most teams choosing not to run their KERS systems due to the weight penalty not being offset by the power available, it marked the beginning of a Ricardo project that would have far broader applications. The company looked at many different methods of storing energy recovered from the drivetrain, including the now familiar battery packs, as well as super capacitors and flywheels.

The system Ricardo settled on was dubbed Kinergy, and consisted of a high speed composite flywheel in a hermetically-sealed housing. At the inception of the project, the

The really clever part of the Ricardo system is the separate output shaft, removing the need for a seal between that and the flywheel

> "intrinsically different to the other products on the market"



Magnets are embedded in the output shaft, which is sealed within the flywheel housing. A second magnetic power take-off shaft is then rotated by the magnetic field created between the two, and can be geared to suit different applications

Williams Formula 1 team was also working on a flywheel system, which used the flywheel as a 'battery pack', with the flywheel powering a motor generator unit. Thanks to encouragement from UK Government's Technology Strategy Board, Ricardo and Williams, along with a number of other companies, formed a consortium with a brief to advance the technology and bring it into the wider commercial market. At the time, Ricardo group technology director, Neville Jackson, said: 'The development of highly optimised flywheel-based technology offers the prospect of the effective and low-cost hybridisation of price sensitive vehicle applications with consequent benefits to fuel economy and CO^2 emissions reduction. Ricardo is pleased to be able to lead the KinerStor consortium, which brings together a crucial mass of skills and expertise in this important area of future automotive technology.'

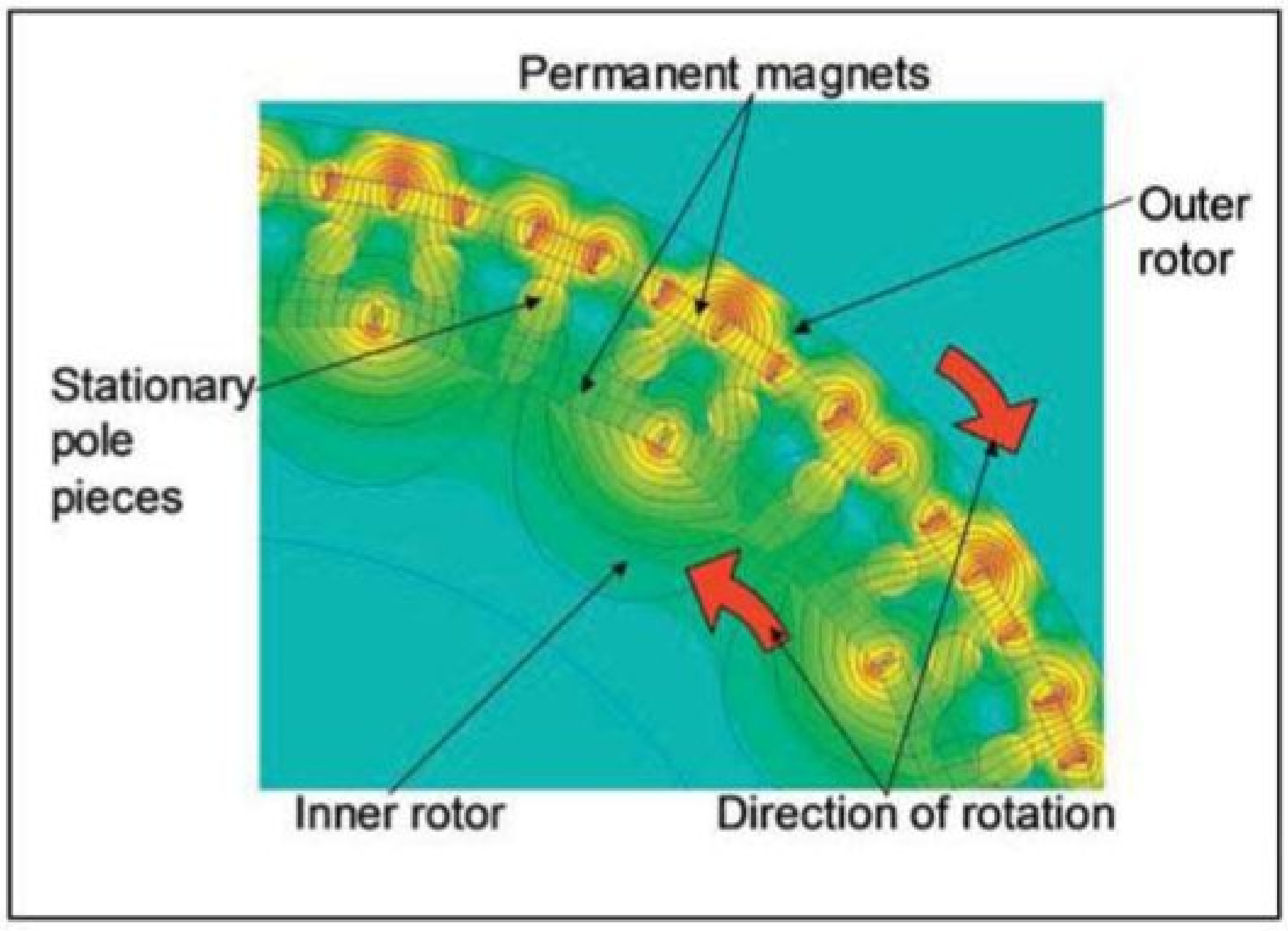
Fast forward a number of years and, despite the fact flywheel hybrids have yet to appear in Formula 1, the wider aims of the project are starting to bear fruit.

Many readers will be familiar with the flywheel hybrids produced by Williams Hybrid Power and British company Flybrid, both of which have already seen competition use – Williams' system in the Porsche 911 GT3 hybrid and Flybrid's in the Hope Racing Le Mans project. Ricardo's system, however, is yet to surface in racing, but is intrinsically different to the other products on the market. Flybrid's system, which has already been covered extensively in *Racecar Engineering*, relies on an output shaft from the flywheel to transmit drive. This creates issues for engineers, notably that in order to achieve sufficient rotational speed (in the region of 60,000rpm) the flywheel housing needs to be hermetically sealed, with the flywheel spinning in a vacuum. If the flywheel was left to spin at normal air pressure, the friction generated would lead to excessively high temperatures and eventual de-lamination of the composites. This makes sealing the output shaft where it exits the vacuum chamber a complex issue, but one that has been overcome in the Flybrid system. Ricardo's solution was more straightforward – remove the output shaft from the equation entirely.

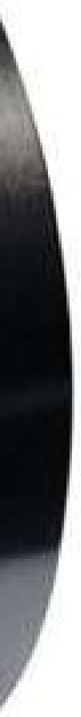
> “the Kinergy system uses a magnetic gearing and coupling system”

HOW IT WORKS

Instead, the Kinergy flywheel system uses a magnetic gearing and coupling system, which allows the flywheel housing to be completely sealed. To achieve this, a series of magnets are embedded in the output shaft of the flywheel, which is itself contained within the flywheel housing. Outside the housing sits a second power take-off shaft, which also contains a series of magnets. As the inner shaft rotates, the fields of the two sets of magnets create torque, which causes the power take-off to rotate. Usually this effect could only take place over a distance of less than a millimetre, which would require the flywheel housing to be unfeasibly thin, but the engineers on the project overcame this shortcoming by embedding ferrous pins in the casing itself so the casing wall transmits the magnetic field and the wall effectively disappears, allowing acceptable air gaps to be incorporated within a comfortable



The magnetic field created between the two magnetised shafts creates torque. With no meshing parts, the system is both efficient and robust



Like the other flywheel-based systems on the market, the flywheel itself is contained in a hermetically sealed vacuum and spins at 60,000rpm

The first application of the Kinergy system is in a bus. Combined with Torotrak's CV transmission it offers an efficient, environmentally sound solution in an area where hybrid technology can make a real impact

engineering tolerance. The magnetic drive also removes the need for a reduction gear system to lower the rotational speed of the shaft from 60,000rpm. As the fields of the individual magnets remain distinct from each other, those on the flywheel can be 'meshed' with those on the output shaft, creating a virtual gear ratio. By using a magnet ratio of 10:1 on the output shaft, the speed of the shaft can be reduced to a more useable 6000rpm, with a consequent increase in torque. Additionally, efficiency is extremely high, at more than 99.9 per cent.

The system is robust, too. In the event of a serious torque spike, there are no gears to shear. Instead the magnetic connection will simply slip and can then be quickly re-instated by simply backing off the torque.

As yet, the system has not made it into F1, but the engineering concept is sound and, thanks to the spur of competition, development was undertaken at an accelerated rate. This meant that by the time engineers came to look at the possibility of applications beyond racing, the majority of teething problems had been ironed out. Adaptation of the system for use in other applications was eased thanks to the relatively simple nature of a flywheel as an energy store: they are scalable, modular and have a high power density, meaning they can absorb and release energy very quickly. Unlike battery systems, with their higher energy density but much slower ability to absorb and release it over time, modern flywheel systems are closer to ultra-capacitors in operation, making them ideal for delivering short bursts of power, such as during acceleration. In this way, flywheels can be viewed as a complementary technology to batteries. Equally, when used in a hybrid powertrain, they offer an attractive alternative to ultra-capacitors, out performing them in terms of cost, volume, weight, efficiency and ease of manufacture.

PUBLIC TRANSPORT

The new home that Ricardo found for the Kinergy system is about as far from the high-speed world of Formula 1 as it is possible to get – a public transport bus. Working with partner, Torotrak, whose CVT (constantly variable transmission) provided an ideal method of transmitting the drive from the flywheel to the wider drivetrain, Ricardo began work on a scaled-up version of the Kinergy system for mass transport applications. Odd as it may seem, public transport is one of the areas where flywheel hybrid technology can have a real impact on both running costs and environmental impact. John Fuller, product leader for Kinetic Energy Recovery Systems at Torotrak explains: 'The recovery and re-use of kinetic energy during stop-start drive cycles is a priority for bus operators, not just because of the positive impact on emissions but also because it reduces fuel costs and brake wear. Electric hybrid systems are expensive, often doubling the transaction cost of a bus, but initial cost estimates suggest that the Flybus system could be available at a fraction of the cost of an electric hybrid, whilst simulation results indicate fuel savings comfortably in excess of 10 per cent.'

The vehicle chosen for integration with the Ricardo-Torotrak system was the Optare Solo, a UK-produced, medium-sized bus. The idea being that the system could be incorporated into new builds, or be retro fitted to an existing fleet. To this end, the package was designed to fit onto a redundant power take off already incorporated into the Solo's Allison automatic transmission. Extensive simulation undertaken by the design team showed that incorporation into an existing vehicle, even one not originally designed for hybridisation, could provide considerable efficiency gains. 'Simulation work by Torotrak, based on an Optare Solo bus and using the readily available 60kW system with 400kJ of energy storage capacity proposed for this first demonstrator, produced fuel savings of 20 per cent over the official UK bus test cycle,' explains Torotrak engineering director, Roger Stone. 'In this initial project, the CVT and flywheel hybrid system will be applied to the vehicle's driveline through the existing and previously unused power take off facility incorporated within

> "efficiency is extremely high, at more than 99.9 per cent"

The Ricardo-Torotrak system is being tested in UK-built Optare Solo buses. The system has been designed for incorporation into new builds or retro-fitting into existing ones and offers significant efficiency gains in both

the standard Allison automatic transmission. Further simulation shows that an optimised system, using a 110kW system with 1MJ energy storage capacity, will produce further significant improvements in fuel savings over the same test cycle.'

TESTING CYCLE

The product is now well into its testing cycle and was unveiled to industry figures at the 2011 Low Carbon Vehicle event at Rockingham, UK. Initial results are encouraging and it is hoped the system will mark the beginning of a new era in efficient mass transport solutions.

> "significant improvements in fuel savings over the same test cycle"

If the Kinergy project proves one thing to those who doubt motorsport's relevance to the wider automotive market it is this: when the rule makers allow it, racing pushes technology development forward at a far higher rate than would usually be the case. This is a view backed up by Jackson: 'I think that technology flow from motorsport to mainstream automotive has provided some important innovations, but the case for this is sometimes overstated, given the differences in mainstream automotive business dynamics and objectives. However, the recent advances in mechanical hybridisation based on high-speed flywheel systems clearly appear to owe much to the FIA's introduction of KERS in Formula 1. This rule change effectively catalysed and focussed research and development in this area. It is very probable that flywheels would have been developed for automotive applications eventually, but the interest from motorsport arguably served to shorten the likely timescales.'

With the introduction of a complete new rule package to Formula 1 in 2014, and the work being undertaken by the ACO to encourage new technology in endurance racing and at Le Mans, hopefully motorsport will once again lead the race in the advancement of mainstream automotive development.

A LIFETIME IN MOTORSPORT

It is not often that you find a motorsport company that has been in existence since man first decided to race automobiles. Beyond manufacturers, the ruthless world of racing makes it challenging for companies to be successful for more than a few years. However, UK-based Ricardo plc is the exception to the rule, being a company that has been successfully involved in motorsport for the past nine decades.

Born in 1885, Harry Ricardo (later Sir Harry Ricardo) was a naturally talented engineer. He designed his first engine at the age of 17 and filed his first patent for an engine in 1906. The company he started, Engine Patents Limited, formed the basis of what is today Ricardo plc.

In 1915, Ricardo set up an engineering company based in the seaside town of Worthing on the south coast of England and found in the British military one of his first customers. Having identified a number of flaws with the Daimler engine used in the first generation of tanks, he designed a new four-stroke engine to meet the war department's requirements.

The 1921 Triumph Ricardo motorcycle represented the company's first foray into racing, but it went on to be involved in the development of racecars such as the Alfa Romeo 162 GP car in the early 1940s. This association with motorsport has continued to this day and still forms a core component of the company's business strategy.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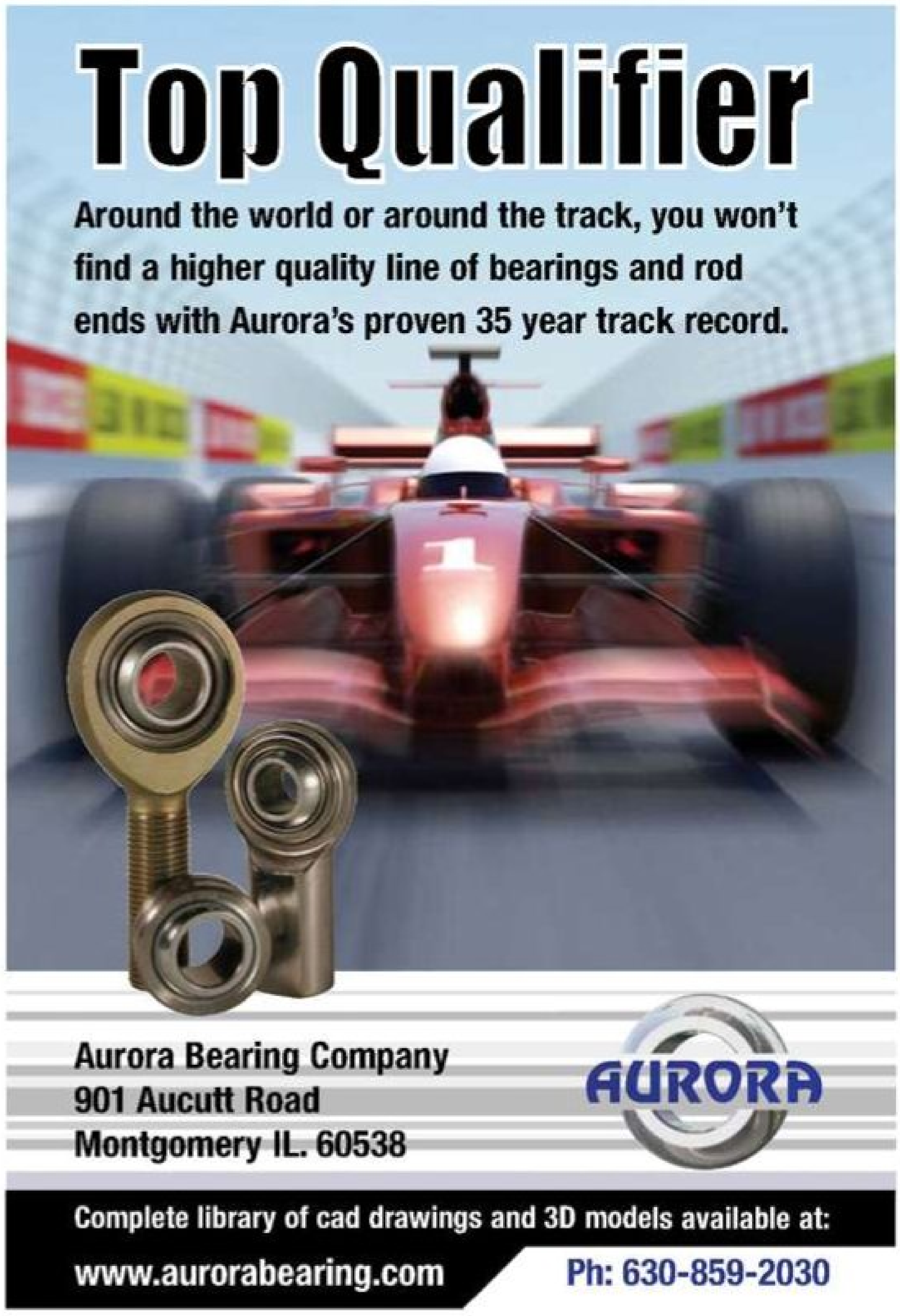
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The return of the Lotus Exige

BY SAM COLLINS

When Lotus announced its six 'new era' models at the Paris Motor Show in 2010 it would be polite to say that the response was mixed at best. The new cars were criticised for being too heavy and too tame, and seemed to lack the lightweight, high-performance ethos for which the English car maker was best known. A long running naming dispute with Team Lotus further put people off the brand.

But at the 2011 Frankfurt Motor Show that all changed. With great fanfare, Lotus CEO Dany Bahar, unveiled a new Evora variant, but it was the supporting act that stole the show, when Lotus took the covers off a re-introduced Exige.

Originally conceived in 2004 as a high performance derivative of the Elise, the Lotus Exige has gone on to become a regular sight at amateur races and track days, with variants being built to GT3 and Speed GT regulations. But, more recently, it appeared the car had been dropped from the company line, to the dismay of many.

The new Exige S features Lotus' 'new era' styling and the 3.5-litre Toyota 2GR-FE V6 engine from the Lotus Evora range, now fitted with a Harrop HTV 1320 supercharger, which utilises Eaton's Twin Vortex Series (TVS) technology and helps the V6 kick out 350bhp. This larger powerplant has taken the weight of the Exige S up by a little over 100kg, but increases its already impressive power-to-weight ratio by more than enough to compensate. The end result is a two-wheel drive road car with a better power-to-weight ratio than a modern day World Rally Car.

> "a two-wheel drive road car with a better power-to-weight ratio than a World Rally Car"

Of course, Lotus is under no illusion as to where many of these new cars will end up, and consequently it offers the Exige S with an optional race pack. This gives drivers the choice of a fourth mode for the onboard electronic systems. Lotus calls it DPM (Dynamic Performance Management) and it has three settings as standard – Touring, Sport and DPM off. The race pack adds a competition element to

With its dramatic livery and bonnet-mounted spotlights, it's immediately obvious where the English manufacturer wants to take the new Lotus Exige R-GT

TECH SPEC

Lotus Exige S road car

Weight: 1080kg

Chassis: epoxy bonded aluminium alloy extrusion and steel rear subframe

Wheelbase: 2370mm

Dimensions: front - 1453mm; rear - 1499mm; length - 4052mm; width - 1802mm

Engine: mid-mounted, transverse, 3.5-litre, 24-valve V6; Harrop HTV 1320 supercharger; Lotus T6e ECU

Power: 345bhp at 7000rpm

Torque: 400Nm / 295lb.ft at 4500rpm

Transmission: EA60 six-speed transverse manual with open differential

Suspension: unequal length wishbones; Bilstein dampers; Eibach springs, anti-roll bars

Brakes: AP Racing four-piston calipers; 350mm front discs; 332mm rear discs

Tyres: 205/45 x 17 front; 265/45 x 18 rear Pirelli P-Zero

TECH SPEC

Lotus Exige GT-R Rally car

Weight: 1200kg

Chassis: homologated steel rollcage bolted and bonded to aluminium and epoxy bonded chassis

Body modifications: front and rear underbody protection; WRC-style side protection; Lexan windows; roof-mount cockpit air scoop

Engine: 3.5-litre V6; Harrop HTV 1320 supercharger; twin 34mm restrictors

Transmission: six-speed sequential; two homologated final drives; LSD, homologated driveshafts

Suspension: front and rear double wishbones; three-way adjustable dampers

Brakes: upgraded calipers, hydraulic 'fly-off' handbrake; improved air cooling

Wheels: 7 x 17in front; 8 x 18in rear

Tyres: 205/60 x 17 front; 225/65 x 18 rear

this, offering better traction out of corners, different suspension settings and launch control. This will be of particular interest to hillclimbers and those who compete in Solo events. Others will no doubt fit the new Exige S with rollcages (on offer via Lotus Motorsport) and take them racing.

COMPETITION PEDIGREE

Unsurprisingly, the staff of Lotus Motorsport want to put the new car into competition and the new FIA GT Rally category is where they want to run it. 'My motorsport career started in Rally. In fact, I even took part in the Talbot Sunbeam Lotus' Italian Rally Championship, winning a race in San Marino in 1981, so this is a very nostalgic moment for me,' explained Claudio Berro, head of Lotus Motorsport.

'With the new R-GT rules in Rally, it's a very interesting time for us to return to the sport. Naturally, our approach will be different to when we won the championship with Talbot three decades ago, but I think our philosophy is definitely the same – we want to compete and, ultimately, we want to win.'

The Exige R-GT is the result, and it certainly caught the attention of the assembled press at Frankfurt. Powered by the same 3.5-litre V6 engine as the new roadgoing Exige, significant changes have been made to the gearbox and the restrictors on the engine in order to control the power, which is now down to 302bhp, breathing through twin mandatory 34mm restrictors. The manual gearbox of the Exige S road car has been replaced with a six-speed sequential 'box with a limited slip differential and FIA-homologated halfshafts, while overall weight has been increased to the regulatory minimum of 1200kg.

Developing the race version of the Exige S in parallel with the road car has allowed Lotus' technicians to make rapid advances in terms of safety and reliability. Berro: 'We have learnt a great deal from working with the Evora and creating various race derivatives over the past 18 months, particularly how best to adapt a road car for the track and competitive racing. We were able to put this learning to good use with the Exige [R-GT] project. In my mind, Rally is probably the ultimate motorsport – it combines the excitement of track racing with the specialist skills needed for road racing – [and] we believe it's one of the best ways to demonstrate the capabilities of our products.'

Initially, Lotus will offer the R-GT in asphalt trim, but a gravel spec car will be built in the future. It will make its race debut in the GT class at Rallye Monte Carlo in 2012, with San Remo and the Tour De Corse also on the calendar.

THE DESIGNERS
PAT SYMONDS

"In the 1970s, the guys with the empirical experience were way ahead of the guys with the understanding"

Behind the alarmist headlines of the 2009 season is a very different man to the 'accused', a thoughtful, passionate engineer with an impressive track record

BY CHARLES ARMSTRONG-WILSON

In 2009, Pat Symonds found himself at the centre of a media feeding frenzy over the 'crashgate' saga. Two years on, and with a consultancy role at Marussia Virgin Racing, the furore has largely died down. At the time, the media painted a distorted view of a quiet man who has been able to carve out a long career in F1, mostly with the same team.

At the age of 12, the young Pat decided he was going to design cars for Ford. Identifying the roots of this mindset is not difficult. His father was in the air force working on Blenheims, Victors and Valiants and instilled a love of engineering in his son. Then, on leaving the forces, Symonds senior opened a Ford dealership. However, despite winning Ford sponsorship to study engineering, Pat's proposed career became sidetracked. By the time he finished a masters at Cranfield College, it was 1976 and things were looking pretty bad for the British motor industry.

'I could work on trucks or be a component engineer,' he recalls. 'Neither was very interesting.' But at Cranfield, Adrian Reynard was in the same class, 'He made me think there was something in motorsport, although it was not really a career path.' Symonds responded to an advert from Royale, went to meet Rory Byrne and got the job to work on their F3 programme. However, before he could get started, the money for the project disappeared and he found himself out of a job.

By this time, though, he was set on his new career direction. 'I thought I've got to get into motorsport, so I wrote to everyone I could think of. Fortunately, Hawk in Southend were looking for someone and I got the job.

'Back then I was very focused on three-year plans. I was going to do motorsport for three years, then go back to Ford. But at end of three years I got into Formula 1 and that became another three-year project… 34 years ago.

'Hawk was a fabulous place to work,' he recalls. 'David Lazenby ran the place, Derek Warwick was the driver and Derek Daly was a welder. I was the designer, straight out of university designing racecars and aircraft parts. The great thing was it was a manufacturing facility as well, with fabrication, a good machine shop and great people there to help me. Lazenby taught me so much.' While there, Symonds evolved the design of the Formula Ford 1600 and 2000 Hawks and designed a monocoque F3 car from scratch for Jan Lammers.

"I would draw a car, make a large part of it, assemble it, drive the truck, mechanic on it and engineer at the race"

DATA ENTRY

'My specialisation in my masters was vehicle dynamics and vehicle modelling and I was desperate to apply those techniques to racecar design. But it was very difficult. We had no computers. Back then, the gulf between theory and practice was greater than ever. We had a little bit of Dunlop tyre data, but nobody wanted it because they didn't know how to use it. I knew how to use it, but it was probably pretty misleading. That's one thing that hasn't changed.'

It became clear that a computer was going to be vital, and Symonds came up with an ingenious way of getting access to one. He enrolled on a welding course at a college that had a computer and learned to weld. At the same time he was putting jobs into the computer to analyse three-dimensional suspension geometry. 'They said, "but aren't you on a welding course?"

'I was trying to bring my theoretical knowledge in but it was too early really. In the

From left to right: the Toleman TG181 was Symond's first taste of F1. When the car continued to underperform in its second season, Symonds was put in charge of the team and developing it into a successful racecar; when Toleman later morphed into Benetton, innovation became the team's hallmark – with the '93 car being the only F1 car ever to race with four-wheel steering and a revolutionary twin-clutch gearbox appearing in '99

1970s, if you looked at engineers in Formula 1, how many of them had a degree, let alone anything further? There was Harvey [Postlethwaite] who I did my thesis with, trying to model the Hesketh. Rory [Byrne] had a degree but it was in chemistry. But there weren't many professional mechanical engineers. In the 1970s, the guys with the empirical experience were way ahead of the guys with the understanding. Now the balance is the other way.'

VACANT POSITION

When a second pay cheque from Hawk bounced at the end of 1978, Symonds decided it was time to move on. Around this time Rory Byrne had left Royale to design an F2 car for Toleman and Symonds was able to secure the vacant position. 'In '79 we were running Kenny Acheson, and Rory's RP24 was in production. It was a massively successful year and we won more races than ever before in a year. I went on to produce the RP26 FF1600 and RP27 FF2000 cars.

'I was 26 and we won the first European championship. I would draw a car, make a large part of it, assemble it, drive the truck, mechanic on it and engineer at the race,' although he admits that race engineering was not very sophisticated then – 'The driver described problems, and I would try and take out what he didn't like.'

> there was something in motorsport, although it was not really a career path

By now he felt his theoretical knowledge was starting to come through. 'There were a lot of pit-lane myths that were not necessarily accurate. I was fortunate in not knowing the myths, just knowing what was needed. I've always understood what drivers wanted. Even today with huge modelling, we still have the interface between man and machine that no one really understands. There are driver models, but they are robots, path following etc. That is still an incredibly difficult part.'

By now his three-year plan was running over schedule, but the opportunities kept coming. Robin Herd offered him the chance to engineer March's F2 effort and he mentioned it to Toleman's Alex Hawkridge at Brands Hatch. 'He said, "You don't want to do that. We're going to start a Formula 1 team." I said 'yeah, okay,' but I wasn't convinced. "I really want you to come and work for us. I'll pay you £10,000 a year…" I thought crikey! He then said, "…and I'll give you a Golf GTi." That was it then.' And so began his long career in F1.

He recalls that confidence at Toleman was running high at the time on the back of their Formula 2 title win in 1980, and that some of the decisions were nothing if not courageous: 'We decided we ought to do our own engine because it would be better than everyone else's, so we persuaded Brian [Hart] to do one. Tyres are pretty important too, so we ought to do our own tyres. Why are these guys running 13-inch wheels and tyres? That's not the right way to go. Get Pirelli on the 'phone, we need bigger wheels than that.

INCREDIBLE OPTIMISM

'We had incredible optimism. I remember being sat in pub having a sweepstake about how many points we'd score in our first year. Nobody got the right answer, which was zero, and continued to be zero the following year. We didn't even qualify until Monza.

Fridays we would be 10 seconds off the pace, so we would work all night to be nine seconds of the pace the next day.'

On into the 1982 season, the team was running an updated version of the TG181 and still struggling. Then, whilst in Rio for the Brazilian GP, team owner, Ted Toleman, called a meeting by the hotel pool. 'He said, "We're going nowhere, we can't update this car, we need to move forward." He decided that Rory and his assistant, John Gentry, would no longer go to races, and sent them back to work on the new car. He turned to me and said, "You're going to run this team." I was 29. I thought, okay I can do that.

'That was a really important lesson in my life. We were not allowed to take anything away from the new car so we focused on utilisation of existing resources. Take what you've got and don't keep changing it.' It was surprisingly successful.

ENORMOUS STEPS

The team also started a wind tunnel programme at Southampton University and Imperial College and made some enormous steps, as might be expected. These included a shaped monocoque to extend the size of the ground-effect venturis. They were also the third team in F1 after McLaren and Lotus to build a carbon composite tub. However, this was not such a huge leap for Toleman as its previous chassis was made in a very similar way, but using aluminium skins instead of carbon. 'The first one was amazing,' recalls Symonds, 'we opened the mould in huge anticipation and there was this lump of aluminium in the bottom. It had collapsed in the autoclave.'

> **"I've always understood what drivers wanted"**

From then on, innovation would become a hallmark of the team through all its incarnations to the present day. Subsequent Tolemans featured ground-effect front wings, and exploited a loophole in the rules to run extra wide rear wings, followed by the first multi-plane rear wing.

Under the Benetton banner in 1993, the team raced the only GP car with four-wheel steering ever. Its Front Torque Transfer system was fitted to the cars in 1999, as was a twin-clutch gearbox. Symonds was also probably the first person to bring Design of Experiment (DoE) techniques into F1 for use in vehicle and aerodynamic development. 'I started getting involved in DoE absolutely years ago, but it probably took five years for it to be adopted. Sometimes it was like herding cats until you get your message through. Now, at Renault, it's a recognised technique.'


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Once under Renault ownership, the team pioneered the use of dynamic absorbers, or mass dampers, until they were banned. However, Symonds feels they could have appeared earlier, not least because they had previously used them to stabilise wing mirrors.

LAUNCH CONTROL

One of the team's best kept secrets, though, was its exceptional starting ability. Variously attributed by the press to everything from weight distribution to an ability to sense the jump-start sensors in the track triggering. In reality, while there was a slight rear weight bias compared to other cars, it was really down to the development of effective launch control.

Automotive consultant, Ricardo, was brought in to model the whole vehicle under launch conditions – a system which was further developed by the team's control engineers. A mapped system was then installed in the cars that required the driver to merely release a button. 'I think a lot of people thought you needed a lot more slip than you did. You only want 10 or 11 per cent, although that's the difficult bit. If you get it slightly wrong it can bog down. It always amazed me we had that advantage for so long. Every race I would think the others will catch up, but it took several years.'

DRIVER FEEDBACK

A big part of Symond's job over the years has been working with drivers. In 1984, Ayrton Senna joined the team and Symonds was his race engineer. 'We were growing up together and I recognised he was different.' In particular, he valued Senna's feedback: 'We didn't have data acquisition then, you relied on your driver so much. Testing at Zandvoort he came into the pits and said there's something funny with the engine, a slightly different noise. Brian [Hart] looked all over it and everything seemed fine. Ayrton said okay and went out again, but didn't even finish the lap before the engine blew up.'

Helping Schumacher to two driver's titles was another milestone in his career. 'Michael was a pleasure to deal with – so much dedication, such a work ethic and a really nice human being. He really knows people, their families, and their kids.'

Unfortunately, the events of the 2009 Singapore GP marred Symonds' unblemished career. The actions of that day he will regret forever more, but it will never quash his enthusiasm for the sport, or for engineering in general

A remarkable part of his career is the amount of time he spent with the same team, even if it did go through several incarnations. His only break was for a year in 1990 when, under new management, the team recruited John Barnard and, understandably, a number of the established engineering crew felt sidelined. At the time, his old friend Adrian Reynard was making a bid to enter F1, and 12 of the senior engineers from Benetton, including Symonds and Byrne, left to join the project. 'That was a really nice year because it was time to think,' he recalls. 'All those questions that you asked yourself but never had time to answer, it was nice to have the time to answer them.'

However, when the team failed to secure an engine contract, Reynard had to pull the plug. Data was sold to Ligier, parts to Pacific and the intended factory site to Benetton. With Barnard gone, the refugees returned, bringing with them much of what they had learned in their year away. That was also the Tom Walkinshaw era, of whom Symonds is not a great fan. However, with him came Ross Brawn who he holds in the highest regard. 'I thoroughly enjoyed working with Ross. He is a bloody good technical manager. 'I was very flattered that, when he decided to go to Ferrari, he recommended to Flavio [Briatore] that I became technical director. At the time I was really happy in my job as chief race engineer and doing a bit of R and D. I really didn't want the new job as I had the best job in the world, so why would I want to change it? But I did it and actually thoroughly enjoyed it, even though they were perhaps the toughest years of my professional career.'

> **"We didn't have data acquisition then, you relied on your driver so much"**

He has high praise for other, too. 'Benetton was having a difficult time when David Richards came along. I really like David and I really like his management style. He's totally involved and very modern. I'm always looking for new ways to do things and David's like that. A lot of the things I believe in, like training and education, he wanted to do also.'

By 2009, Symonds had been in F1 for 29 years and was still driven by a passion for the sport. However, the repercussions from events at Singapore the previous year were to prove costly. 'I knew it was happening,' he admits. 'When I look back I wish I'd stopped it happening, and I guess I could have. But when it all came out, I only had one aim and that was to protect the team. I think I did that, but I paid dearly for it.'

THE YEARS SINCE F1

Since leaving F1, Symonds operates as a consultant, not just in engineering, but also management. He has also turned his hand to journalism, writing technical features for motorsport titles, including *F1 Racing*. However, he feels that F1 is unfinished business. 'I'll never, ever lose my love of engineering,' he says. 'One thing I like about writing is it's keeping me researching things. I subscribe to no end of literature searches and still read technical papers as they come out. I've never been afraid to keep learning. It's the single most important thing and to me it's the most pleasurable.'

Strategic planning
Rockingham's new business model

It has been 10 years since the Rockingham International Raceway, Europe's fastest race circuit, opened with the first of two American CART races held at the British track. The inaugural race was won by Gil de Ferran, while Dario Franchitti won the second in 2002, but the series never returned and the oval track is now largely dormant.

Far from being a disaster, however, the track is looking forward to a new future as a champion of new technology, and is aiming to build relationships with high performance motor manufacturers who can use the oval track to demonstrate their cars to customers at hand over.

It may be the fastest circuit in Europe, but that's not been enough to attract major series to the Northamptonshire venue

'I want another big UK event, either cars or bikes, but also for consumers to be able to come and try new technologies here,' says Charlotte Orton, CEO of the Rockingham Motor Speedway. 'I see Rockingham growing as that centre, not only for cars and bikes, but also for communications and solar panels. As our business grows, there will be more money that we can invest in racing.

Rockingham has also established the Rockingham Education Partnership, along with the Enterprise Education Foundation (EEF). The Partnership has been set up to work with young people aged 11-25 to provide hands-on projects based around the business, and it is here that the growth is expected to happen.

'We have also written a karting in schools programme, which will be a significant programme and can go national,' says Orton. 'It is the business side of it, bringing in the enterprise skills and addressing those in motorsport. There will be a team involved, but it will cover everything that goes with running a race team.'

The oval is Rockingham's unique selling point, yet there are no plans to increase the amount of racing on the banked circuit. 'I look at everything, but it has to fit in with what we are looking for and has to pay its way,' says Orton. 'We love the Australian V8s, but commercially I have no idea how that would stand up. If I could find the right promoter to write out a cheque, we could host the best events, but it is not sustainable.

'You have to have your headline events. You wouldn't have your soul if you didn't have good race meetings.'

Wirth Research enters IndyCar

Following its split with the Virgin Racing F1 operation, Wirth Research has announced a new long-term technical partnership with California-based Honda Performance Development (HPD) - a collaboration which began in 2003 and will now extend beyond the company's Sportscar involvement to cover HPD's new IndyCar project. Encouraged by the two companies' previous work together, notably the results achieved by the ARX-01 and 02 LMP projects, the engineers are now assessing potential new Sportscar projects.

'Our relationship with Wirth Research has already delivered some remarkable results in all of the world's greatest Sportscar series and races, including both the 12 Hours of Sebring and the Le Mans 24 Hours,' said HPD vice president, Steve Eriksen. 'We have total trust in Wirth Research's proven design, development and engineering expertise and are now looking forward to further success with jointly developed prototype contenders. On top of this comes our new IndyCar project. With the advent of new multi-engine regulations, plus plans to allow manufacturers to introduce their own bodywork packages, our special relationship with Wirth Research takes on additional impetus and importance in the next few years.'

Nick Wirth, company president, is equally proud of his company's track record with HPD and is looking forward to furthering this success, as well as meeting the challenges presented by the new IndyCar programme: 'The results we have achieved together to date at the peak of international Sportscar racing speak for themselves and underline the level we have achieved with our CFD-based aerodynamic technology and the other key elements of our unique, all-digital development process.

'Now we have taken full advantage of the flexibility and efficiency offered by these groundbreaking technologies to ensure our successful Sportscar programme goes from strength to strength. Moreover, we will be in a position to offer similar technical resources to the Honda IndyCar teams in 2012 and beyond.'

All-electric Prototype to make assault on world lap records

Drayson Racing Technologies has announced its new programme for 2012, and it is a complete departure from the company's endurance racing roots. In association with British company, Lola, the group will develop an all-electric car for an assault on lap records around the world.

The car will be a Le Mans Prototype and will produce more than 850bhp through a wholly electric drivetrain system. It will feature the latest in inductive charging, composite battery power, moveable aerodynamic devices and electrical regenerative damping. Thanks to all this, the B12/69EV will be one of the most advanced zero-emission competition cars in the world.

'We looked at our options at the end of last year. We had a fantastic year, were third in the ILMC and had a brilliant time racing in America, but felt we had done that with a flex-fuel car because of the different types of fuel in racing,' says Paul Drayson, who, together with Jonathan Cocker, competed in the European Le Mans Series and the ALMS. 'I made the argument to the ACO that this isn't tenable. We were hoping that, for 2012, the rules would change so that we could race a second generation bio-ethanol fuel car at Le Mans, in China, and all over the world, but that didn't happen. Doing the same again, are we likely to do better than third in the ILMC? No.

'We had been looking before at hybrids and electric drives. Again, though, it didn't look as though the regulations were moving fast enough to make hybrids a winning combination because there are a lot of complications with it.'

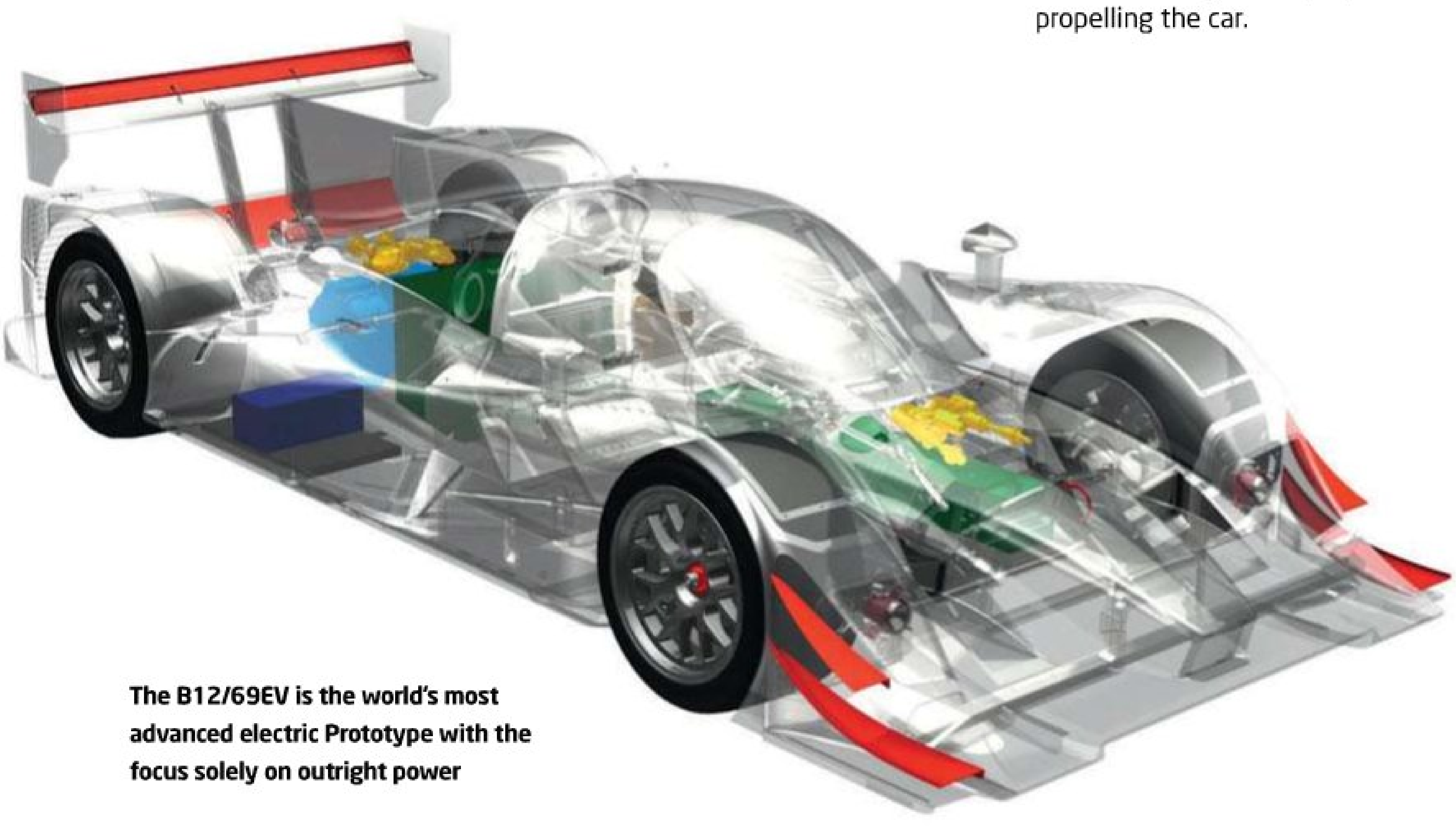
Instead, the company decided to promote the outright performance of electrical power, and is working with Halo IPT on a wireless charging system that will see racecars remotely charged as they compete around a racetrack.

Inductive Power Transfer uses the phenomenon, discovered in the 1800s, that electrical current produces a magnetic field, and that a coil placed in this field will generate voltage. Halo IPT wireless charging uses the magnetic field to transfer power into electric vehicle batteries, so consequently needs no wires and can be fitted to any car.

BAE Systems' Advanced Technology Centre has announced it will be developing 'multi-functional materials' for integration into the proposed car. These materials combine the structural strength of composites with the ability to store electrical energy able to power onboard electronic devices and systems.

Research activity has already successfully demonstrated the ability to amalgamate standard battery chemistries with composites to create a 'structural battery'. This material is manufactured in the same way as normal composites and can be shaped into complex 3D structures. Unlike concepts that embed traditional batteries into structures, however, BAE Systems' structural power capability uses patented technologies to incorporate the chemicals that batteries contain directly into composites. The integration of energy storage into structural elements also provides notable weight savings over traditional solutions. Currently, energy densities – the amount of energy stored per unit of weight – that have been demonstrated are comparable to existing traditional commercial vehicle batteries.

Further development of the technology will continue to push the energy storage density available. For the Lola Drayson B12/69EV, structural battery technology offers the opportunity to dedicate the main batteries solely to the purpose of propelling the car.



The B12/69EV is the world's most advanced electric Prototype with the focus solely on outright power

Cosworth all at sea

Cosworth is a company regularly associated with motorsport, but the company's involvement in racing of all varieties extends well beyond four wheels. This is highlighted by the group's recent announcement of its involvement with Artemis Racing, an America's Cup sailing team. The world of performance sailing is a hotbed for technology development and Cosworth Group electronics have already been used in both offshore and inshore racing. The group is not new to the America's Cup either, having supplied teams in the previous two matches.

Cosworth electronics are perfectly suited to the extreme environments encountered by top level racing yachts

Artemis Racing, however, will be the first challenger to use the company's new LightWave processor. The system features advanced sensors and analysis software to enable the team to acquire the maximum amount of data from their AC45 and AC72 craft during the development programmes leading up to the 2013 America's Cup. Simon Holloway, programme manager for Cosworth Group, said: 'It's very exciting to be providing Artemis Racing with our latest LightWave processor. We've been working hard to make sure our technology is absolutely the best available, using our experience from developing systems for champions on the track and on the water. The America's Cup programme provides the ideal opportunity for the team to make full use of the processor and extra systems like synchronised video and strain gauging.'

UK Karting Green Paper update

The UK MSA Kart Committee has published the first proposed regulation changes resulting from the Karting Green Paper, a discussion document on the future of the sport that was issued last year by the Kart Sporting Committee.

The proposed changes, regarding new classes and class homologation, are available for consultation online at www.msauk.org/regulations until 7 October 2011. The two documents, which should be read in conjunction with each other, include proposals to provide stability for competitors and teams, such as introducing a three-year homologation period for new classes. MSA Kart Committee chairman, Rob Jones, said: 'The main concern arising from the consultation process was "too many classes". These proposals seek to address this and therefore provide stability and confidence for competitors in at least one area of karting for the future.' The Green Paper will be considered further at the next meeting of the Kart Committee on 2 November 2011, when championship structures, and the findings of a sub-group that has reviewed cost-cutting measures, will be discussed.

Development of new technologies will cut vehicle carbon emissions

Ultra-lightweight engine designs, advanced battery management systems and the next generation of electric motors are just three of the new low carbon vehicle technologies to be developed by leading British companies with funding from the government-backed Technology Strategy Board and the Department for Business Innovation and Skills (BIS). The Technology Strategy Board and BIS have jointly agreed to invest £10 million in grants to 16 collaborative research and development projects that focus on achieving significant cuts in CO2 emissions for vehicle-centric technologies in low-carbon vehicles. UK racecar manufacturer and consultancy, Prodrive, will be involved in the project, alongside a number of other UK businesses.

Mark Prisk, the UK minister for business and enterprise said: 'This new government investment is part of our strategy to put the UK at the forefront of low-carbon vehicle technology and is another step for the UK towards a low-carbon economy. Developing such highly innovative strategic technologies is vital if we are to mass produce low-carbon vehicles in the UK and make this country a more attractive location for sustained investment by global vehicle manufacturers and suppliers.'

Prize money can't buy

It would probably be safe to assume that most people reading this magazine will have doodled endless racecars on their exercise books when young, but the chance of actually seeing a car being built was a far-off dream. However, one lucky youngster form Surrey, UK, was given just that opportunity.

The Big Bang UK Young Scientists and Engineers Programme teamed up with McLaren Automotive to give young people interested in a career in engineering the chance to win an exclusive tour of the famous McLaren Technology Centre, and meet the engineers responsible for the new MP4-12C high performance sports car. The winner was Cameron Tait, 11, from Windlesham in Surrey, who made himself popular with his friends when he took them along on a VIP tour of the factory. As part of the tour, which included lunch in McLaren's private dining area, the boys had the opportunity to quiz racing engineer, Jenni Oakham, and automotive engineer, Chris Gosling, about their jobs. 'I really enjoyed talking to Cameron and his friends about the exciting work we're involved in at McLaren,' said Gosling. 'There are a number of routes into engineering – whether you enter the industry as an apprentice or as a graduate, like I did. I hope we've shown them the variety of jobs in automotive engineering alone and that inspires them to consider engineering as a future career for themselves.'

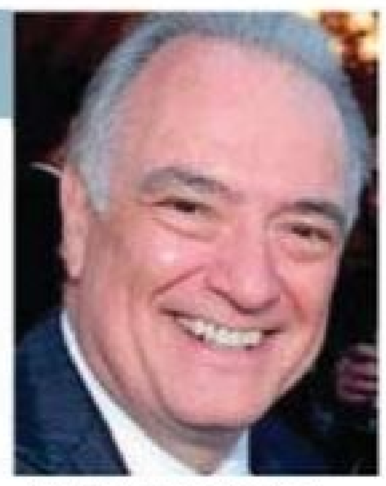
BAB moves into motorsport

The British Assessment Bureau (BAB) has been granted extended scopes by its regulator, UKAS, allowing it to certify businesses involved with motorsport under the ISO 14001 environmental management standard. The extended scopes, which cover the design and repair of race motor vehicles and motor cycles, as well as motorsport events and management, required BAB to demonstrate its technical competence and knowledge of the industry. Upon receiving the news, BAB's operations director, Samantha Hicks, commented: 'We are delighted to have been granted these extended scopes, as we have worked hard to demonstrate the necessary requirements to satisfy UKAS. Our aim now is to engage with the motorsport industry to convey the virtues of environmental management and the benefits of the ISO 14001 standard.'

To promote its ISO 14001 certification service to the motorsport industry, BAB has launched a 'Go Green Motorsport' initiative to raise awareness of the benefits of environmental management. With corporate social responsibility becoming increasingly important in the business world, it's harder than ever for potential sponsors to associate themselves with a sport that, at first glance, appears less than environmentally responsible. BAB aims to help the motorsport industry change its current negative image.

STRAIGHT TALK

Overseas opportunities



CHRIS AYLETT

Now is the time to start boosting your exports in 2012

Business planning for 2012 will be a nightmare in the light of all the global economic news – increases in supply prices, unreliability of stocks and suppliers and unpredictable demand. Yet, during this difficult period, international trade in motorsport business continues to grow, whether in the established markets of the USA and Europe or the developing markets in Asia, Eastern Europe and South America.

Motorsport Valley companies in the UK have long built their business strength from export sales, and all business indicators and forecasters are encouraging small and medium-sized businesses to find new export markets. Exporting is no more complicated than finding business in a new sector, it just comes in several languages and uses different currencies!

Motorsport is lucky in having several business shows for our sector, which attract international buyers looking for products. Each is an effective, cost-efficient way to interact with buyers, so make good use of your time, keep focused and prepare well.

In the USA, SEMA in Las Vegas (1-4 November) is good for large volume aftermarket business and motorsport, PRI in Orlando (1-3 December) is the world's largest motorsport trade show with thousands of international and US visitors, while IMIS (8-10 December) in Indianapolis is a great new show with buyers across the motorsport market.

> "Make 2012 your 'year of export'"

In Europe, PMW in Koln (15-17 November) has built a good reputation for attracting European and Eastern European buyers, Birmingham, UK's Autosport International (12-15 January) and Autosport Engineering attracts both UK and international buyers and Motosport Expotech in Modena (2-3 February) attracts buyers from the growing, lucrative and hard to access Italian market.

These shows set the seal on international business for 2012 and beyond. I suggest any motorsport manufacturer plan to attend at least one in the USA and one in Europe – either as an exhibitor or an organised visitor.

Budgets are tight, so taking an exhibition space at more than two is beyond most motorsport companies, but visiting the shows to meet buyers is vital this year. All the above events are focused on 'trade only', where you know organisers have worked hard to attract buyers from our industry. Your challenge is to make that future buyer aware, in advance, that you are there too, and meet with them. Everyone in there to do business with someone, make sure it's you.

You can contact the MIA on info@the-mia.com and let us use our experience of all these shows to help. You don't have to be an MIA member to ask for help. In the UK, UKTI (see www.ukti.gov.uk) also offers financial grants, as well as advice. So check the visitor list before you go and sign up to every network event your energy will sustain, as these are where business introductions are made. Remember to take plenty of business cards and a good 'elevator pitch' to persuade whoever you meet that they should meet up again the next day.

Business is growing in Asia, as India and China build new race circuits and attract major events. South America has an established motorsport industry with healthy demand and the USA market is vast, offering opportunities in off road, drag racing, oval racing and single seaters. You simply cannot afford not to attend a USA show, with an open mind, and find your piece of this market.

Europe is the UK's latest export customer and many buyers are already, but there are always new ones and you need to visit all the European shows to find them.

Make 2012 your 'year of export'. Don't wait for your domestic market to give you sales growth, as I doubt it will. Find the budget to visit the shows or, better still, exhibit. Prepare well in advance to use your time and budget effectively, and work with the MIA's international experience to make sure you come home with business.

Attending trade shows is important, but being well organised in advance is more so

McLaren and GSK form partnership

McLaren Group recently announced that it has formed a long-term strategic partnership with one of the world's leading pharmaceutical corporations, GlaxoSmithKline (GSK). This collaboration brings together two British companies, both of which are focused on innovation and hi-tech research, and will run initially to 2016. The two companies say this relationship is not a conventional business consultancy – it is more specific and dynamic than that. McLaren is hopeful that its expertise in analytics, data management, strategy modelling, processes, telemetry and human IP will aid GSK in its business development. The initial focus of the partnership will be on GSK's manufacturing, r and d and consumer healthcare businesses, and specifically its GSK Nutritionals business unit, which markets key brands such as Lucozade, Panadol and Sensodyne.

GSK Nutritionals will construct an all-new facility at its London headquarters, based on McLaren Racing's existing Formula 1 race strategy mission control centre. This facility, it says, will drive faster decision making around variables such as wholesaler stocking, inventory management, pricing, responding to retailer requests, competitor activity and market and customer needs. Andrew Witty, CEO, GlaxoSmithKline, said: 'I am delighted to announce this partnership with McLaren, which brings together two British companies whose continued success hinges on the ability to innovate and rapidly respond to change and competitor activity.

Cartek nomination

Electronics specialist, Cartek, has announced that its new FiA Rain Light has been nominated for 'Best Gadget' in the MSA Reader Awards 2011. Anyone who has chosen to use the light and appreciates its quality and performance can vote for the product here: https://www.surveymonkey.com/s/msareaderawards2011

Easing the blisters

Stories reverberated around the Belgian GP paddock about blistered tyres, but Pirelli says the problem is with the teams, not the rubber

The Belgian Grand Prix at Spa Francorchamps at the end of August saw a great deal of discussion surrounding the amount of camber being run by Formula 1 teams in the run up to the Italian Grand Prix at Monza. It was suggested that some teams, including points leaders Red Bull, were exceeding the tyre manufacturer's recommendations and it was causing the tyres to blister badly. The talk in the paddock was that as much as 4.3 degrees of negative camber was being used, whilst Pirelli told teams that four degrees was really the limit for its tyres at Spa. This led to the tyres overheating on the long straights at the Belgian track, causing the so-called blisters to appear.

BY SAM COLLINS

As a result, the FIA stepped in at Pirelli's request to enforce a 3.35-degree limit at Monza.

'Spa would not have been a tough race if we had had some dry running before the race,' said Pirelli's motorsport chief, Paul Hembery. 'As you can imagine, you do set-up work in Friday practice and, because of the wet weather, that didn't happen. If we had a dry Friday we probably wouldn't have even talked about the camber issue.

'At Monza blisters are common anyway, and anyone involved in motorsport knows it is because of the speed. But bear in mind we have only got one structure of tyre and only four compounds to use. If you wanted a tyre that has zero blisters at Monza, I could do it tomorrow morning. But if you want to do the whole season and for it to work at all the races, that is a different question.'

Despite the claims made by some in the press about the tyres, Pirelli had few issues at Monza, though Hembery explains why his team asked the FIA to police camber use there: 'Coming into Monza we asked the FIA to enforce the 3.35-degree limit, because we wanted to ensure people did not exceed it. We can ask the FIA to step in on a race-by-race basis, but we do not use it all of the time. We only give guidelines, but there can be a tendency to hide behind that and we don't want to. If it does happen that teams are having issues because they are pushing too hard, you have to reduce your flexibility. We try to give them as much flexibility as possible and not give them hard and fast rules. It's a very hard thing to do when you have 12 different chassis, so it is meant to be a working range for camber rather than a fixed ratio with absolute value.'

ALTERNATIVE THEORY

But not everyone in the paddock believes that the high-speed sections at Spa, combined with the excessive camber being run by some cars, caused the blisters. Sam Michael, the outgoing technical director at Williams F1, told *Racecar Engineering* that he thought the problems were caused by the landscape at Spa, with the change in lateral and vertical direction at the very high speed Eau Rouge complex putting huge loads into the rubber. Hembery though disagrees.

Most of the rumours centred around the camber angles being run on the front tyres, which led to Pirelli asking the FIA to enforce the 3.35-degree limit at Monza, but more to ensure they collect as much useable data as possible

'Rubbish! It is certainly not true, and besides, other teams have other theories.

'We work on managing standing waves, which you get in all tyres. It is how you deal with that which matters. If you get it wrong, you get tyres that fall apart, but we didn't get it wrong and our tyres have not fallen apart. At Spa, the issue was with the teams. The tyre structures were fine. Those that exaggerated had issues and those that didn't, didn't.'

Certainly it is true that there were a number of teams on the grid in Belgium that had no trouble whatsoever with the tyres at Spa. But it is also fair to say that Pirelli would have liked more data. 'We would prefer to see more in-season testing if it was possible, only because it lets us understand what has evolved with the cars and what has changed, but of course that's selfish from our point of view because it doesn't take into account the costs to the teams, so we are happy that they found a balance with one session of in-season testing in 2012,' reveals Hembery. 'Testing is going to become a bit more virtual in the future. Most of our testing will be done through simulation, particularly now that we have a lot of race data. We know that our simulations are valid in terms of mid-season testing. We also have the in-season test next year, which helps us a great deal because we will be working with the cars involved. What we've found so far is that the levels of loading are so different to what you expect them to be so, unless you're on an actual car, it makes it very difficult to do valid outdoor testing. Though with a full season's data perhaps we will need less testing.'

SPICED-UP RACING

Pirelli has received a lot of praise this season. Its twin compounds have spiced up the racing, even with the double aids of KERS and DRS. 'Overall, we feel quite pleased and confident with our first season. We have a lot of races under our belts on different sorts of tracks. But we are reluctant to shout too loudly until we've been to Brazil. We have some tough races to come – Suzuka can be tough on tyres, Korea we know is severe and Brazil isn't exactly kind on tyres. I will give an overall balance after Brazil,' smiles Hembery.

But that does not mean that the Italian firm will be resting on its laurels, and the factory in Izmit Turkey is already developing next year's rubber. 'For 2012 we will change the compounds around a little bit to close the gap between them. We will use a new rear tyre structure and a new profile. The wet tyre will be changed with a new structure and pattern for the full wet. Nothing outlandish for 2012 though, just refinements. In 2013 we will do some really interesting things, but you will have to wait and see what they are...'

GRAHAM JONES OBITUARY

There can be few motoring journalism careers to rival that of Graham Jones. From *Autocar* road tester to *Racecar Engineering* editor, via stints as an F1 PR man and as a writer on one of the world's great newspapers, Graham really did do it all.

Canadian by birth, Graham moved to the UK in 1978 after graduating from the University of Victoria in British Columbia. A keen club-level competitor, his aim was to combine a passion for motorsport with his other great interest, writing. He realised that ambition, initially as assistant editor of *Cars and Car Conversions* magazine, before moving to *Autocar* in 1982 as a member of the road test team. He progressed from there to road test editor, and then to technical editor.

After a two-year stint back in Canada, as motorsport writer and columnist for the *Toronto Star*, Graham returned to the UK and moved into the automotive PR arena. He took on the challenge of helping set up PRISM in 1993, an in-house public relations and sports marketing agency based at Ford headquarters in Warley, where he was responsible at one stage for PR and media communications for all European-based Ford motorsport programmes.

Taking the lessons learned from his experience at PRISM, Graham was involved in setting up the London-based Global Sponsorships Information Centre in 1997, to coordinate PR and communications activities related to all of British American Tobacco's European motorsport sponsorship programmes. At various times, these included the Suzuki Grand Prix Team in the World Motorcycle Championship, the John Player Gold Leaf F1 Powerboat Team, plus the Tyrrell and British American Racing Formula 1 teams.

In early 2001 he was asked by former Tyrrell sponsor, Paul Stoddart, to take on the role of communications manager for the Minardi Formula 1 team, which the Australian entrepreneur had recently acquired. Graham spent the next seven years working with Stoddart on a number of motorsport ventures that, in addition to the F1 team, included the European Minardi F3000 team, Minardi F1x2 team and Minardi Team USA in the ChampCar World Series.

Describing himself as 'a frustrated engineer', Graham was also a pretty quick driver, and he competed at various times in International Conference of Sports Car Clubs and Firestone Firehawk events in North America, as well as in Triumph Sports Six Club races in the UK.

In a move that displayed a certain degree of symmetry, he returned to the world of journalism as editor of *Racecar Engineering,* which coincidentally incorporates the *Cars and Car Conversions* title that brought him to the UK in the first place.

Graham appeared to be winning his battle against illness and, after a short spell away from the magazine, returned to continue but, in early 2011, took the very tough choice to stand down as editor.

Away from the office he was passionate about motorsport and enjoyed discussing the latest happenings in MotoGP and Formula 1 over a few pints down the pub. He continued to enjoy his Model A Ford hot rod right up to the end, driving it to a show just weeks before his passing. *Mike Breslin*

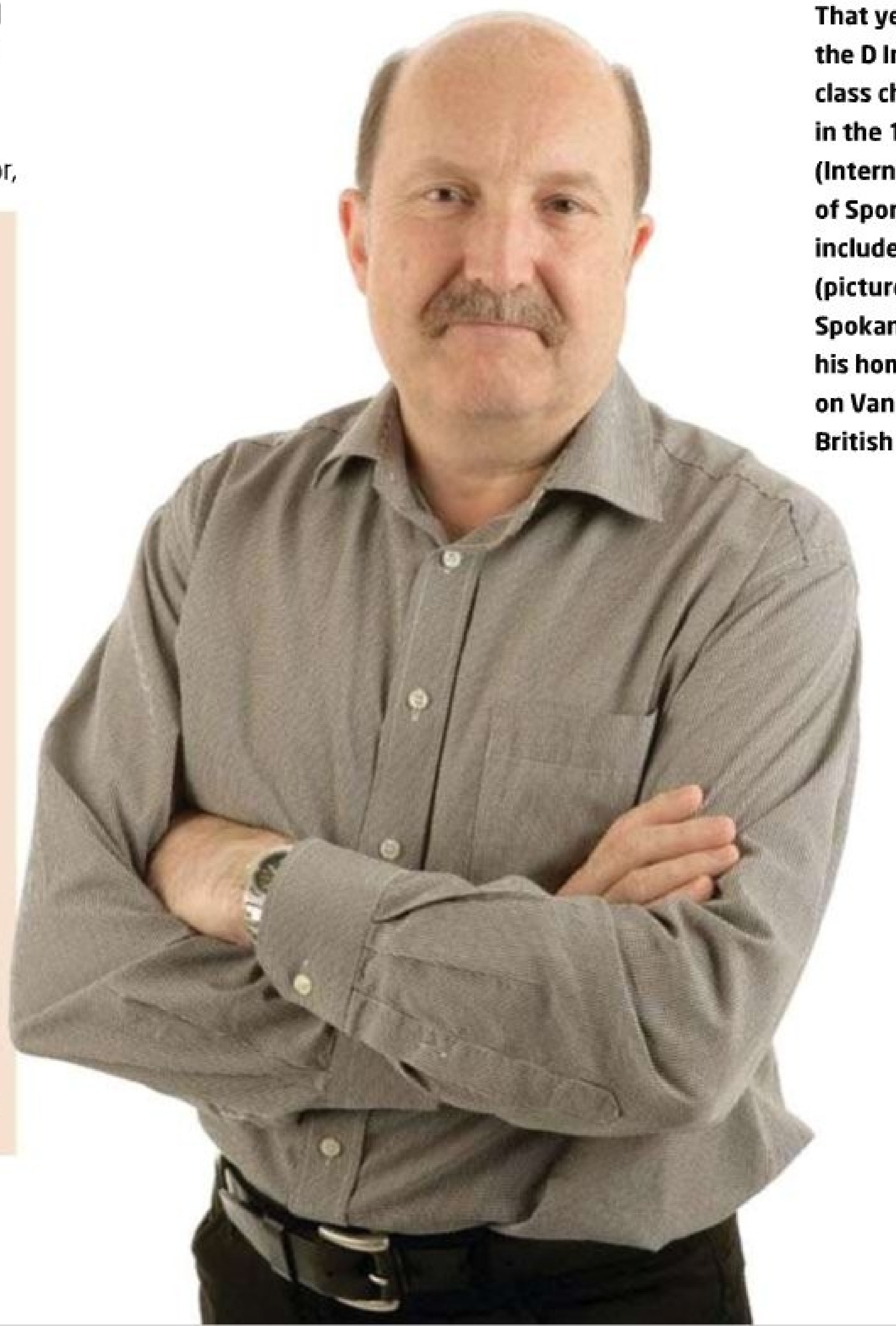
Graham Jones 1949-2011

I first encountered Graham in the early 1980s, when we both worked for Haymarket Publishing. I was on *Autosport*, he on its newly acquired sister magazine, *Autocar*, as a key member of its editorial team.

Having spent some time on the opposite side of a six-foot partition wall, I can tell you that there was no one in the building who worked harder than Graham. His commitment to his work was absolute, and genuinely impressive. And over all the hours, with that attractive Canadian voice in the background, I never once heard it raised. He was a natural gentleman, as well as an outstanding journalist. Many years later, he earned universal respect and popularity when he braved the hard-bitten and often cynical community of Formula 1 reporters as a team PR man. I was delighted when he took the editor's chair on the magazine that I had helped to create, and he undertook the role in typically professional style. Now that he has left us, we are all very much poorer.

Quentin Spurring

Above: Graham in 1976 at the wheel of the 999cc Mini Cooper S he raced with his friend, John Kendrew. That year Graham won the D Improved Sedan class championship title in the 13-race ICSCC series (International Conference of Sports Car Clubs), which included events in Seattle (pictured), Portland, Spokane, Vancouver and his hometown of Victoria on Vancouver Island, British Columbia.



What they said...

I have known Graham for at least 20 years. We always used to meet up for a beer or two at the Joiner's Arms in Woodside Green, Croydon, along with Jim Brotherwood and Jim's brother, Bob. Both, sadly, have since passed away. Graham, when he was home in between races, always liked to talk about his career in the world of motorsport, and was always interested in how everyone else was doing. He was a true gent in every sense and will be severely missed by all that knew him. He has moved on to join Jim and Bob in the great beer house above, God bless you all. Have a beer for me.
Roger and Jaqui

I am truly saddened to hear that we have lost Graham. It brings it home to us all that life can be fleeting and none of us are indestructable. I will always be grateful to Graham for giving a group of us amateurs a bit of the limelight, when he wrote an article for *CCC* about the club racing scene here on Canada's west coast. In the summer of 1978 he came up to Westwood and took a picture of the Victoria Motorsports Club members attending the race and gave brief outline of the cars and the class structure used in the International Conference of Sports Car Clubs. I keep a copy of that edition (Nov '78) safe to this day. Thanks Graham.
Paul Whitworth

10 years ago I had the opportunity to speak with Graham on the 'phone, pitching a far-fetched idea to him about getting the Minardi team to work with the Royal Australian Navy during the 2002 Australian GP. In his typically friendly manner, Graham offered a positive response, and the rest is history. Over the following 10 years, we became friends and, whenever I had the chance, sharing a beer with Graham was always a good option. Sadly, he never got to find out that I finally achieved a career in the F1 industry - of which he was a catalyst. I will miss him greatly and my family and I offer my deepest condolences to his family
Mark Campbell

Very sad news indeed. I met Graham in 2001 when I started in F1 and he was such a great bloke, with an easy manner and always around for a chat and a friendly word. A gentleman in the truest sense of the word. He will be deeply missed and my thoughts go to his friends and family at this time.
Jason Swales

I was really saddened to learn of Graham's passing. In the '70s he was my best friend and we spent the 1976 racing season campaigning my 999cc Cooper S in the ICSCC series in BC, Washington and Oregon. We had many adventures in the course of that season (on and off the track) and Graham won the 1000cc sedan championship. That was one of the most enjoyable seasons ever so, just remember Graham, wherever you are, you have to keep at least three wheels of a Mini on the pavement. You will be missed.
John Kendrew

I was very saddend to receive an email from Graham's brother, Trevor, telling me of Graham's passing. I have been friends with Graham since the 1970s when we were both members of the Victoria Motorsports Club in BC, Canada. We have stayed in touch all these years but, of course, not as often as we should, but that always seems to be the way with friends. I did photo work for Graham in North America when he was at *CCC* and *Autocar*. Graham was definitely one of the good guys.

Sheila and the rest of Graham's family have lost a great friend and family member. When Graham raced on the west coast of Canada and the USA he raced a 999cc Mini Cooper that could be heard all around the track. You new it was coming, and you knew it was coming fast. I think we all suffered hearing loss around that car! Graham, you are a friend and always will be, and you will be truly missed. Cheers, raise a pint to Graham.
Paul Bonner

Many more heartfelt comments about Graham can be found at www.racecar-engineering.com

Sparking an interest

With a focus on electronics in this month's *Racecar Engineering*, it seemed appropriate to highlight some of Autosport International 2012's exhibitors that are offering electric solutions for those in motorsport and wider afield.

One such company that has made a name for itself, despite only 10 years' experience in the field, is DC Electronics. Its wiring looms, control panels, sensors, ECUs and power-assisted steering products have infiltrated into all echelons of motorsport, from Touring Cars to Rally, from GT cars to Formula 1, as well as Superbikes and power boats.

Not a company to turn down a challenge, it's also the official product sponsor of The Bloodhound Project, a mission that Richard Noble OBE has set himself to create a car capable of setting a land speed record of 1,000mph. DC Electronics has designed and built the engine wiring systems used to control the jet engine, as well as the harnesses for the rest of the vehicle and support vehicles. Its experience within the demanding and precision-centric world of F1 makes it the perfect partner for such a project.

Many other companies will also be offering electronic solutions at Autosport International, including:

Deutsch

Experts in the design and manufacture of electrical connectors and fibre optic connectors, as well as specialised electronics and components.

Hall 9, Stand E427
www.deutsch.net

Euroloc

A West Midlands-based company with over 30 years' experience in supplying rotating electrics to the automotive market.

Hall 9, E1048
www.eurolec-components.co.uk

Raceparts UK Ltd

An online shop offering worldwide supply of all forms of motor racing parts, spares and equipment.

Hall 9, E363
www.raceparts-direct.com

DC Electronics is a regular exhibitor at Autosport International, and one that, like many others, experienced a positive and fruitful show in 2011: 'We made plenty of new contacts. Autosport International is always a good show to see existing and potential customers, both from the UK and internationally,' said Sandra Cunliffe, director of DC Electronics. 'We had a very busy show and saw many projects that had been put on the back burner now moving forwards, so there was a lot of positivity.'

But DC Electronics is not keeping all the secrets of its success to itself. Dates have been announced for the 2012 Formula Student Workshops, where company co-founder and director, David Cunliffe, will offer advice to the next generation of budding electrical engineers interested in a career in motorsport. Alongside Paul Webb, autosport product specialist at Deutsch, electronic connectors expert Cunliffe will provide information on various topics, including splicing, crimping and soldering, contra-winding cable looms and the application of heat sleeve, moulded parts and boots.

The courses run from 26 January to 2 February 2012, with universities able to register by emailing sales@wiringlooms.com.

For more information visit www.wiringlooms.com or speak to the team in person at Autosport International in Hall 9, Stand E252.

Also exhibiting this year is Hampshire-based DMS Technologies, who supply portable and static power solutions to motorsport outfits, as well as aviation, defence, transport, marine, rail and telecoms industries.

Its purpose-built, 18,00sq.ft manufacturing facility allows it to run both long and small batch production lines, with the company designing, developing, manufacturing and testing its specialist systems in-house.

Recent new additions to the company's range include 12 and 24V low voltage disconnect units, which protect batteries from over discharging. It operates nominal voltages with a factory default disconnect setting of either 10.8V or 21.6V, with the ability to control currents up to 10A onboard or up to 200A on an external relay. The unit also boasts extremely low power drain, remote indication and operation, wide operating temperatures and is fully protected against spikes, surges and reverse polarity.

Also added to DMS Technologies' product line is the Red Flash split charger, an ultra-low power loss device used to charge separate battery banks from a single source. It can help extend the life of batteries by ensuring a balanced charging regime and has incredibly low power consumption.

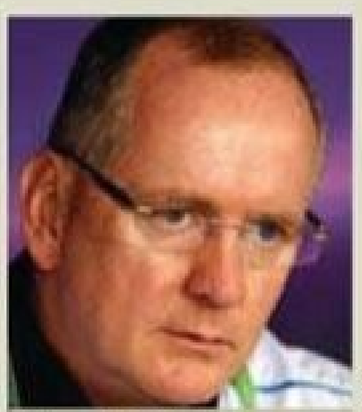
More information can be found at www.dmstech.co.uk, while the team will be on hand in Hall 9, Stand E160.

RACE MOVES

Peter Bonnington is now **Michael Schumacher's** race engineer at Mercedes GP. Bonnington was previously assistant race engineer, but has now taken **Mark Slade's** position on the pit wall. Slade has chosen to take on a factory-based role with the team.

Sam Michael is to join the McLaren team as its sporting director in 2012. Michael, who left his post as technical director at Williams after the Singapore Grand Prix – a move that was announced earlier this year – will take responsibility for the development and management of the team's trackside operations. Michael was at Williams for 11 seasons.

Mark Gallagher has resigned from his role as general manager of Cosworth's F1 effort after two years at the Northampton-based engine supplier and will now move on to pursue other interests in motorsport. He has a stake in the Status Grand Prix GP3 team. Gallagher had previously worked at Jordan, Pacific, Lola and Red Bull, and joined Cosworth in 2009.



Mark Gallagher

LAT

Kim Spearman is the new head of F1 operations at Cosworth, following the departure of **Mark Gallagher**. Spearman has been at Cosworth for 24 years and, during his time at the company, has been involved in various motorsport championships around the globe.

Legendary Formula 1 designer, **Gordon Murray**, has joined Group Lotus as a member of its Advisory Council. His new role will involve advising Group Lotus on current and future development of its company and products. Murray helped design winning F1 cars for both Brabham and McLaren, but he has more recently focussed on his own Gordon Murray Design company, which is working on developing innovative city cars.

Zytek Engineering has appointed former motorsport journalist and marketer, **Chris Witty**, to help develop the commercial side of its motorsport operation, including sales and new projects. Witty has been involved in motorsport for over 40 years and in that time has worked in all areas, from Formula 1 to World Championship Rallying.

There's been a management re-structure within the

Rob Austin

INTERVIEW

Q Your team has been one of the first to campaign a Next Generation Touring Car (NGTC) in the BTCC. How would you describe NGTC?

It's come about in order to reduce costs. Essentially, how they differ from the current [S2000] regulations is that there's a bit of a beefed-up rollcage, because the whole front of the car is basically cut off and fitted with a common subframe. All the cars will have common front and rear subframes, in fact. They'll also run the same suspension rockers, dampers and so on.

Q But does the engineering challenge remain?

Yes, definitely. There's still quite a bit the teams need to do: the development of the bodyshell, bodywork, radiator mountings etc. There's also obviously a lot of damper valving options, springs and there are options on various suspension geometries. There's still a great deal you can change and there are a lot of ways you can go with it.

Q You're the only NGTC car to run rear-wheel drive. How did that come about?

All my experience is rear-wheel drive, and I believe that a racecar should be rear-wheel drive. That's why we chose the Audi, because the engine layout has to be the same as the road car, and the options on gearbox and diff allow for a west-east positioned engine for front-wheel drive, or north-south for rear-wheel drive.

Q What development issues have you had?

There have been quite a few teething issues with the NGTC concept. Also, we chose the wrong engine supplier initially, so we struggled for a few rounds with engine reliability. But having swapped to a Lehmann unit now it's far better, far more reliable and we've got some good power out of it.

There are a lot of the things we know we need to do, but we simply haven't been able to do them because we're too busy racing, and all this stuff requires some simple downtime to do it. But we've plenty of things in the pipeline.

This year's been a development year really. We've shown the car has buckets of potential, and given a full winter on it I think we'll hit the ground running next year, and we should be quite well up there.

Rob Austin, team manager / engineer / driver, Rob Austin Racing

Rob Austin started his racing career in karting at the age of 11 and rose through the ranks to Formula 3, where he was a race winner, before lack of funding ended his competitive career. In 2005 he set up Rob Austin Racing, competing in various Ginetta one-make championships, GTs and historic racing. This year Rob Austin Racing has entered the BTCC with an Audi A4 developed to the incoming NGTC rules. The car has impressed many with its pace, and scored a second place finish at the Rockingham round of the championship.

Q Might you have an advantage over the bigger teams in being a year ahead of them developing the NGTC car?

That is exactly why we jumped on board with the programme early!

Q Has Audi shown any interest in the project?

They are watching us, and I'm hopeful

that once we've had a win with it and we're right up there, then there might be some more interest.

Q The rear suspension seemed to break quite easily when you were hit at Knockhill. Is this a weak point on the NGTC cars?
Part of it is that when you've got the freedom that the S2000 cars have, they build them like tanks. We don't really stand a chance in wheel-to-wheel stuff, because their suspension is so strong. I think that once everyone is running NGTC you will certainly see less side-to-side, wheel-to-wheel contact, and people will have to be careful. I don't know whether they've done it deliberately or not.

Q You're known as a driver, but you're also now very much an engineer and team manager: is it possible to be all three?
I also drive the truck! But I do have an engineer on board, too. From my point of view, driving the car does help as we develop it.

Q What other motorsport is Rob Austin Racing involved in?
We've got two historic F1 cars – a Surtees TS16 and an Arrows A4. We recently won the FIA Historic Formula 1 race at the Nürburgring in the Surtees. We also did some filming over there for this new Hunt-Lauda movie [*Rush*, directed by Ron Howard and due out in 2013], and I'll be playing Brett Lunger! It was very cool. We're going to be doing some more filming in May next year, to re-enact the crash, and I'm very excited about that.

Q How do you keep a racecar historically accurate when you know all the modern engineering tricks?
It's difficult. But it's quite strict, and the guy who used to design the Arrows cars, Tony Southgate is one of the scrutineers – so we can't mess around with it too much! But then again, it's also quite useful to ask him how he did it back in the day.

Q What's the future for Rob Austin Racing?
Hopefully we are going to be in British Touring Cars for a long time. The aim is to establish ourselves as a front-running team. But we're never going to stop the historic stuff – those F1 cars are proper racecars to me. I love them, and I personally very much enjoy the historic weekends.

The plan is to eventually step down as driver. It's a business at the end of the day, and we've put in a massive investment to get up and running. For this year, though, my job is to prove the car.

MARTIN HINES OBITUARY

Martin Hines, fondly known to many as 'Mr Karting', has passed away after a long battle with cancer.

Hines, who won 17 karting titles, including three FIA world championships, was also a successful motorsport entrepreneur, setting up his Zip Kart business with his father in 1964. But the North Londoner, who was born in Hampstead in 1948, easily put as much into karting as he took out and was largely responsible for the early career successes of a number of drivers who went to greater things: David Coulthard, Lewis Hamilton, Anthony Davidson, Jason Plato and Gary Paffett among them.

While Hines will be remembered for his karting adventures – particularly at the wheel of 150mph 250cc Superkarts – he also dabbled in racecars, founding the Zip Formula entry level series in the early part of the last decade. It is also believed he had plans to set up his own British Touring Car Championship team for 2012.

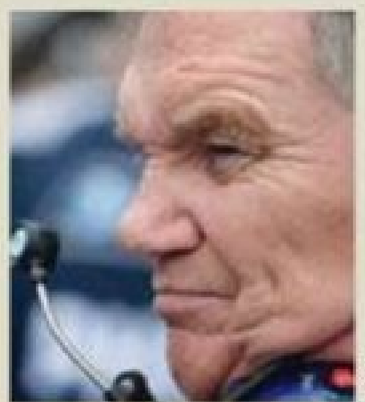
A huge influence in British motorsport as a whole, and karting in particular, he will be sadly missed by all who knew him.

Martin Hines – 1948-2011

RACE MOVES

Australian Supercar V8 series, with **Martin Whitaker**, formerly the CEO, taking on the newly created role of international director – to help with its plans to host at least six events outside Australia by 2015. **Shane Howard** will assume the role of acting CEO until a fulltime replacement can be found. Meanwhile, the series has also announced **Peter Trimble** as its general manager.

Williams F1 co-founder and engineering director, **Patrick Head**, is one of the four FIA representatives on the FIA Endurance Commission, the



LAT

Patrick Head

body responsible for organising the World Endurance Championship from 2012. Head joins Le Mans legend, **Jacky Ickx**, plus **Yoshiki Hiyama** and former CART boss, **Andrew Craig**, on the commission. The ACO, which will promote the World Endurance Championship, also has four representatives including **Pierre Fillon** and **Gerard Neveu.** Meanwhile, Audi Sport boss, **Dr Wolfgang Ullrich**, will represent the manufacturers and Felbermayr's **Christian Reid** is to be the teams' representative. Former GT racer, **Sir Lindsay Owen-Jones**, will preside over the commission.

Chris Carrier is now crew chief on the no 33 Kevin Harvick Inc car in the NASCAR Nationwide Series,

LAT

Chris Carrier

replacing **David Hyder** in the role. Carrier has most recently been employed as crew chief on KHI's no 8 NASCAR Truck, and before that he was a crew chief in the Cup from 2000 to 2008.

Cory Howe, a crew member on the no 50 MAKE Motorsports car in the NASCAR Nationwide Series, was injured while working beneath the team's Chevrolet at Bristol Motor Speedway. Howe was treated with stitches to lacerations on his face and hands, but the injuries were not severe enough to keep him in hospital.

Roush Fenway's no 16 NASCAR Nationwide car is now tended by **Chad Norris**, who has taken over the role of crew chief on the car from **Chris Andrews** – who is to move to another position in the organisation. NASCAR has reinstated crew

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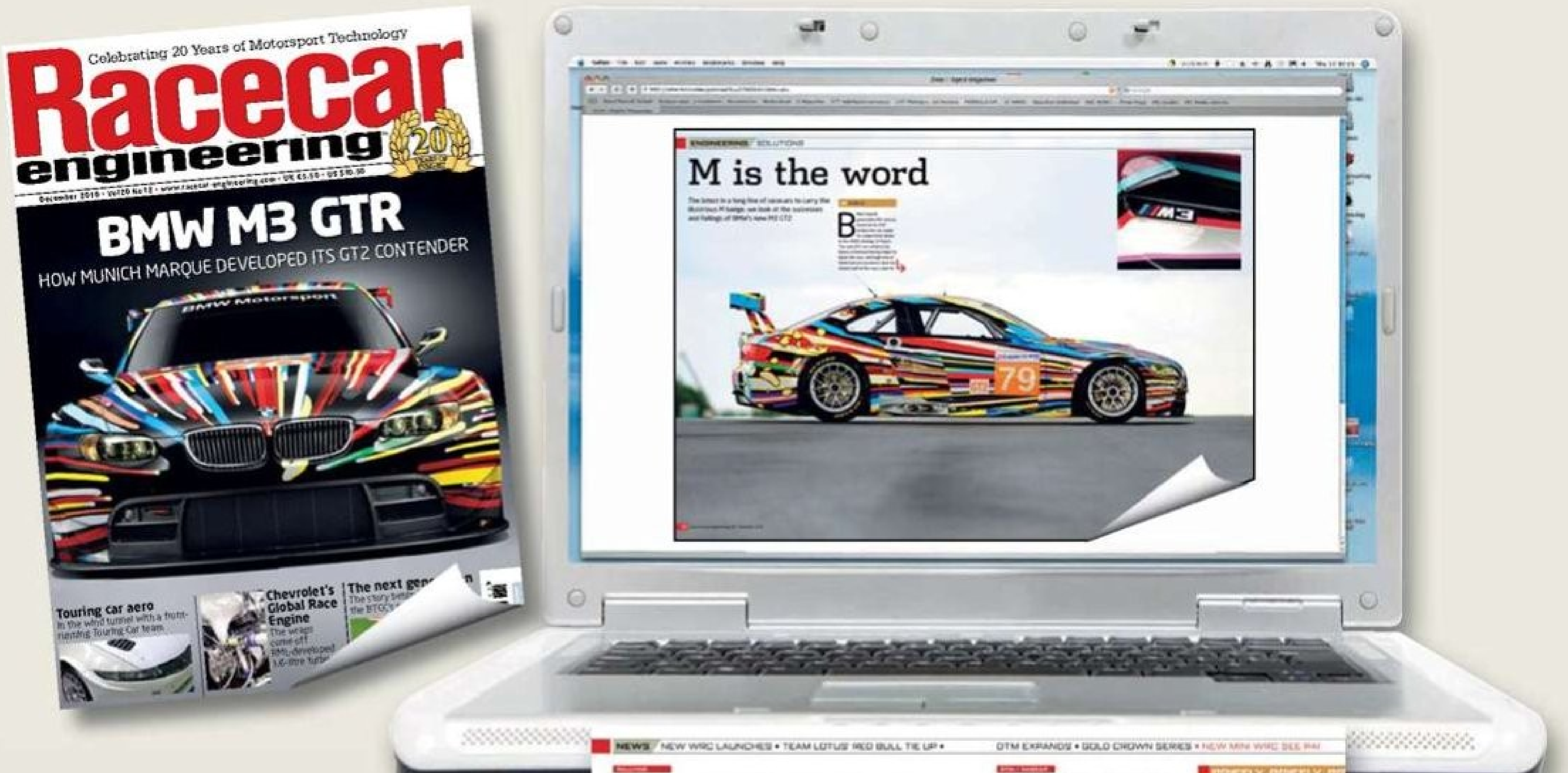

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RACE MOVES

member, **Troy Hartman**, upon his successful completion of its Road to Recovery programme. Hartman was suspended for violating the sanctioning body's substance abuse policy earlier this year.

The Formula One Teams' Association (FOTA) has appointed **Oliver Weingarten** as its new secretary general. Weingarten, who replaces **Simone Perillo** in the position, was previously the in-house lawyer at the English Premier League. Perillo, who has been at FOTA since its inception in 2008, is to leave motorsport and pursue political ambitions in his native Italy.

Riad Asmat is now CEO of Team Lotus, Caterham Cars and Caterham Team AirAsia – the three components in Tony Fernandes' motorsport portfolio. Asmat was

LAT

Riad Asmat

a key player in the establishment of Team Lotus in 2009 and has overseen the growth of the F1 team, the establishment of the GP2 team, plus the acquisition of Caterham Cars.

Former F1 driver, **Derek Warwick**, has been elected as president of the British Racing Drivers' Club (BRDC), succeeding **Damon Hill**, who announced earlier this year he was stepping down. Meanwhile, BTCC star, **Jason Plato,** has been appointed to the board of directors at the BRDC.

Former NASCAR Sprint Cup Series team owner and crew chief, **Ray Evernham,** is to return to Hendrick Motorsports in an 'unofficial' capacity next season, having spent this year working as a consultant for Hendrick's road car businesses.

Teruyuki Yamazaki, chairman and CEO of machine tool manufacturer Yamazaki Mazak Corporation, has died at the age of 82. Teruyuki was the son of the company's founder and joined the business in 1947, being appointed president upon the death of his father in 1962.

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

Luca di Montezemolo INTERVIEW

Q What do you expect from Ferrari in Formula 1 next year

I'm tired of losing the championship at the last race. That has happened too many times to us. Look at Felipe in Brazil in 2008 and Fernando last year in Abu Dhabi. Next year I expect a competitive car from the start of the season with clear rules and with competitive rules. That was not the case in 2009, for example. We will be in a position to once more win the championship.

Q Will your future involve Italian politics?

I am very much committed to Ferrari, more than ever. The other day we presented the new Ferrari 458 Spider to 400 clients, then I went to Monza and, after that, Frankfurt for the Motor Show. Monza was a weekend of passion and I am very busy with Ferrari. I am happy and I have to give a lot of my time to Ferrari because there are a lot of things to do to make sure we have victory in the championship next year, and into the new era of Ferrari dominance. I am very happy that my team manager is so confident and I look forward to the fact that he will be in a condition to deliver on it.

Q You proposed three-car teams some years ago. Have you given up on that?

I will do my best to convince everybody that third cars are what we need in Formula 1. There are three basic reasons for this. The gap between the best five or six teams and the back is too big. Secondly, to race for a small team today is very expensive when you have to develop a new car and is difficult. Thirdly, I want to see new drivers in Formula 1. Look at the past. Giancarlo Baghetti won a fantastic race in Formula 1, his first in fact, with the privately-run Ferrari.

I would like to see McLaren, Ferrari, Williams and Red Bull supplying other teams to make sure they are more competitive. It means they spend less money, and then we can give room to the drivers of the future.

In Formula 1 now we have this ridiculous situation where we are the only professional sport where it's impossible to train. There are cars that are three or four seconds behind and teams with of a lot of economic problems, so I think the customer cars are the

correct solution, and I'll do my best to convince people to move in this direction.

Q You are unhappy about the move of Gilles Simon to PURE?

What I don't like today in Formula 1 is that I'm obliged to give all of the numbers from my engine, and my engine itself, to the Federation, and then the guy in charge of engines at the Federation is now leaving and going to a private company with all of my numbers and data. Racing in Formula 1 is one of the most important and advanced research and development laboratories for Ferrari. We have developed floor aerodynamics, KERS and semi-automatic gearboxes in Formula 1 and this is something that is very important to transfer to my road cars. If Formula 1 became the same for everybody then there's no reason for Ferrari to be in Formula 1.

Q Crowds at F1 circuits seem to be going down a bit – what do you think can be done?

This year we have races where perhaps somebody has been leading by too much, but also there has been overtaking. I think somewhere between big leads and too much passing would be better because the spectators are sometimes confused. They don't understand when a car comes out of the pits which position it is in. The problem, in my opinion, is to have the right balance for the people in front of the television and the people at the track.

For me, at Ferrari, the spectators at the circuit and their passion are crucial. I want to see flags, Ferrari flags! It is essential to find a good balance in terms of ticket price though.

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BUMP STOP

Electric avenue

The Frankfurt Show is one of the major events in the motoring world's calendar and it was interesting to see how the manufacturers view our motoring future. There were launches of new, more powerful and lighter cars, and so many electric cars that it was hard to move without bumping into one. Mercedes' press conference was pretty much all electric, with dancing spacemen, a *son et lumière* special and, bizarrely, some large-breasted men pulling lorries.

There was even an entire hall dedicated to electric mobility, featuring impossibly-proportioned ladies draped over furniture in a concerted bid to make electric cars as appealing as the new Ferrari 458 convertible and the Bentley GTC. What was abundantly clear was that the majority of the industry is heading towards an electric future, and racing is heading down the same route.

The FIA has recently launched its Formula E category, which is intended to move electric cars up the agenda in terms of credibility. Is it a cunning plan, though, or a gimmick? If the industry *is* heading electric, it makes sense, but the regulations demand, for example, that the cars make an artificial noise. This makes it a gimmick. An electric car does not make much noise, in the same way that a Chevrolet V8 engine is not quiet.

"Is it a cunning plan, though, or a gimmick?"

Formula 1 is busy trying to implement an electric motor for a car's trip down pit lane. This, too, is a gimmick. Porsche is trying to make its electric motors last for 16 miles in its 918 and Mercedes is aiming for a 600km range in its cars of the future, so what is a few hundred yards in what is supposed to be the pinnacle of technology?

Is racing any the poorer for not being noisy? In my opinion, no. Firstly, the majority of the audience will be watching on television, or listening to commentary on the radio. They won't care if the cars are noisy or not. At the track, who would argue that the Le Mans 24-hour races in 2008 and 2011 were not as exciting as they could have been because the Audis and the Peugeots didn't make a loud noise as they went past? Sure, I love the Corvette V8 as much as the Judd V10, but they do what they are supposed to do. There are some who say that the diesels should be fitted with speakers to entertain the crowd. To do what, exactly? Play a little Metallica, perhaps? Making another technology try to do something it is not supposed to do is a wasted effort, and that's not racing.

So, is electric at all exciting? If it requires dancing girls to generate interest, probably not. Perhaps it is better to look at the performance figures of the Toyota electric powertrain in the Radical chassis at the Nürburgring. Driver Jochen Krumbach set a lap time of 7m 47.794s in the car, on road tyres. The car enjoyed 590lb.ft of torque, and had a top speed of 161mph. By anyone's standard, 7m47 is a quick lap time, and it smashed the previous lap record set by Peugeot of 9m 01.338s only weeks before. (Peugeot, incidentally, released its first diesel hybrid at Frankfurt. How long will it be before the Hybrid4 908 hits the track?)

Now British peer, Lord Paul Drayson, is creating a Time Attack electric car in association with Lola, and all the time more projects are arising, which is part of the ACO's problem in writing the rules for Le Mans 2014.

The issue, of course, is longevity. A time attack car will do just that – attack lap records, but it won't achieve a great mileage. The Lola / Drayson programme will feature technology that remotely charges the car as it goes around the track, and that is something that can definitely be applied to road cars in the future. This creates a real link between road and race cars, a necessary link to keep our sport relevant.

However, the lingering question is where the electricity will come from in future. Nuclear seems to be the preferred option, but power stations are notoriously difficult to get past the planners and local residents. There is also the not insignificant issue of mining the core materials for a battery, and then, more importantly, the recyclability of the battery components. At Frankfurt there was not one single stand that dealt with that rather expensive problem...

EDITOR
Andrew Cotton


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