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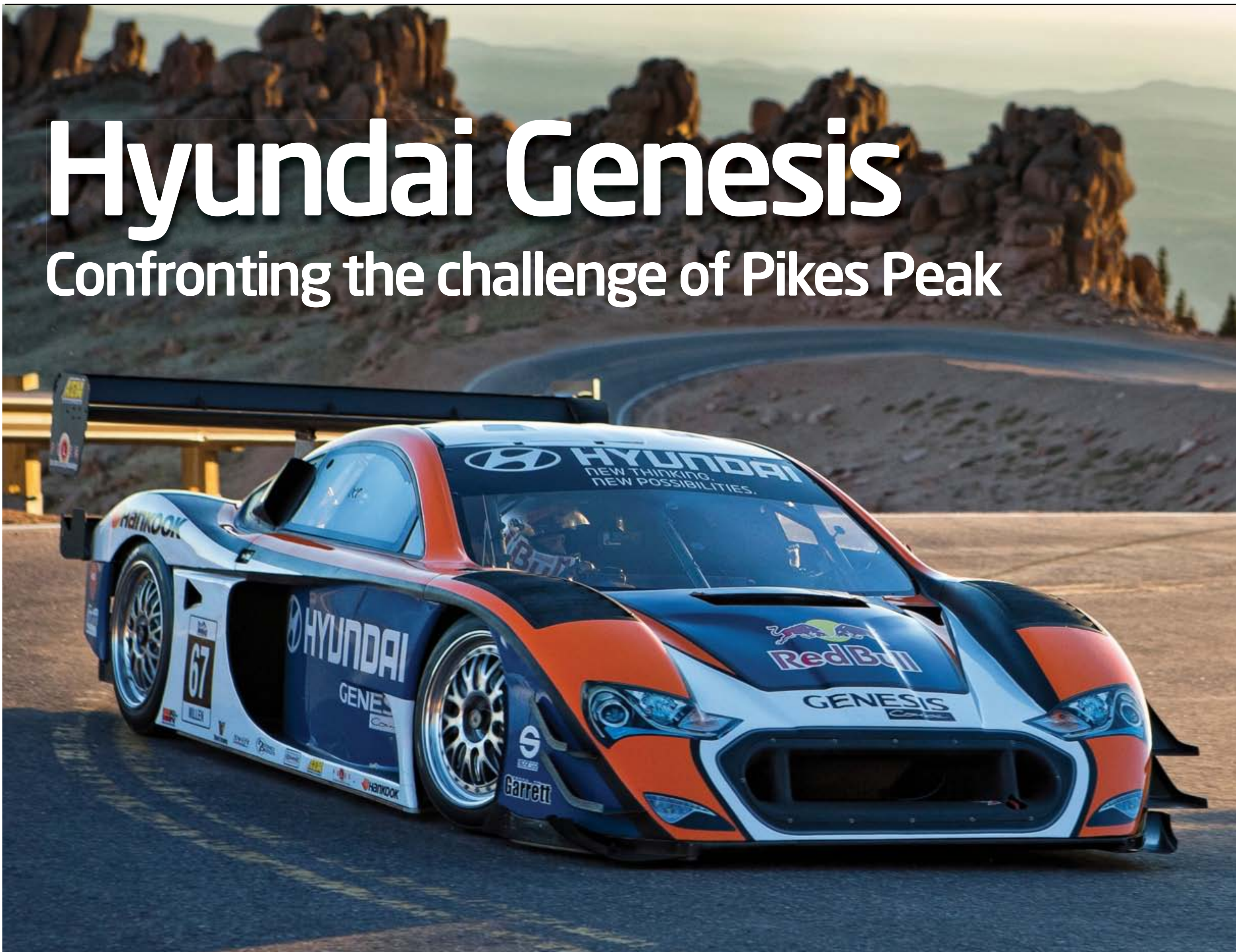

Hyundai Genesis

Confronting the challenge of Pikes Peak

Toyota GT86 Hyundai Genesis PM580T Formula Student 2013

Tuner's treat

The complete guide to Toyota's incredible GT86

Formula Student

Electric power dominates 2013 UK competition

Ford Fiesta R5

Under the skin of M-Sport's mid-range rally car

September 2013

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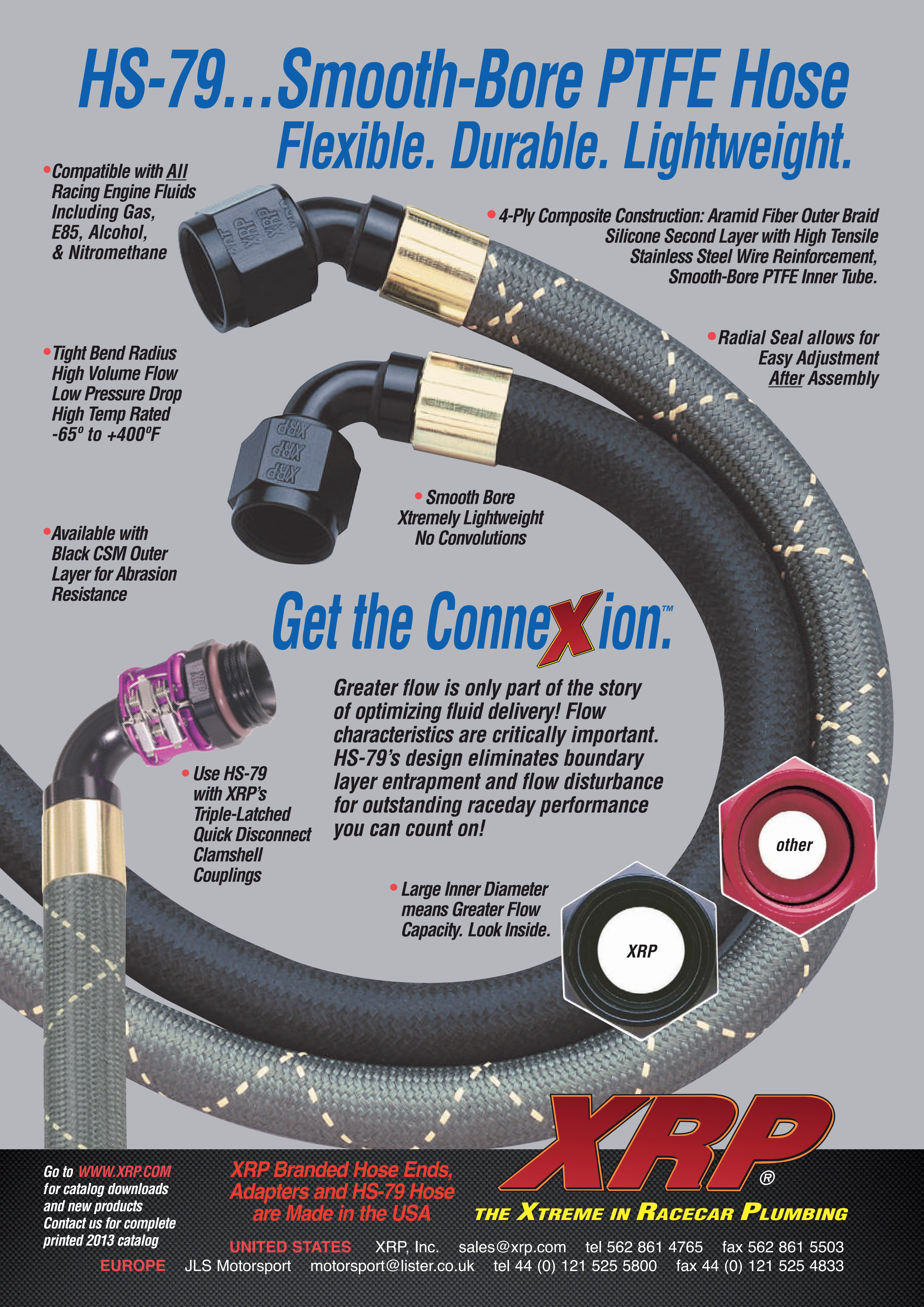
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Profit and dross

Motorsport's endless obsession with cash is as irritating as it's essential

Roman poet and philosopher Lucretius was on to something in *De Rerum Natura* (On The Nature Of Things) when 'nothing can come from nothing' was quoth. It is particularly true in racing, where the prime mover is not the internal combustion engine, but money, as referred to by the truism 'How fast do you want to go? How much do you want to spend?' and 'The only thing that beats cubic inches is cubic money.' For teams, a lack of money is the root of all evil. The importance of it in life can be measured by the fact that it is only equalled by sex in the number of euphemisms used to allude to it, and does seem to be related to it also in direct or oblique ways.

Let's start with what money is used for. Practitioners of that most dismal of sciences, economy, typically define it by the three roles it plays:

- It's a **store of value**, meaning that money allows you to defer consumption until a later date.
- It's a **unit of account**, in that it allows you to assign a value to different goods without having to compare them. So instead of saying that a Cartier Pasha Seatimer watch is worth 10 cows, you can just say it (or the cows) cost €6500, and is considerably easier to carry around than said bovines.
- And it's a **medium of exchange** – an easy and efficient way for all of us to trade goods and services with one another.

All of these roles have to do with buying and selling, so that's how the world thinks of money – it seems strange to think of money in any other way. So our noble sport, when not paid for by the amateur, is an exchange of services and products. If you're not paying for the product, you are the product being sold, and that applies to all free to air TV channel spectators. You, dear couch spud, are being sold to the advertisers.

Profit is sweet, even if it comes from deception, Sophocles professed, and that is the reason manufacturers invest, and one uses the word advisedly, in motorsport. The aura of speed, glamour and power is expected to wash over and polish the image of their mundane bread and butter products, even if the cars racing are merely badged and bear no relationship to them. For the other sponsors it is the transfer of perceived testosterone into their shampoos, razors and drinks. It is a mindset equivalent to thinking that if you rub yourself against a suntanned girl, you too will become tanned. Not true, but fun.

Much as dung attracts flies, the money circulating in an expensive sport attracts parasites. For proof, witness the swarms of investment bankers buzzing around the sport. They have been called everything from soulless bloodsuckers to Satan's scabrous handmaidens, and worse. And together with the Mr Tenpercenters, they require highly paid lawyers, who rack up millions in legal fees, not to mention first-class airfare, hotels and sumptuous gourmet meals – hardly the kind of expense that they think they can afford, so they have to charge for it. Money that is not getting back to the content generators.

I would love to see the day when participants would be paid one symbolic euro/dollar/pound annually to race and work in the field. Methinks the stampede for the exit by the leeches that infest the business could cause grave danger to innocent bystanders. The caveat 'motor racing is dangerous' on the back of the ticket then would be very true.

And much as dung, money is the fertiliser that pays for the people, equipment and suppliers that come together to design, equip, run and maintain the car you are racing. If you want a good driver, you will have to pay him well, that's why he is called professional. You will always be in thrall to the hard choice: 'Cheap, fast and reliable – pick two.'

The eternal call to cut costs in racing gives me a wry smile, as I've been hearing it since the dawn of time. When it comes to the crunch, I'm there with the rest searching for additional budget for more wind tunnel time, more equipment, more testing and more people.

Our hero clearly didn't spend much on clothing, or hair product, in 1976

Racing is still the equivalent of the myth of Sisyphus, the king of Ephyra punished by being compelled to roll an immense boulder up a hill, only to watch it roll back down, and to repeat this action forever – but also trying to get the $200 each time you swing past Go. The consolation is that success will bring in the necessary finance to make it affordable to try again. Money can not buy you happiness, but it can buy you horsepower.

But do not be mistaken: 'Racing is the best way to convert money into noise' and 'the only way to make a small fortune in racing is to start with a big one', or, 'I know there is money in racing – I put a lot into it.'

Much as dung attracts flies, the money circulating in an expensive sport attracts parasites

Team owners complain about engineers, as Enzo Anselmo Ferrari said, maybe apocryphally: 'there's three ways of losing money: with horses, quickly; with women, in pleasure; with designers, for sure.' And engineers complain about team owners: 'Not enough tunnel time', 'We need more testing', 'We need a proper driver', 'We need more power.' They all need budgets.

Drivers also are not immune, even if they have different monkeys on their backs, as noted by James Joyce in his short story *After The Race*: 'Rapid motion through space elates one; so does notoriety; so does the possession of money.'

Even God himself can be quoted. Here's Walter Hayes, former head of public affairs at Ford of Britain, discussing Jim Clark's win at Indianapolis: 'When Jimmy won in 1965, it was $150 for each lap you led on. He led for 190 of 200 laps. Jimmy never talked about money but he was so enchanted by this idea. He said, "It was so funny, I was like a cash register. I kept going around thinking, click, click, $150, $150..."'

Germany invented the concept of cars, France created a sport out of the concept, Great Britain made a noble art of the sport, and Italy turned the art into a religion, while the USA made it a profitable show. Maybe a stereotype that has changed with time, but attesting again that small coloured rectangles of paper are essential to keeping the circus alive.

Lest it be said that one is biting the hand that feeds us, one can only say that reality should not be offensive, it just is. If you, dear reader, are a prospective sponsor, I will be happy to hear from you.

As a final thought, one is indeed fortunate to actually be paid to do something one loves. Beats working for a living. As Woody Allen said: 'Money is better than poverty, if only for financial reasons.'

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The hybrid GT future

It's coming soon to a series near you, but many kinks will need to be ironed out

Following on from my recent column concerning the future of GT racing, a hugely important factor in its continued good health is going to be the assimilation of hybrid GT cars into the mix.

The introduction of such ultra-high performance roadgoing GT cars as LaFerrari, McLaren P1 and Porsche 918 surely indicates that the way forward, even for Supercars, is hybrid. Of these, the 918 is probably the most significant, given the marque's history in GT racing. Porsche's customer racing division is a valuable source of income for the marque and also serves to continually publicise its products. Porsche will want to offer this petrol/electric hybrid as a replacement finally for the iconic but elderly 911 to their many GT3 and GTE race team customers. In Porsche's own words: 'The 918 will act as the gene pool for the Porsche sportscars of the future.' There is every reason to suppose that Ferrari, McLaren and others will follow suit.

The FIA have general thoughts on how to bring hybrids into GT racing. They, together with the ACO, have greatly encouraged energy recovery in racing, mandating KERS in F1 and in the LMP1 class. At the same time, they do not want to disadvantage competitors or prematurely obsolete the existing worldwide pool of GT cars. Bernard Niclot, technical director of the FIA, confirmed that hybrid GT acceptance had been under discussion for two to three years. As well as the practical aspect above, the criteria being considered includes (a) there being sufficient makes and numbers of homologated hybrid GT cars in production to justify opening up the regulations to them; (b) these hybrid systems to be affordable to teams, including the running and replacement expenditure; (c) there must be no safety issues in their operation; (d) non-hybrid cars should remain competitive; (e) the systems must be relevant to passenger car technology. Current thinking is that 2016 would be the earliest date for acceptance of hybrid GT cars into top-level racing to be evaluated. My view is that this may well need to be brought forward.

Even with the Balance of Performance 'tools' available, GT racing is more difficult to manage because it is harder to adapt a hybrid road car into a racing car, rather than issuing a set of regulations to which the racing vehicle is specifically designed. Some energy recovery systems will lend themselves better to competition than others and there will be more to evaluate. Nonetheless, after in-season adjustments, BoP should be attainable.

However, the problem really starts with an offshoot of hybrid power – the configuration of the drivetrain. For weight, balance, packaging and efficiency reasons alone, having at least part of the hybrid power delivered via the front wheels in addition to the conventional drive to the rear wheels is logical, such as the system seen in the forthcoming Porsche 918.

Hybrid GTs have been mooted for a while. Now it may be their time

With few exceptions, AWD has long been outlawed in all forms of major motorsport except rallying and off-road. This general rule was introduced because of AWD's inherent traction advantage over 2WD. An additional factor was the desire to prevent the increase in costs of more complicated transmissions. There was, too, the concern that the racing would be less spectacular as cars driven through all four wheels would be more likely to corner 'on rails'.

But perhaps the time has come to re-assess this blanket ban. With a hybrid GT car in which a significant portion of its power can only be transmitted via the front wheels, it is no longer a matter of disconnecting or removing the FWD components in order for it to participate, such as with the new Bentley GT3.

A precedent at the highest level has already been set with Audi's e-tron LMP1 cars, allowed by the ACO to participate with the caveat that the front wheels can only be driven once a certain road speed has been attained. Contemporary racing cars are so complex that the addition of FWD components is not the issue that it was 50 years ago. Similarly, the powerful control systems now essential to operating these vehicles already provide the basis for accommodating AWD management software. As for spectator spectacle, tyre and aerodynamic development mean that the days of racecars drifting and power-sliding in corners are, sadly, long gone anyway.

Many say that Hybrid GT cars will be accepted into top-level racing by 2016. I think it will be sooner

The major issue that remains is how to equalise the wet weather performance and tyre degradation of AWD versus 2WD cars. Since the BoP concept's inception, the FIA and the ACO have come a long way in using much more sophisticated methodology to arrive at the measures applied to each individual make and model of GT car. But surely one of the biggest problems to overcome is that there are so many constantly varying levels of grip when a track is damp or wet, compounded by the choice of intermediate or rain tyres. Trying to simulate this when setting BoP for AWD cars must be hugely difficult. Even if it is achievable, there remains the key question of what can be done about it?

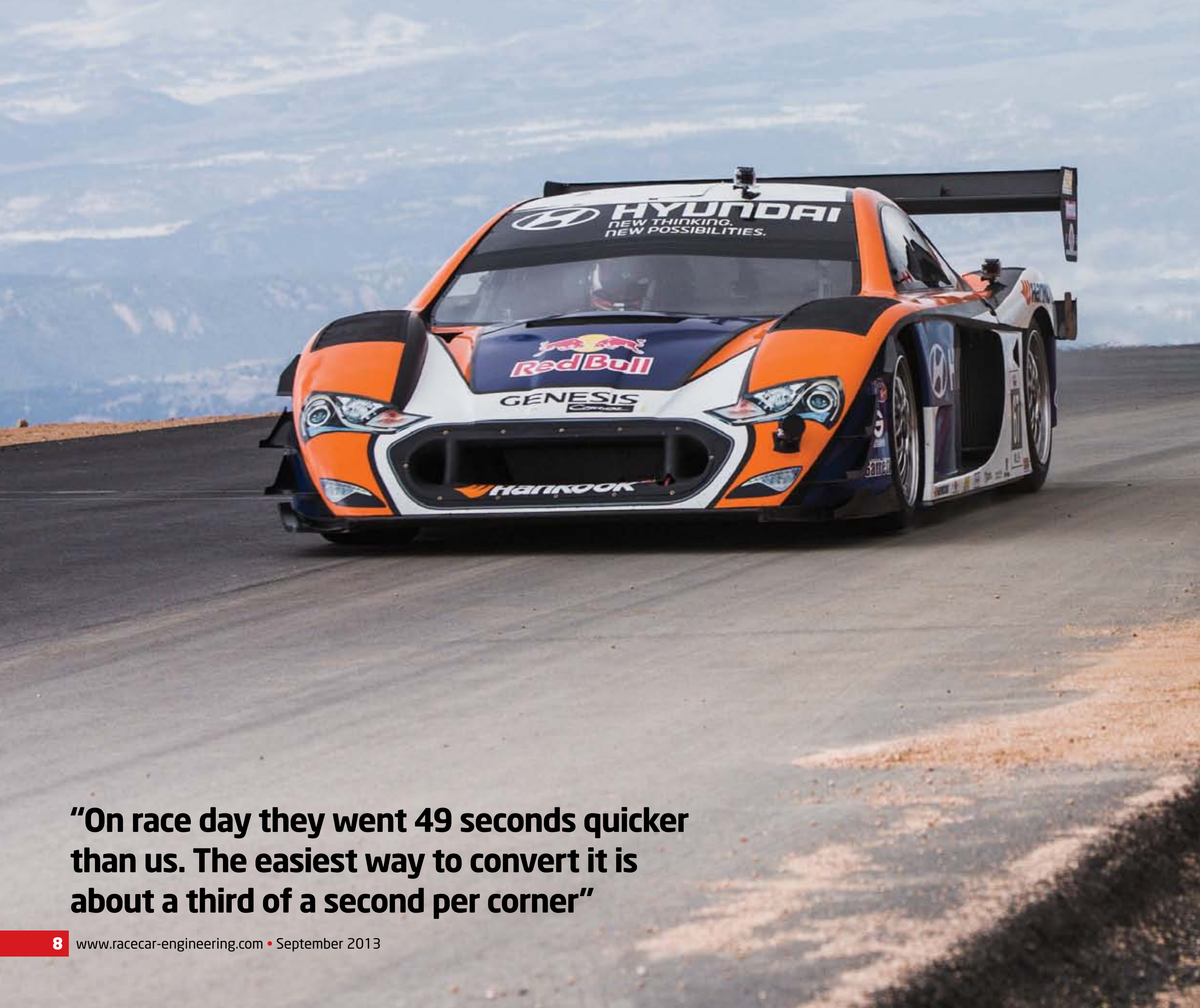
One possibility is the ACO solution applied to Audi's LMP1 cars as mentioned previously, although it is not universally popular. An alternative could be to regulate through the control software that only a low percentage of the total available torque can be delivered to the front wheels once intermediate or wet tyres are fitted, but for some hybrid cars this could be too big a handicap (although BoP might be able to manage this). Perhaps AWD cars should have narrower intermediate and wet rims and tyres than 2WD, or of a harder compound.

Far greater brains than mine will be able to offer solutions to equalise the performance between the two modes of driven wheels, but this may be the greatest of the challenges that the seemingly inevitable advent of hybrid GT cars into motorsport will introduce.

Genesis of a challenger

Rhys Millen's 2013 Pikes Peak challenge was overshadowed by the record-breaking run by Sébastien Loeb. But his second-placed performance, on a tight budget, was remarkable in itself

BY DON TAYLOR



"On race day they went 49 seconds quicker than us. The easiest way to convert it is about a third of a second per corner"

As the 2013 run for the Pikes Peak overall record played out in June, Sébastien Loeb and his Peugeot shattered the overall record set by Rhys Millen in 2012. Millen, pinning his hopes on a new car he built himself, finished second.

Coming away from the 2012 Pikes Peak International Hill Climb (PPIHC) as the King of the Hill overall record holder, Rhys Millen immediately had thoughts of returning to defend his crown. He set out to build the fastest car he could, within his time and budget constraints, not knowing what the level of competition was going to be in 2013.

A little background: surprising many, Millen won overall last year in a production-based vehicle, a Hyundai Genesis Coupe. This same vehicle has served double duty as Millen's Formula Drift racer as well as a Pikes Peak, Time Attack division entry. The Gen Coupe was capable of winning in both applications, and it has now captured the PPIHC Time Attack Class in four of the last five years. The breakthrough overall win in 2012 came as a result of Millen's 20 years of experience driving the mountain, his understanding of the ever-changing conditions on the road (rain, sleet, large temperature swings and even ash blown over the asphalt surface from nearby forest fires), plus having a proven car. It all came together in his record-setting, 0.02 second victory over Romain Dumas.

For 2013 however, Millen thought he would need a much faster, Unlimited Class car for the 91st running of the event. Last year was the first time it was run with the 12.42 mile public road being fully paved, meaning no more dirt sections. With that enticement, well-qualified road racing drivers and cars were bound to come out of the woodwork for the challenge. Last autumn, rumours had Audi bringing a LMP car, Honda with an IndyCar, and Red Bull preparing one of their F1 cars. None of them made it, but it was later announced that Sébastien Loeb and Peugeot had formally entered the 2013 event, but were keeping vehicle details closely guarded. And then there was Romain Dumas, who wanted another shot, this time with a Norma hillclimb chassis.

Hyundai Motor America's marketing group had supported Rhys Millen Racing (RMR) for many years in Global RallyCross and Formula Drift, as well as at Pikes Peak. After the 2012 victory, Hyundai also wanted to retain the title. They agreed to provide financial assistance for Millen to defend the crown in a new, Hyundai-powered vehicle of his design. 'I partnered with Hyundai to build the car of my dreams,' he said. The actual go-ahead came in December 2012.

Millen was now ready to once again apply what he and the rest of the Millen family had learned through their years of building and driving their own successful Pikes Peak cars. He gathered a skilled workforce of Southern California fabricators and mechanics that he knew could do the job, those who otherwise would be occupied with off-road racers, hot rods, sportscars or with aerospace projects. They all came together in the RMR shops, located in the California

As with all Pikes Peak entrants, sufficient cooling is a serious concern

Rhys Millen's 2013 car was 2WD with a mid-engine configuration

A 2006 Crawford Race Cars Daytona Prototype chassis was used

The stock Hyundai powerplant was turbocharged to deliver 850-900HP

ocean town of Huntington Beach, AKA Surf City, ready for the intense, six-month project.

Looking at the performance of his 2012 car as reference, Millen figured if he had 150 more HP and 500lb less weight, he could knock 46 seconds off his winning time of 9:46, and make it into the eight minute territory. To accomplish that, he'd need a car significantly different from his production-based car, one more purpose-built for the task.

CLIMBING POWER

Fortunately, the engine choice was pretty simple. Millen felt that the basic Hyundai engine package he raced the previous four years was the way to go. Hyundai's Lambda, lightweight, all-aluminium DOHC V6, when fitted with a Garrett turbocharger, could be expected to reliably crank out 850-900HP, a significant improvement over the 2012 car's 700HP.

The engines were built in-house. Pistons and rods were replaced, and displacement was increased from 3.8 to 4.1 litres. A low-profile, machined aluminium pan and pumps were fitted to create a dry sump system. Otherwise, the engine retained its stock block, head, valvetrain and accessories. The fact that Millen has obtained such high power levels with outstanding reliability from a turbo-boosted, basically-stock engine is testimony to the robustness of the Hyundai powerplant, and today's production engines in general.

Another longtime RMR supporter, AEM Performance Electronics, provided the engine controller unit, all chassis/engine sensors, as well as an engine water injection system. A 10 per cent water/gasoline mix was run.

But what about the rest of the car? Completely designing and building his own chassis, as Millen had done in 2011 with his original PM580 – a 4WD Pikes Peak special – was not an option, based on his December start date. And although having 4WD once again was tempting, he recognised the additional complications that could result, and decided to keep it simple: 2WD, with a mid-engine configuration. Therefore a search began for an existing chassis as the starting point for his car. After considering a Radical chassis at one point, Millen was able to purchase a Crawford Race Cars 2006 Daytona Prototype (DP). It seemed logical that the now fully paved Pikes Peak course, all 156 turns of it, would be road racing car-friendly, as opposed to suiting the many compromised vehicles that had come before to challenge the previously dirt/asphalt combo.

Max Crawford of Denver, North Carolina, whose company had built the chassis, took great interest in the project. He offered full access to information on that car, and ended up providing some aero bits that were previously developed to make his DP car faster, but were rejected by the Grand American Series.

The chassis structure and suspension would remain basically as designed. The car was totally disassembled and checked over. Suspension parts were sent out for magnafluxing. The rollcage received some modifications: the new body would require moving the A-pillar and replacing the forward roll hoop. It was also the opportunity to add some additional lower bracing to the rollcage as per recommendations from Crawford.

Since the Daytona Prototype cars are designed with a structural engine bay large enough to accommodate a variety of production-based V8 engines, the Hyundai V6 could be slipped in with room to spare. And it was, accommodated with the machining of new engine plates.

With no time or budget for aero testing, the car would have to rely on Rhys Millen's experience, Max Crawford's input, and intuition

The Crawford DP came with an Xtrac, DP 386, five-speed sequential transaxle. Andrew Heard of Xtrac in Indianapolis was consulted. He knew the unit, and overhauled it in a few weeks. While the transmission was away, an adapter plate was being fabricated to allow the Korean/UK hardware marriage to be consummated with the addition of a new clutch and input shaft.

Next there was the task of fabricating the engine's turbo plumbing. Again, the roomy engine bay was an advantage, allowing space for exhaust headers, turbo ducting, and the required coolers.

Sufficient cooling is a serious concern for Pikes Peak cars of all types, even electrics, given the thinner atmosphere from the start at 9390ft, all the way to the Peak's 14,110ft altitude finish line. Cooling concerns challenged the converted DP car's original heat removal system's capacity in several ways. The altitude factor, combined with increasing the HP from 500 to 900, and switching from a naturally aspirated to turbo engine, all conspired to overwhelm the original coolers. The engine bay is now flanked by a massive turbo intercooler on the left, and a hefty oil cooler on the right. Large openings were added to the body sides to feed air to these units. The engine's water radiator remains in front.

Meanwhile the suspension layout and components required little attention. The Brembo brakes and six pot front, four pot rear which came with the car proved to be adequate, even with steel rotors. With assistance from the local Brembo rep, new pad options were made available.

Steering hardware did require some changes. First, more steering angle would be needed for the tight switchbacks. Millen's experience building Formula Drift cars, where steering angles of 50 degrees or more are common, paid off. Teeth were added to either end of the rack to add travel, without disturbing basic rack mounting geometry or steering ratio. This modification increased full wheel steer angle from 18 to 24 degrees.

Additionally, the hydraulic power assist to the steering was replaced with an electric unit. Specifically, it is the standard power steering motor in the production Hyundai Sonata road car, which provided an inexpensive, reliable and tidy alternative to the heavier hydraulic system. Millen was familiar with the unit, as he had worked with the supplier on one for his previous Unlimited Class Pikes Peak car. The gains were a weight saving of 10 pounds by eliminating hoses, fluid and hardware, and a reduced power drain on the engine.

To save time, the wiring harness was brought over from the PM580 and moved into its new home, with trimming and tailoring performed as necessary. It was also determined that the DP car's original three-piece, BBS aluminium wheels and offsets would be serviceable, at 18x12 inches front and 18x13 inches rear.

Tyre requirements have evolved, as the dirt section was progressively eliminated. Today, soft compound slicks are most common – assuming it isn't raining. In that case, teams need to also have both intermediates and rains ready. Millen called on a supporter of his in other programmes, Hankook, to supply the tyres. Millen initially tried their 'soft' compound, but found it was not soft enough. Hankook scrambled, and by race week came through with new tyres of a compound which would be just right.

"I partnered with Hyundai to build the car of my dreams"

BODY WORK

As Hyundai Marketing's interest was in promoting their US-sold Genesis Coupe, besides using its engine, it would be desirable to have the PM580T visually resemble the production car. Not a problem. RMR has its own composite subsidiary – WO-Ven. Having produced the models, moulds and parts for many movie cars, racecars and after-market street parts, the operation was fully capable of turning out a new body in short order. With the work done under his own roof, Millen could set the shop's priority. Perhaps more importantly, the art-schooled racer could oversee the form taking shape and direct every subtlety to his liking. The result was perhaps the best looking car at Pikes Peak this year. The mid-engined car has the proportions of the front-engined

NEW HEIGHTS FOR EV ENTRANTS

In this age of spec racing, and highly restricted rules, it is refreshing to see that the Pikes Peak International Hill Climb organisation is thriving by not only being OK with, but encouraging, innovation. Sparked by that philosophy, the Electric Class – started in 1981 – has been rapidly growing in interest. As the performance of EVs in the hillclimb event has increased dramatically in the last couple of years, some are predicting the day in the near future when an EV can win the event overall.

This year, rain showers during the running of the EV group prevented a full showing of their true capability. Nobuhiro 'Monster' Tajima, a long-time veteran and fan favourite, escaped most of it to prevail in his E-RUNNER, and was fifth fastest overall. Even slowed by the weather, with a time of 9 minutes 46 seconds, he tied the overall Pikes Peak record set last year by Rhys Millen – demonstrating how much EVs have improved since last year's best of 10m15s.

Mitsubishi's matching pair of all-new MiEV Evolution IIs were often quickest in the practice stages, but finished second and third in class with a best of 10m21.866s. Mitsubishi spokesman Roger Yasukawa said: 'If we had full dry conditions, we would have been about a minute faster', which would have put them in the 9:20s. Last year's Electric Class champion, the 2WD Toyota EV P002, didn't get to show what it had, and failed to match promising practice runs on the rain-soaked track.

Earlier, in the dry, sunny morning runs, the quickest motorcycle to the summit of the all the 60-odd bikes present was an electric Lightning, putting all of the petrol-burners on notice.

Pikes Peak is very well suited for demonstrating an electric vehicle's capabilities. The high altitude climb, which goes through elevation changes that leave internal combustion engines panting, has no such performance degradation effect on EVs. Plus, the short length of the event – 12 miles in about 9-10 minutes – is no problem for an EV's sometimes limited range. Add to that the openness of the rules, and the international exposure, and it's no doubt that other manufacturers will also see the value of this nature-at-its-best showplace for EV performance

Don Taylor

Nobuhiro 'Monster' Tajima was fifth fastest overall from 143 starters, and tied the overall record of 2012.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Genesis Coupe. Casting the greenhouse shape directly from the production car, and using the production windscreen, helped establish the visual linkage to the Gen Coupe. Fully retained was the production car's distinctive design cue, the 'saddleback' quarter window. The lower body would have 10 inches sliced out of it, giving the car an overall height of 44 inches, or 10 inches shorter than the production car.

The body plug was a combination of fibreglass sections, foam and filler. Traditional body modelling methodology was employed, including the hours of manual sanding and shaping required. Therefore, the final form is a unique piece of hand-crafted, rolling sculpture.

The production car's 'saddleback' quarter window was retained, but the lower body was 10 inches shorter, at 44 inches

With no time or budget for aero testing, the car would have to rely on Millen's past experience, Crawford's input, and intuition. For downforce he'd depend on the splitter, front dive planes, an extended rear diffuser, the rear wing, and keeping the car as smooth as possible in between those elements.

The RMR PM580T Hyundai Genesis PPIHC came together around mid-May. The body panels were fitted. The transmission was received back from Xtrac. And with the powertrain end of the car brought together, final fitting and routing of the turbo/ exhaust and cooling plumbing could be completed.

As soon as the engine could be fired up, the next stop was the chassis dyno. Global Motorsports Group in Santa Ana prepared Porsches and Audis for competition, and they're across the street from Porsche Motorsports US. They had time available on their Mustang AWD 500SE Chassis Dynamometer. Spending a couple of days on that dyno, the engine's tuning was mapped for the high altitudes of Pikes Peak.

Then came track testing. Hyundai provided access to their Proving Ground, in the desert, just 85 miles north of Los Angeles. Its winding road course, at least in some of its turns, resembles Pikes Peak. The chassis was instrumented for suspension travel, steering and brake pressures. Chassis engineer Buddy Fey was brought in to assist in chassis setup, drawing on his experience with that generation of Crawford DP. He had been the Crawford factory team's track engineer.

But it would take getting on to Pikes Peak itself to begin the serious tuning on the car. The surface of the road and altitude are unique, and cannot be matched elsewhere. The team was onsite early enough to be included in the first official testing days in early June. Getting heat into the tyres was a major concern, with only the not-soft-enough compound tyres available at that point. Among the changes made: front camber was increased, the sway bars were disconnected 'to soften the car up', and stiffer springs were installed.

With various tweaks, the car got faster during the week of practice and qualifying. However it was clear that the Peugeot was setting the mark, forcing Millen to focus on bringing the Hyundai along as far as possible.

CLEAR SECOND

On race day, Millen's car could not match the speed of Loeb's record run of 8 minutes and 13.878 seconds. But Millen achieved a significant time improvement from 2012 and stood alone, uncontested in second overall with a time of 9:02.192. A serious contender, Jean-Philippe Dayraut, finished third, more than 40 seconds slower, at 9:42.740. Romain Dumas's Norma had broken down early in his run, keeping all from seeing his potential.

In the end, Millen felt he had surpassed his goal. He had built the second fastest car to ever climb Pikes Peak, and had shaved 42 seconds off of his old time, all with deteriorating weather conditions at the top. With perfect weather, Millen believes sub-nine minutes is achievable.

Reflecting on his programme a few days after the race, Millen gave thought to the performance differences between his car and the Peugeot: 'The advantage over our car was the ability to put every bit of power to the ground. On race day they went 49 seconds quicker than us. The easiest way to convert it is about a third of a second per corner. They are probably making all of that up on corner exit, with four-wheel drive, with the downforce, with the gearing, being able to pick the throttle up that much quicker on each corner, and carry that corner exit speed. But I am real proud of what we had achieved, and what my team has built, given our time and budget.'

Millen tried Hankook's 'soft' compound but found it wasn't soft enough. Hankook scrambled and by race week came through with a new compound

TECH SPEC

RMR Hyundai Genesis PM580T

Engine
Type: Hyundai Lambda, DOHC V6
Cubic capacity: 4100cc
Number of valves: 24
Position: mid-rear
Number of cylinders: 6
Maximum power: 850-900HP
Torque: 800ft lbs
Maximum revs: 7200rpm
Top Speed: 140mph

Transmission
Type: transaxle
Gearbox: five speed sequential

Chassis
Frame: steel tube frame, with aluminium honeycomb panels
Bodywork: carbon composite

Suspension/brakes/steering
Suspension: double wishbones and pushrod/rocker arm actuation at all corners
Springs: coil over dampers
Dampers: pressurised dampers
Anti-roll bars: front and rear
Steering: electric power steering
Brakes: hydraulic double circuit brake system with one piece light alloy calipers
Brake discs: ventilated carbon discs
Diameter (front): 355mm
Diameter (rear): 320mm
Wheels: aluminium three piece
Tyres: F 280/690/18, R 320/710/18

Dimensions
Length: 4506mm
Width: 2006mm
Height: 1118mm
Front/rear overhang: 1690mm
Wheelbase: 2794mm
Wing: 1985mm wide
Fuel tank: 91 litres
Weight: 1107kg

The next big recurrent racer

Versatile, affordable and blessed with superb cornering ability, the GT86 looks set to be a tuner's dream for years to come

BY SAM COLLINS

Every now and again a production car comes along that seems purpose-built for racing, and seems to inspire tuners to create a veritable cornucopia of competition derivations. Previous examples have included the Austin 7, VW Beetle, Mini, Ford Escort (Mk1 and Mk2) and the Peugeot 205. And now a new name has joined that list, the Toyota GT86. Mechanically, nothing links these cars together beyond the use of an internal combustion engine, but all of them have one vital thing in common – they are extremely affordable.

The GT86, 86, or Scion FR-S – depending on which market you are in – was developed in collaboration with Subaru. Toyota invested in Subaru's parent company, Fuji Heavy Industries, in 2005 and lifted its shareholding in 2008 to more than 16 per cent. The 86 is the first result of that collaboration. Around this time, Toyota's product planning and product management divisions aggressively promoted the concept of a sportscar with a horizontally opposed engine and a front-engine, rear-drive layout. However, most of the actual vehicle engineering work was conducted by Subaru, which markets the car as the BRZ.

For Toyota, the new car was something of a statement. The firm's president Akio Toyoda said cars must have an emotional presence that inspires drivers. 'Personally, I love the smell of petrol and the sound of an engine, so I hope that this type of vehicle never disappears,' he said. 'I hope that motor vehicles will continue to provide dreams and inspiration to people for all eras. I believe that if it is not fun, it is not a car. Today it is said that young people have little interest in cars as there are much more interesting things. As an automobile maker, I find this quite frustrating. It is for this reason that we are committed to making cars that will evoke this feeling of "fun to drive" again in as many people as possible. This is Toyota's declaration.'

The first racing versions of the GT86 took a little while to appear. The wraps were taken off the first production car at the Tokyo Motor show in late 2011, but the first competition cars only appeared around six months later. But there were rather a lot of them, so many that we only have space to detail some of the more major projects. Many of these can be considered works programmes, though on the whole they are aimed at promoting the sales of tuning parts.

Like many, TMG Toyota's customer-focused engineering consultancy based in Cologne, Germany saw the new sportscars as an opportunity. It decided to develop a

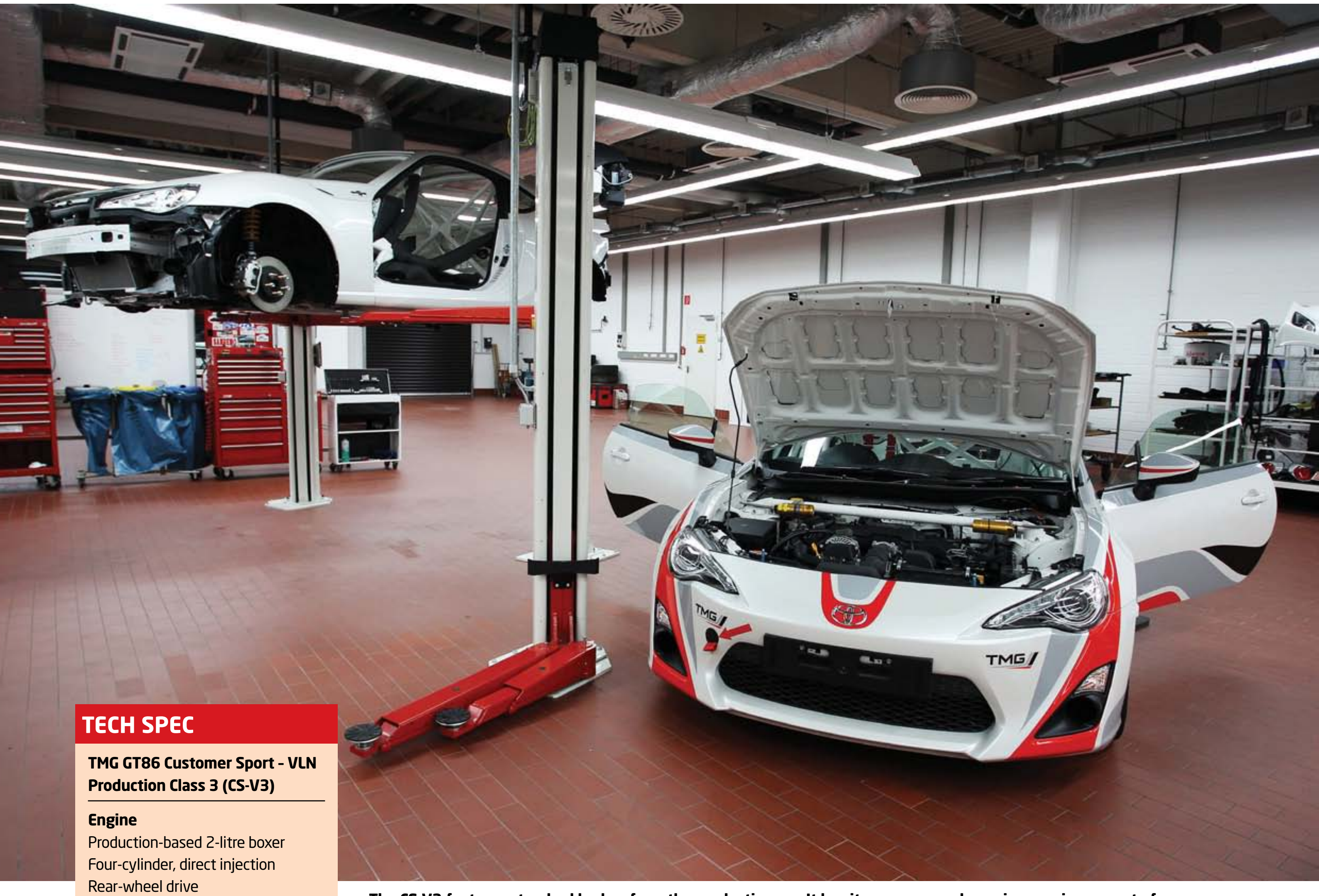
new cost-effective competition car based on the 86. Dubbed the GT86 CS-V3, it is the tamest of the works 86s, but also the most cost-effective. It retails at just €38,500 excluding taxes, just under €10,000 more than the base model production car.

The CS-V3 was built to compete in VLN races including the Nürburgring 24 Hours, but quickly found a market overseas with the first car being sold to a customer in Switzerland and the second to one in the USA. One of the reasons for its low price is that is close in specification to the production car, although this isn't the case for the one sold in Europe as Nico Ehlert, TMG's senior engineer, customer motorsport explains. 'There is a version of the 86 built in Japan that is a lower specification,' he says. 'It is not on sale in Europe, but for us this car is the best donor. It lacks all of the things like a navigation system and automatic heaters that you find on the European versions, and that makes it easier to build into a competition car. Once the donor cars arrive from Japan we strip them down, removing the entire interior as well as the bumpers, window glass and all of that. Only the engine stays in. After the strip we take the car to a subcontractor for the rollcage installation and interior painting. From then we build the car up using a standard kit.'

This kit includes most of the usual competition car parts, including the typical safety equipment, but not all that many pure performance upgrades. Indeed many standard production parts are utilised on the car as the VLN regulations for its class restrict the use of competition parts in some areas. The suspension however is not one of them, and here competition car parts are used. 'We have chosen to use Ohlins dampers which have been specially created for this car, they are not an off-the-shelf part,' says Ehlert. 'The damper is adjustable in bump and rebound, but not in fast and slow rebound as we felt that would be too much for entry-level drivers to deal with.'

The brakes, however, must be based on standard parts. 'The brakes use a standard caliper, as the regulations insist on OE brakes,' says Ehlert. 'But it is fitted with racing pads and braided hoses are installed. However, even with the standard parts the

"I have never driven a car that handles like this. It's so controllable"



The CS-V3 features standard brakes from the production car. It has its own one-make series running as part of the main VLN Championship, and many entrants participate in the ADAC 24 hours at the Nürburgring

TECH SPEC

TMG GT86 Customer Sport – VLN Production Class 3 (CS-V3)

Engine
Production-based 2-litre boxer
Four-cylinder, direct injection
Rear-wheel drive

Exhaust: racing exhaust

Top speed: 225km/h

Max torque: 205Nm 0-100km/h ~7secs

Transmission
Production-based six-speed manual

Suspension
Motorsport suspension kit

Brakes
Ventilated front and rear discs
Racing pads
Additional brake cooling

Tyres/wheels
Tyres: racing slicks – 24/61 17
Wheels: 17-inch alloys

Dimensions
(length x width x height)
4240x1775x1285mm

Wheelbase: 2570mm

Safety
FIA-approved rollcage
Racing seat
Six-point safety harness
Electronic fire extinguisher system

Price: €38,500 excluding tax or €45,815 including German VAT

braking is great, but it's not a pure production spec brake setup. All the parts are OE, but some parts come from one version of the car and others come from a different version. This allows us to get better performance and still remain inside the rules.'

Other standard parts include the transmission, fuel tank and bodywork. On the production car a large rear wing is an optional extra, making it legal for use on the racecar. However, TMG opted not to use it as they found that it was merely an aesthetic part and did not produce any downforce.

The mixed identity of the 86/BRZ has the potential to cause a few homologation headaches in the future and the brake setup on the CS-V3 is a good example of this. 'Strictly speaking, parts from the BRZ cannot be used in place of the Toyota production

The Gazoo Racing flavour of the GT86 competes in the Super Taikyu series

parts, but on some parts the Subaru logo is present so it does not really meet the regulations in that way,' says Ehlert. 'The nature of the car means that this is inevitable – on the brake calipers and engine block you will find Subaru engraved. The rule-makers have allowed this as long as the parts are homologated for the GT86, not the BRZ, and where we have to be careful is with parts from Subaru's high performance brand STI, which has developed its own BRZ variants.'

The CS-V3 comes with a range of optional upgrade packages, which customers can choose at the time of purchase or retrospectively.

'There is a higher spec option package which features a limited slip differential, but we use the standard production version found on the European GT86,' adds Ehlert. 'The regulations do

The TRD Griffon is significantly upgraded from the base car, with several modifications to reduce weight, and a whole host of racing-spec TRD accessories

not allow us to use a motorsport part here. A CAN-based data acquisition system is also an optional extra as a plug and play kit with GPS, lateral and longitudinal acceleration as well as a number of open channels.'

When the car was in development, TMG found that the engine could overheat in high ambient temperatures not normally found in Europe, and realising that the car could have a potential market in places like the Middle East it made some changes to the exhaust layout and oils system to accommodate this. 'There is an oil cooler upgrade, though the engine is totally standard. We experienced a slight increase in oil temperatures during endurance runs at high temperatures, so we felt that it could become an issue. If the car is to run in locations with high temperatures such as Dubai, we recommend this upgrade. The 86 has its catalytic converter right next to the oil pan which heats it up.'

To reduce the temperatures further, TMG relocated the catalytic converter rearward in the exhaust system, with a motorsport part used instead of the standard component, which reduced back pressure and fuel consumption.

The CS-V3 has its own one-make series running as part of the main VLN Championship, and many of the cars racing in it take part in the ADAC 24 hours at the Nürburgring. Also running in the 2013 edition of that race was a second specification of the GT86 developed in Japan by TRD and Gazoo Racing to compete in the Japanese Super Taikyu series. 'That car is built to a much more open rulebook,' says Ehlert. 'They can do almost anything they want apart from the engine. It has bigger brakes, a stiffened chassis, a flat floor and bigger aero.'

Also featuring the standard power unit is the recently revealed TRD Griffon Project, created by Toyota Racing Developments. It is a development of the GT86 designed specifically for track driving and has curiously been named after a shaggy-haired Belgian dog. Modifications have been made throughout the car to reduce weight, strengthen the

TECH SPEC

TRD Griffon

Base vehicle
Toyota 86 (Model: ZN6)

Engine
Type: FA20 – 2-litre naturally aspirated horizontally opposed engine
Maximum output (net): 147kW (200ps) or more / 7000rpm
Maximum torque (net): 205Nm (20.9kgf-m) or more/ 6400-6700rpm

Powertrain
Strengthening clutch cover
Metal clutch disc
TRD mechanical LSD
Strengthening diff carrier mount bush
4.8 Final Gear

Suspension
Height adjustable suspension set (KW Ltd)
TRD stabiliser set
Pillow ball upper mount
Strengthening front lower arm and bush
Strengthen rear suspension member
Strengthening rear upper arm bush
Enhanced lateral link and bush
Strengthening trailing link and bush

Tyres/wheels
Tyre: ADVAN Racing Slick 250/640R18
Wheel: RAYS TE37SL 18-inch 9.5J +45

Body
Material: carbon composite

Dimensions
Length×width×height: 4650x1920x1480mm
Wheelbase: 2820mm
Total length: 4334mm
Width: 1800mm
Overall height: 1235mm

Weight: 1034kg or more

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The mixed identity of the GT86 and BRZ has the potential to cause a few homologation headaches in the future

chassis and introduce racing-spec TRD accessories. The overall shape follows the same lines of the original coupe, but the bonnet, roof, doors, boot lid, rear wings, bumpers, wider front wings and rear diffuser are all made from lightweight composites. Further weight savings are made by using polycarbonate instead of glass in the window.

The cabin is fitted with a TRD driver's bucket seat, gearshift knob, ignition button and oil pressure and water temperature gauges, all likely to become commercially available tuning parts. There is also a Momo steering wheel and Takata seatbelts. Many of the car's components have been strengthened or upgraded: the standard Torsen limited-slip differential has been replaced by a TRD mechanical LSD and the suspension has been significantly reinforced. Coil-over suspension kit is used and the final gear ratio has been shortened to 4.8:1.

Further performance-related changes include an oil cooler for the engine and a TRD monoblock brake caliper kit with racing spec brake pads. The Griffon runs on Yokohama Advan tyres, and depending on territory, features Rays or TSW 18-inch wheels.

The Griffon may also form the basis of its own racing series in future according to some company sources, but how that would fit with the CS-V3 championship is unclear.

The fact that all three of the cars mentioned so far have retained the 2-litre boxer engine in standard trim is initially something of a surprise, but Toyota and Subaru are both extremely proud of it. While the boxer architecture is clearly a Subaru development, Toyota also has a significant amount of technology on the engine. During the car's development, Tetsuya Tada – Toyota's chief engineer – stunned Subaru when he announced targets that included a naturally aspirated, high-revving sporty engine capable of developing 100hp per litre while also achieving good fuel economy. Tada sought advice from Takamitsu Okamoto, who led engine development for the Lexus LFA, and he advised a redline around 7600rpm and a bigger bore than the 84mm proposed by Subaru. After some 'animated discussions' within Toyota, it was decided to combine Toyota's D-4S direct injection know-how with Subaru's engine, and to reconfigure the engine from the bore and stroke proposed by Subaru. The prototype engine with the next-generation D-4S achieved the 100hp per litre output goal on its first bench test, revving smoothly beyond 7000rpm. The production engine's redline is 7500rpm with maximum output of 147kW. But when the first press cars were released to the media, many magazines were surprised that a sporty Subaru boxer engine was normally aspirated and they found it to be underpowered. However, Ehlert feels that they missed the point. 'Everyone wants to race the 86,' he says. 'The miracle of it is the driveability. I have only driven it on the road. Everyone in the media complains that the power output is a bit low, but I have never driven a car that handles like this – it's so controllable. It's built for cornering. If you compare sector times on the track with big powerful cars, you lose a bit

GPRM'S GT4-SPEC GT86

British GT grids could be expanded in 2013 with a new GT4 car in the shape of the Toyota GT86. GPRM, the Buckingham-based motorsport engineering company, is well advanced with the design and development of what it intends to be a cost-efficient, entry-level GT86-based endurance car. GPRM embarked on the GT4 project immediately after the Britcar24 in September 2012 where the new Toyota sportscar made a successful UK race debut. Design, build and running of that project was undertaken by GPRM under the revived Team Toyota GB banner. The car used a standard production engine and gearbox as Toyota wanted to prove the pace and reliability of its new car.

'We always had a GT4 spec in mind while building the car for the Britcar24. It has a full FIA/MSA approved rollcage, ATL competition fuel cell, air jacks and more,' explained GPRM's Gary Blackham. 'The car has excellent handling – drivers are able to hustle even the top class cars through the corners. The only disadvantage was power as we ran a production standard engine (197bhp) and gearbox because that is what Toyota GB specified. The car ran flawlessly, but we were at least 150bhp down on the class leaders. The turbo on the GT4 car will give the chassis the power to be fully competitive.'

As a result the GT4 car will offer a turbocharged,


The new GT4 incarnation of the GT86 from UK engineering firm GPRM

four-cylinder engine to give competitive power somewhere in the region of 350bhp. However the most attractive aspect of the car could be its affordable price with GPRM confident it can deliver a race-ready GT4 car for under £100,000 (not including tax or donor car).

Blackham sees the low purchase price and running costs of the GT86 as a major attraction. 'You could buy a GT4 GT86 and race it for a season for the same budget needed just to buy a more exotic brand. We think a low-cost, reliable car is just right for the series at this time.'

The 'Super 86' from Nobuhiro Tajima's Monster Sport company features a bespoke 3-litre twin turbo V6

on the straight but you more than make up for it on the corners. It's really quick.'

The standard engine also appears in most, but not all of the racing variants. The GT300 BRZ, for example, is fitted with the turbocharged Impreza WRC-based EJ20 boxer engine instead. In some racing classes 200bhp is simply not enough. In the Far East, however, tuners have taken work on the 86 to a whole new level, which sees very little of the base model left, if any at all. This is certainly the case with the version built by Pikes Peak legend Nobuhiro 'Monster' Tajima. With his Monster Sport company releasing a new range of parts for the 86, he decided to contest the 2013 Pikes Peak hill climb with a GT86, but the former record holder wanted to reclaim his crown so the car would have to be extreme. The result was what is dubbed the 'Super 86' – a tube frame car fitted with a bespoke 3-litre twin turbo V6 engine which produces 670ps/82.5kg-m. The four wheels are driven via a six-speed sequential transmission. The only real nod to the 86 is the carbon fibre bodywork which takes some vague styling cues from the production car, and is tailed off with the large multi-element wing typical of Pikes Peak cars. As it happened, it was eventually decided that Tajima would take his 2012 electric car back to Colorado this year, but a 1000bhp version of the Super 86 seems likely to run in 2014. In the meantime Tajima is using the car to contest the All Japan Dirt Trial championship, a series that is somewhere between Rallycross, stage rallying and Sprinting.

Perhaps, though, the real spiritual home for all small Japanese sportscars is the Super GT's GT300 class, and the Subaru BRZ has been running in it since 2012, built to the JAF GT300 regulations. But the GT86 has

TECH SPEC

2013 Monster Sport Super 86

Engine
Model: Monster original V6 twin-turbo
Format: water-cooled V-type 6-cylinder 4-valve DOHC twin-turbo dry sump
Displacement: (Bore × stroke) 2977cc (90×78mm)
Maximum output * Net: 670ps/7800rpm
Maximum torque * Net: 82.5kgf-m/5000rpm

Powertrain
Transmission: six-speed sequential
Differential: Front/rear hydraulic control
Centre: mechanical multi-plate

Suspension
Front/rear: double wishbone

Tyres/wheels
Tyre: N/A
Wheel: N/A

Frame
Steel space frame

Body
Material: carbon/Kevlar composite
Aerodynamics:
Rear: two wings + diffuser

Dimension
Length×width×height: 4650x1920x1480mm
Wheelbase: 2820mm

Weight: dry, no driver – 1080kg

The Dome GT300 is built up around a 'mother chassis' (bottom left) developed by the firm in association with Toray Composites. This is due to make its race debut in Thailand in December

yet to arrive in the championship, and it is fair to say that it is overdue. Bandoh Sport GT300 tube frame chassis are thought to be the basis of a V8-engined GT86 racing in the Thai Supercar Challenge, but Super GT fans will have to wait a little longer to see the 86 come home. In 2014 there are moves to allow GT300 cars to be built up around the so-called 'mother chassis' developed by Dome and built by its partners Toray Composites. The first of these cars will be the GT86.

The idea is similar to that found in Japanese F4, where all of the cars share the same cordless carbon fibre monocoque, but the technical development is largely unrestricted. In the case of GT300, any team that opts for the mother chassis route will have to prepare its own bodywork and mechanical components and build them up around the single spec tub. The tub has been designed to be front-engined rear wheel drive, just like the 86 and Super GT organisers GTA have decided to build the first car up with the body of the Toyota. It seems unlikely that it will feature the production car's 2-litre boxer, as GT300 cars need around 450bhp to be competitive, such as the EJ20 engine used in the BRZ or the Toyota RV8K found in the custom LMP1 cars, 2013 GT500 cars and the Prius GT300. It is likely that this variant, which is expected to hit the track, will be the fastest GT86 racing car in the world, but this is almost certain not to be the case for long. Tuners everywhere are developing GT86s for competition and it can't be long until the power levels and performance start to creep up.

One thing is for sure, the 86 is going to be a regular sight on tracks all around the world for many years to come.

MODS AND STOCKERS

The GT86 is being tuned at all levels, and not only by big factory operations. In the UK, the first GT86 to compete was in a Sprint event. It was prepared by Fensport Performance, a private tuning firm based in Cambridgeshire. While it is a private project, the base car was supplied by Toyota's UK subsidiary, but has been increasingly modified. One of the initial tasks was to take weight out of the production car by using components such as those available from Racecar Battery. The usual racing suspension and internal parts were also used. A Helix uprated four paddle clutch and lightweight flywheel saw clutch clamping force increased from 540 to 1000kg. The standard clutch was always a weak link when racing, according to Fensport, and aerodynamic changes were also undertaken.

For 2013 the car had a rollcage installed for the first time and its power was substantially increased with the addition of a turbocharger. By mid-2013 the power was in excess of 330bhp and climbing. Visit www.racecar-engineering.com for more on this and all of the other GT86s.

"If the car is going to run in locations such as Dubai with high temperatures, we definitely recommend the oil cooler upgrade"

R5 vs the regulations

With new cost and weight caps to contend with, M-Sport began their Fiesta R5 programme early. But there were a string of problems to negotiate while developing the first rally car to be homologated under new FIA rules…

BY MARTIN SHARP

M-Sport were involved in discussions throughout the period when the R5 regulations were being written. It began a feasibility study in January 2012 and decided to go forward with the Fiesta R5 programme at the end of March. The original plan was to homologate the car in April 2013, but building a project team was delayed by two other – ultimately still-born – projects, so the target homologation date became July 2013.

Regulation detail remained provisional until the end of 2012, but by June last year, M-Sport was well into the design phase, having secured suppliers for long-lead items such as the transmission.

Chris Williams leads M-Sport's R5 engineering team. He explains that supplier allocation for many smaller items came much later, as the tight R5 regulations made identifying the preferred layout more complicated than configuring, say, a World Rally Car.

'The problem we have is that the regulations are very strict on how many parts you can have,' he says. 'You need to decide on a lot of symmetry. For instance, you are allowed two struts, but that must include left/right, front/rear and gravel and tarmac, so you need to decide what your strut case would be and then you can use it in the places where you need to use it. And then the uprights all have to be the same. There's a theory or philosophy we've been working on for a while now – we know a good suspension travel helps us on gravel. With the 2006 Focus WRC we were probably first to put the damper down in front of the driveshaft, and we followed that with the R5. But to do that and have the upright that fits every corner of the car is quite difficult to do.'

The team investigated five different layouts, each involving fairly big compromises. These were whittled down to two options and, given the rule restraints, the engineers are reasonably happy with the final chosen layout. 'There will never be an absolutely perfect one because you have to compromise so much,' says Williams, 'but once you've got that kind of scheme sorted, you need to decide on your wishbones, because you're only allowed two. Once you have your scheme sorted, which we achieved in reasonable time, the problem is then trying to

"The problems come when you go to suppliers and say what you want and how much you can pay – and they laugh"

M-Sport say the Fiesta R5 is the most important car they've ever built

manufacture the parts for the right cost. You might be able to get it all to work, and you might have a scheme that's good, but can you make it within budget?

'The problem is, when you've got some of the modelling done, and go to a supplier and say "This is what I want. I can't pay more than this", they laugh at you.'

Such a drawn-out development period is never the case with a World Rally Car, where each part is designed with no real compromises, certainly not on price. With the R5 project, design planning involved getting to the best it is possible to get, then further design loops to bring components to regulation price.

The homologated R5 front wishbone is the seventh evolution. The first iteration worked superbly, but the cheapest supplier quoted three times the regulation cost. The team discovered that the process of manufacture relates more to final cost than the cost of the materials involved, but manufacturing in a cheaper way demands more expensive material.

Trial wishbones were fabricated at a reasonable price, but to make them perfect required final machining. Each wishbone would need to go on a jig for that process, which added too much cost. However, doing all the machining first and assembling and fabricating afterwards carries distortion dangers when the parts are welded together – concentric bearing-carrying holes becoming oval, for example. M-Sport's discovered solution was to use dummy bearings – specific plugs in place during welding to retain the shape – then gently warming the part afterwards to remove residual stress.

The team discovered that they could have just about as much suspension travel as they wanted at the rear, but not at the front – for an intriguing reason. On a World Rally Car the wheelhouse area is free. It's also free on the R5, but crucially the standard headlamp unit must remain, unmodified, in its original position. This is the limiting factor to the Fiesta R5 front suspension geometry – on the final evolution, at full bump there is just 0.5mm between the headlamp and the tyre. Skoda Motorsport, still in the early development decision phase of its projected R5 programme, has a similar problem.

The M-Sport team adapted its design to the problem: 'We don't have the same geometry as we do on a WRC car,' explains Williams. 'Because of our limitations we've changed the geometry. We're not unhappy with what we've done, it's just different to what we would normally be doing, and we've changed it around so that we've got very good suspension travel, but at the cost of some of the other geometry.'

The rules allow R5 cars to use parts from other models, irrespective of manufacturer. A combined alternator/starter unit is allowed and the M-Sport team searched for a suitable assembly, concluding that suitable candidates would require an excessive redesign, so they went for separate assemblies. Unusually for this level of rally car, the steering is electrically assisted – a motivation in the search for a suitable alternator. It is a modified version of that fitted to the Ford Cougar, the latest Focus and the C-Max.

After assessing offerings from a number of transmission suppliers, the team settled on Sadev, who have supplied M-Sport since the Group N Fiesta ST in 2005. A selection was made from two optional layouts, and after discussions with the FIA this was approved. One hundred transmission sets were ordered and 30 per cent of the cost was paid up-front, so unit cost is good.

The Fiesta R5's transmission is equipped with a gear cut and the rules allow different RPM limits in each gear, providing 7500rpm is not exceeded. This enables the team to adapt gear shift and cut strategy depending on the gear engaged.

More than six weeks of development time were lost however when the FIA rejected the Fiesta RS WRC-style rollcage for R5. 'After our original concept of not changing the cage – with which we have a lot of experience and spent a huge amount of money designing and testing – we ended up doing a whole new cage,' says Williams. 'Luckily, in testing it, the guys at Ford in Germany were very helpful. We can do some of the work – we can put it on and torsion test, stiffness test, plus all the gauging for the WRC and Super 2000. We did six different variations.' The modelling was done in Germany and the models sent Stateside for overnight analysis on a supercomputer, a process taking some four weeks of back and forth until the team found what they wanted – almost the same weight as the WRC cage and the same stiffness.

It seems that when the Fiesta Super 2000 rollcage was homologated, it was very much like the Focus RS WRC cage – which was a free design. The regulations had changed and the FIA was lenient in its interpretation. 'But they just said "We no longer interpret it that way,"' says Williams. 'There is no free design. It's cost me a lot of time, unfortunately. There are new people there now, and it's how they want it to be – you can no longer use what you've done in the past and things that have been approved as being a precedent.'

TESTING TIMES

Initial testing of a new rally car usually involves calibration, fixing teething troubles, and not doing much mileage. 'By lunchtime of the first day we'd run out of things to do on that side and started performance testing,' says Williams. 'So we caught ourselves slightly unawares – we weren't ready to start the performance testing, actually going out there and trying to run at full power and trying to get base setups. We weren't really expecting it.

'After four days we were pretty much at full speed. A couple of parts weren't lasting as long as we had anticipated, and we could see roughly why, but every 150/200km we changed them and kept going.' This was the first gravel test in M-Sport's Greystoke forest facility, and things went similarly well at the first tarmac test.

A recent change to the rules is a 30kg hike of minimum weight for the car with one spare to 1230kg. Williams doesn't envisage it as a concern. Having persuaded AP to forge R5 brake calipers on the basis of bulk-buying, the brakes are virtually identical to those on the WRC. And the car has already been tested heavy with no problems.

After the FIA rejected M-Sport's original WRC-style rollcage, a new design was created; the R5 features MacPherson struts with Reiger dampers

He knows why the FIA has raised the minimum. 'If you're to build a car to the regulations, there are certain items that are free. A good example will be a seat – anybody can fit whatever seat they want, and so long as it is homologated 8862 you can go and get whatever seat you want. Now, out there in the marketplace from the very cheapest versions to the most expensive versions, the weight difference is considerable. The FIA base car that we sell comes with a cheap seat.

'So effectively, what they're saying is that someone in a base car should have as much opportunity to win as the guys who can spend all the money. But if you can tune the weight of things, which the regulations allow, the person with the most money will always be able to have a better car, and there's nothing we can do about it. So it either makes us buy whatever's the latest out there on the market – and you can't do that, it's ridiculous – or someone will always be upgrading their cars.

'And it doesn't just go for seats – it goes for harnesses, and even batteries. There isn't really a cheap battery that suits the R5 regulation, but there is a manufacturer who will sell you – at €900 – a lithium-ion battery with extra ballast built into it which meet the regulation, and you'll probably pick up 800 grams. When you roll this out across everything it adds up.' An expensive top-range seat weighs 9kg, while a seat at half the cost weighs nearly 20kg. So, around a 20kg saving on two seats alone.

However, such loopholes are few. There's discussions with the FIA over the Fiesta R5 options list – a lightweight fire extinguisher, and the most expensive Sparco seat. The regulations are published and the simple expedient of an extra 30kg overall would seem a sensible compromise answer to a problem that's always been around and has already addressed by the detailed nature of the R5 regulations.

"If you can tune the weight of things, those with the most money will always have a better car"

Containing costs not only involves buying in bulk – there's a need for a different mentality on the structure and design of certain parts which the FIA has cost-capped at unachievable levels when taking the conventional rally car build route. Williams praises the FIA's efforts in this regard. When he started the project, M-Sport technical director Christian Loriaux told him: 'You will not build that car for that – you're never going to do it. I know how much the Super 2000 cost to do, I don't think you can do it.'

'Well now we've looked at this and we've looked at that,' says Williams. 'And I think we can.'

POWER SUPPLY

Previous FIA rulings on engine position allowed 25mm radius freedom of the crankshaft axis. R5 rules state that the engine cannot be sited lower than the standard position, but can be 25mm up and/or forward or 15mm back. This was decided in early technical meetings to simplify situations where engines would be taken from another car to power the R5 car. The maximum rearward inclination of the unit remains at 25 degrees from vertical. That many modern production 1.6-litre engines are just over 1600cc was also taken into account, hence the 1620cc R5 maximum.

Nigel Arnfield, M-Sport's senior engine engineer, was distracted by feasibility studies for still-born projects before he could start fully developing the R5 engine. And then there was a false start. First work was on Ford's 1600cc Ecoboost engine fitted to the production Fiesta ST as per the initial rules, but manufacturers without 1.6-litre units were interested in the category, so the regs were changed to allow everybody to use a 2-litre as the base engine. Therefore M-Sport can use the 2-litre Ecoboost from the Mondeo and S-Max – the same as used in the Fiesta RS WRC.


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'That was good news for us because it put us back into using the base engine we've been building for some time,' says Arnfield. 'That made life a little bit easier and we gain some strength from it being a bigger block.'

Revised bore and stroke (85x71.3mm) drop the unit to 1600cc. The bore is quite large because of the combustion chamber diameters in the cleaned-up standard cylinder head. The R5 cost cap on valves is tight and virtually precludes replacements, but the standard valves have proven adequate – particularly the sodium-filled exhaust valves, and test work has shown the standard seat material to be OK. Arnfield admits he would have been 'in a bit of bother' if he hadn't been able to make the standard valves work.

The ultimate aim is 2000km between rebuilds, the same as a WRC engine. Evidently the standard head and valve gear will have a hard time and will need monitoring as the engine gets more into a life of competition.

However, M-Sport has already managed that distance in testing.

The turbocharger must be from a production road car, under the price cap with no variable geometry or exotic materials. Logically this means a unit from a high-performance 2-litre road car. Arnfield considers this choice key, but is frustrated that the chosen unit has to go to a vote with all the teams. As his is the first to be made 'public', later-arriving rivals know his choice so they can go his way or opt for a route of their own.

Two different turbo units were tested initially and the final choice required some installation changes, but the regulation prohibiting any part of the unit from being below crank centreline aids the installation task. If that rule didn't exist, teams would naturally site the unit as low as possible to aid the c of g, creating a packaging nightmare and big heat management issues.

Teams are not allowed to use fresh air valves in R5, so they cannot bypass the engine with the anti-lag system. 'So the ALS is really simple,' says Arnfield. 'It does mean complaints of a lack of torque down at the bottom of the RPM range where the turbo won't work. But it's cheap.'

Although the rules allow modified standard crankshaft castings, this is an unlikely option. Arnfield opted immediately for a machined steel billet crank. Using more economical steel, it's a third of the cost of the Fiesta RS WRC crankshaft, but obviously won't have the life of a WRC crank.

Steel connecting rods are topped with Cosworth pistons and the M-Sport-designed camshafts initially exhibited some lobe wear in testing, which Arnfield and his engine team are confident has been overcome. As per the rules, only the pressure relief valve in the oil pump is modified.

The team was fortunate to find that completely standard 2-litre Ecoboost direct injection hardware – injectors, fuel rail and high-pressure pump – is entirely up to the job of serving this 1600cc turbo motor. 'It's so pleasing because that has taken a huge amount of work out of the system for me,' says Arnfield. 'I ran the standard parts immediately on the first dyno engine – it was all fine,

WEIGHING UP THE OPTIONS

As any BMW owner knows, buy a new base-spec road car and you'll have a problem when it comes to selling it. You might have eschewed pricy extras in the showroom, but that lack of 'loading' hits the residual value of your motor when it comes to flogging it.

And that's what M-Sport has found its rally car customers also believe. Over years of selling Fiesta ST, R2, R2000 and Super 2000 Fiesta rally cars, the team has learned to not second-guess what its customers want. For example, the Fiesta ST was a Group N car. While it was possible to cut the standard inner door liner around the roll cage bar, M-Sport offered a carbon-fibre door liner as an option.

Andrew Wheatley, M-Sport business development manager recalls: 'We looked at it and said; "Pah! It's almost the same weight as the standard liner; it's £300. We'll never sell any." But we sold virtually all the cars with the carbon-fibre inner doors.'

There were 42 Fiesta Super 2000s sold. Two roof vents were offered: the original Focus WRC vent which carried over to Fiesta RS WRC, and an R2 vent. The WRC vent is heavier and cost £2500, while the R2 was £120. 'Only four out of the 42 took the cheaper route,' says Wheatley.

'You don't need a roof vent to start a stage, so you've got to look through all those options and ask – what do you need to do the rally? You don't need a £2500 roof vent.

'We say to customers: "You can have the base car, or you can have the car with any of those options." But, from our experience, we also say; "These are the bits you're going to want."

'Every single customer wants the same spec, the important thing is that it has nothing to do with the purchase cost – it's all to do with the residual value, because the biggest single cost of running a rally car is what it's worth when it's 12 months old." Here, Wheatley points at some Group N rally cars which lost half their value in a year.

These attitudes to options are nothing new. Go back in time to the Super 1600 Junior World Rally Championship: the base Suzuki Ignis S1600 was sold with a lengthy options list, including the correct camshafts at £12,000 a pop per set. A one year-old S1600 Suzuki would have cost €180,000.

Today the works Fiesta RS WRCs are not painted because they are wrapped, so all WRCs have a very thin layer of primer and lacquer mix – the lightest possible finish. All WRC customers want them painted white, adding 8kg to the base weight. Because a painted used rally car is worth more.

M-Sport's experience with customer choice indicates that an option list must be available to rally car customers, yet the option possibilities are significantly reduced under the R5 regulations, and any improvements found will be steps and not evolutions. This means confidence in stocking a specification of parts and confidence in sales over a longer period.

'A customer might say: "I can have a seat that's a bit lighter than the ones you supply, so take them out," says M-Sport engine specialist Nigel Arnfield.

'If you've got somebody who wants to win, they'll spend whatever it takes to make gains.'

FIESTA R5 OPTIONS PACK

Sparco ADV-SC seats
Hydraulic jack
Endless brake pads
Front brake pressure sensor
Roof vent
Lightweight mirrors
Mudflaps kit
Sliding side windows
Map light and loom
Monit TC100 trip computer and loom
Safety kit
Helmet hammock
Intercom and fitting kit
Quick release windows fitting kit
Wheel brace
R5 software kit
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"Our indication is that the R5 is faster than the RRC everywhere"

I've not had a moments concern over it.' And the components sit neatly within the cost cap.

Life Racing electronics are used for the engine ECU and M-Sport has adapted the programming to rally usage. The result is 280bhp between 5000rpm and 5300rpm with the 32mm diameter inlet restrictor, and Arnfield points out that the 2.5 bar manifold pressure limit restricts maximum torque to 390Nm.

However, R5 engine outputs differ in a subtle way compared to those of WRC units, which also have a 2.5 bar limit – but that's absolute pressure. The R5 uses an FIA-supplied simple pop-off valve to regulate that pressure, so manifold pressure in the R5 is relative to atmospheric pressure. This means a WRC model can blast up a mountainside maintaining its 2.5 bar and losing no torque, while the R5's manifold pressure has to drop as it climbs and produces progressively reducing torque.

If the pop-off valve deploys, pressure drops immediately to 1.8 bar, and restoring 2.5 bar requires shutting and opening the throttle – a severe penalty. Hence M-Sport runs a complicated boost control strategy involving momentary fuel cuts.

In an attempt to bring the performance of 1600cc Regional Rally Cars to that of normally aspirated 2-litre Super 2000 cars, the FIA dropped the World Rally Car's 33mm diameter inlet restrictor to 30mm to create the RRC. At sea level, an RRC and R5 have the same maximum torque, but on its 30mm restrictor the RRC chokes early. At approximately 4750rpm the R5 can maintain 2.5 bar a further 500rpm longer – and when it chokes it is choking at a 32mm restriction instead of 30mm – a significant difference of some 80-100gm/h of air.

'Our indication is that the R5 is faster than the RRC pretty much everywhere,' says Williams. 'The only thing I would say is that the Regional car is a World Rally Car – World Rally technology, cooling, suspension, brakes, damping. Understandably, the R5 isn't that – so can you maintain the performance on a really rough, gravel rally the same as the other car? I think it's a little unfair to think that it can. I would say on the medium length stages you'll be OK, but I don't think you'll be able to keep with a Regional car over 40km of a Greek rocky road. Certain bits will act against you. The RRC is optimised totally – the cooling, the turbo, the suspension. With the R5 we've had to make some compromises.'

The FIA rules that the price of a base R5 car must remain static until 2015. M-Sport's base Fiesta R5 costs £156,000 (€180,000). A new Fiesta Regional Rally Car, with free WRC upgrade kit, is £390,000 (€451,000). At the time of writing, more than 18 orders for Fiesta R5s had been taken, with 100 cars planned. M-Sport boss Malcolm Wilson knows a great deal rests on the Fiesta R5, and that for his company 'this is the most important car M-Sport has ever built.'

R5 REGULATIONS (ABRIDGED)

- Four-seat touring cars or large-scale production cars, supercharged petrol engine, four-wheel drive. Must be from 'family' of 25,000 produced in 12 consecutive months and homologated in FIA Touring Cars [Group A]. Min weight: 1230kg
- Magnesium alloy [except for road wheels], ceramics and titanium alloy prohibited unless fitted to the production model
- Only one layer of carbon or Kevlar allowed. But bodywork side protections may be of several layers of Kevlar or fibreglass.
- Engine capacity class 1390-1620cc with no cylinder capacity calculation coefficient and no more than four cylinders. RPM limit: 7500rpm. Min weight: 20kg
- Stainless steel or cast iron exhaust manifold with four uniform tubes. No part of the turbo can be below crank axis. Exhaust manifold max price: €1400. Exhaust system free downstream of the turbocharger
- External machining of the block is allowed to enable the fitment of the gearbox and items such as engine mounts and alternator mounts. Must be homologated
- Engine's crankshaft axis position must not drop lower than standard, can be up to 25mm up, and/or up to 25mm forwards, and/or 15mm rearwards
- New injection system can be homologated; production injectors and pumps must be from a Group A-homologated vehicle; new rail allowed, must have threaded fuel line connectors. For direct injection only, max low pressure fuel circuit eight bar: high pressure; 200 bar average over a cycle
- ECU, drivers, power box, dashboard and data logger must be homologated. ECU must contain a 7500rpm rev limiter which cannot be modified by the competitor. 29 sensors and 21 actuators allowed. Max price of all electronic kit: €14,000
- Turbo must be homologated in VR5, have a 32mm restrictor and limited to 2.5 bar boost pressure. The complete turbo must not cost more than €1000
- Intercooler can be original or homologated in VR5. Total volume between restrictor and butterfly must not exceed 20 litres. Water/air intercoolers not allowed unless the production vehicle has one: no mods are allowed
- Radiator must be in same location as standard production, water spray not allowed – max price of radiator: €280, water pump: €350
- Fuel cell max price: €1650; tank with protection, pump, quick refuelling, fixation: €4000
- Wiring loom free. New alternator allowed – min weight: 4kg; combined alternator/starter: 8kg
- Sequential, mechanical control, five forward ratios + reverse in aluminium alloy housing min thickness: 5.5mm; two sets of gearbox ratios allowed. Max price of complete gearbox + front and rear diffs + front/rear unlocking system + cooling: €28,500
- Max price of clutch + discs: €1000
- MacPherson struts only, all four hubs and their carriers must be identical, min weight: 10kg, steel
- If brake calipers come from a large-scale production catalogue or a competition parts catalogue it is possible to homologate only one – four pistons maximum. Max price of four complete calipers: €3200. Same as above for front brake disc + bell, max diameter: 355mm/thickness: 32mm [asphalt], 300mm/28mm [gravel].
- Max price of complete steering rack: €3000, power steering system: €1000, two steering arms right/left [ferrous only]: €800, steering column: €600
- R5 caged 'shell with bare engine block must weigh more than 385kg. Max price: €18,500
- Overall width: 1820mm
- Rear aero device – fibreglass, must fit in a 'box', max price: €800
- One Joker for every item modified. Three Jokers allowed in the first 24 months after homologation. After 24 months up to five Jokers can be homologated in one extension only. After that, two extra Jokers can be homologated
- Max price of a new R5 car ready for an asphalt rally before tax and registration: €180,000

PROPOSED TECH SPEC

Ford Fiesta R5

Engine
M-Sport developed 1.6 turbo
Direct injection powerplant
FIA regulated 32mm restrictor
Life Racing engine control unit and power management systems

Transmission
Sadev five-speed sequential gearbox mated to Sadev front and rear differential units

Suspension
Front and rear MacPherson struts with Reiger external reservoir dampers, three-way adjustable
Front and rear antiroll bar options

Bodyshell
M-Sport designed bespoke rollcage
R5 aero package

Uprights
Machined aluminium uprights of a universal design – strengthened suspension links

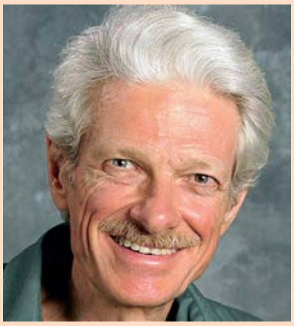
Fuel system
ATL 80-litre competition standard fuel tank, centrally mounted

Brakes
AP Racing forged four piston front and rear calipers
Gravel: 300x28mm ventilated discs
Asphalt: 355x32mm ventilated discs
Hydraulic handbrake

Wheels
Gravel: 7x15"
Asphalt - 8x18"

The Corvette C5 braking conundrum

Why is our questioner's Z06 so quick to slip into 'ice' mode?



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QUESTION

I've found conflicting information re weight transfer in pitch with regards to braking. I have a Corvette C5 Z06 and when I add too much rear rebound, without any other changes, the car seems to go into 'ice' mode, and the braking forces are near nill until the car gets a chance to reach steady state and braking forces return.

I thought it was due to the rear shocks not allowing the front tyres to load properly due to 'slow' weight transfer outlined in the JRZ quote below, but I've also read the opposite which may be correct:

'Rebound damping can also affect weight transfer, cornering, and feel of the motorcycle. The lighter the amount of rebound damping front or rear will greatly affect your weight transfer of the motorcycle. If you lessen the rebound damping in the front forks of the motorcycle, it will transfer weight quicker to the rear of the motorcycle as the brakes are released or under acceleration. The same goes for the rear shock – if you lessen the rebound damping in the rear, it will quicken the weight transfer to the front of the motorcycle especially as you apply the front brakes, and on turn in.'

I understand that drag racers use soft front rebound to increase grip which would be similar to my situation, but on the opposite end of the car. I'm just not sure of the correct definition/mechanism.

Many people confuse weight transfer – or dynamic wheel load transfer – with sprung mass or suspension displacement

THE CONSULTANT SAYS

Many people make the mistake of confusing weight transfer (dynamic wheel load transfer) with sprung mass or suspension displacement, or make the mistake of supposing that weight transfer can be inferred from sprung mass or suspension displacement. Actually, weight transfer due to x and y axis (longitudinal and lateral) accelerations is not mainly the result of sprung structure movement with respect to the wheels. It occurs even in vehicles with no suspension. We cannot even say that a suspension change that results in more displacement change at a given corner, end, or side of the vehicle implies more load change there.

However, we also cannot quite say that the amount or speed of suspension movement has no effect at all on weight transfer. The biggest effects come from differences in resistance to roll displacement at the two ends of the car (for cornering) and differences in resistance to pitch displacement at the two sides of the car (for braking and forward acceleration). Such differences will affect dynamic diagonal percentage. There are also smaller effects even when front/rear or left/right differences are absent. Because these effects are small, I don't see any way they could result in wheel lockup on initial brake application. If an ABS system is reacting to slow rear suspension extension by going into an 'ice' mode, it is responding to something other than actual wheel lockup or any actual delay in wheel load transfer.

Let's consider what happens upon abrupt application of the brakes, assuming the car is running straight and assuming the suspension is entirely symmetrical. For racing or autocross, this situation typically occurs at the end of a straight. It upsets the car least if we apply the brakes with a gentle 'squeeze' rather than a 'slam'. However, we don't want to waste any time. We want to bring the car up to full retardation as quickly as the car will tolerate. The more we reduce jerk (change of acceleration), the sooner we have to get off the throttle and start brake application. The more abruptly we can apply the brakes, the longer we can delay braking.

When the brakes are applied swiftly and the car is brought as quickly as possible to straight-line braking at the limit of adhesion, assuming that the car has less than 100 per cent anti-dive and anti-lift, the sprung structure pitches forward, with the rear suspension extending and the front suspension compressing. With some delay, it assumes a steady state with a forward pitch displacement, and holds that until the driver starts releasing the brakes. During the delay period, the sprung structure accelerates forward in pitch, possibly briefly attains a fixed forward pitch velocity, then accelerates rearward (decelerates forward) in pitch, to a pitch velocity of zero. At this point, the car is in a steady state of straight-line limit braking.

At any point here, longitudinal load transfer depends almost entirely on only three things: the amount of rearward acceleration, the height of the cg (centre of gravity or centre of mass), and the length of the wheelbase. Suspension displacements matter to the extent that they influence cg height. Anything that reduces rear suspension extension or increases front suspension compression lowers the cg and reduces load transfer.

In steady-state braking, with pitch velocity at zero, this will depend entirely on the anti-dive, anti-lift and springs.

But the dampers also have an effect when there is some forward pitch velocity.

We can slow the pitch motion by increasing front compression (bump) damping, or by increasing rear extension (rebound) damping. However, while these have similar effects on pitch velocity, they have opposite effects on the magnitude of load transfer while the effects are present. This is because they have opposite effects on cg height. Slowing front compression temporarily increases cg height, and therefore temporarily increases load transfer. Slowing rear extension temporarily reduces cg height, and therefore temporarily reduces load transfer.

Although these effects are real, for a low vehicle with a fairly long wheelbase and fairly stiff suspension the effects are of very small magnitude. For a realistic range of settings, we are probably talking about at the most a quarter of an inch difference in cg height around peak pitch velocity.

In the case of drag racing sedans setup for maximum front end lift, we are looking at much greater suspension movement. To obtain this, the front springs are made extremely soft. The front dampers are valved to extend very freely and compress very reluctantly. There is then perhaps an inch or a bit more increase in cg height at launch, compared to a general-purpose setup.

The first few milliseconds of the launch are the most important part of the run. The car is accelerating the full length of the strip, and any gain in acceleration right at the start translates to greater speed over the entire run. Therefore, we want the front end up as quickly as possible.

We should note that with advances in drag tyres and pavement, we don't necessarily set up drag sedans for maximum front end lift anymore. With really good tyres, even a nose-heavy sedan may be limited by wheelstand rather than wheelspin. In that case, we don't want to maximise front end rise. The ideal is to launch the car with all the weight on the drive wheels, and none at all on the front wheels or the wheelie bar casters, with the rear tyres at optimal percent slip. But if such a car is on any sort of street tyres, we probably will want maximum front end lift.

In addition to the effect from cg height, there are small secondary effects from pitch inertia. When the sprung mass is not moving in pitch, it doesn't want to start moving in pitch. Once it is moving in pitch, it doesn't want to stop moving in pitch. At the start of brake application, pitch inertia reduces forward load transfer. As steady-state braking is reached, pitch inertia increases forward load transfer. Any increase in damping, front or rear, reduces pitch velocity, pitch acceleration and pitch jerk. That correspondingly reduces effects from pitch inertia. But again, when pitch displacement is small, any effects due to pitch inertia are small, even with fairly light damping.

So, to answer the basic question: does adding low-speed rebound damping at the rear temporarily increase forward load transfer, or temporarily reduce it? It temporarily reduces it. However, the effect is so small that it would not cause wheel lockup and trigger the ABS.

There are cars that have so much anti-lift that the rear suspension doesn't extend at all in braking, regardless of damping. In some rear-engine cars with trailing arms, the rear suspension even compresses slightly in braking. Such cars do not exhibit any abnormal braking behaviour, with or without ABS.

Well, then, why does this Corvette do what the questioner describes? My first inclination was to suspect that maybe the brake pads have poor initial 'bite', or perhaps there's a pinched line somewhere. But the questioner says the effect goes away when the rear rebound is softened, and comes back again when the rebound is stiffened again. I invite any Corvette experts to weigh in, but through further correspondence with the questioner I have found a wiring diagram for the car's ABS system.

The Corvette C5 in question was fitted with Penske shocks

The car is a 2002 model. The shocks are not JRZ's – the questioner was just citing that company's literature. The shocks on the car are actually Penske single-adjustables. These are currently set up to have the adjustability on the rebound. They can also have the adjustability on the compression instead. The adjustment is a bleed with a check valve. The check valve can be reversed. I would think it might also be omitted entirely, making the bleed work in both directions.

The car has ABS, traction control and stability control. It does not have the computer-controlled 'real-time damping' (RTD) found in later versions. There are four wheel speed sensors, a steering position sensor, a brake fluid pressure sensor, a lateral acceleration sensor, and a yaw rate sensor. There are no suspension displacement sensors, and no pitch accelerometer is shown. However, there is something called the body control module (BCM) that apparently handles the stability control. The schematic doesn't show what's in the BCM, but it communicates with the ABS controller through a serial bus, and the stability control works through brake and throttle intervention.

There are cars that have so much anti-lift that the rear suspension doesn't extend at all in braking

The traction control and stability control can be turned off, but not the ABS, although maybe it can be deactivated by removing its fuse. I think what must be happening is that when the rear rebound is stiffened, something in the BCM is not sensing the expected pitch that would normally go with the brake fluid pressure rise, and concludes that the car must be on a low-mu surface. This prompts the ABS to exercise 'prior restraint' and not apply enough brake to cause lockup on ice.

The reason for having such an 'ice' mode rather than letting the system respond to wheel lockup is that when wheel lockup occurs on ice, a layer of water forms at the contact patch, and once this happens, there is so little friction that the wheel may be reluctant to start turning again even if the brake force is modulated. If the car has begun to slide laterally when the wheel is locked, that alone may keep the contact patch melted. Therefore, it can be desirable to not let the melting at the contact patch occur. This requires pre-emptive intervention.

The questioner has been using the stiff rear rebound setting to improve transient behaviour for autocross. He has asked if using stiffer bump damping at the rear instead might work. My diagnosis of the cause is somewhat tentative at this point, but if I'm right about that, then more compression damping at the rear probably would be a good approach. Note that this would involve different shim stacks in the shock, not just flipping or removing the check valve.


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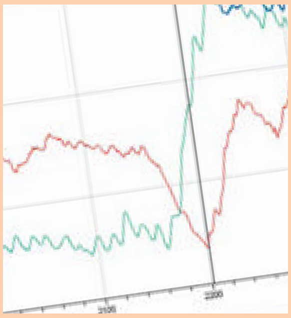


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

Getting your race off to a great start

In all forms of racing, launching away from the line well can make a huge difference – and there's more to it than driver feel

Getting cleanly off the line in a standing start race can mean the difference between a podium finish and ending up at the back. Those first few metres of a race can be critical to gain track position and defending a good qualifying result.

There is no magic to getting a car to start well – all that's needed is maximising traction while steering clear of whoever is in front, or defending from those behind. Simple, really. In most racing disciplines the start relies heavily on the driver to launch the car perfectly by modulating the clutch and throttle to optimise wheel spin and traction and making sure the engine does not bog down. Most racing drivers will have a good feel for how launch a car well, but using data, simple visual aids and control strategies can help give the driver that little bit extra to edge ahead.

Starting with just what is required for start line analysis, it's best to look at what controls the driver is using. In this case the obvious ones are clutch, throttle and wheel speeds. In most racecars the throttle and wheel speeds are monitored

Equation 1: calculating wheel slip and squat

Wheel slip can be calculated in the following way:
([Speed RL_Omega] / [Speed]) * 100 - 100 //proportion of rear left wheel slip compared with system speed
Similarly the squat:
[Disp_Damper RL_Omega] - [Disp_Damper RR_Omega] / 2 //average of rear damper position sensors

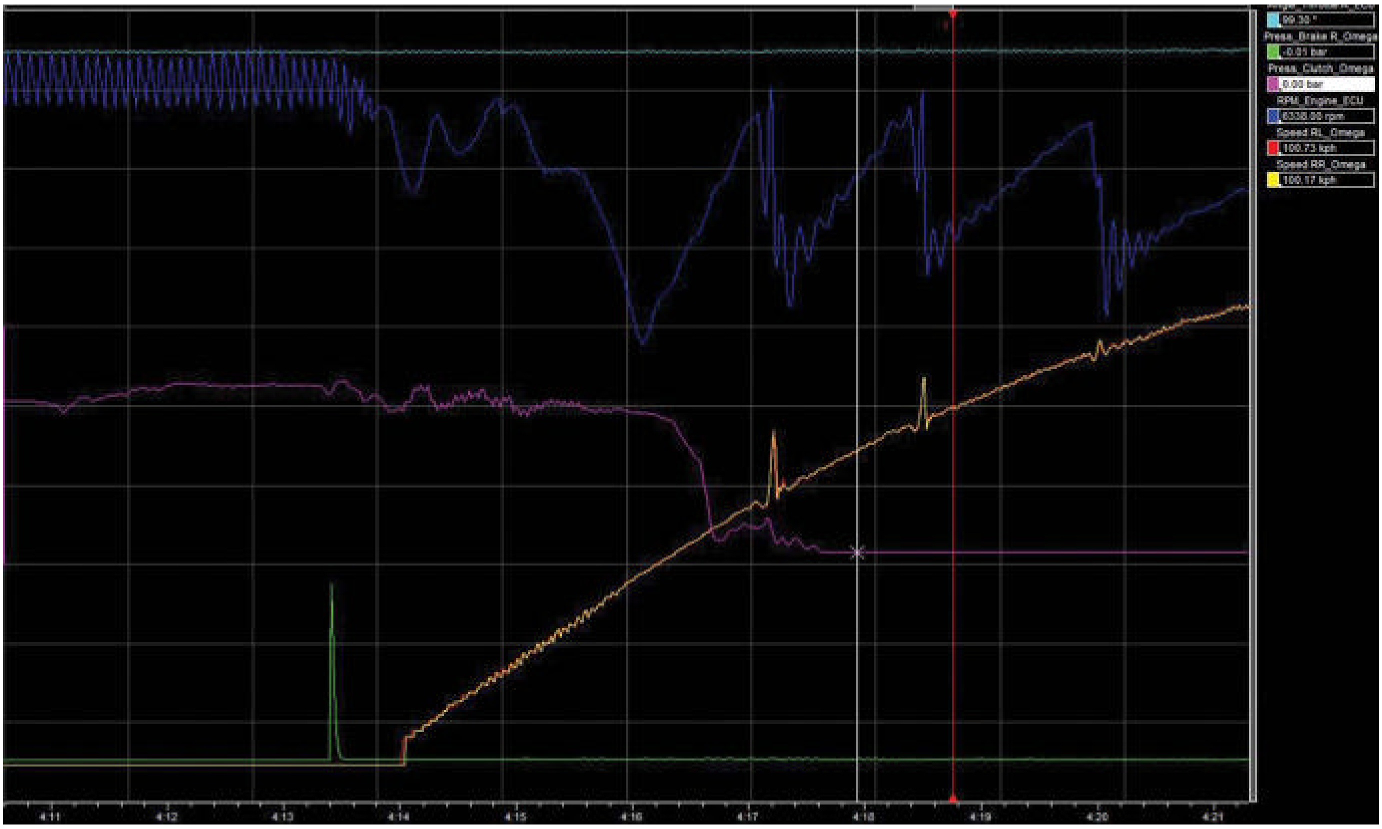
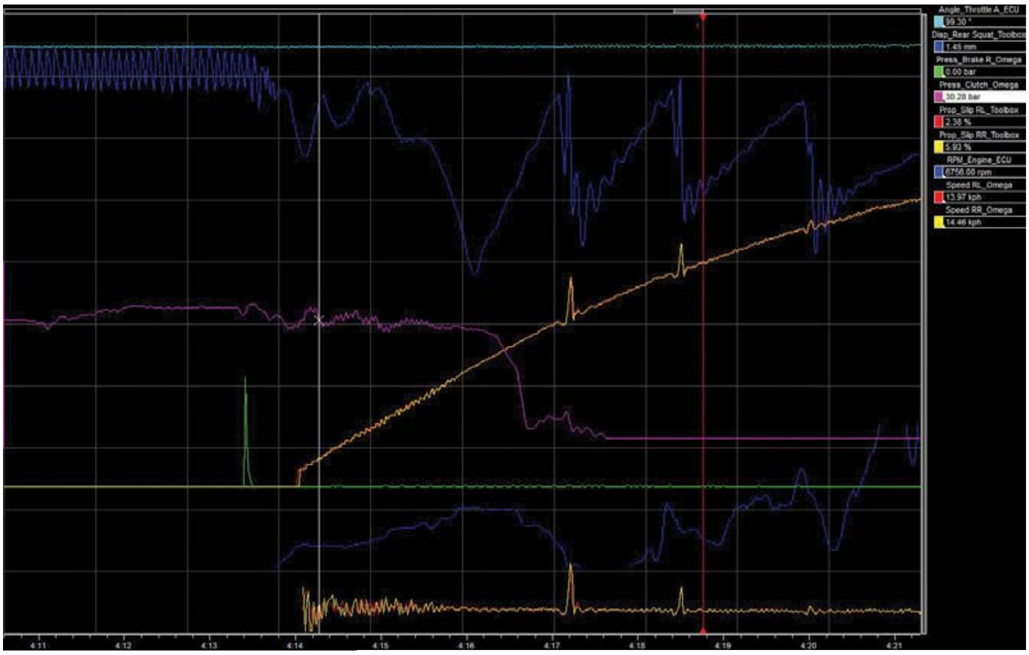


Figure 1: typical start line data, showing the procedure described above. Note the use of clutch only to control the traction



but the clutch may be a bit less common. There are two ways of monitoring the clutch – first of all the pressure in the hydraulic line and second the position. Additional sensors can provide vital information as well, brake pressures can tell when a line lock has been released and damper pots can give information about squat.

Running through a typical standing start in a racecar, the driver will line the car up on the start line and then press the brakes and initiate a line lock, if such equipment is fitted. Then the clutch is brought up to the bite point, and as the lights turn on, the throttle is pressed to bring the engine to the desired RPM level. As the lights go out, the line lock is released and the clutch modulated to control the tyre slip. In some cases both the throttle and clutch are used, depending on the car and the preference of the driver.

CLEVER CHANNELS

In order to obtain more information during the start phase, it is possible to use some clever maths channels.

Looking at the squat, or how much the rear of the car is pushed down before launching, and the amount of slip seen by each individual driven wheel can give further clues as to why a start was successful or not. In the first image (**Figure 1**) there are some slight wiggles in the wheel speed traces, but using a slip channel shows more clearly what is going on. See **Equation 1** on p37 for how to calculate wheel slip.

Looking at the graph on the left, our start line analysis now has more revealing information and it is possible to start to quantify the desired wheel slip and squat in order to optimise the launch.

Given the information we have been able to gather about the start line procedure, it is now time to put it into practice. Using the display system on a racecar, this data can be fed to the driver using a separate start page or an overlay.

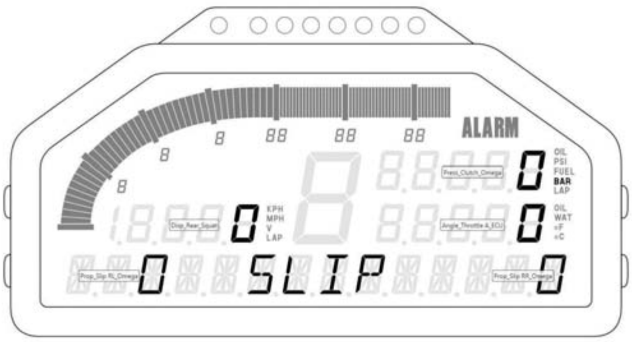


Figure 2: In this case an overlay is triggered by selecting the start line ECU map

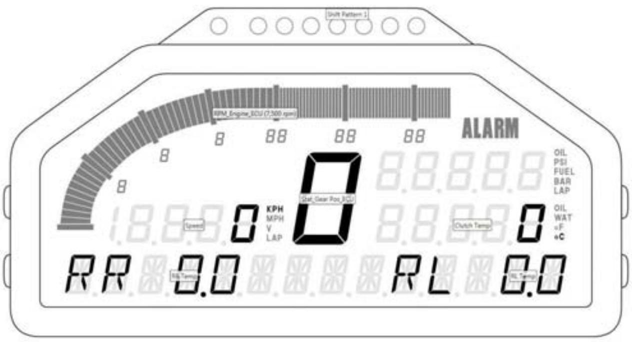


Figure 3: the clutch temperature can also be monitored and optimised for start line conditions

STARTER'S ORDERS

There is more that can be done to assist making the most out of the racecar during a start procedure. As the start is all about getting as much power to the ground as possible while still maintaining traction, the temperatures of the tyres are critical. During a formation lap, we see drivers accelerating hard and braking hard as well as weaving left to right in order to get as much heat into the tyres as possible. Electronics can again be used to make sure this is as consistent as possible by measuring the tyre temperatures and relaying this to the driver via the on-board display. Similarly, the clutch temperature can be monitored and optimised for start line conditions. The formation lap screen could therefore look something like **Figure 3**.

All of the above has been aimed at assisting a driver in a car that has no electronics that can directly interfere with the race start process. If the regulations permit, this opens up a whole different host of challenges where the car control systems are fed information and it automatically adjusts some of the parameters otherwise controlled by the driver.

Using data, visual aids and control strategies can give the driver that little bit extra to edge ahead

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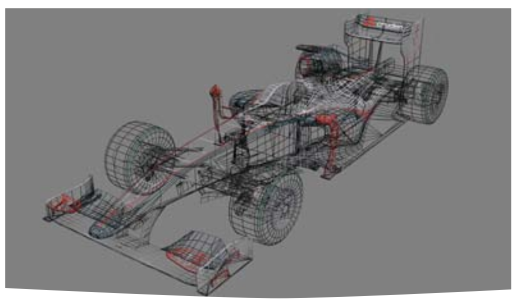

Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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The Lola once-over

In the first instalment of a new project in the wind tunnel, we have a little something that may interest history buffs...

The opportunity to look at the aerodynamics of a sports racer that originally competed 35 years ago was not one to be passed up. This particular 2-litre Cosworth BDG-powered Lola T390 ran mostly in Germany during the late-70s, and had recently been restored by Gerry Wainwright Motorsport, who kindly prepared the car for our session.

It was evident from old photos that various efforts had been made back in the 1970s to add front downforce to the T390, with a range of splitter lengths, occasionally accompanied by end fences. The restoration adopted one of the more modest configurations from those earlier days. At the rear of the car the owner had specified a rear wing to the original dimensions and with a comparable profile. The underside featured no aerodynamic trickery whatsoever; there was no diffuser and the bottom of the engine and transmission bay was open, so the flat underside of the wide chassis and of the front splitter panel constituted the 'underbody'.

The Lola arrived at the wind tunnel only a few days after the first track test following its restoration, a session which had highlighted what appeared to be 'aero understeer'. With a static weight distribution of approximately 42 per cent front, 58 per cent rear we were going to be working towards a front downforce percentage around 37 per cent to 38 per cent for a safe and comfortable balance in steady state cornering. What would the wind tunnel tell us about the 'baseline' aerodynamics as recently track tested? The initial data is shown in **Table 1**.

Table 1: the coefficients on the Lola T390 'as delivered' to the wind tunnel

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline data	0.524	0.346	+0.001	0.347	-	0.660

Table 2: the coefficients on the Lola T390 'as delivered' to the wind tunnel, correctly ballasted

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Baseline data	0.517	0.390	0.038	0.352	9.8%	0.754

Table 3: coefficients on the Ligier JS49 in an 'aero balanced' condition

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Ligier data	0.564	1.554	0.592	0.962	38.1%	2.755

This first run produced an even bigger surprise than usual, with a tiny amount of front lift in evidence. However, it was soon realised that we hadn't ballasted the car correctly to simulate the driver's weight, and having done that (which settled the car to its correct static ride height) the results in **Table 2** were achieved.

So running at the correct static ride heights, which saw the splitter nose at 40mm above the ground rather than 50mm in the first run, the car did generate some front downforce, but perhaps, as expected both before and after the track test, the balance was well off, with just 10 per cent of total downforce on the front wheels. This focused our attention for the bulk of the session on obtaining an improved balance.

HISTORIC VS MODERN

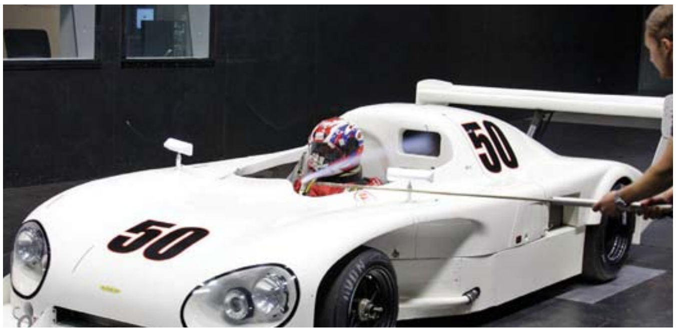
Before we get into the details of configuration changes to the Lola, let's take a brief look at data we obtained on a modern '2-litre sports racer' – the Ligier JS49 we studied in Aerobytes back in 2009 – for comparison. It can be almost guaranteed that the cars in the series the Ligier competed

The Lola T390, which ran mostly in Germany in the late-70s

The Ligier JS49 we studied in 2009 makes an interesting comparison

Rear ride height was raised with 'tyre shims'

The race tape brought useful gains as always



Air flowed into the rear compartment through the aperture next to the driver

Applying more tape brought still more benefits

in, then known as VdeV but now as the 'Speed EuroSeries', will have advanced still further in the intervening four years. However, see **Table 3** for some data to compare to the Lola's.

So, taking these configurations as representative, 30 years of aerodynamic development had all but quadrupled downforce for just a 9 per cent increase in drag. A significant amount of that will of course have come from the modern car's underbody, and the Ligier had a very effective rear diffuser, plus also front diffusers aft of the splitter. But the comparison would be fairer if we used data from the Lola once we had balanced it, so we will return to that later.

Table 4: the effects of increasing rear ride height

	CD	-CL	-CLfront	-CLrear	%front	-L/D
+10mm RRH	0.522	0.442	0.088	0.354	19.9%	0.847
+20mm RRH	0.529	0.497	0.150	0.347	30.2%	0.940

Table 5: the effects of increasing rear ride height, relative to the baseline configuration, as Δ (delta) values. NB negative changes on CL, for example, = more downforce

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
+10mm RRH	+5	+52	+50	+2	+10.1%	+0.093
+20mm RRH	+12	+107	+112	-5	+20.5%	+0.186

Table 6: the effects of blanking part of the front radiator inlet

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Taped rad inlet	0.516	-0.516	-0.195	-0.321	37.8%	-1.000
Change, counts	-13	+19	+45	-26	+7.6%	+0.060

Table 7: taping over the aperture next to the driver's head

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Taped aperture	0.505	-0.557	-0.196	-0.361	35.2%	-1.103
Change, counts	-11	+41	+1	+40	-2.6%	+0.103

RIDE HEIGHTS

As usual then, the armoury of modifications to shift balance in one direction or the other was pressed into action on the Lola, and the first thing tried was rear ride height increase. This was carried out for expediency using 'shims' placed under the rear tyres. In order to get a good idea of the extent of the effect, two fairly substantial 10mm increases were made, even though a 20mm increase in rear ride height would probably not be desirable from the mechanical dynamics viewpoint. The results are in **Table 4** in raw form, and in **Table 5** as 'delta values', that is, the changes arising, with changes to the coefficients in 'counts', where 1 count is a coefficient change of 0.001.

So the changes brought about by increasing the rear ride height were more or less linear, essentially producing very useful increments of additional front downforce with minimal change at the rear, and accompanied by quite small drag increases.

One observation on this car was that air exiting from the front-mounted radiator was neither ducted away nor directed along a path by which it could very easily escape, and the concern was that this would be contributing an increment of front lift. Cooling had apparently not been an issue in track testing, indeed some of the front inlet had been taped over to prevent over-cooling, and so the idea of taping over part of the inlet was tried next in the wind tunnel to see what the response would be in the data. **Table 6** shows the effects.

This was one of those 'composite' results where the configuration change produced downforce gains at the front and losses at the rear, but overall the balance was already pretty much on target and, with drag reducing as well, efficiency had climbed to its best so far.

However, there was more refinement work to do yet and while the roll of tape was to hand the aperture next to the driver's head in the front of the engine cover was taped over to see what the response would be. It was felt that unless there was good reason for air to flow into the engine compartment from here (and the smoke plume had shown a ready willingness for it to do so) then it might help to block it off. The results are in **Table 7**.

As surmised, drag and rear downforce were indeed helped with this simple modification, though clearly %front suffered a little.

Next month: we'll see how more front downforce was obtained.

Racecar's thanks to Gerry Wainwright Motorsport

Electric shock

The 2013 Formula Student competition made worldwide motorsport history – an electric car beat a combustion car. And the surprises didn't stop there...

BY GEMMA HATTON

There is no doubt that hybrid and electric vehicles are taking centre-stage in the modern automotive and motorsport industries. In 1997, it all started when the Toyota Prius became the first mass-produced hybrid vehicle; next was the first mass produced all-electric vehicle which came in the form of the Nissan LEAF in 2010. 2012 saw the first hybrid win at Le Mans by the Audi R18 e-tron Quattro and in March this year alone, more than 6.3 million hybrid vehicles were sold worldwide. This trend will undoubtedly continue, as 2014 becomes more electric than ever with the world's first electric race at the launch of Formula E, and the increased usage of hybrid powertrains in Formula 1.

And it's exactly the same for Formula Student.

The first electric Formula Student car to take part in a competition is thought to be what was called a 'hybrid in progress' (ie electric only), designed by the University of Florida for the 2007 Formula Hybrid competition. In the UK the bar was raised higher the same year with the introduction of a special alternative fuels category, dubbed class 1A. In 2012 it was decided to merge the classes with both conventional and alternative powertrains running in the same class.

At the Silverstone competition this year, electric cars made up 20 per cent of the Formula Student field, which at first seems a relatively small proportion. However, overall first and second place were both won by electric teams. The main issue is the extravagant investment required for an all-electric concept, something which most universities cannot afford. Many teams, when asked, would go electric if they had the extra funds, manpower and time required. The 'electric percentage' will undoubtedly increase over the coming years as more teams compete, the series becomes more global and students see the increased potential of electric powertrains.

Many teams said they would go electric if they had the funds, manpower and time required

Another record-breaking fact for this year's competition: not only was it the hottest event held in the UK, but also the driest. Sun shades, shorts and regular barbecues made the paddock almost glamorous compared to previous years of trekking around in Wellington boots, battling with the wind and rain. Of course, with unexpected highs of 28degC (82degF), teams and their cars now faced an unknown challenge of dealing with the heat – most teams had

ETH Zurich dominated the event with their all-electric car, the first win for an alternative fuelled vehicle in FSAE completed minimal testing, and those that did tested for a day at most in mixed conditions. It was going to be an interesting weekend, not least for those teams using electric drive. Some were even seen taping bags of ice to the electric motors ahead of dynamic events in an attempt to keep them cool.

The performance characteristics of the EVs were clear from the first dynamic events. Unsurprisingly, with torque instantly available, the electric cars dominated the acceleration event, claiming the top three positions, with the University of Stuttgart coming first, Delft University of Technology taking second and TU Dresden third, after the disqualification of the car from Karlsruhe (see p52).

The most visually obvious trend for this year's cars was the integration of advanced aerodynamic packages, and there all being electric. TU Delft coming first this time with a fastest time of 51.365, the Stuttgart car was close behind at 51.795, and only a tenth of a second denied Zurich second place. They finished third.

The toughest event is left until last and is the Formula Student equivalent of a grand prix. With 22km to complete, including a mandatory stop, driver change and hot restart the car's reliability is pushed to its limits, and with 300 points up for grabs, completing the endurance discipline is what every team works towards. Every year cars fail, don't restart or even catch fire which completely changes the standings. This year, however, with the added factor of the extreme heat, only 21 teams finished. That means 68 per cent of the cars failed – the highest dropout rate recorded.

In the past, the notorious Silverstone weather has caused

The Warsaw team ran a striking design featuring two rear wings, a front wing and an underfloor

were some highly interesting approaches, particularly for the acceleration event where reducing drag is essential. Most of the aero-dominant teams either adjusted parts of the rear wings, by altering the position of the slats to reduce frontal area, and therefore drag, or dropped the entire rear wing assembly down to increase top speed. This may seem an obvious tactic, but to actually implement adjustable aero into a Formula Student car can be extremely challenging and demonstrates a high level of forward thinking from the teams. It is fair to say that this year's aero designs were the most extravagant, with the Karlsruhe Institution of Technology team running a full DRS system, which gained their combustion car sixth place in acceleration. However, the most striking aero design by far was the Warsaw team from Poland which ran two rear wings, a front wing and an underfloor.

The same form was repeated in the sprint with the top three havoc with sudden heavy rain, so for this year's event, the top 10 cars from the sprint event took to the track at the same time in a 'shoot-out' to make it fairer, and – unsurprisingly – there was plenty of drama. The first teams on track were Zwickau, Karlstad and the University of Bath who were the fastest car, lapping at 65.1 seconds. After overtaking Zwickau, Bath then found themselves stuck behind TU Graz, who were a few laps in and ignored three blue flags. Last year's winning Chalmers started their endurance, but only survived three laps before a rear left wishbone failure – a real shock for such a popular front-runner. Next to join was the Munich team, with their monster rear wing, but their car only lasted two laps due to a driveshaft problem. Zurich began their race, while the Bath car was next to fail at the driver changeover when the engine failed to restart. Karlstad followed suit by also retiring

AMG'S CONTROVERSIAL ENGINE

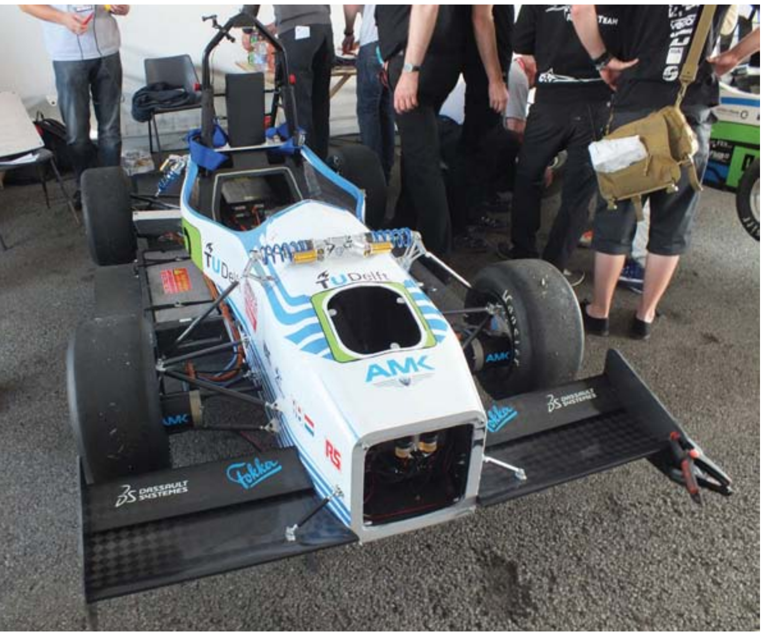
It is fairly unusual for the legality of cars to be protested at Formula Student or indeed at any FSAE event, but that's exactly what happened this year. During technical inspection the event officials suspected that the students of UAS Graz and Karlsruhe had not done all of the work on the engine themselves. Both teams use an AMG 595cc twin developed specifically for FSAE events. This led to the technical scrutineers requesting an official ruling as to the legality of the engines fitted to both cars, specifically in relation to section IC1.7 of the 2013 rules which states the following: 'Turbochargers or superchargers are allowed if the competition team designs the application. Engines that have been designed for and originally come equipped with a turbocharger are not allowed to compete with the turbo installed.'

The concern was that from the start of the design process, the engine was designed with the turbocharger installed and this is the package fitted to both cars. It was not clear how much contribution was made by the students and how much by AMG.

The protest committee met and produced the following conclusions:

- The intent of the regulations is that if an engine is purchased with a turbocharger fitted then it should not be eligible for the competition with that turbo installation, so the team must design the installation of the turbocharger.
- The fact that the engine was originally designed with this turbocharger should not be considered as an issue if the original design was produced by the students.
- The main question to answer was therefore: did the team design the installation of the turbocharger?
- After discussion between the protest committee and the team members and with feedback from other sources, it was concluded that the turbocharger installation had been designed by the team with appropriate levels of advice and support from AMG etc.

So the engines were deemed legal under the current regulations, but the information from the protest has been forwarded to the FSAE rules committee to consider future rules changes which could affect the legality of such engines and whether such engines conform to the spirit of the regulations. Many in the paddock have suggested that they feel future rules should only allow for commercially available mass-production blocks such as the Honda CBR or entirely student developed engines.



TU Delft's electric car was a much fancied runner, but failed to deliver

from the race, as the all-famous Delft team came off the start line, but without their new aero package. The electric Karlsruhe car joined the track but due to previously breaking the rules, (see sidebar, p52), their car was running at a very slow 1 min 16 secs per lap. Zwickau were the first of the top 10 to finally complete the event.

Stuttgart's combustion car was one of the few to finish, and as Hertfordshire completed 15 laps before an electronics failure struck, while Oxford Brookes also dropped out with a broken exhaust, which burnt the car's chassis badly. That left the competition wide open for the overall best Brit position.

Out of the top 10 best Formula Student teams in the world, only two finished

Meanwhile another previous winner, Delft, aborted their race after a disappointing four laps. The electric Stuttgart car joined the drama, but theirs was a short-lived race due to steering issues on the first lap. Another one bit the dust as TU Graz pulled to the side of the track with smoke and steam billowing out of their car, causing a major hold-up for the rest of the teams. The second car to cross the line was Zurich, which only left Karlsruhe running, but that car had damage to one of its motor-gear units. So, out of the top 10 of the best Formula Student teams in the world, only two finished, which although disappointing, made for a very interesting results table.

Outside of the top 10 shoot-out, the endurance event continued to be just as dramatic. The battle of the Brits continued came a close third behind Zurich, which won ahead of Zwickau.

After an eventful five days in Silverstone, the overall winner was a fight between the two electric machines of Zurich and Zwickau. But with Zwickau just behind on five out of the eight judged events, Zurich won by 70 points, with the successful endurance result helping Stuttgart Combustion to take third.

The top British team only finished 15th, but that was a fantastic achievement for the University of Huddersfield – which proves the effectiveness of having a reliable car that scores consistently. The other surprises were last year's winners, Chalmers, finishing 17th and the event favourites, Munich and Karlsruhe electric coming 27th and 30th respectively.

COMPOSITE CONTRAVENTIONS

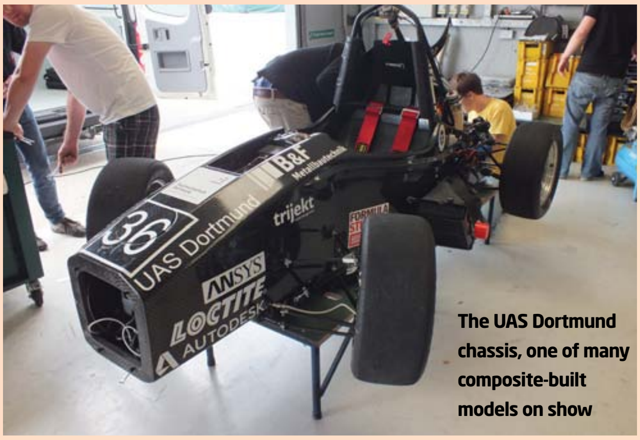
I am frustrated by a few things from this year's FSAE competitions, but one gripe has been with me for some years now and I'm fed up of it! It concerns carbon fibre chassis. For me these are all of very bad design indeed, not as engineering objects themselves – indeed some of them are very nice – but as objects designed to fulfil a specific purpose. In the rules there is a very clear statement, indeed it's rule A1.2, almost the first rule in the book: 'For the purpose of the Formula SAE competition, teams are to assume that they work for a design firm that is designing, fabricating, testing and demonstrating a prototype vehicle for the non-professional, weekend, competition market ... additional design factors to be considered include: aesthetics, cost, ergonomics, maintainability, manufacturability, and reliability.'

I have been increasingly of the opinion that this rule is being largely ignored. I have been that amateur weekend racer mentioned in the rules, and I know many others. To a man they all say that they would not buy a car with a composite chassis. 'Too expensive,' they say, 'if you crash it – which if you drive like we do you will, a lot – you can't tell how bad the damage is without specialist equipment. And if you have a really good hit, you'll probably write the chassis off as they are near impossible to repair.'

Further to this, amateur racers look for longevity from their chassis. Formula Ford 1600 chassis racing today are often more than two decades old – indeed I used to race a 1960s Formula Vee chassis against 21st-century designs, and it could corner with the best of them. The life of a composite chassis is not fully understood, but the consensus in the sport seems to be that they are only good for three or four years before needing either replacement or major repair work. Something else that makes them really unrealistic for the non-professional, weekend, competition market. Students argue that carbon fibre chassis must be the best route because 'that's what they do in F1'. They contest that the composite tubs are lighter and stiffer. This is certainly true, but they have lost sight of the point of the competition. F1 teams do not build cars for the non-professional, weekend, competition market despite the performances of some pay drivers at the back of the grid.

What frustrates me is that the design judges in all competitions seem to have forgotten this too, or simply don't realise that composite cars don't comply with rule A1.2, and we regularly see carbon chassis cars in the design finals. Yes the carbon cars with big budgets are very nice things with good aesthetics and ergonomics, but to my mind I cannot see how they can get good points in the design competition as they fall down on the cost, maintainability, manufacturability, and reliability criteria. But then I suppose I'm not a design judge.

Sam Collins



The UAS Dortmund chassis, one of many composite-built models on show

OVERALL WINNER: ETH ZURICH

This year's ETH Zurich car featured four internal AMZ M3 AC hub motors produced from scratch by the team. They produced the same power as their predecessor, but came in at 40 per cent lighter

Once the Karlsruhe electric car had been disqualified from two dynamic events, it is fair to say that the competition was essentially dominated by the team from Switzerland. Its neat electric car impressed many including the design judges, winning that event. The major development for the electric teams this year was the integration of four wheel drive, which Sven Rohner, ETH Zurich's team leader explains. 'This year we focused on our drivetrain concept. We changed it from last year's rear wheel drive to a four wheel drive system, which is a major challenge because not only do we have more motors, but more electrical components and therefore more noise within the communication lines.' Last year, Zurich ran two outer run AC hub motors, whereas this year's car features four internal AMZ M3 AC hub motors which were entirely made by the team. Weighing in at 5kg, the new designs produce the same power as the previous model (32kW) but are 40 per cent lighter. 'The motors are something we are really proud of because we started with a white piece of paper and developed the electrical and the mechanical aspects, which allowed us to alter the moment curves and generate efficient designs.'

Composite chassis remain controversial in FSAE, and many consider them to be outside of the spirit of the competition, but the Swiss team has been running carbon fibre monocoques since 2008, and Rohner believes that is the right choice, 'F1 use carbon fibre monocoques and it is possible to repair because if you know from the beginning then you make decisions when designing other parts to accommodate repair. Also, as it is naturally stiffer than a normal steel spaceframe, monocoques are the way to go for increased performance.' Due to implementing the hub motors, the surface area of the chassis could be reduced, allowing the chassis weight to be reduced by 13.3kg.

Another weight saving measure is the use of composites in the wheel rims. While far from unique in FSAE, the Swiss designs are very neat indeed. 'They are single piece and weigh around 850g – one of the lightest in Formula Student. If compared to common aluminium shells, our rims are

"The composite wheel rims are single piece, weighing around 850g"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OVERALL WINNER: ETH ZURICH (continued)

TECH SPEC

Length: 2930mm

Width: 1410mm

Height: 1550mm

Wheelbase: 1240mm

Track: 1200/1160mm

Weight - no driver: -170kg

Weight - distribution including driver: 107kg/131kg

Suspension: Double unequal length A-arm. Pushrod actuated horizontally oriented air springs and oil dampers

Tyres: 18.0x6.0-10 Hoosier LC0/R25B

Wheels: 6.5-inch single-piece CFRP

Brakes: Floated, hub mounted, 190mm dia., water-jet cut

Chassis construction: Single-piece CFRP monocoque

Engine: 4xAMZ M3 electric motor

Fuel system: Lithium polymer accumulators

Max power: 4x35kW @ 16.000rpm

Max torque: 4x28Nm @ 0rpm

Transmission: 1.5 stage planetary gearbox

Differential: None

Final Drive: 1:11.8

less than half the weight, yet double the stiffness and have increased yield strength.' Of course, with the integrated gear and hub motor on a 10-inch wheel, space is somewhat restricted. 'It is really on the edge and tight in there, which is another advantage of our self-developed rims,' says Rohner, 'because we can design it to be stiffer, to allow us to go a little tighter – something we wouldn't have been able to do with aluminium shells.'

Like most of the top cars in the 2013 competition, the ETH Zurich car features large wings, and the trend towards downforce-generating devices has come as no surprise to the Swiss students – it was the first team to fit wings to an electric FSAE car. 'Last year, aero was more of a "nice to have" feature,' Rohner adds. 'Although we completed simulations, wind tunnel and track testing, it wasn't a fully integrated package – so we could run without it if there were any problems. After learning the performance gains from last year, we integrated aerodynamics into every single part right from the beginning.' A front and rear wing, shaped undertray and rear diffuser made up the aero package. Particular attention was paid to the font wing as this controls the entire aerodynamic characteristics of the car. According to the team, the overall aero package increased the downforce by 30 per cent while maintaining the same level of drag.

While the high temperature endurance caused many top teams issues, the Zurich car ran strongly and quickly. 'One of the reasons why we finished endurance was because we really pushed the manufacturing of our car to be complete by May,' Rohner says. 'We had a lot of time to evaluate and deal with all the issues, but you also need luck, and we were lucky to be able to fix all the problems we had to finish the race.'

It is likely that some teams in the future will copy, or at least be heavily influenced by, the Zurich design, but Rohner believes it is inevitable anyway as he feels that the design concepts of top teams are converging. 'In the last three to four years, we have seen major concept changes for electric cars. For instance, our team started with DC motors, no aero and 13-inch rims. Now with 10-inch rims, four wheel drive and an integrated aerodynamic package. This is the winning concept, which is proved by other top teams such as Delft and Karlsruhe.' If that is the case then expect to see a range of similar cars in 2014.'

"This is the winning concept, which is proved by other top teams"

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KARLSRUHE

Had it not been for its double disqualification from dynamic events, the electric car from the Karlsruhe Institute of Technology would have challenged for the overall win. It certainly was a neat piece of design, complete with a fully functional DRS wing.

Its aerodynamic package was an area that even the team were not entirely convinced about, as team captain Benedict Jux explains. 'This car is our second with an aerodynamic package, and it's hard to define how effective it is,' he says. 'It has some positive aspects, especially for an electric car. It's difficult to design because of the drag and the efficiency. It improves performance during skidpad and autocross and especially during the endurance, but if you have some problems or need some more energy it can be a burden. That's why this year we designed DRS to decrease drag and improve the efficiency.' Most of the evaluation work was done using CFD, and the team were keen to point out that they used Star CCM software to develop it, but they also had not ignored some well-proven techniques, and wool tufts were evident on the underside of the wing when the car arrived at Silverstone.

Aerodynamics aside however, most of the work on the car was put into its four wheel drive powertrain. Unlike other cars driving all four corners, the Karlsruhe car does not use hub motors – instead it is fitted with four inboard IPM motors.

A lot of development was put into the four wheel drive powertrain

'The special thing is the drivetrain,' says Jux. 'It's the first Formula Student car with this type of drivetrain, no one tried this concept before. The four-wheel drive concept that we built in the last few years was a centre motor in the back and the wheel hub motors in the front. This year two teams are having just wheel hub motors, which have much more unsprung mass. We decided that for the performance of the car, it is better to put the motors in the centre to reduce unsprung mass and lower the centre of gravity. The challenge is probably the dynamic control, if you want to use the advantages of the four wheel drive, but to get it to work it's not that difficult. All four wheels turn forward.'

Reducing unsprung weight was a key aim for the Karlsruhe team, and for that reason it moved to smaller 10-inch wheel rims. 'I think you can see on our car that one main goal was to reduce the unsprung masses. We did some tests at the beginning and bonded some weights into the uprights which had a big influence – up to three-tenths difference per lap just because of the increase unsprung mass. So for the wheels we have gone smaller, it has lower masses and less rotational inertias. Most teams have changed and the results from the event show that better teams prefer 10 inches.' But the smaller rims create their own issues especially when they are made from carbon fibre which has a direct influence on brake temperatures.

'We don't have any experience about 10-inch rims and our brakes,' says Jux. 'Our brake manager says that he's not really sure this will work out for the whole of endurance so we have fitted brake ducts just for safety reasons. It's not a problem we have had with 13, but we heard of some problems from other teams last year, especially with CFRP rims. The rims are really hard to develop.

'We had a 13-inch rim which took about two years to develop, but now we have this which we will carry over on to future cars. They give weight reduction and maybe a little bit of stiffness, but if you know how stiff your rim is, you can manage it with other parts.'

Just how strong the Karlsruhe car really was will probably never become clear. It was certainly fast, but it was not legal, and when running in fully legal specification in the endurance it lacked pace. But the team were worried if it would go the distance on a single charge anyway.

CAUGHT

A number of teams were disqualified from the acceleration event at Silverstone, all of whom were running electric cars. Karlsruhe, University of Southern Denmark and Group T International University College were all found to have breached part EV2.2 of the 2013 Formula SAE technical regulations which states that: 'The maximum power drawn from the battery must not exceed 85kW. This will be checked by evaluating the Energy Meter data. A violation is defined as using more than 85kW for more than 100ms continuously or using more than 85kW, after a moving average over 500ms is applied.' The penalty for this is disqualification and all three were removed from the results. The biggest loser was Karlsruhe, which had won the event before its disqualification. It then repeated the violation in the sprint event and lost another strong finish, taking it out of overall contention.

PENALTY: DISQUALIFICATION

WHEELY SMALL

It often seems that Formula Student is driven by the need for weight reduction. Over the last few years, teams have been downsizing their engines from four to two cylinders to reduce weight. More and more teams have been trading their steel spaceframe chassis for full carbon fibre monocoques to reduce weight. This year was no different, as teams switched from 13-inch to 10-inch wheels; to reduce weight. Indeed the overall top four cars had 10-inch wheels.

The theory behind the smaller wheel is not only the weight saving, but the effectiveness of the weight saving in that area. As you may know, unsprung mass is defined as the total weight of components that are not supported by the suspension, which includes the wheels, tyres and uprights. The importance of reducing this mass is because it is effectively uncontrolled, so the lighter it is, the better the contact between the tyre and the road surface.

After evaluating the dynamic equations, the translational and rotational inertia effects of a wheel can be expressed as an equivalent non-rotating mass, therefore it can be proved that the equivalent mass of a tyre is twice its static mass. In numbers this means that if 0.5kg is shaved off each wheel, it would feel 1kg lighter. Multiply this by four and you can quickly see the huge gains in weight reduction that can be made. The knock-on effect of reducing the rotating inertia is that it improves the performance drastically, as more power is available to accelerate the car, provided you are not traction limited, in which case the performance gains will still be made, just at higher speeds. Another benefit, although relatively small in comparison, is the effects under braking, as less rotating inertia reduces the brake load, and therefore heat.

'The main advantage of the 10-inch is the weight saving and the improved acceleration characteristic due to the smaller circumference of the wheel, and therefore the lower final drive,' says Oliver Hickman, consultant manager from Brunel Racing. 'Whether or not we downsize for next year is a tough call because it would change how we run the engine – we're currently setup to compensate for the 13-inch wheels, so we still get the good acceleration. The risk you get on the 10-inches, especially in damp conditions, is the increase in wheelspin due to the higher acceleration, as most teams don't have intermediate tyres. With the 13-inch you have a higher top speed. Although it's not a massive difference, it's definitely something we need to test and verify.'

10-inch wheels offer a substantial weight saving, but there are disadvantages

The smaller wheels require smaller components, so downsizing not only has the multiple benefits of reducing inertia, but also the knock-on effects of even more weight reduction. However, the 10-inches do create major disadvantages – yet the constant push for lightweight concepts make these a small sacrifice, as the Stuttgart combustion team described: 'Of course the packaging is very difficult with the brakes, because the system is very small and therefore gets hot easily and quickly. Also, as the front wing blocks air getting to the brakes, we've added brake ducts for cooling to utilise the flow from under the wing to travel into the duct. There are some disadvantages, but in the end you get more points with the 10-inch wheels than without.'

Marcus Linder, team leader for Chalmers, agrees. 'It's basically due to the weight saving. Although the data does show the 10-inch wheels are worse in terms of peak lateral force and tyre temperatures, the gain we see in having less unsprung mass is worth the change.' A further trend is the teams that run the 10-inches now make them wider. 'We can get a better response and behaviour from the tyre when it is wider due to the increased contact patch,' says Chalmers, 'and the widening doesn't affect the maximum lateral force too much.'

Not only has the actual size of the wheel changed for weight reduction, but the design of the wheel too, with some teams now developing carbon fibre rims.

David Turton, driver for Team Bath and next year's project manager describes their concept: 'This year was the first time we've run carbon fibre rims with an aluminium centre and we have saved an approximate 600g per wheel. As well as this, there are stiffness gains to be made as the camber control is improved. Naturally, the design on CAD differs to real-life when the car is fully loaded, as it all deflects, which is why stiffness is so vital, because it directly relates to wheel control. We tried developing the rims in 2011, but it's only this year that they were fully ready to implement on the car, which has just come from refining the design and practising the in-house lay-up technique. The lightest carbon wheels on the grid are on TU Graz and Zurich, which have a three spoke carbon design and weigh in at just under 900g per wheel.' As impressive as this sounds, whether these lightweight wheels actually run in the race is another question. However, carbon rims look like the future, but once again the development costs and time required are powerful factors in determining just how many teams we will see with them next year.

"Downsizing for next year would change how we run the engine"

ADJUSTING AERO

The use of aerodynamic devices is quickly becoming a necessity in Formula Student. Last year, after the monster rear wing fitted to the Monash car, more wings, diffusers, undertrays and active aero concepts were seen at Silverstone than ever before.

'It's amazing the difference it makes, despite the fact that we race at very low speed,' explains Dave Turton, current driver and next year's project manager for Bath University. 'The average corner speed is 40-50km/h, so you would think that it's not fast enough for aero benefits. We have done back-to-back comparison with and without the wings and have found lap time. However, this is mainly due to driver confidence when braking.'

Bath have quite a small aero package when compared to other teams such as Munich and Monash, which is nearly three times the chord length, yet still weighs a small 10kg.

The Polish entry had the biggest wings, but perhaps not the most effective

Karlsruhe's car was also bewinged. Note the wool tufts on the underside

'It then becomes a trade-off between downforce and mass,' adds Turton. 'If you have advanced manufacturing processes that make the wing lighter, you can run larger wings, yet still achieve the same centre of gravity and mass penalty. Our aero is approximately 11-12kg including the mounts.'

Monash are renowned as the 'pioneers' of aero in the Formula Student world and it has been their area of focus since the very beginning. Of course, access to their own full-scale wind tunnel has helped. Monash state that their size wings are the absolute minimum required to actually gain a benefit, in which case the circuits may need to become a little wider.

AERO RESISTANCE

One team that has resisted the challenges of aero until this year was Delft, which believes that bigger is not always better. 'It's been really difficult, but luckily we have a lot of aerospace engineers in our team,' said a representative. 'We also have great facilities at our university so we complete wind tunnel testing on scale and full-size models, and so far the rear wing produces roughly the same amount of downforce as the CFD predicts. With the massive wings you see on other cars, you just add weight, which doesn't make sense for our lightweight concept. This year with the simulations we concluded that an aero package would give us more points in the competition, but maybe next year the rules change and aero may not be so important.'

As mentioned in the race report, the adjustable aero systems were also making appearances this year with both the electric and combustion cars from the German Karlsruhe team running a very F1-style DRS. However, many of the teams, such as Chalmers, don't see the benefit, as team leader Marcus Linder suggests. 'We did the analysis into whether it would be worth having DRS,' he said. 'But even though there is a potentially small gain, it introduces many problems from the control side as it adds complexity. However, we do adjust the wing depending on the type of event, but once it's running the aero remains static.'

Other teams have similar approaches, such as Team Bath. 'For the acceleration event we tried to neutralise the rear wing by adjusting the trailing edge. It costs nothing to implement other than a few extra holes in your sideplate, provided you're not traction limited at high speed. In terms of DRS, it is a difficult one. In Formula Student you have no chance to learn the circuits, so to not only learn them and learn the use of DRS could be driver overload. It's also extremely risky because if the DRS stays open you'll lose a lot more time in that scenario, than the gain you would make with it fully working.'

A valid point, as Mercedes ably demonstrated with Michael Schumacher's DRS a few seasons back. However, this is not stopping teams from developing active aero, as Turton commented: 'A team in Oklahoma has an active front and rear wing, which is impressive, so all their multiple elements in the wing open and close when the car drives into corners. Another American team has an active rear wing that splits, so that they can activate half of the rear wing depending on the steering angle. Therefore, when they turn into a corner they use the angle of attack on one side of the wing to counteract body roll and increase the vertical force on the inside tyres. Of course, in theory it is interesting, but in practise if you're counter steering, the system could be unstable unless you have an advanced control system. Nonetheless, the corners at Silverstone are relatively slow speed, so just how much benefit do you really get from aero?'

"It's amazing the difference it makes, despite the low speeds"


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Stalwart competitors Stuttgart and Washington are celebrating their first FSAE wins

FSAE MICHIGAN

Universitat Stuttgart have competed in Formula SAE Michigan since 2010 and finished in third place every year. To some, a third place finish might be enough. However, to Stuttgart it meant there was always room for improvement.

'We have finally been able to go the whole way to victory,' said team captain Alexander Jorger. 'All the hard work that was put in, in addition to the European competitions the year before, enabled us to finally win the sole event that Rennteam has participated in but never won so far. But we did it – meaning Rennteam Uni Stuttgart has achieved 13 overall championships. And that feels awesome.'

Formula SAE Michigan's competition returned to Michigan International Speedway (MIS) for its sixth year at the venue. There were 120 teams registered for the competition, however, only 104 brought working vehicles. SAE International registered teams representing colleges and universities from Austria, Brazil, Canada, Estonia, Germany, Mexico, Singapore, South Korea, the US and Venezuela.

Technical inspection saw more than 46 cars in scrutineering on Wednesday in early inspection due to an extended schedule; setting a new limit of cars having been reviewed on the first day.

For those cars that passed all three steps of technical inspection on Thursday, teams took to the track on Friday morning, completing their acceleration and skid pad runs. With temperatures of 65 degrees and overcast (usual for Michigan), Cornell University took first place in the acceleration discipline with the fastest time of 3.830 seconds. Meanwhile in skidpad, Ecole De Technologie Superieure topped the board with the fastest time of 4.901 seconds.

The University of Washington finished first overall at Formula SAE Lincoln

In the afternoon, teams completed their runs for the SAE autocross. Finishing in first place with a clean run and best time of 47.857 seconds was Oregon State University which was only 0.85 seconds faster than second place finisher Missouri University of Science and Technology. Clinching third place was Universitat Stuttgart with 48.827 seconds.

Teams who completed the event and placed were assigned a position in the Ford Endurance run order. Eighty-four cars took the green flag; 41 cars finished the event with both drivers completing their 12 laps each. One team finished over the maximum time allowed and only received points for finishing all 24 laps.

Placing first in this year's endurance was University of Akron, which had a clean run and total time of 1363.225 seconds over 24 laps. Coming in second with an adjusted time of 1370.749 due to hitting two cones was Tallinn University of Technology. Third was Michigan State University with an adjusted run time of 1371.872, also due to hitting two cones.

TOP 5 OVERALL

1st	Universitat Stuttgart
2nd	Tallinn University of Technology
3rd	University of Akron
4th	Ecole De Technologie Superieure
5th	Universite Laval

FSAE LINCOLN & FSAE ELECTRIC

The University of Washington was awarded overall first place at the 2013 Formula SAE Lincoln competition in the internal combustion class. Always a contender in Formula SAE, this was their first championship victory. Universidade Estadual de Campinas captured the first victory in the inaugural 2013 FSAE electric class competition held in conjunction with the FSAE Lincoln event – this team previously competed in FSAE Brasil.

The Formula SAE Lincoln competition continued its success for a second year at the Lincoln Airpark. Registrations for FSAE Lincoln had a limit of 80 cars for the internal combustion class while FSAE electric class allowed for 20 registrations. SAE International registered teams representing college and universities from Brazil, Canada, Japan, Mexico and the US.

Taking first place in the cost event and receiving the SAE Cost Awards was the University of Illinois – Carbondale in the internal combustion class, and Universidade Estadual de Campinas in the electric class.

Six teams participated in the design finals, with Car #4 University of Washington declared the winner. Although they did not make the design finals, Car #201 Universidade Estadual de Campinas impressed the judges and was awarded first place in the FSAE electric class design award. The design judges also recognised the FSAE electric class second placed car of University of Kansas – Lawrence and the University of Washington in third place.

San Jose State University completed a successful acceleration with the fastest time of 4.123 seconds. The skidpad event saw McGill University taking first with the fastest time of 5.340 seconds. Meanwhile, the electric car of Universidade Estadual de Campinas won both acceleration with a time of 4.452 seconds and skidpad in 5.444 seconds.

In autocross, 54 cars started, topped by the time of 51.569 seconds set by Missouri University of Science and Technology. Finishing close behind in second was Auburn University having their best time of 52.100. Coming home third was University of Illinois – Urbana Champaign.

Fifty-four cars took the green start of endurance. There were 28 finishers, headed by University of Washington, with a total adjusted time of 1403.120 seconds over 19 laps. Coming in second with an adjusted time of 1406.909 seconds with a completely clean run for both drivers was California State Polytechnic University – Pomona. And in third place was Missouri University of Science & Technology. First in the electric class was Universidade Estadual de Campinas with 1824.652.

TOP 5 OVERALL

1st	University of Washington
2nd	Auburn University
3rd	Missouri University of Science & Technology
4th	University of Kansas – Lawrence
5th	University of Texas – Arlington

Recruitment drive for Mercedes AMG HPP

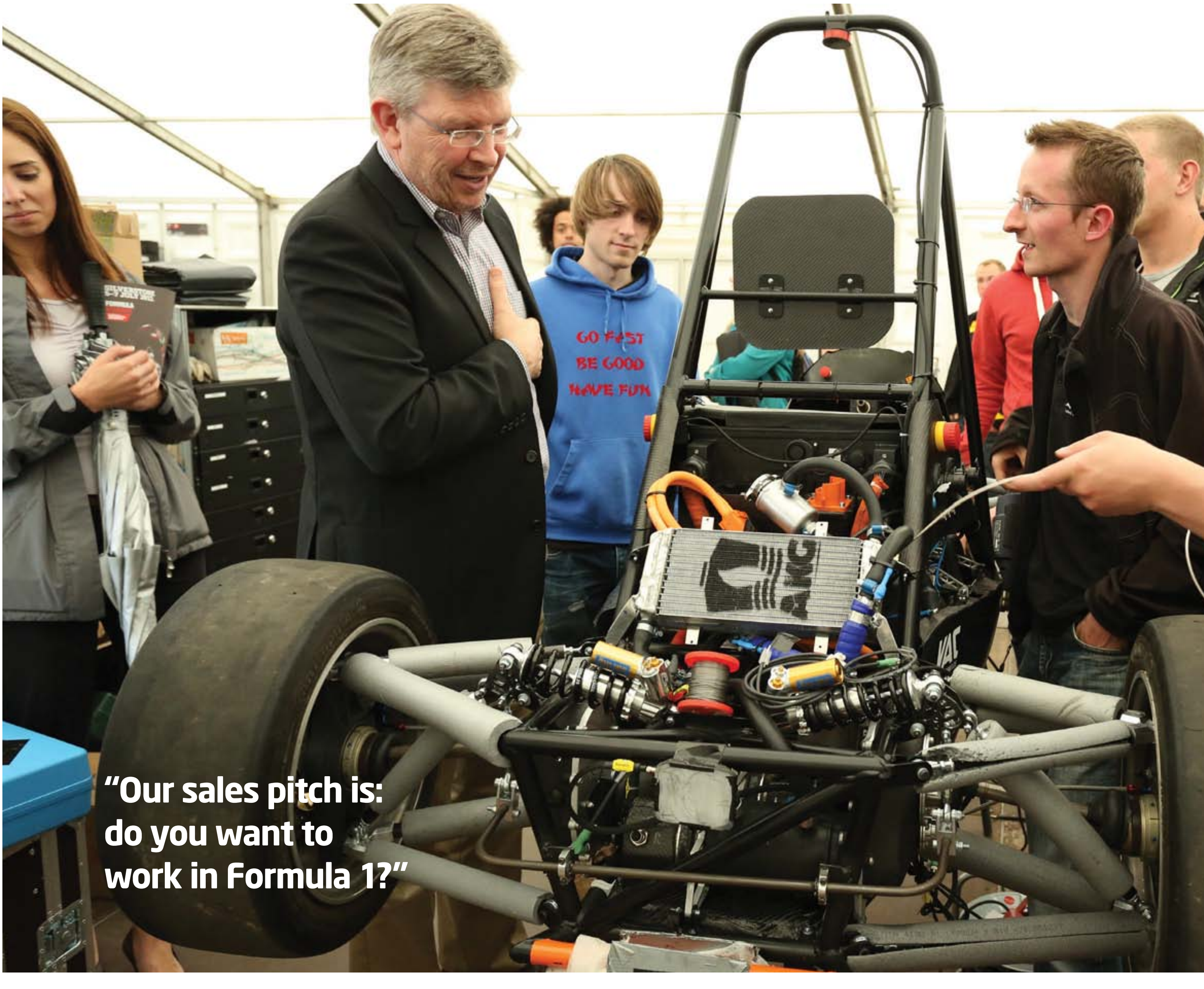
For one manufacturer, Formula Student has proved to be a rich source of engineering talent. But the hunt for great young minds doesn't stop there…

By ANDREW COTTON

One of the big attractions in the Formula Student UK paddock was the Mercedes AMG Petronas Formula 1 showcar situated next to the *Racecar Engineering* stand. The draw for the students was not just that here was a real-life F1 car in attendance, but also that the staff around the car were there to encourage applications for graduate placement schemes at its Mercedes AMG High Performance Powertrains company, based just 30 minutes away in Brixworth, Northamptonshire.

Mercedes AMG HPP is rapidly gaining a reputation among students for its schemes, particularly at the Cranfield University in the UK, and at Formula Student events. The schemes offer a wide range of opportunities, working on various parts of the current and future Formula 1 power units.

'You don't know where the gems are, and essentially we are after the best students that we can find,' says Paul Crofts, head of materials engineering at Mercedes AMG HPP. 'While



"Our sales pitch is: do you want to work in Formula 1?"

the quality of the students at Cranfield is very high, it would be naive to think that it's the only place that they come from. It is a bit of a numbers game. The more people you talk to, the more people you will be exposed to and the more likely it is that you will find the gems of the engineers.'

Students who approach the stand are encouraged to apply for the scheme – with new Formula 1 technology on the way in 2014, fresh thinking is critical for success. Although the next placements start in September 2015, there will still be a significant amount of development focused on performance and efficiency ahead of the 2016 season and beyond.

'I think at the moment, we are not that sure what the students will be working on because we haven't had a new engine on track yet,' says Crofts. 'At the moment it is like doing the 400m race at the Olympics, but everyone is in a different stadium. We have no idea how far ahead or behind we are, so we are not sure what the students will be working on. Clearly, though, anything around boosting systems, electrical hybrid systems, harvesting systems, deploying energy more efficiently – they are going to be the areas that we are continuing to work on, as well as more traditional camshafts, exhaust pipes and so on. It is across the range. Formula 1 is about detail, and every detail, so we will be leaving no stone unturned.'

Recruitment starts in September 2013 and runs through to Christmas for a placement that starts in September 2014. In that time, Mercedes AMG HPP is looking to recruit the very best engineering students from all walks of the discipline.

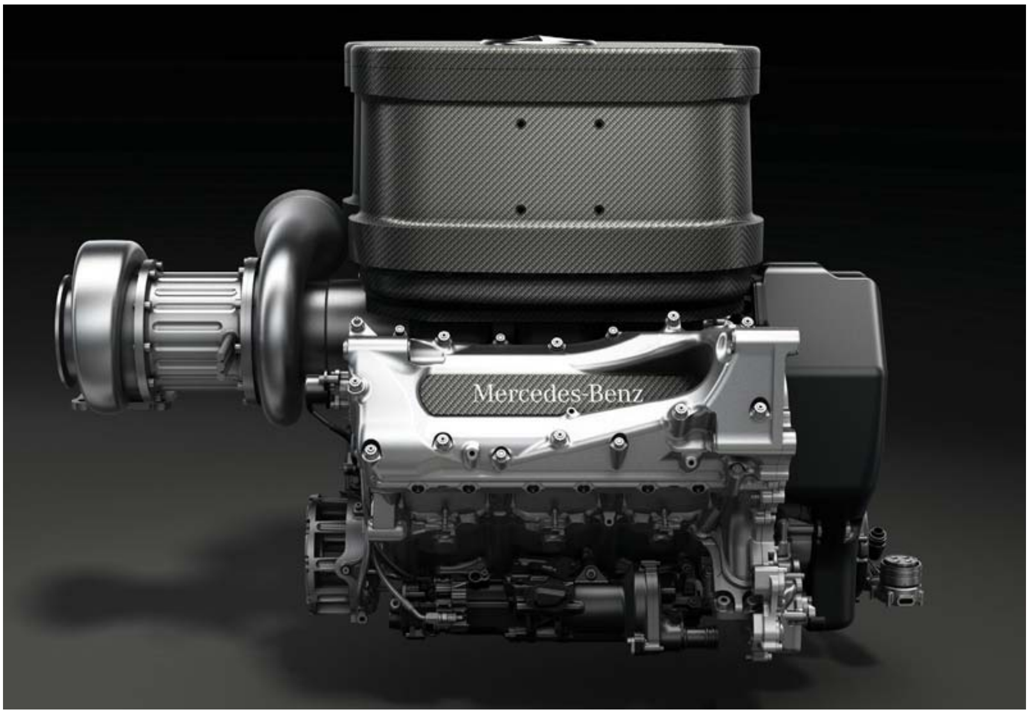
'We have a two-year formalised training programme where each graduate rotates through our various engineering departments building up experience depending on what their base degree is,' says Crofts. 'We take on mechanical engineers, manufacturing engineers, electronic engineers, software engineers and we tailor it to that background, but we give them variety, so they get a bigger overview of our business.

'Once we highlight that to them they start to get interested. Then we highlight the fact that we are in the UK. Mercedes AMG HPP may not have a high profile in the outside world, but we are not a stealth company any more. Still, we have to remind them that we are local, and that we're only 30 minutes from Silverstone. The key thing is that candidates have to apply nearly a year in advance. Our application window is September to Christmas this year to start the job in September 2014.'

'We recruit about 10 graduate engineers each year, and take on about 25-30 placement students, who are just as likely to come from this event because it is not only final year students, it is years 1, 2 or 3. Generally speaking, 50 per cent of our graduate engineers have had involvement with Formula Student at some point, so it is important to us. Our graduate programme has only been going for five years, but our retention

"Half of our graduate engineers have had an involvement with Formula Student at some point, so it is important to us"

Standout students may work on current and future Formula 1 power units



With a new breed of Formula 1 engines on the way, there is huge demand for fresh thinking in engineering the quality of the students at Cranfield is very high, it would be naive to think that it's the only place that they come from. It is a bit of a numbers game. The more people you talk to, the more people you will be exposed to and the more likely it is that you will find the gems of the engineers.'

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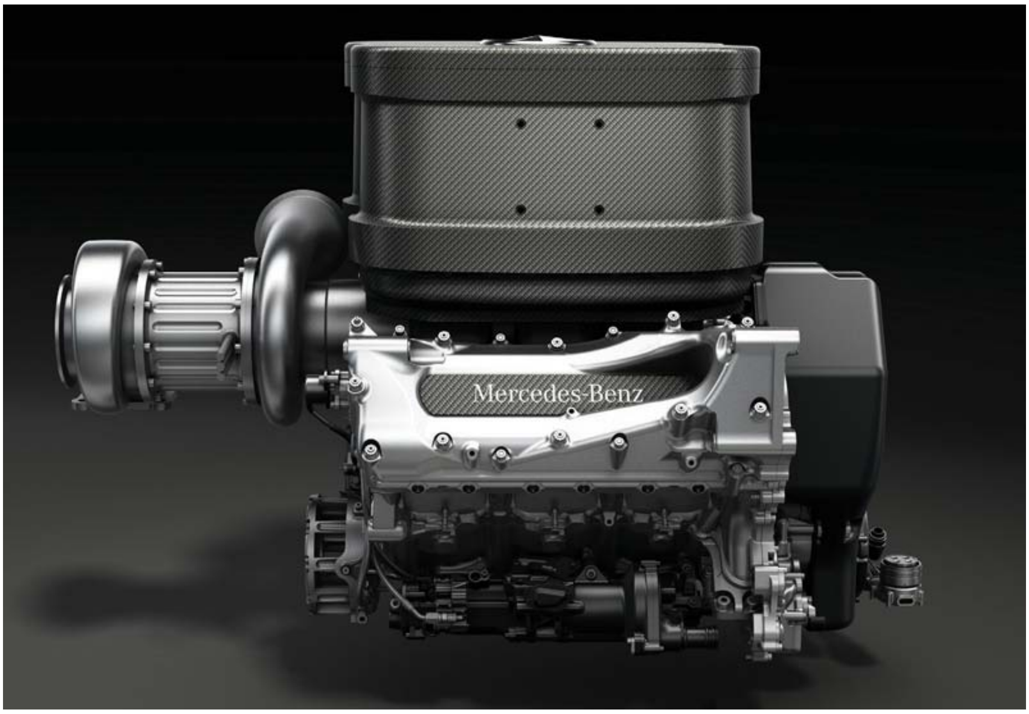
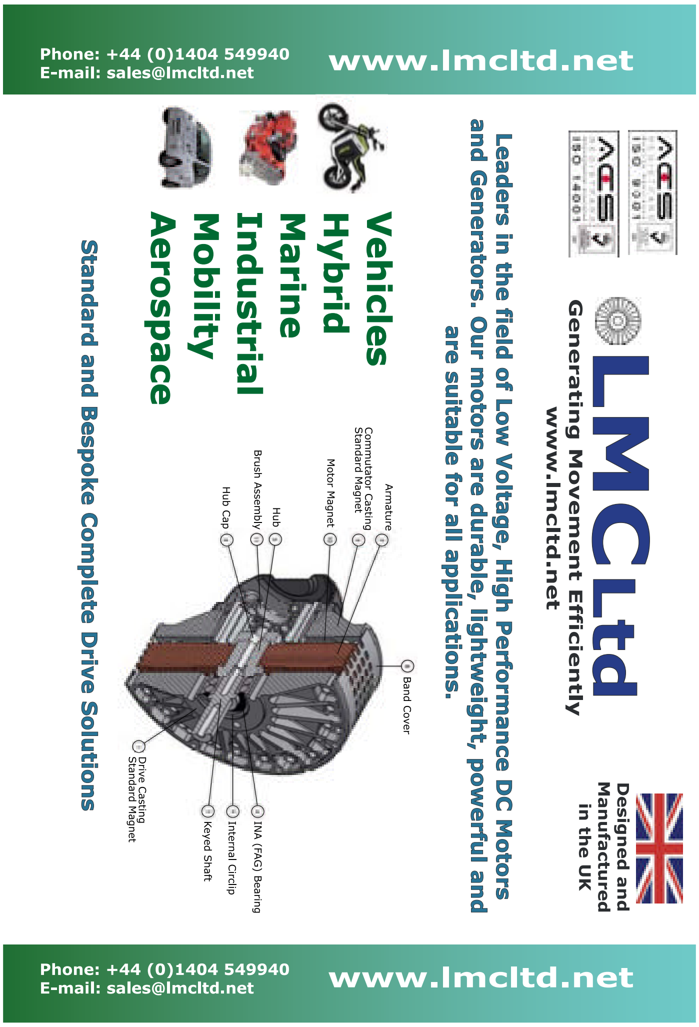
WRI2

Standout students may work on current and future Formula 1 power units



With a new breed of Formula 1 engines on the way, there is huge demand for fresh thinking in engineering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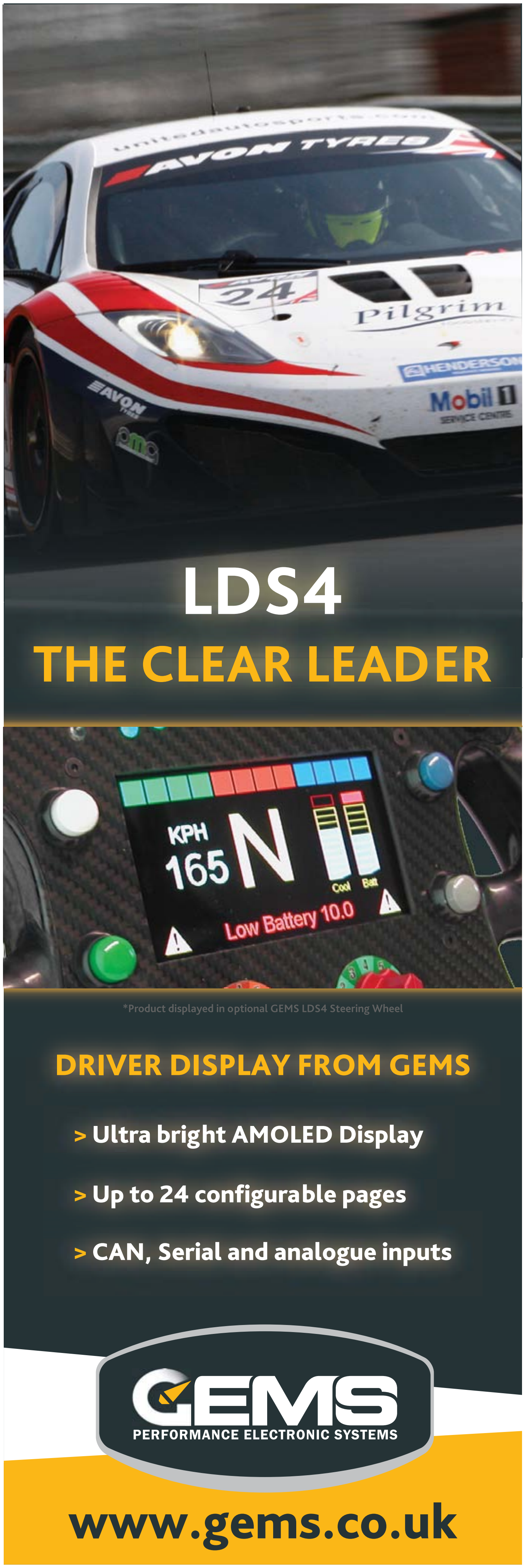
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Racing circuits

Electronic technology in motorsport has enjoyed an enormous rise in recent years, but the fine line between peak performance and catastrophic failure remains a challenge for engineers

BY CHARLES CLARKE

Life was very different when your biggest electrical gremlin was a spade terminal coming off an ignition coil. With the advent of the ECU and all its support devices and the electronic actuation of clutch and gears, life has got a whole lot more complicated. Let alone hybrid drive and the various e-formulae.

The early, modern, flappy paddle F1 era was plagued by numerous electrical failures – some taking place in tense competitive situations.

As with many of the technologies adopted by F1, in the early days, F1 used Mil-Spec electrical and electronic hardware under the assumption that if it was good enough for fighter jets, it was good enough for racecars. This worked pretty well up to a point, but it was mostly the connectors that caused the problems. This was compounded by the lack of appropriate space to locate components as a lot of the early electronic hardware did not benefit from the micro-miniaturisation and circuit integration that we have today – witness the size of mobile phones in the early-90s.

Very few environments test the integrity and reliability of electronic components like motorsport. Temperature extremes, vibration, moisture and crunching impacts can all combine to provide a severe test for all types of components – particularly electronic connector systems.

In fact, so severe are the environmental conditions, that purpose-designed electronic connectors have been developed to meet the specific needs of the motorsport industry. These are lightweight, ultra-small connector systems that maintain total contact integrity whatever the extremes of temperature and vibration, while also resisting the ingress of water, oil and other liquids and gases. They have also been designed to make installation and replacement a simple, quick and completely reliable operation.

Based on and often exceeding recognised military and aerospace standards, these connectors are used in many areas including batteries, starters and alternators, fuel pumps, engine control units, communications equipment, data acquisition systems and harnesses. Their design and construction enables them to overcome the environmental demands while meeting the performance, size and weight constraints specified by designers of the latest motorsport systems.

As well as meeting the exacting performance levels, the connectors also need to be available on demand, and in any quantity.

Lane Electronics is a leading supplier of electrical and electronic connectors, and has a specialist motorsport division to supply from stock these purpose designed connector products following its appointment as an assembling distributor for Souriau. Souriau is one of only two manufacturers to produce these high-performance connectors designed specifically for the harsh environments found in all types of motorsport.

The Souriau 8STA Series of circular connectors consists of several connector types, each designed to meet specific motorsport applications. The series also includes the industry's smallest circular connector, the Size 02. This is derived from established military specifications MIL-DTL-38999 and JN1003 and its ultra-compact design and lightweight construction make it ideal for connecting sensors and other complex electronic systems.

It features a rugged aluminium body, plated with conductive black zinc or nickel as standard. The new connector incorporates a positive locking mechanism with locked colour indicators, as well as six colour-coded keyway orientations plus universal to meet a multitude of orientation requirements. The Size 02 connector is designed to be 'scoop proof' – ie it is impossible for the plug connector to be inadvertently skewed into the mating socket so as to damage the pins or electrically short the contacts. It is fitted with removable gold-plated copper alloy contacts with an endurance level of 500 mating cycles.

The Souriau 8STA series of circular connectors

Stack's Pro-4 DVL kit with harnesses, bullet camera, mic, remote control record trigger switch, PC configuration software and PC config cable

MoTeC's Accident Data Recorder can capture lateral, longitudinal and vertical chassis g-forces

The operating temperature range is -55degC to 175degC and, when mated, the connector meets the requirements of IP67, which means it can withstand salt spray and other motorsport fluids.

St Cross Electronics is involved in making wiring looms for automotive, aerospace applications and motorsport. According to managing director Dax Ward, they buy copper cable, cut it to length, attach connectors and assemble it into a wiring loom.

St Cross are normally told what material to use when they receive a commission, as most of their customers are up to speed with technology and are always keen to use the latest and most appropriate materials for their application.

'When you're dealing with top-level teams in Formula 1, they are very much aware of current developments and the kind of materials that will help improve their performance,' says Ward.

'Things are changing quite significantly. Wires are getting smaller and lighter in weight. We are now using 30 AWG wire, which has the same pull-off tensile strength of 22 gauge wires a few years ago. I've been working in the wiring and connector industry for nearly 30 years now and all the time materials are getting lighter and stronger, driven by applications like aerospace and motorsport.'

The St Cross customer base is varied in motorsport, from low-level to hi-tech teams, and the quality of the materials they select is closely linked to their budgets. Things have moved forward in a general sense, so that the standard and quality of the wiring has increased right across the board. Even weekend racers are using much better quality wiring these days than they were 20 years ago.

"In racing, we are putting electronics in all the places where they don't like to go"

'NASCAR is probably one of the most aggressive environments for our looms,' says Ward. 'Some of the teams we supply are still using 2012 looms and they've been taken out, rebuilt, flown across the country, reinstalled and are still working, which speaks volumes with regard to the robustness of the product.'

'Things are continually getting smaller and in some cases where a connector has the same size as last year's Autosport connector, it's carrying many more cables,' says Ward. 'I can't see cable sizes getting any smaller than 32 AWG, as it is so difficult to terminate such fine wire. We can automatically strip and crimp wires, but when you get down to 32 gauge wire, there is very little you can do with it by hand. You have to strip it and crimp it with a machine because it is so fine. The automatic machines have inspection systems to make sure that only the insulation has been stripped and the conductor is not damaged. If you are doing this by hand you would need to inspect by microscope.'

Having automatic stripping and crimping adds a cost to the final product. Also, in industries like aerospace, some of the strip lengths are very short, of the order of 0.5mm, and it is virtually impossible to crimp this small strip length by hand.

'For most applications we use Raychem or Tyco Electronics cables, which is 55A type wire with PTFE insulation,' says Ward. 'This cable is very strong with good current capabilities due to the insulation, and it's a very good quality product, but it's not the cheapest available. It's probably 10 times the cost of a standard UL-listed wire.'

In 2006, McLaren Electronics Systems was chosen by the FIA to supply Standard ECUs to all teams in Formula 1. The system debuted on all cars at the start of the 2008 season, and has been reliably controlling the complete powertrain ever since.

The control system is based on the STAR topology, now in its third generation. This topology, which was pioneered by McLaren Electronics in 1998, is built around one central ECU, which is responsible for the intelligence behind all the functions on the car.

'We now supply all of the teams in F1, so they have a single set of electronics and a single version of the software,' says Dr Peter van Manen, MD of McLaren Electronic Systems. 'It's tuned by the different teams to link with their chassis and whatever sensor configuration they choose to run.'

The ECU is relatively small because there is very little space, or very little free space, on a Formula 1 car as the packaging is so optimised or tight. This gets progressively worse every year as packaging gets more optimised. Anything you put in the car is going to compromise the aerodynamics, so if you're

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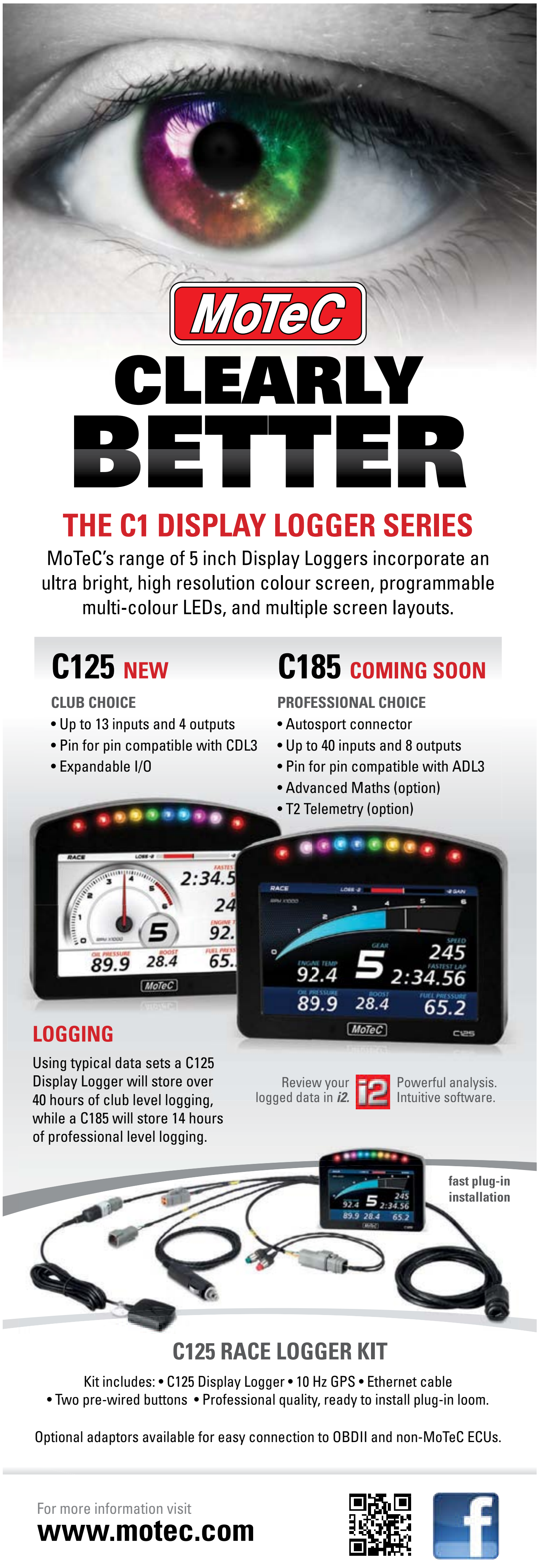

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An example of a wiring loom from St Cross Electronics

making electronics, what you need to do is make them small and efficient, so that they don't require any or little airflow across it to keep it cool or operating at its optimum temperature.

'The other problem you have is that temperatures are high in the regions where you want to put electronics,' says Van Manen. 'Particularly around the wheel areas – for wheel speed sensors – and around the engine bay for the ECU and other control equipment, because of the hot exhaust and it being all enclosed.'

The exhaust is running at about 1000degC. Anything that is mounted anywhere near the engine or gearbox has to be capable of operating at anything between 150degC and maybe up to 170degC, and the wheels can experience radiant heat from the carbon discs when the wheels are glowing. It is radiant heat, so sensors can be protected and moved further away to help them survive.

There is very high vibration shock to racing electronics, particularly on an F1 car. The engine speeds are high - they are revving to about 18,000 rpm - which creates a lot of high-frequency vibration. You also get a lot of shock loading from the road surface and going over bumps and kerbs. Generally speaking the electronics will be AV mounted (anti-vibration). These are not very soft mounts, but there will be a level of anti-vibration capability in the mountings.

'This kind of mounting doesn't really do anything when it comes to kerb strikes,' says Van Manen. 'But it does take the edge off some of the very high-frequency engine vibrations, where you've got very low amplitudes but quite a lot of energy.'

The engine is very open and it's got high energy ignition coils. There are telemetry signals everywhere and nowadays there are electric motors for the KERS (kinetic energy recovery system), so there is a lot of electromagnetic interference. 'You have to design your electronics and your sensors so that they are not adversely affected by this kind of interference,' says Van Manen. 'There is very little – if any – electromagnetic shielding on any of the harnesses these days, because it makes them heavier. We generally deal with it within the electronics and the sensors by having protection from conductive emissions. We do that with a mixture of inductors and capacitors on the connectors coming in. Also, a closed unit is essentially a Faraday cage, so it protects the electronics from electromagnetic noise.'

"You have to design your electronics and your sensors so that they are not affected by electromagnetic interference"

Today the standard F1 electronics enclosure is made from machined aluminium. 'Previously, when we weren't supplying the standard components, we used to put our electronics in machined magnesium casings, as they were lighter,' adds Van Manen. 'But machining magnesium on a large scale doesn't make economic sense.'

The units are also protected against water ingress, as wet races are relatively common in Formula 1 and the electronic units are housed just inside the radiator duct which provides a handy scoop for lots of standing water, particularly in the tropical rainstorms sometimes encountered in Malaysia. Consequently, McLaren pressure tests all of the electronics before shipping. When systems are run in rally cars, the electronics are quite often sited in the passenger footwell and on some rally stages, the passenger footwell can be underwater for significant periods of time.

'Basically, in racing we are putting electronics in all the places where electronics don't like to go,' says Van Manen. 'Electronics don't like high temperatures, they don't like water, they don't like vibration and they don't like electrical noise – racing cars have all these in abundance, so it's quite a design challenge.'

As far as the harnesses are concerned, they are obviously potentially a very heavy part of the whole electronic system and consequently there is very little or no screened cable being used. The wires are quite thin – 24, 26 and 28 AWG wires. And there's quite a lot of design effort put in to keeping the harness runs very clean and very direct.

McLaren don't make the harnesses for the cars. There are a number of wiring harness specialists in the UK and the US that supply all motorsport companies. McLaren provides complete electrical interfaces for interconnects and some advice on the architecture, and it's up to the teams to create and commission the harnesses themselves.

The wiring looms tend to be made from relatively high grade electrical wiring, the kind you'd find in military applications and aerospace. This results in consistency and light weight. Consistency is important from the point of view of the insulation properties and also the flexibility of the wires. Most F1 teams use the same sorts of harnesses as reliability is so crucial – no one can really afford to buy cheap wiring harnesses.

There is some variation depending on which racing category you're operating in, and the toughness of the operating environment. F1, NASCAR, IndyCar and sportscars tend to opt for the best quality motorsport harness with all the sleeving around it and the sophisticated motorsport connectors. In some of the lower cost formulae, where you're using a racing version of a road car, there may be elements of the wiring that are more standard road car type without the added cost of the special sleeving and all the hi-tech connectors.

These days connectors are really robust – the whole electrical/electronic systems

Today's connectors are really robust, with more reliable components

are very reliable these days. Part of it is the fact that the components are better and more reliable. Part of it is the fact that if you have a clean architecture for these systems, they fit into the car neatly, the cable runs are optimally positioned and you keep the system as light as possible. By default, you end up with something where the connectors are in a natural place anyway.

The mobile phone analogy is valid for the size evolution in motorsport electronics, but you find with each new generation of electronics that the size doesn't necessarily get smaller, and generally it doesn't get any bigger, but it offers a lot more processing power, a lot more storage and a lot more interfacing in a Mohr's law kind of way.

'This year we've introduced the new standard ECU, which has replaced the one which has been running for the last five years and the amount of processing power in the new unit is of the order of 10 times its predecessor from five years ago,' says Van Manen. 'The reason for doing this is that in F1 we have a new powertrain next year and there is a greater complexity of tasks that need controlling.'

In 2000, McLaren moved to model-based software which allows them to develop software more quickly and more consistently, and that really underpinned the move to the standard electronics for Formula 1. If you can imagine having a single set of software that is dealing with a number of different engines and different gearboxes, it has to be quite elegant and quite modular. A model-based system makes it all quite manageable.

The models are created using Matlab and Simulink – and getting that into the units is a mix of McLaren design and standard products. Model-based code didn't come into series automotive production until 2003-2004, so the sport was ahead of the curve.

The Formula 1 ECUs contain about 5000 components and have about 20,000 solder joints, so any one of those solder joints breaking will either stop the car or reduce its performance, so there is quite a lot of care needed in the manufacture of the ECU.

There is no internal cooling within the units, so they need to be electrically and thermally efficient. 'You're relying on anything that gets hot having a conductive heat path through the walls and the lids of the units to get the heat out,' says Van Manen.

A racecar in race trim is carrying about 120 sensors, and of those about 25 or 30 are supplying information to the control system. The rest are monitoring performance to optimise its speed on the track.

A lot of care and attention is given to the failure of sensors, wiring and power supplies etc, so in a modern Formula 1 car, in terms of the electrical system, there are few, if any single point failures that will stop a car. This obviously helps in terms of the overall performance and reliability.

'Consequently we put a lot of attention into how we design the units and screen test them to ensure that you get that reliability,' says Van Manen. 'To be honest it's the only way you get to enjoy your weekends, otherwise you'd be worrying about things breaking all the time.'

If there is a bad solder joint, the screening will pick it up. 'We started to supply all the teams in NASCAR at the beginning of 2012, and since that time our control units have covered something like 1 million racing miles without a single failure that has stopped a car on the track in racing,' says Van Manen. 'There are standard electronics in NASCAR, IndyCar and in F1 and they all come from us.'

In NASCAR there are a lot more racing miles, and there is a lot more track contact than in IndyCar or Formula 1, so it's a real test of the Electronics. The engines are also revving at half the speed, so the vibration is different and the engine cycles are less. There's also a lot more racing in NASCAR – there are 43 cars on the grid every week between February and November, so the season is a lot longer than Formula 1 and there

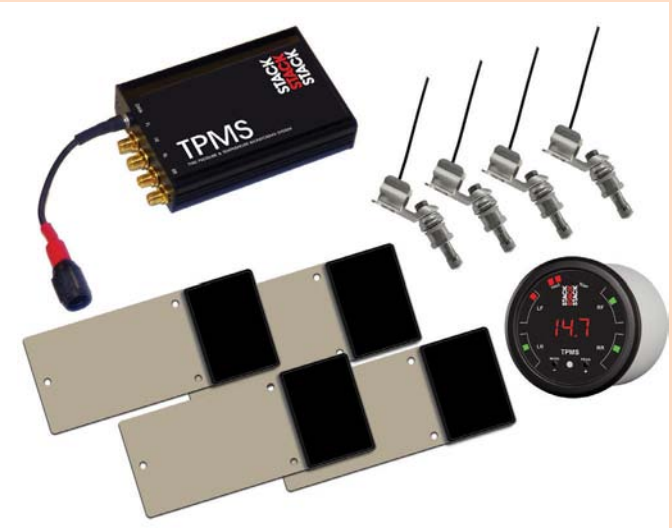
BATTERYLESS MONITORING FROM STACK

Stack has developed its first commercially available batteryless tyre pressure and temperature monitoring system (TPMS) and it is being used by competitors across all motorsport. But why is the Stack system so innovative?

Conventional TPMS systems contain a pressure sensor element and associated conditioning electronics and RF transmitter in the sensor mounted inside each wheel, together with a necessary battery to power them. The battery is sealed in the sensor and has a limited life of typically 1-5 years (depending on application), after which the whole sensor must be replaced. High operating temperatures, commonplace in motorsport, or higher sampling rates, significantly reduce the battery – and sensor – life.

Stack's batteryless TPMS sensor uses SAW (surface acoustic wave) sensing element technology. This technology is passive, and does not require any additional conditioning electronics, nor battery power source, in the on-wheel sensor.

Being batteryless has some specific benefits. Stack TPMS sensor is the smallest and lightest available, weighing only 13g. Battery based sensors are typically around 35-70g.



With no battery, the passive sensor can operate at very high temperatures – more than 150degC – without affecting sensor life. Significantly higher sampling rates – eg 40Hz compared with 1Hz for battery-based TPMS – can be offered without affecting the sensor life. The benefits of higher sampling rates are the ability to see the dynamic effect of wheel and tyre loading through individual corners and from lap to lap, as well as much faster response and earlier warning of a tyre deflation – up to 0.9 seconds earlier.

Stack's batteryless TPMS has extended the inherent sensor life from 1-5 years to 10-15 years. 'No batteries' eliminates the requirement to replace batteries in-season, reducing operating costs, and increasing long-term system reliability.

Developing a batteryless design has enabled Stack to make a professional TPMS system accessible and affordable to all levels of motorsport, giving drivers an early warning of punctures or pressure loss. In the long term this will lead to increased safety in motorsports.

For more information go to www.stackinc.com/tpms

BRAINPOWER AND HORSEPOWER

The principles of engine data logging and management to maximise performance are well known. However, applying this approach to driver performance is not as common, and certainly not at the grassroots level.

This is now changing, and Buckingham, UK-based Racelogic is at the forefront of a small revolution in the way that drivers can learn how to get the best out of themselves and the car.

Advances in micro miniaturisation and electronics robustness have allowed Racelogic to produce Video VBOX – a graphically enhanced GPS video data logger. This device is small enough to attach to the dash of a car or motorcycle and robust enough to perform in the harshest vibration environments encountered in all levels of motorsport.

When using a Video VBOX, a novice driver can access a vast amount of data to help reach the podium far faster than before. This is especially the case if the equipment is used in conjunction with an instructor, who can focus on aspects of circuit-driving skills that need work, based on quicker laps they have driven themselves. Many coaches have taken up the use of the Video VBOX as a part of their instruction.

'There are techniques that you can learn by yourself, but it can take years to do so', says Rob Barff, racing instructor and driver for Von Ryan Racing in the Blancpain Endurance Series. 'Using the video and data from Video VBOX shortcuts this process massively.

'Practice does make perfect with good coaching. But with the data interpretation we now get very detailed analysis on a lap-by-lap basis, whereas in days gone by when driver coaches were just sitting alongside their clients in racing conditions, they'd only get a general overview from the coach.'

'Now they get that broad perspective, plus – over a cup of tea at the trackside and in a very much more conducive environment and in a productive state of mind – they can analyse driving patterns, general areas of competence that can be left well alone, and areas of concern.'

The video and data presented through Circuit Tools – an intuitive and easily interpreted analysis software package that ships with Video VBOX. This not only aids the driver in addressing their problems, but also helps to dial out the 'false positives' of already-attained ability. Never before has an amateur driver had so much benchmarking so readily accessible.

'What I love about Video VBOX and Circuit Tools is this rapid application,' says Barff. 'The range of layouts in the software makes it very easy to present the theories I need to explain to my clients. It amounts to accelerated learning, regardless of experience.'

are almost double the number of cars involved. And a typical NASCAR race is 400 or 500 miles long. There are about six or seven times the number of race miles involved in NASCAR than in Formula 1 or IndyCars.

Standard ECUs are used in Formula 1 to ensure that no extra software is being used to control the car or help the driver. In New Zealand a standard Vi-PEC V88 ECUs is used to ensure that NZV8 TLXs achieve parity in terms of power from the different engines involved – Holden, Ford and Toyota.

Andre Simon, owner and director of Wellington-based Speedtech Motorsport Ltd (STM), is charged with the task of ensuring an even playing field by creating engine parity between the three manufacturers.

'Many people doubted we could get parity between three completely different engines, but with modern technology and with electronic throttle bodies, we can match power right through the rev range,' says Simon.

"Materials are getting lighter and stronger all the time, driven by applications like aerospace and motorsport"

This is done by installing a custom-developed electronic control unit (ECU) from Vi-PEC into each car, which controls fuel delivery, ignition timing, cam control (if required) and throttle to allow equal tuning and mapping right across the rev range.

'Back in the old days, when they were trying to get performance parity, they did it with air restrictors, ballast and rev limiters,' Simon adds. 'But none of that worked because you had two engines with vastly different torque curves. Strangling engines with a restrictor doesn't solve the torque disparity'.

STM conducted a series of pre-season tests on a 5-litre Lexus-sourced TRD quad cam fitted to a Toyota Camry and a 6.2-litre Chevrolet LS3 push-rod in a Holden Commodore.

'We tuned the LS3 to 560hp (418kW), but when we got the Camry engine on the dyno, its peak power was 530hp (395kW). If we were trying to match peak power, there's only 30hp (22kW) in it. It's not massive.

'However, what you lose track of, if you're concentrating on peak numbers is that they peak at about 6400 rpm. If you come back to 5000rpm, there's a discrepancy of almost 100hp (75kW) between the two engines.'

To negate the problem – and to bring the engines back to something approaching parity – STM mapped the throttle openings relative to the RPM, so that the output curves of each engine are not only comparable, they're almost identical.

'The NZV8 category asked for 2 per cent variation in engine performance curves, and we actually got closer to 1 per cent.

'We can do all of this and, basically, the driver doesn't even know it's happening – it's so smooth and seamless at the engine that he doesn't feel it. We end up with two engines that are identical in power delivery and torque curve.'

With such accurate and effective engine parity being produced in the workshop and confirmed through dyno testing, STM maintains that a neutral chassis could be fitted with any of the three engines and performance between them would be so close that a driver wouldn't be able to discern the difference. However, they do point out that each of the engines will have different weights and different centres of gravity, which may have an influence on chassis dynamics and affect the handling of the car.

To back up the testing done in the workshop, the STM team generated data at the racetrack to further reinforce their success in ensuring a fair and even playing field.

Quantifying regressive damping

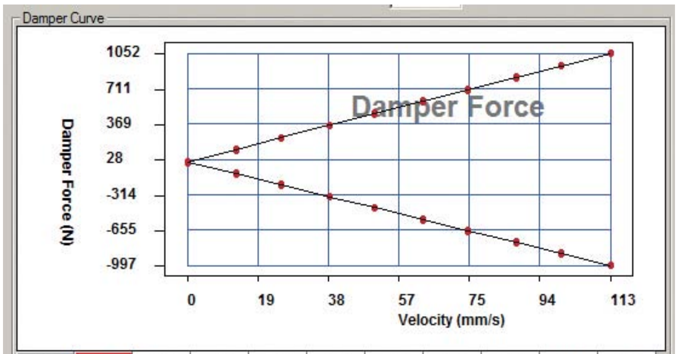
Through simulation, a look at what this option offers compared to other dampers

BY DANNY NOWLAN

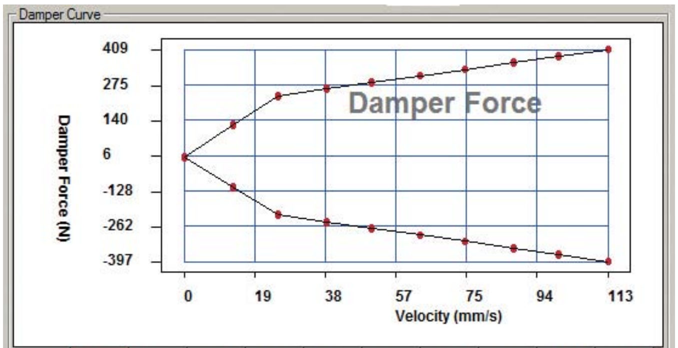
A colleague of mine referred me to a recent article in *Racecar* on the Penske regressive damping system. As I was reading the article it certainly got me thinking about a few things. However, the thing that kept running around in my head was whether this can be quantified and could we use a tool like ChassisSim to help in specifying what we want from the dampers?

Before we start this discussion it would be wise to explore what regressive damping looks like and what it offers. This is illustrated in **Figure 1** where the three different types of damping are illustrated.

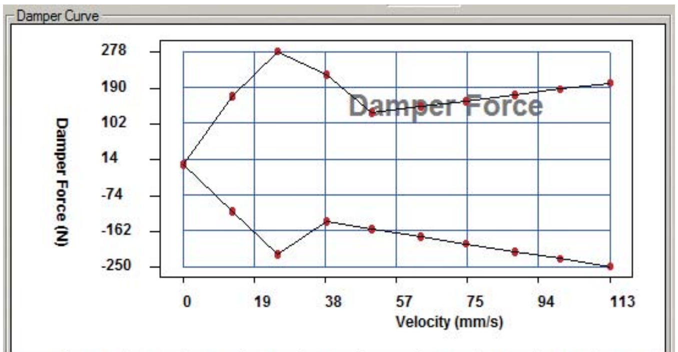
The first damper type you see illustrated in the top graph is linear. The advantage of linear damping is that it's simple and is the building block of all damper analysis. Its big disadvantage is that you can't tune for both body control and bumps at the same time – you must choose one or the other. This is due to the fact that it is a one-size-fits-all solution. The next damping type illustrated (right) is digressive damping. This, in one form or another, is what you see on the bulk of racecars running around today. The idea with digressive damping is that you have the low speed section that handles body control and driver feel, and a high speed section that handles the bumps. The low speed damping ratios are usually much higher than the fronts to handle this situation. This is the school of damper tuning I grew up on and while it's far from perfect, it is functional and if you know what you are doing you can get a fair bit down the road with it.



vel	0	13	25	38	50	63	75	88	100	113
Bump	0	121	233	354	466	587	698	819	931	1052
Rebound	0	-115	-221	-335	-441	-556	-662	-776	-882	-997



vel	0	13	25	38	50	63	75	88	100	113
Bump	0	121	233	259	283	309	333	359	383	409
Rebound	0	-115	-221	-247	-271	-297	-321	-347	-371	-397



vel	0	13	25	38	50	63	75	88	100	113
Bump	0	168	278	221	127	142	156	171	185	200
Rebound	0	-115	-221	-141	-158	-177	-195	-214	-231	-250

Figure 1: (top) linear, (middle) digressive and (bottom) regressive dampers

The regressive damper system shown in the bottom graph offers some interesting tuning possibilities. The first thing that jumps out is that the damper force vs peak velocity curve has quite a jump to it. The big advantage that this brings to the party is the ability to fine-tune the damping ratio throughout the speed range so we can really nail down what we need. It's not active/semi-active suspension, but it is a step up from what we have. Also, from a tuning perspective you can almost think about it like a spring that is able to dial in the forces where you want them, which therefore makes it very user-friendly. That being said, you do have the possibility of getting yourself hopelessly confused.

Before we get into our analysis, just remember that new tools, such as regressive damping, don't make your analysis tools obsolete. If anything, the ability to calculate damping ratios and natural frequencies becomes more vital because it allows you to understand what you are actually doing. You ignore this at your peril.

For the purpose of this article, we are going to show the comparison between an F3 car at a very bumpy circuit using digressive and then regressive damping. For the purposes of this illustration we'll be using ChassisSim. Due to the fact that ChassisSim is fully transient, it's the only lap time simulation software that can perform this analysis. That being said, the techniques I'm about to show you readily cross over to race

The ability to calculate damping ratios and natural frequencies is vital

data anyway. We'll be using ChassisSim purely because it saves us the fuss and bother of having to run a car.

The first step in deciding where to go with regressive damping settings is to have a good look at damper displacements and damper velocities. This is going to have a big say about what you do with the damper curves. This is illustrated in **Figure 2**.

The key thing we are looking for is what the damper velocities are doing when we are hitting the peak bumps. This is going to determine where we are going to dip down in the damper curve. In this particular example we are going to concentrate on the rear. As we are bouncing off the bumps, the peak damping velocity is 140mm/s.

So what we are going to do is choose our 'regression point', the point where we are going to drop down the damping rate at 80 per cent of the peak velocity value we see in the data. In this case it will be 112mm/s, so we'll round this down to 110mm/s. The damper curve we are going to try will look like **Figure 3**.

As you can see, we have backed off the damping curve at our regression point. One thing I have done slightly differently is that I haven't backed the curve totally off in the high speed. But what I have done is backed it off when it is needed. One consequence is that we have increased the low speed damping rates. On our digressive damper we had low speed rates in the order of 8000-9000N/m/s. In this damper curve the low speed bump rate has jumped to 17000N/m/s. It will be interesting to see how this plays out.

The simulation results from ChassisSim were interesting to say the least. There was a minor reduction in lap time, but it was only 61.47s plays 61.41s for the standard lap time. However, what the data did show was improved damper control at the rear. This is shown in **Figure 4**.

The baseline is coloured black and the regressive damping is black. Focusing our attention on the bottom two traces, we can see that we have definitely improved our control of the rear in some places by over 1mm without sacrificing our

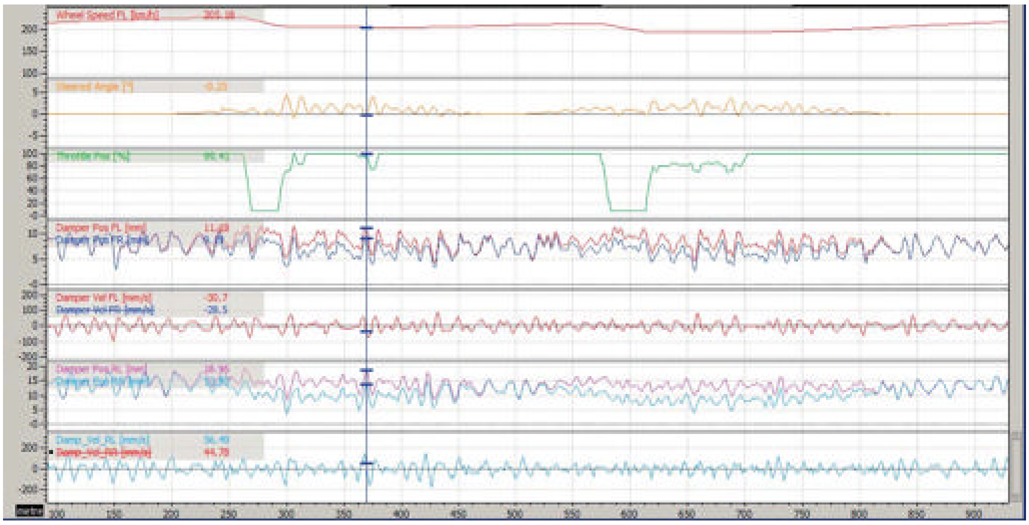
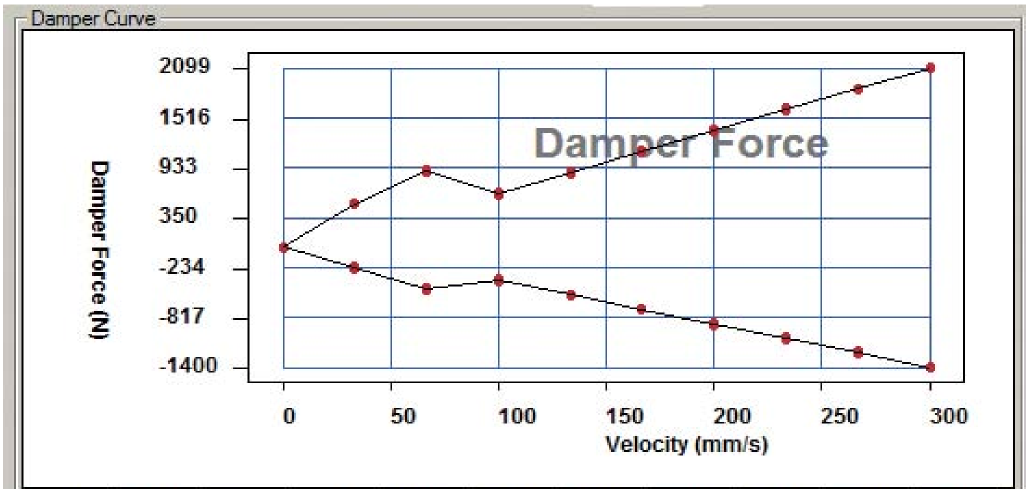


Figure 2: damper velocity and damper position analysis



vel	0	33	67	100	133	167	200	233	267	300
Bump	0	511	900	629	874	1119	1364	1609	1854	2099
Rebound	0	-244	-490	-384	-553	-723	-892	-1061	-1231	-1400

Figure 3: proposed damping curve

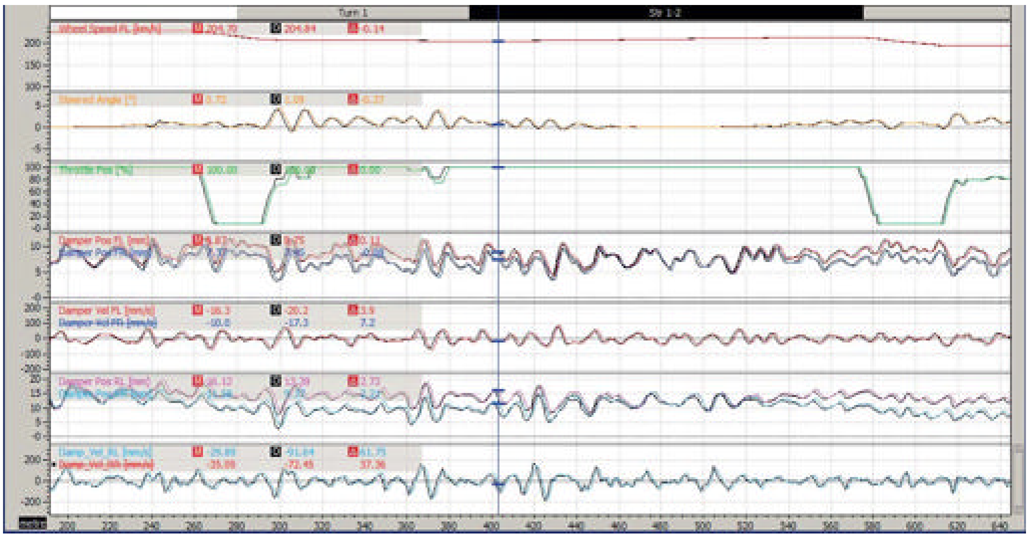
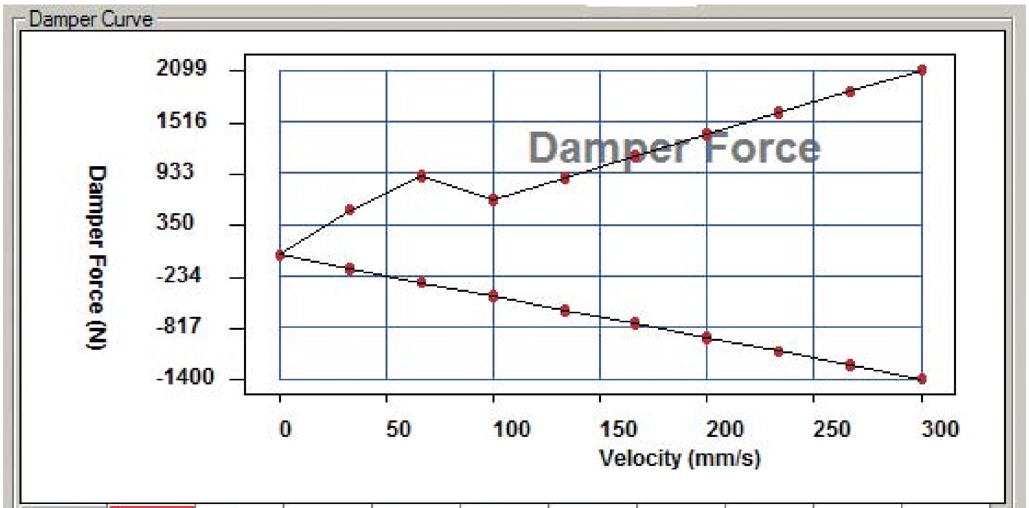


Figure 4: results of regressive damper 1 vs the standard damper

In ChassisSim, regressive damping definitely showed that we improved our control at the rear



vel	0	33	67	100	133	167	200	233	267	300
Bump	0	511	900	629	874	1119	1364	1609	1854	2099
Rebound	0	-156	-311	-467	-622	-778	-933	-1089	-1244	-1400

Figure 5: damper velocity and damper position analysis

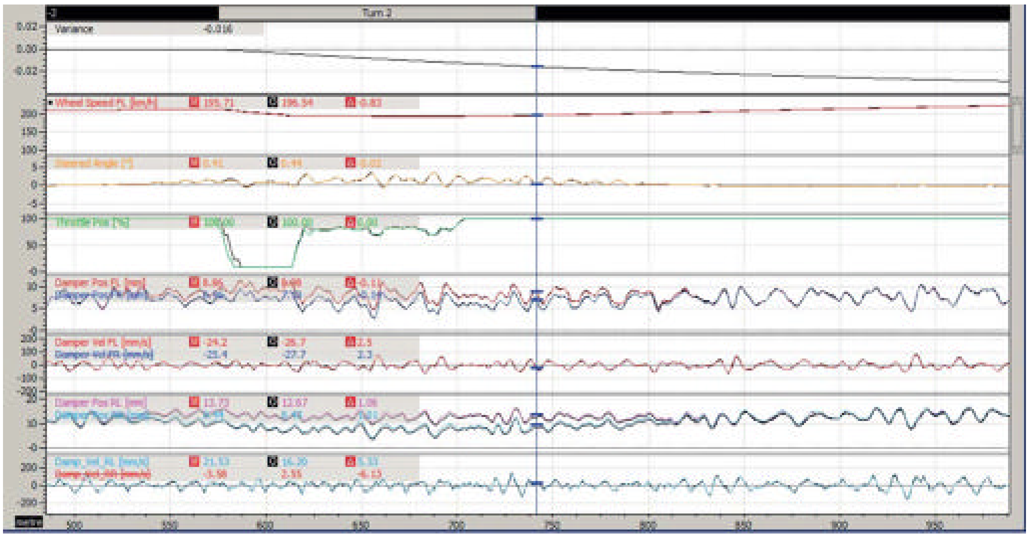


Figure 6: regressive damper 3 results

EQUATIONS

Equation 1

$$C = \frac{\partial Force}{\partial Velocity}$$

$$= \frac{410 - 141.5}{(25 - 10) * 10^{-3}}$$

$$= 17900 N/m/s$$

In order to determine damping ratios we need to convert this to a wheel rate. To jog your memory we have **Equation 2**:

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

Here we have:

C_{WHEEL} = damping rate the wheel sees
C_{DAMP} = damping rate at the spring damper unit
MR = motion ratio (damper movement/wheel movement)

Equation 3

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

Equation 4

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

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

Here the terms of the equation are:

K_b = wheel rate of the spring (N/m)
C_b = wheel damping rate of the spring (N/m/s)
m_b = mass of the quarter car
ω_0 = natural frequency (rad/s)
ζ = damping ratio

behaviour in the high speed. This is definitely something that is worth pursuing because it gives us a lot of fine control on what we want out of the damping.

The next thing to try was tuning the regressive damping in the rebound section, but this was not successful. The bottom line is that the lap time increased by 0.2s to 61.61s. The point of this simulation was to see if we could tune the low speed section in rebound for better control, but it confirms the old axiom that low speed rebound does hurt mechanical grip. However, this is certainly not a hard and fast rule.

The last simulation that was tried was backing off the rear rebound curve, and this proved to be successful. The damper curve that was tried is illustrated in **Figure 5**.

While the lap times were very similar, there was a 1km/h gain in turn 2. The plot for this is shown in **Figure 6**.

The baseline is coloured, while the regressive damper setting is black. As can be seen focusing on the last two plots, while the damping velocities have stayed the same, the rear is moving about 1mm less than the standard car. This gives us some very interesting tuning possibilities.

As a final sanity check, all three configurations were run through the ChassisSim shaker rig toolbox. The results where very interesting and they are shown in **Figure 7** over the page.

The black is standard, the red is our first damper setting and the green is our last result. At a glance you would think this is not that impressive. The contact patch load variations didn't show a massive improvement. In fact if anything they were worse in the first damper setting (by 2kg) and we just pulled it back by our third damper change. However, the devil is in the detail. Given that this is a high downforce car, we want the pitch and heave response to be as decoupled as possible. If we look at the frequency response in the 7Hz range, there is a slight increase in the heave response. However the pitch response drops off like a stone. The thing about 7Hz is that this is the frequency you start hitting bumps and this is going to be of great assistance as we start hitting kerbs and track undulations. This is a good thing.

Another thing that I should add here is the importance of calculating your damping ratios and knowing what they mean. The very first article I ever wrote for *Racecar* outlined the importance of this. The thing about regressive dampers is they give you the ability to fine-tune this on a much finer scale. Consequently it would be very remiss of me not to recap this. Firstly let's present the equations. Remember to work out damping rate we have in **Equation 1**.

In order to determine damping ratios, we need to convert this to a wheel rate. To jog your memory we have **Equation 2**.

Once we have all this we can calculate our damping ratios. The equations you need to work through are presented in **Equation 3** and **4**. The power of the quarter car is that given a damping ratio we want we can readily calculate the damping rate we want. Once we know the damping rates we're looking for, we can then turn to a damper builder and show them that this is the damping curve we want. This is why this technique is so powerful. To finish this off, the damping ratio guide is presented in **Figure 8**.

Do remember these are guides to get you going and not absolute rules.

One thing that should be said is that while regressive damping is a good thing, it should not be confused with a magic bullet. This is pretty obvious as displayed by the simulation results. While the results certainly showed promise, we were not seeing massive drops in lap times either. This is not a bad thing, because when we change one thing in a setup, we need to change other things to take advantage of this. To not recognise this situation is sheer foolishness, but the great thing is that regressive damping is one tool that can be added to a race engineer's toolbox. This is where transient simulation software like ChassisSim becomes your best friend.

Regressive damping is an innovation that does show promise. Even though this analysis was limited in scope, it did showcase the potential of this technology. One of the things we did to tune this was to choose our regression point at 80 per cent of the peak of the damping velocity. This was certainly not a waste of time and the simulation results show that this is an idea worth pursuing. This also shows what a valuable tool simulation is in specifying what you want from the damper. However, the big thing this brings to the table is much finer control over the damping ratios you want. This is a good thing. Ultimately though, the use of this is up to the intelligence and experience of the race engineer using it, which is the way it should be.

Remember: there are no magic tricks in this business.

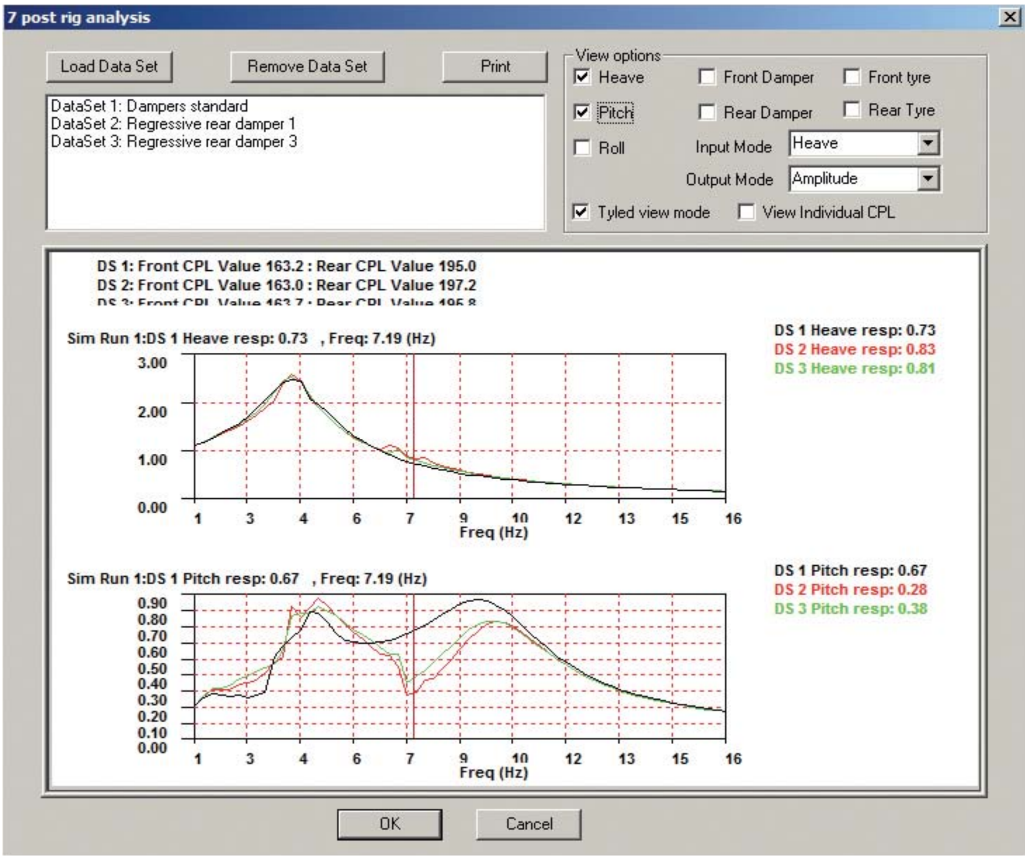


Figure 7: shaker rig results comparing standard to regressive damping results

Region	Value
$\zeta_{LS-Bump}$	This is body control so, if it is a bumpy circuit the ratio is 0.5. If the circuit is smooth choose 0.7. If the tyres need to be worked hard then choose 1.2.
$\zeta_{LS-Rebound}$	This will be dependant on a number of factors. Where body control is not significant use 0.3. However where body control is significant use 0.5 to 0.7.
$\zeta_{HS-Bump}$ $\zeta_{HS-Rebound}$	This is the high pass area of the damping curve. The values here should be 0.3 to 0.4

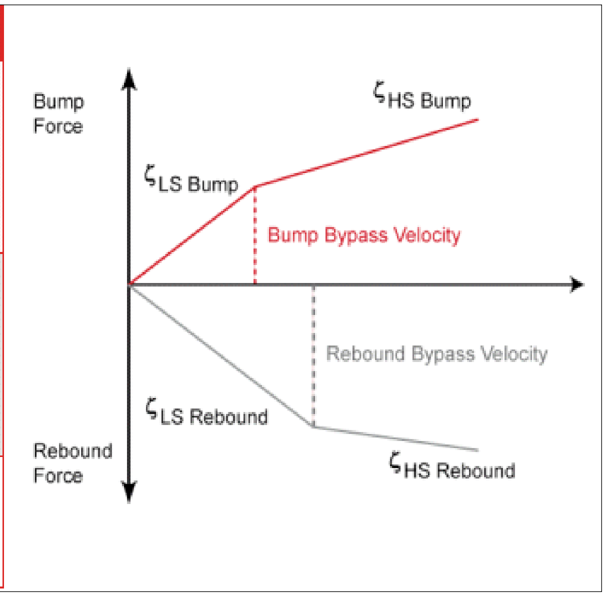


Figure 8: damping ratio guide

Regressive damping should not be confused with a magic bullet

A stiffer station wagon

A custom brace for a Subaru Legacy estate car has cured our correspondent's concerns that it could roll over when pushed hard

I've read the Consultant, Mark Ortiz, for a long time, along with numerous SAE papers, magazine articles, columns and books concerning chassis and suspension designs and theories. Long ago, it occurred to me that all the above have assumed that the suspension was attached to a very stable platform. So, I concentrated my efforts on stiffening chassis, since there are so many adjustments that can be made as designed in by suspension design engineers.

Lately, I went through an experience with my street car and that seems to back up my thoughts. I had bought a Subaru Legacy station wagon with about 135,000 miles on the clock. It lacks a bit of power with only a 2.2-litre engine, but it does have a manual gearbox. When I began to push the wagon hard through a couple of my 'test curves', I found that it understeered a lot and it gave me the feeling that the car would roll over the outside front wheel. After putting up with the problem for over 50,000 miles, I finally decided to do something about it. Unfortunately I found that I couldn't afford the spring, shock and roll bar kits that are on offer so – recalling that I had enjoyed good luck with a strut tower brace I had installed in my 240Z back in the 70s – I opted to build one for the Subaru.

I have access to a lathe, a band saw, a Bridgeport and a tig welder and, using some surplus tubing from a Formula Ford project I have designed and built, I built a strut tower brace. The brace immediately cured the understeer and I no longer felt as though the car was going to roll over the outside tyre. The only problem was, I could feel the rear tyres doing a little dance when I negotiated my 'test curves'. Since a brace worked on the front, I made a simple one-tube brace for the rear and voila! The rear tyres settled right down.

"The new strut tower brace immediately cured the understeer"

Further evidence came about 5000-6000 miles later when the inner corners of the front tyres wore down to the steel cords. These were snow tyres and since summer had arrived, I put the summer tyres on and had an alignment done. Again the inner corners wore away. When I put on a new pair of front tyres, I stood the tyres straight up (the original specs called for a little negative camber). I've now run this set of tyres for a year, through winter and summers. Wear across the treads has been even for a year.

In NASCAR racing, a large rectangular lower tube is mandated. Many cars have their upper and lower control arms mounted above and below this rectangular tube. I have yet to see proper support for this mounting system, though one Ford team owner began to add tubes to triangulate the upper tube with the rectangular tube and cross-chassis tubes. This team owner not only added cross-chassis tubes, he added diagonals across the front, plus a bolted in X-member in front of the engine. Not many NASCAR teams have followed his lead, which in my mind has led to teams having to change suspension settings during the races through tyre pressures, rubber spring stops, spring jacking and so on. Chassis simply are not stiff enough.

My Subaru wagon continues to go exactly where I steer it, and I don't have my heart in my throat when driving hard and no longer fear drifting over into oncoming cars on our narrow New England roads. So, who says racecars do not contribute to improving street cars?

Richard H Yagami

An example of a cross-brace, added to aid stiffness and stability. As a general rule, the stiffer the chassis, the more reliable the handling

Russian cash injection helps secure future of Sauber in F1

Formula 1 team Sauber has been able to secure its long-term future in the sport thanks to the the timely intervention of a group of three Russian companies.

The Swiss team has signed a deal with the Investment Cooperation International Fund, the State Fund of Development of Northwest Russian Federation, and the International Institute of Aviation Technologies.

It is not known how the shareholding of the team will now look, or if there will be a change in its management. However, it seems some conditions have been set and Sauber team principal Monisha Kaltenborn has admitted that Russian driver Sergey Sirotkin, who is just 17, is being prepared for a drive in 2014: 'We will do everything possible to prepare him for his entry into Formula 1, so that he will be our driver next year,' she said. The teenage Formula Renault 3.5 driver is the son of Oleg Sirotkin, who heads up the International Institute of Aviation Technologies.

The investment could not have come at a better time for Sauber, as it has recently emerged that some of its creditors had lodged complaints with the Debt Enforcement Office in Hinwil, where the team is based. Some reports stated that the team needed $20m to simply see out this season, and there had been talk at the German GP that lead driver Nico Hulkenberg had not been paid for two months.

But while this is not being billed as a buyout, some sources have suggested that the Russian concerns have forked out $170m between them. Sauber would not confirm this, and was more keen to emphasise the possible technical advantages of the tie-up. 'With the National Institute of Aviation Technologies, one of the leading scientific research institutions in Russia, the Sauber F1 team will benefit from the advanced know-how of the front-end Russian scientists and engineers,' it said.

'The objective of the partnership is to open up new perspectives and revenue streams by commercialising jointly developed technologies.'

Specific details of the package to secure Sauber's future remain unknown

Citroën targets growth markets with WTCC assault

Struggling French car giant Citroën is hoping that its recently confirmed entry into the World Touring Car Championship will help boost sales of its products in emerging markets.

Citroën, which joins the WTCC next year with multi-World Rally champion Sébastien Loeb, saw its sales in France fall by 14.5 per cent in May, while the combined European sales of PSA Peugeot Citroën, the second-largest carmaker in Europe, fell 13.4 per cent in May of this year compared to the same period last year.

With this in mind the company is now focused on improving sales outside Europe. At the end of 2012 it stated: 'PSA Peugeot Citroën's strategy to expand its international presence has produced results, with the percentage of assembled vehicles sold outside Europe climbing from 24 per cent of the total in 2009 to 33 per cent in 2011 and 38 per cent in 2012. The group confirms its target of generating 50 per cent of sales outside Europe in 2015.'

Frédéric Saint-Geours, executive vice-president, brands, said: 'PSA Peugeot Citroën has felt the full force of the sustainable decline in Europe's automobile markets. This situation makes our international strategy more necessary than ever. We stepped up our global expansion in 2012 and will continue in 2013, with a growing presence in China, Latin America and Russia.'

PSA Chinese sales for 2012 were up 9.2 per cent while in Russia it saw sales rise by 7.4 per cent. Latin American sales declined, however, with a drop-off of some 8.3 per cent, despite an expanded car sales market in the region.

The WTCC calendar has rounds in Russia, Argentina, China and Macau, as well as a good geographical spread for the rest of the race calendar, so it is easy to see its appeal to Citroën.

'Citroën Racing has spent the last few months looking in detail at the opportunity of going ahead with this programme,' said Citroën CEO Frederic Banzet. 'The WTCC is based on several aspects that are essential to Citroën: extensive media coverage, regulations that keep costs down and a genuinely global race calendar. Our involvement will help us to develop the brand in promising growth markets such as China, Russia and South America.'

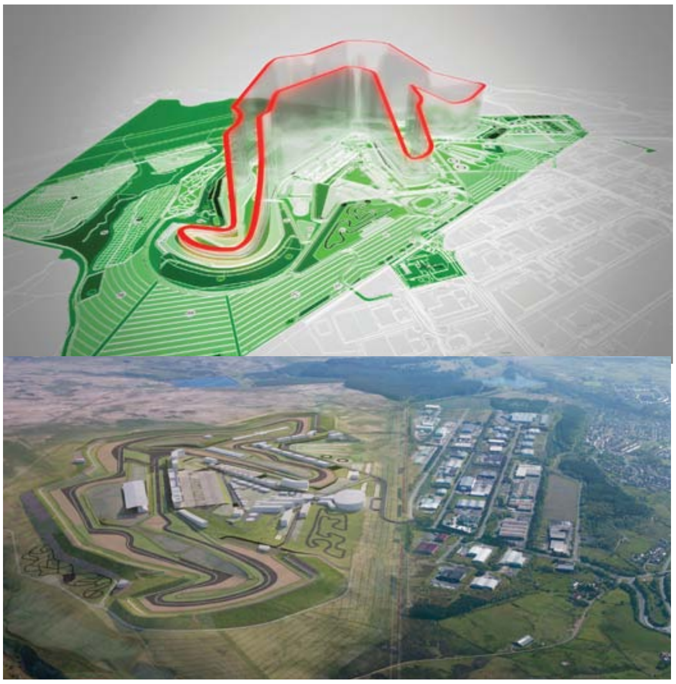
Circuit of Wales developer hits back at industry critics

The man behind the £280m Circuit of Wales development has said criticisms from within the UK track operating industry arise from a lack of understanding of its business model.

Michael Carrick, whose Ebbw Vale development was recently given outline planning permission by Blaenau Gwent Council, was responding to a statement from the Association of Motor Racing Circuit Owners (AMRCO), which was issued in the run-up to the meeting at which approval was ultimately to be decided.

In the statement Jonathan Palmer, chairman of AMRCO and head of MotorSport Vision, said: 'The UK circuit industry welcomes innovation and investment, however history and experience suggest that an investment of this magnitude in a motor racing circuit will never produce a return for investors.

'It is a real concern that this will turn into a white elephant at the expense of much-needed public funds.'



Outline planning permission has been given for the Ebbw Vale development

But Carrick insists that Palmer simply does not understand the Circuit of Wales business plan. He told *Racecar*: 'I think he's talking out of ignorance about our business model if I'm honest – I can understand why, but the business model isn't around how do you exploit the circuit activity, the business model is how do you make an industrial complex work.' Carrick explained that the project, which will feature a low carbon industry hub, commercial and retail complexes, and hotels, should be considered in the same way as an airport development, rather than just a race circuit. 'It's an economic catalyst. If you put the infrastructure there then you provide the facilities for other businesses to take advantage of that and relocate for that,' he said.

The scheme is to be funded by the company behind the project, the Heads of the Valleys Development Company, with input from the Welsh government and also private investment, much of which will come from pension funds.

The impressively undulating 5.6km circuit aims to host Moto GP, yet while it seems chiefly focused on bike sport, it is also hoping to hold a WTCC encounter and there is even talk of bringing V8 Supercars to the UK for the first time. Work on the circuit will begin at the end of this year, subject to further detailed planning permission, and it could run its first race meeting as soon as 2015.

Bad press could put manufacturers off F1, says Audi boss

Negative publicity in F1 could deter major corporations from joining the sport, says the chairman of Audi, who has also played down rumours that the German manufacturer might be looking at entering F1.

The comments came in the wake of huge negative publicity generated by Pirelli after its disastrous British Grand Prix, which featured a number of spectacular tyre failures. It is not known how much the debacle has hit sales of Pirelli road tyres as yet, but sales were already on the slide in Europe before the Silverstone race, according to its report on the first quarter of 2013 – although in the company's defence this was put down to the gloomy European economic situation.

Audi chairman Rupert Stadler has now said that the risk of such negative publicity, coupled to the attention given to drivers instead of the manufacturers, means that Formula 1 is now hard to sell to car makers.

When asked if Audi, or indeed sister VW group company Porsche, might be enticed in to Formula 1, he told the German business magazine *Wirtschafts Woche*: 'It's an interesting thought but, believe me, that's not how the world of motorsport functions. We ask ourselves, particularly in these days, whether it makes sense to be in Formula 1. Up to 90 per cent of everything discussed in F1 is not about the manufacturers, but about the drivers.

'Much is also talked about the tyres, and also the losers are discussed a lot, with pleasure. Only every now and then the involved automakers come into play, and not usually in a positive light,' Stadler said.

Despite this there are still rumours that Audi might switch to F1 in the future, particularly as it has little left to prove in sportscars – this year it scored its 12th Le Mans win – and from 2014 it will be competing against stablemate Porsche in the World Endurance Championship. F1 might also seem more attractive because of the new-for-2014 turbocharged V6 engine formula and its emphasis on energy recovery systems, which VW Group is known to have pushed for with the FIA, despite it not being involved in the sport.

LAT

Sergio Perez's catastrophic tyre failure at the British GP in June

Calls for industry to make the most of new £1bn automotive strategy

The chief executive of the MIA, Chris Aylett, has urged motorsport companies to make the most of an all-new UK government and motor industry commitment to invest well over £1bn of additional funds into the vehicle and component manufacturing sector.

This new funding, which will be put in place over the next decade, is to bolster existing investments that have been announced in the last few years, with industry and government funding projects such as the creation of an Advanced Propulsion Centre, thousands of new motor industry apprenticeships and the setting up of an Automotive Investment Organisation. The development of the strategy also sees the provision of finance for tooling investments in the supply chain, and a renewed commitment to encourage the UK as a lead market in the production and sale of low emission vehicles.

The investment, which is to be split between both parties – government and industry spending £500m each – will benefit motorsport, too, says Aylett. 'It's up to us, as an industry, to fully grasp these opportunities – and yet keep winning on Sunday. Motorsport has unique capabilities to deliver lightweight, energy-efficient vehicle technologies and propulsion solutions to global OEMs, so making both the British automotive and motorsport sectors even stronger. We can't wait to get started.'

Aylett continued: 'This strategy is the largest opportunity for new business which the UK motorsport industry has seen in over 50 years – a really significant step. It's taken many years of effort, and untold commitment by the MIA and others to get here, but it opens a new chapter for our industry in the UK.

'The fast-growing UK automotive industry has acknowledged its need for solutions from UK motorsport, and this Government policy will help open these multi-million pound opportunities for motorsport companies, and attract more investment into motorsport companies too.'

BRIEFLY

Andrett-E

IndyCar outfit Andretti Autosport is to field a team in the FIA Formula E Championship, the series for electric racecars. The team, run by 1991 IndyCar (CART) champion Michael Andretti becomes the third confirmed entry, joining Drayson Racing and the China Racing organisations on the grid. Formula E's first season will run from September 2014 to June 2015, and will take place on street circuits. Berlin was recently announced as the final venue on the calendar. Meanwhile, it's been reported that Formula E intends to run to a €2.5m budget cap for teams, though this has yet to be confirmed.

RECORD AUCTION PRICE

A Mercedes W196 Formula 1 racecar set the record for the highest price for any car ever sold at auction at the Bonhams Goodwood Festival of Speed Sale in July. The W196 is the car pedalled by Juan Manuel Fangio during his second championship-winning season in 1954. Sold at £19,601,500, it smashed the previous record price (a Ferrari 250 Testarossa Prototype, sold for £10,086,400 in 2011) by over nine and half million pounds.

The 2.5-litre straight-eight W196 – chassis number 00006/54 – is the car in which Fangio won both the 1954 German and Swiss grands prix, the first two wins for Mercedes in its postwar racing comeback season. The car's then innovative design marked the successful introduction to Formula 1 of fuel injection and all-round inboard-mounted brakes.

Williams continues to win big off the racetrack

Williams has announced it has scooped a slice of £16m's worth of UK government funding, while it has also completed a commercial tie up with Nissan performance arm Nismo.

The Grove-based group, which has been having a torrid time of it on the track with still no points on the board for its F1 team at the time of writing, has been awarded government funding to develop flywheel-based energy storage systems originally pioneered for use in Formula 1. The money will go to Williams Advanced Engineering, the part of the group that commercialises F1-based technologies.

Williams's flywheel system is among 30 projects which have won a share of the £16m, which is the first phase in a £35m Energy Entrepreneurs fund, aimed at encouraging innovations in low carbon technology.

The company has already adapted its F1 energy storage systems for use in hybrid buses, while it is developing flywheel systems for other modes of public transport, too, such as trams and monorails, as well as for electric power stabilisation sectors – the work for which it has received the funding.

Williams group CEO Mike O'Driscoll said the company aims for its F1 energy storage systems to be integrated into power grids within the next two years. 'The goal is for an energy storage system first developed for an F1 car to be installed on a power grid within the next two years.'

Meanwhile, Williams Advanced Engineering has also signed a deal with Nismo, the performance arm of Nissan, to collaborate on the development of high performance road cars.

Nismo tells us that Williams will use its expertise in aerodynamics, simulation and material science in developing future Nismo products, to be launched worldwide from 2014. However, there was no comment on whether the companies will work together on motorsport projects, such as the ZEOD RC electric racecar, which is to fill the Garage 56 slot for experimental vehicles at Le Mans in 2014.

NASCAR to invest in technology in competition department shake-up

NASCAR has vowed to invest heavily in technology as it strives to simplify and improve its entire rule-making and regulation enforcement regime, while also making the workings of the sport more transparent to fans.

The US stockcar governing body has said it's reinventing its competition department and it has announced a series of changes to be implemented over the next 18 months, with the aim of having all of them in place by the season opener in 2015. Its aims are to improve the way rules are enforced while making the sport easier to understand.

The changes proposed include a move to a digital format rulebook, which will be made available to teams in an electronic form that will not only be in line with the CAD systems used in team workshops, but will also tighten up on grey areas by using more detailed images in the place of blocks of text. There will also be a standard group of officials across all three main NASCAR series, and an improved parts inspection and approval process.

The suggestions came as a result of a steering committee led by Mike Helton, Steve O'Donnell, Gene Stefanyshyn, Robin Pemberton and Steve Phelps, which guided four internal working teams to create a blueprint for transforming the sport in the areas of rules, governance, deterrence, penalties and officiating, and inspection.

O'Donnell, senior vice president of racing operations, said that the initiative will take some extra investment on the part of NASCAR: 'In general if you look at it, it's a little bit of a culture shift in how we've done business. Our goal is to take a lot of the assets available to us, and really reinvest, and put even more money back into our R&D efforts. What that will allow us to do is get ahead of things in a much advanced way.'

LAT

The planned NASCAR shake-up aims to improve transparency within the sport

$400m Daytona facelift greenlit as ISC reports boost in income

International Speedway Corporation, the leading US track operating company, is to invest up to $400m in its scheme to radically improve Daytona International Speedway, while it has also reported a strong second quarter for 2013.

ISC, which was setup by NASCAR founder Bill France Sr and is primarily involved in the ownership and running of NASCAR tracks, announced that its board has approved a plan to completely rebuild the 'front stretch' area of the fabled speedway, and work on the project has now started.

Lesa France Kennedy, ISC's chief executive officer, said of the decision to go ahead with the project: 'We are truly creating history with this unprecedented endeavour. I commend the board's decision to move forward on our plan to redevelop the company's signature motorsports facility, thereby shaping the vision of Daytona for the next 50 years.'

The redevelopment is expected to cost between $375m and $400m, and ISC says it has already pumped some $15m into the project, which will start with the building of five new spectator entrances – called 'injectors' – each of which will lead to three different concourse levels. There will also be 11 'social neighbourhoods' each the size of a football pitch, stretching along the start-finish straight, itself close to a mile long. Each of these areas will be designed so that fans can still see the racing as they mix and socialise within the spaces.

Meanwhile, ISC has reported a strong second quarter performance with net income of $22.4m, compared to net income of approximately $13.7m in the same period in 2012. The half-year figure is also up, with net income for the six months ended 31 May at $36m, compared to a net income of $30.9m in 2012.

'We are pleased with our financial results for the quarter and year-to-date,' France Kennedy said. 'While consumer-related revenues at our events to date generated mixed results, in part due to inclement weather, we remain optimistic that the economy is poised for stronger growth.'

Test centre continues to thrive

Well-known UK engineering, research and test consultancy MIRA has reported a fourth consecutive year of growth, with the company turning over £43.5m of business while registering a 17 per cent increase in profit in 2012.

MIRA tells us it set an ambitious growth strategy in 2010 and has since achieved an overall 34 per cent growth. The strategy incorporates three key areas: growing its core engineering and testing business through diversification, expanding overseas operations and developing the MIRA Technology Park at its UK headquarters in Nuneaton.

Dr George Gillespie, chief executive officer at MIRA, said: '2012 was a harder year than anyone expected. Yet despite the challenges that we, and our customers, faced, we have managed to deliver another year of growth. I am extremely proud of that, and our determination to achieve our vision remains unfaltered.

'I am pleased to report that R&D spend increased by 22 per cent to two per cent of total turnover and, if combined with grant funded collaborative projects, it actually increases to five per cent.'

BRIEFLY

MK Honda

Honda is to base its Formula 1 operation in Milton Keynes in the UK when it returns to the sport as McLaren's engine supplier in 2015. The Japanese car maker will develop and manufacture its V6 turbocharged units at its R&D centre in Tochigi, Japan, but the engines will be maintained at a new Mugen Euro base in Milton Keynes, into which the Honda performance and motorsport brand will be moving in the autumn, after seven years based in Northampton.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INTERVIEW: ANDREW COE

Andrew Coe is CEO at International Motor Sports, the organiser and promoter of Wales Rally GB, the UK round of the World Rally Championship. He has been at IMS, the commercial arm of the MSA, since 2001 and before that he worked in tennis, in charge of technical regulations and commercial activities for its world governing body. Coe has worked in the sports industry for 35 years.

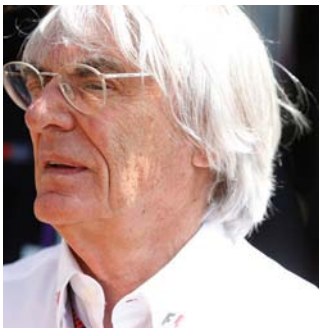
Do you think the fact you're from a general sports background rather than a motorsport background gives you some advantages?
I think it gives you a perspective on the fact that in sport there are a lot of common issues, and particularly in terms of the commercial side of things. Having an understanding of how sport works from a political and commercial point of view, and balancing those two extremes, is very useful. I think a lot of people who work in sport do only have a sporting perspective, they are perhaps people who have taken part in the sport, or it's their passion, and that's fine. But I think you also need people from outside the sport who can take a bit more of an objective view and say actually, sport is also a business, and therefore you need to be able to balance both sides of the equation. From my point of view I've hopefully seen a little bit of both sides over the years and I am able to do that.

How did International Motor Sports come about?
Just over 12 years ago the MSA decided it would separate out the commercial side of its activities from its regulatory side, so in effect we had more freedom to operate in a more commercial environment than a governing body is able to do. If you're a political body you have more limitations on the culture that you can adopt. For us, on the International Motor Sports side, we can be more overtly commercial, albeit the group includes the MSA, and as a group we are not for profit, so anything we make as a commercial arm is effectively reinvested back into the sport.

Last year's rally attracted the smallest number of spectators and the smallest entry ever. Why was this?
Going back two years now, we were asked to run the event in September rather than the normal end of year slot, and we agreed to give it a try. But last year unfortunately there was the Olympics that summer. It was a very strange year for UK sport. Also, there's the fact that in rallying the amateur drivers are actually a big part of the show – rally people won't go into a forest just to see the leading 20, 30 drivers, they want to stand there pretty much all day long. In September we find ourselves in the middle of the domestic rally calendar, and a lot of drivers and amateur crews said 'we'd like to be there but we can't risk tearing our car up and then being unable to finish our normal domestic championship'. So we had a big fall-off in the number of cars, and we had an equally unenthusiastic response from ticket buyers, but I'm very happy to say we're back to our normal slot for this year in November for the final round of the championship and I'm very encouraged by the great reaction we've had to the route, the relocation to north Wales, and hopefully that will translate into lots of people coming back to see Great Britain's round of the World Rally Championship.

Why do you think the move to north Wales will work?
For this year we have been very fortunate in working with Toyota, which has a site in Deeside [for the service park]. So we're delighted to have this new partnership. It's the

Formula 1 boss Bernie Ecclestone indicted



LAT

Prosecutors in Germany have indicted Formula 1 boss Bernie Ecclestone on a bribery charge. The charge stems from a $44m payment made by Ecclestone to a German banker, Gerhard Gribkowsky, the man who oversaw the sale of F1 to CVC back in 2006. Gribkowsky was sentenced to eight-and-a-half years in prison in Germany last year.

The 82-year-old F1 boss told the Financial Times: 'I have just spoken to my lawyers and they have received an indictment.'

In 2006 Gribkowsky was in charge of managing the sale of Bayern Landesbank's 48 per cent stake in F1 to private equity firm CVC Capital Partners, which ultimately handed control of the sport to CVC.

Ecclestone's legal team is expected to submit its response to the court in August, and the court will then appraise the arguments of both prosecution and defence, before making a decision in September on whether the case will be heard.

Common regs for 'US DTM'

Representatives from the DTM, the Japanese Super GT, and Grand Am, which will run a North American DTM-style series, met at the Norisring in July and agreed to use common regulations in 2017.

The North American version of the German DTM series, announced in March 2013, is due to launch in 2015 or 2016.

The new North American series is expected to run in conjunction with the USCR events, and the next committee meeting is due to take place at the Daytona 24 hours, expected to be the first round of the USCR next year, in January. Another committee meeting is also scheduled for the 1000km race at Suzuka in summer, 2014.

SPONSORSHIP

The NASCAR European Touring Series will now be known as the **NASCAR Whelen Euro Series**, following a long-term tie-up with the US automotive company. Whelen is already a serial backer of NASCAR championships in North America.

The **Lotus F1** team has announced that **Altran UK** is now a technical partner. The company, which describes itself as a 'global leader in innovation and hi-tech engineering consulting', will provide the race team with specialist engineering services, with a group of Altran UK engineers based at Lotus's Enstone headquarters.

ideal spot, in many ways, for us and for the event, because it's connected to a fantastic network of roads. Ideally for us it means that we're a 90 minute drive time for 36 per cent of the UK's population, which hopefully will open up the event to lots of new people and also people who remember the event but perhaps have not been able to make the journey down to south Wales.

It's been reported that you recently signed a new deal with the Welsh Government for £1.65m, is that correct?
I'm not able to confirm that, but you're not far away.

Will that give you everything that you need to run the event successfully?
Not really. Basically it operates on a model whereby it's an award from the Welsh Government to help with the running of the event. The actual staging costs of the event is higher than that, but International Motor Sports then takes on the risk of marketing the event, selling the tickets, and trying to get a revenue out of it.

BRIEFLY

Cell mates

General Motors and Honda have teamed up with the aim of developing the next-generation of fuel cell systems and hydrogen storage technologies.

The thinking behind the new collaboration, which aims to launch products to the market in 2020, is that the two companies will be able to share expertise, economies of scale and common sourcing strategies.

Both companies also plan to work with their stakeholders to further advance refuelling infrastructure, which is said to be critical for the long-term viability and consumer acceptance of fuel cell vehicles.

Symonds replaces Coughlan at Williams

Pat Symonds has joined Williams, taking the place of Mike Coughlan, who has now left the struggling Formula 1 team.


LAT

Symonds (pictured) had been working as a technical consultant for Marussia for the past two years, but will now take up the role of chief technical officer, in effect replacing Coughlan, who was technical director. The move is almost certainly a result of the team's struggles this year – at the time of writing it had yet to score a point.

The Williams new boy has a strong Formula 1 CV, having started in the sport as a race engineer at Toleman, staying with the team through its time as Benetton and then Renault, and rising to the position of technical director at Benetton in 1996. His time at the Enstone outfit came to an end after his involvement in the 'Crashgate' scandal in 2009.

'I'm delighted that Pat is joining the team,' said team principal Frank Williams. 'His technical capabilities and sporting successes speak for themselves and I'm sure that his knowledge and leadership will contribute considerably to the success that all of us at Williams are working hard to achieve.'

For his part Symonds believes the team has the foundations in place to return to the top of the sport: 'Williams is a team steeped in success and engineering excellence and I'm honoured to be asked to play a role in returning the team to its rightful place at the pinnacle of F1.

'Sir Frank, group CEO Mike O'Driscoll, and deputy team principal Claire Williams have put in place the foundations for success and I'm immensely excited to begin this new challenge.'

RACE MOVES

Ron Dennis has picked up the prestigious MIA Award for Outstanding Contribution to the Motorsport Industry. The chairman of the McLaren Group, and former F1 boss, was given the award in recognition of his exceptional career, during which he has earned the accolade of the most successful team principal in Formula 1 history, and has also overseen the significant growth and diversification of the McLaren Group.

Sauber chief designer **Matt Morris** is to join McLaren as its new engineering director, after handing in his notice at the Swiss team. He will be replaced by **Eric Gandelin**, who moves up from the role of head of concept design. Morris, who has been at Sauber since 2011, will work under technical director **Tim Goss** at McLaren.

Tim Routsis has now left Cosworth, where he was CEO for the past 10 years and was a key player in bringing the famed engine manufacturer back into Formula 1 in 2010. It is believed that Routsis will be replaced in the interim period by **Hal Reisiger**. Cosworth is not building an engine to the new 2014 regulations after failing to find an industry partner to support its planned project.

Martin Flick is now head of the motorsport department at Bilstein, moving up from the position of head of technology at the German damper manufacturer. Flick, who will now report directly to Bilstein aftermarket director **Thorsten Schwippert**, started out as a mechanic and studied engineering in Cologne.

A square in the centre of Saint Saturnin, a suburb of Le Mans, has been named after **Dr Wolfgang Ullrich**, the head of motorsport at Audi. At the unveiling of the 'Place Dr Wolfgang Ullrich' the Audi boss said: 'I'm totally surprised to receive such an honour'.

Veteran race engineer **David Cripps** is no longer with IndyCar outfit Panther Racing. Cripps's duties at the team have been taken over by **Tino Belli**, who was taken on as technical director of the joint Panther/DRR team at the start of the season. DRR has since withdrawn from the series.

IndyCar race engineer **Neil Fife** has stepped down from his position at the Dragon Racing team, where he engineered the car of **Sebastien Bourdais**. Fife, who also worked in a management role at the team, has been replaced by **Tom Brown**. Brown originally worked in IndyCar in the 1980s, and has more recently worked at Sarah Fisher Hartman Racing (2010) and last season he was at HVM Racing.


A statue of Formula 1 designer **Adrian Newey** (pictured) had been erected at Mallory Park circuit in the UK. Red Bull boss Christian Horner unveiled the piece, which is now part of a collection dedicated to motorsport greats which includes statues of **Colin Chapman**, **John Surtees**, **Mike Hailwood** and **Jim Clark**.

McLaren Automotive, the road car arm of the group, has appointed **Mike Flewitt** as chief executive officer. Flewitt, who joined McLaren Automotive in May of 2012, was previously chief operating officer. Meanwhile, **Ian Gorsuch** has returned to his post as regional director for Middle East and Africa, after a spell in Singapore where he was responsible for McLaren Automotive Asia.

Former F1 team boss **Craig Pollock** has launched a new company which aims to fund talented drivers through the ranks and into the higher levels of racing. BAR founder Pollock, whose 2014 F1 engine supply company Pure failed to come to anything through lack of finance, is to run 'The Pollock Formula' from a base in Luxembourg.

Photographer **Nigel Snowdon** has died at the age of 79. While Snowdon was known for his Formula 1 work in many magazines and the respected F1 annual *Autocourse*, his most famous picture is possibly the one he took of **Steve McQueen** giving a two-fingered salute during the making of the movie, *Le Mans*.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New IndyCar management structure takes shape

Hulman & Co, the parent company of IndyCar and the Indianapolis Motor Speedway (IMS), has revealed its all-new management restructure.

Randy Bernard's role as IndyCar CEO, from which he was removed in 2012, will not be filled, while former IndyCar interim CEO Jeff Belskus has been named chief financial officer of Hulman & Co, in addition to his current role of president. He has also been given the responsibility of overseeing a $100m development plan for the Indianapolis Motor Speedway.

Former IMS chief operating officer Doug Boles has been given the post of president of the legendary race track, in charge of its day-to-day operations and maintenance, and former IndyCar COO Robby Greene is now president of IMS Productions.

The position of president of Hulman Motorsport Properties – a role that involves the commercial responsibilities for IndyCar and IMS, including sales, marketing, PR, TV and broadcast licensing, and licensing of intellectual properties – remains the only position to be filled. Hulman CEO Mark Miles will take on these duties until someone can be found to fill the position full-time.

In an open letter to IndyCar and IMS employees, Miles said of the new structure: 'After nearly six months of observing how operations can be improved, we've designed a structure and nearly completed filling out a team that is focused on the future.'

Derrick Walker's installation as president of operations and competition for IndyCar was confirmed back in May.

Formula 1 tightens up on safety in the pit lane

LAT

The FIA has acted promptly to improve F1 pitlane safety in the wake of the accident that left a TV cameraman injured during the German Grand Prix.

Formula One Management (FOM) cameraman Paul Allen suffered a broken collarbone and broken ribs, plus concussion and severe bruising after being hit by a wheel from Mark Webber's Red Bull, which had not been fixed in place during the stop. Red Bull Racing was subsequently fined €30,000 for the incident.

After the race there was a call for the safety of non-team personnel in the pits to be looked at. 'These cars have so much energy in them and it is a timely reminder that things can go wrong,' said Red Bull team principal Christian Horner. 'The mechanics wear safety gear and helmets, maybe it is time that we looked at safety equipment for the other operational people working in the pitlane. The camera guys are getting close to the action. They are getting some great pictures but it is still a dangerous environment.'

But the FIA went further than Horner's suggestion and announced an immediate ban on anyone except team personnel in the pitlane during the races and qualifying, although cameramen would be allowed to film from the pit wall. This was then tightened further by the sport's commercial rights holder, Formula One Management (FOM), which sent an email to all broadcasters involved in F1 stating that no media personnel will be allowed in the pitlane during any grand prix session.

The FIA has also moved to bring forward its planned reduction in pitlane speed limits. A statement issued by the FIA said that its president, Jean Todt, had requested the World Motor Sport Council now approves the changes immediately – originally planned for 2014.

Pitlane speed limits will now be reduced from 100km/h to 80km/h, except in Australia, Monaco and Singapore, where it will be 60km/h. These could be further reduced on the recommendation of safety delegates or stewards at individual races.

RACE MOVES

Historic race preparation ace **Bruce Stevens**, a man renowned for his ability to get the very best from American V8-engined racecars, has died at the age of 61. Stevens, who succumbed to cancer, had great success with AC Cobras, Ford Falcons and GT40s, among others. **Leo Voyazides**, whose cars Stevens was responsible for, is now to sponsor a Bruce Stevens Preparer of the Year award in his memory.

Orna Conway is the new head of marketing for Europe, the Middle East and Africa for Infiniti, the Nissan luxury division and the title sponsor of Red Bull Racing in F1. Orna joins Infiniti from Audi Ireland. Prior to this she held diverse marketing roles across the financial services and retail sectors, where she specialised in building brand recognition.

Ryan Hess, a crew member in the NASCAR Nationwide Series, has been indefinitely suspended from all NASCAR competition after he was found to have violated the governing body's strict substance abuse policy.

Meanwhile, former NASCAR Sprint Cup Series crew member **Jackson L Dodson II** is now able to work in NASCAR once again after successfully completing the governing body's Abuse Policy Road to Recovery Program. He was suspended from the sport earlier this year.

The late journalist and broadcaster **Chris Economaki** has been named as the third recipient of the Squier-Hall Award for NASCAR Media Excellence. Economaki, who died last year at the age of 91, was the editor, publisher and columnist for National Speed Sport News for more than 60 years.

MICHAEL L LEVITT

IndyCar team owner **AJ Foyt** (pictured) has undergone hip surgery, forcing him to miss the Pocono round of the series. Foyt, who won the Indy 500, the Daytona 500 and the Le Mans 24 Hours during a hugely successful career as a driver, is expected to make a full recovery.

Mercedes-Benz UK has crowned the Apprentice of the Year for Technical and the Apprentice of the Year for Parts. **Richard Griffiths**, of Mercedes-Benz Swansea, and **Lorenzo Puliti**, of Mercedes-Benz Colindale, were each rewarded with a week-long work experience at the Mercedes F1 team.

Former rally driver and FIA World Council member **Mohammed Bin Sulayem** will chair the new Motor Sport Development Task Force, the creation of which was the first action of the FIA's Sport Conference Week in June.

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

PEELING BACK THE STICKERS NUMBER 17: BLACKBERRY

LAT

It's a big deal for a company to change its name. So when Research In Motion decided to call itself after its most famous brand, BlackBerry, you can be sure it was only after much thought and discussion. Who knows, perhaps the men at the top of the Canadian technology giant consulted with its partner in F1, for the Mercedes F1 team certainly knows a bit about changing identity – it was previously Brawn, before that Honda, BAR and originally Tyrrell.

But changing names is not the only thing the two companies have in common, for both organisations came in to this year with a point to prove: the UK-based German team needed to step up a gear and become a true force in the sport, while the maker of the once hugely popular handset has had to contend with Apple's iPhone, as well as rival firms touting Android devices.

In fact, at the time that BlackBerry linked up with Mercedes at the start of this year – in a deal said to be worth $12m a year for three years – Frank Boulben, BlackBerry's chief marketing officer, said that the similar aims of both organisations for this year helped ease the deal into place: 'They think very much like us – Mercedes is at the beginning of a journey to reclaim the top position. We are making a strong comeback with the new platform BB10, so there are very similar trajectories. The two stories marry very well.'

BRIEFLY

Marussia to use Ferrari

Marussia has confirmed it will use a Ferrari powertrain from next year, when Formula 1 switches to its new 1.6-litre turbocharged engine formula. It will be provided with engines and energy recovery systems, full transmission and all related ancillary systems. Despite this new partnership with Ferrari, the Anglo-Russian team will also continue with its technical tie-up with McLaren, where it has the use of aerodynamic facilities such as the wind tunnel.

SMP enter ELMS

Russian GT team SMP Racing has entered the final three rounds of the European Le Mans Series in the LMP2 class, as it prepares to build its own P2 machine for 2015. The French-based team, which currently fields a gaggle of Ferrari 458 Italias in the ELMS and the Blancpain Endurance Series, will now campaign an ORECA-Nissan 03 in P2.

HUB STAND KIT

BG alignment system

New from BG Racing Hub is this hub stand kit designed to allow accurate suspension setup, including ride height, camber, castor and toe angles. The system bolts to the hubs and allows for quicker and more precise setup than if tyres are fitted. The stands are available with a number of different hub adapters to fit a range of bolt patterns including four and five bolt setups as well as centre locks. They are also suitable for vehicles weighing up to 1700kg, which covers pretty much any machinery bar Dakar trucks.
For more information visit www.b-gdirect.com

TOOLS & BRACKETS

The latest from Viper

The prolific Viper Performance has continued to introduce a range of new products for motorsport fabricators. First up is a very convenient interchangeable AN wrench system for fitting hose ends. The kit comprises one smooth rounded edge spanner handle with six interchangeable aluminium jaws covering sizes from -3 to -10 JIC.

The next is a new line of fuel pump brackets designed specifically for Bosch's motorsport pumps. They come complete with liners to suit either 52mm or 60mm diameter pumps, with a dual pump fitment also available.
For further information visit www.viperperformance.co.uk

IGNITION KIT

Webcon Alpha for Ford Zetec Engine

Webcon has released a new version of its Alpha ignition system designed specifically for the Ford Zetec 1.8 and 2.0 engines, found in a plethora of racecars from saloons to single seaters. The kit is designed for electronic control of the ignition system when used with Weber carburettors, although the ECU also has the capability to be upgraded to full engine management for EFI applications.

Utilising the company's new, user-programmable PRO5 ECU, the Zetec ignition kit is supplied with a fully mapped ECU, custom-made OE quality wiring harness, air temperature sensor and communication interface.

The system is calibrated by Webcon and is designed to be a turnkey installation, with the wiring harness using the engines original coil and crankshaft sensor.
More details are available at www.webcon.co.uk

PLENUM

Jenvey 70mm Inlet Turbo Plenum

Jenvey Dynamics have just added a new, larger plenum to their range of inlet systems – the APLC-70 Turbo Plenum. The cast aluminium plenum has been designed to offer maximum flow on turbo and supercharged motorsport engines, with a cover and diffuser pipe that can be arranged in four different orientations to aid fitment. All interfaces are O-ringed for easy rebuilds and all bolts are outside the plenum to prevent possible ingress in the event of a failure.

The plenum can be fitted onto either four separate throttle bodies, a pair of twin throttle bodies or used with any combination of manifold, spacers and a single throttle body. This plenum is approximately 60mm longer than Jenvey's APSC-70 turbo plenum and has been designed to fit on the larger four cylinder and five cylinder engines such as the YB Cosworth as well as the Volvo and Audi five cylinder engines.

For further details visit www.jenvey.co.uk

FIXTURES

Renishaw fixturing

Metrology specialist Renishaw has developed an extensive new range of modular fixturing, designed specifically for use with its CMM, vision systems and its Equator measuring machines. The new modular fixtures offer a wide choice of base plates and components available in M4, M6 and M8 thread sizes, with a range of base plate sizes all of which are hard anodised to reduce wear. Each fixture system is optimised to operate with a particular measuring machine in order to speed setup times.

For more details visit www.renishaw.com

SEATS

MOMO Lesmo One

New on to the Market is Momo's FIA Approved Lesmo One Seat. The seat features a GRP shell, weighs in at 9.5kg and is intended for use in saloon car applications. It is compliant with FIA spec 8855/1999 and is Hans compatible. The seat shape is designed to reduce lateral movements of the helmet and protects the driver's head in case of an impact. Additionally, the cushions are covered in Momo's Airnet material to allow airflow around the driver, reducing heat build-up.

More info at www.momo.it

SENSORS

Penny + Giles TPS

The TPS280DP throttle position sensor from Penny + Giles incorporates a factory programmable Hall-effect sensor and has two outputs that can be programmed individually for angular range, output range and direction.

With no contacting sensor parts to ensure zero signal degradation over the lifetime of the sensor, the TPS280DP has a tested life of more than 60 million operations – more than 18 times the life of an equivalent potentiometer. When powered with 5Vdc, the TPS280DP has an operating temperature range from -40 to +140degC, with a stability of less than ±30ppm/degC.

The TPS280DP is mechanically interchangeable with most existing throttle potentiometers using 32mm mounting centres and is designed to interface with most common throttle body D type spindles. It is available with 200mm or 500mm cable lengths and can be specified with or without a MSS4P Mini Sure Seal connector fitted to the DR25 sheathed spec 55A cable.

For details log on to www.pennyandgiles.com

Why exhibit at a trade show?

Tony Tobias outlines precisely why your business needs to be at Autosport Engineering

Almost 50 years of selling advertising in motorsport magazines and selling stands at motorsport trade shows gives me an insight into what is the best way to communicate with a potential customer.

Have you ever tried making a call to someone you want to do business with and you just can't get them to come to the phone? You leave a couple messages, or send them a couple of emails, and STILL they won't call you back. Few things are as frustrating, and finally, you give up and come to the understandable conclusion that they don't want to do business with you.

But, what if you had met them at a trade show? Then, when you called they would be more likely to talk to you, because now it's personal – you aren't simply a stranger on the end of the line. You will have already met, and if you are lucky enough to have made an impression, you're practically friends now!

Which leaves me with the opportunity to explain why you should spend the money and time to exhibit at a trade show.

Put pretty simply, it's because you want someone to pick up the phone when you call them!

I know many creative entrepreneurs who claim to want to find success, but aren't willing to make an investment in their own business.

And by investment, I mean that they are reluctant to spend money to make money.

Trade shows can be costly, but ultimately they're one of the best investments you can make.

If you are in business, whether it's racing technology or leading edge components and materials, then you should definitely attend trade shows.

They represent a golden opportunity to meet the people that you need to meet – face-to-face.

ASI represents a fantastic opportunity to meet potential clients and forge invaluable business links

Note that we now live in a global marketplace, and you can no longer simply survive by just doing business with customers in your own area.

A trade show brings people from all over the world to do business together.

Often suppliers will ask me 'Wow, how did those guys get a deal with that leading F1 team?' or 'how did those guys setup that deal to distribute their brakes in the USA?'

The answer is always this: they knew someone who opened the door for them. Most deals in business come from knowing someone already, or meeting them at a trade show.

If you're serious about doing what you say you want to do, you have to spend the time and the money to get valuable face time with the people who you want to do business with.

Three reasons to attend a trade show in your intended field

EDUCATION: you learn what's hot, what's not, and what's happening in the world of your industry. You are free to ask people in the same field as you what their opinions are, to help you provide a better product.

You have conversations where you learn something about the people you want to do business with, and that leads to partnerships down the road.

SHOW OF COMMITMENT: by exhibiting, you are able to show the value of what you're offering. Just by being there, you are demonstrating to possible customers that you are committed and that you'll be around a while.

NETWORKING: this is the most important aspect of a trade show! A show gives you the opportunity to rub elbows with manufacturers, competitors, material suppliers, and anyone else involved in the motorsport industry. Potentially your new customers. Most of the big deals we've done came from meeting someone at a trade show.

Why? Because it's all about trust and who you like, and who likes you.

If you're hidden away in your office in the middle of America, or Europe, you won't be taken as seriously as you would if you networked at shows.

Here's just a few of the stories that came directly from exhibiting at Autosport Engineering:

Xtrac: every year, Xtrac is one of the first companies to rebook. 'For us it's important to expand into new territories,' says development director Cliff Hawkins. 'This year we've met new people from France and Italy. People visit our stand and want to talk to us. This year our order book is as full as it has ever been at this part of the year. It's great for business.'

MoTeC: general manager Peter Jackson comments: 'Over the years, time and time again Autosport Engineering has proven to be indispensable as the perfect showcase to reinforce our brand, launch our products and meet focused professional customers. If your business is in motorsport you need to be at the show. We will certainly be there.

Zircotec: 'Autosport always delivers results,' says managing director Terry Graham. 'We have already setup meetings with potential new clients. We have seen a significant rise in visits to our website both during and after the show. We plan to be back next year.'

Autosport Engineering is established as Europe's leading motorsport industry trade show. If you want to create stronger, better partnerships, get out of the safety of your work space and go meet people!

Research what is working for the exhibitors, take notes and ask a lot of questions. That way when you exhibit next year, you'll be ready.

I'll see you at the next show!

Three great new additions to the show lineup

BREMSEN TECHNIK

'Bremsen Technik (UK) has international experience in friction materials for commercial vehicles, high performance, racing and now mountain bikes,' explains commercial manager Paul Jelfs. The knowledge in compounding, technical characteristics and understanding of the market support both the manufacture of specific friction materials and the sales of the exclusive UK distribution of top end products. In the high performance sector, Bremsen Technik is the exclusive distributor for Pagid racing pads, Brembo high performance products and Sachs clutches and suspension units.'

Bremsen will show a full range of Pagid pads

Bremsen Technik will be exhibiting at the Autosport International Show, displaying the new range of Pagid RS racing pads which were introduced this year. Their success is down to new materials that extend the boundaries of performance. The PAGIS RSL designs have increased bite and higher operating temperature ranges. The PAGID RST range of four materials have a graduation of high friction with high fade resistance for different applications. The PAGID RSC is developed for ceramic disc applications. Both RSL and RST have proved to be superior and many top teams are gaining a winning advantage from these products.

'In a year where most companies are still reducing sales in the economic market we are going against the trend with double figure expansion,' says Jelfs.

For full details, visit www.racepads.co.uk

BMRS

Brown & Miller Racing Solutions are 100 per cent dedicated to motorsport, with more than 40 years experience. They specialise in hoses and fittings that are lightweight and virtually satisfy every form of racing application. Their industry standard ProGold convoluted hose system, Smoothbore hose and Adaptor ranges, are just a few of a wide variety of products available. As well as this, BMRS also provide custom engineered fittings designed to optimise hose installations where standard fittings may not be suitable.

'The Autosport international Engineering Show continues to be a worthwhile opportunity for us,' explains owner Barry Miller, 'we continue to develop and add to our product range in order to meet the changing and challenging requirements presented to us. The UK business continues to add to its customer base and our efforts across Europe are showing good results. Furthermore, the USA side of the business is doing exceptionally well, expanding into key locations outside of its North Carolina base. The international sales efforts outside of USA and Europe have and will continue to present opportunities.'

For more information, visit: www.bmrs.net

XYZ

XYZ specialise in supplying top quality built machine tools, with the very best in powerful but easy-to-use CNC controls. They also support all products and customers across the UK from their dedicated XYZ Centres. Formed in 1984, XYZ has grown to be the largest supplier of CNC machine tools in the UK market, and now exports across Europe, the Middle East and Africa. 'We have always considered exhibitions to be the ideal way of displaying products and the ability to conduct a demonstration of a machine is highly effective,' says managing director Nigel Atherton. 'Autosport has been a consistently good show for us, generating millions of pounds in orders over the last 10 years since we started exhibiting.

'We have just extended our factory to 90,000ft and we will introduce some exciting new products at MACH 2014 in April. We are also opening a new Newcastle showroom.'

XYZ will be displaying and completing live demonstrations of their latest machine innovations, such as the ProtoTRAK range of well respected machines, that are used in the manufacture and development of many autosport companies products including the R&D departments of most F1 teams.

See www.xyzmachinetools.com for details.

If you want to make the most of the opportunities afforded to you by the Autosport Engineering Show, held in conjunction with *Racecar Engineering*, book your stand today. For information on how to exhibit, or to attend Europe's premier motorsport show, contact the head of business development, Tony Tobias: **tony.tobias@haymarket.com**

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An enduring problem

Mercedes stormed to victory in the Spa 24 hours at the end of July, adding to the ever-growing list of wins this year for the SLS model. Dubai, Nürburgring and now Spa, it is emulating Audi's 2012 achievements, when the factory went all out to win at Daytona, Nürburgring and Spa.

This rise of the factories in customer racing, nabbing the best of the trophies, has become prevalent. It seems that manufacturers have no qualms about racing their customers where it suits – Aston Martin fielded a factory team in the Blancpain Endurance Series at Silverstone in preparation for the Spa 24, Bentley is likely to request that it races as a factory team in the same series later this year, and series organiser Stéphane Ratel says that he will consult his teams with a view to allowing manufacturers to compete in the BES on a more regular basis.

The theory behind this is that there is a Pro class anyway, and so although the series, for GT3 cars, is setup to cater for customers, the so-called 'gentlemen' drivers who want to race on grand prix circuits only a few times a year, they can't necessarily compete for overall honours.

'Manufacturers are only interested where they see the biggest successes,' says Ratel. 'Even though we have the sprint series, they see the Blancpain as fabulous.'

However, what are the motives of the manufacturers that compete in these events? Are they just trophy hunting against their customers, robbing them of the chance to win big at these prestige events, or is this the portend of a long-term programme with significant support?

Factory teams are welcome at Spa, where performance is largely balanced by the conditions – this year at Spa less than half of the field finished – but allowing them to compete elsewhere is asking for trouble. For example, Audi was incensed at the Balance of Performance, citing the fact that the top R8 LMS qualified 20th overall, and that despite a puncture which caused a slow lap, the third-place finisher managed to get itself lapped six times by the victorious Mercedes. The fact that it was driven by André Lotterer, along with championship leaders Frank Stippler and Christopher Mies, only added fuel to the fire.

'Due to the current Balance of Performance, our teams were clearly unable to keep the race pace at the front,' said Audi's motorsport director Dr Wolfgang Ullrich. 'We were lapped several times which shows how big the differences due to the regulations were in the field. If even Audi's Spa winner from last year, Frank Stippler, Blancpain Endurance champion Christopher Mies, DTM champion Mattias Ekström and our two-time Le Mans winners André Lotterer and Marcel Fässler, were not in contention in this race, this leaves no doubts.'

The problem is, the Balance of Performance is critical to this championship as there are no tightly controlled technical regulations. BoP takes place at the start of the year at a tremendously expensive test at Ladoux, Michelin's test track, and almost all the manufacturers competing this year took part.

The fact that the Blancpain series starts with around 50 cars per race, and at Spa more than 60 started, suggests that the formula is right as it is, and to allow politicking in is only one potential side effect.

Allowing factory teams to compete in customer racing is asking for trouble

Gentlemen drivers don't want to be on track when the pros are taking risks and taking no prisoners in their quest for victory, because – Audi's argument aside – the BoP is pretty much equal across manufacturers who took part at Spa.

Also, the manufacturers will bring their huge hospitality units to the paddock, making those who spend a huge sum of money to go racing look like minnows, and that doesn't work either.

'We have never had factory teams in the Blancpain and the presence of Aston Martin Racing at Silverstone caught us by surprise,' said Ratel. 'Factory teams are welcome at Spa, but I am more reluctant to allow them at other rounds of the series. It is not regulated, but is reflected in the sporting rules. As always, it is not me deciding anything, not without consulting the teams.'

The manufacturers just want to cherry-pick the best races. As more and more of them eye up these big prizes, however, the chance of winning gets slimmer, and the arguments over BoP begin in earnest. For the amateur driver, that's really not why he goes racing.

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