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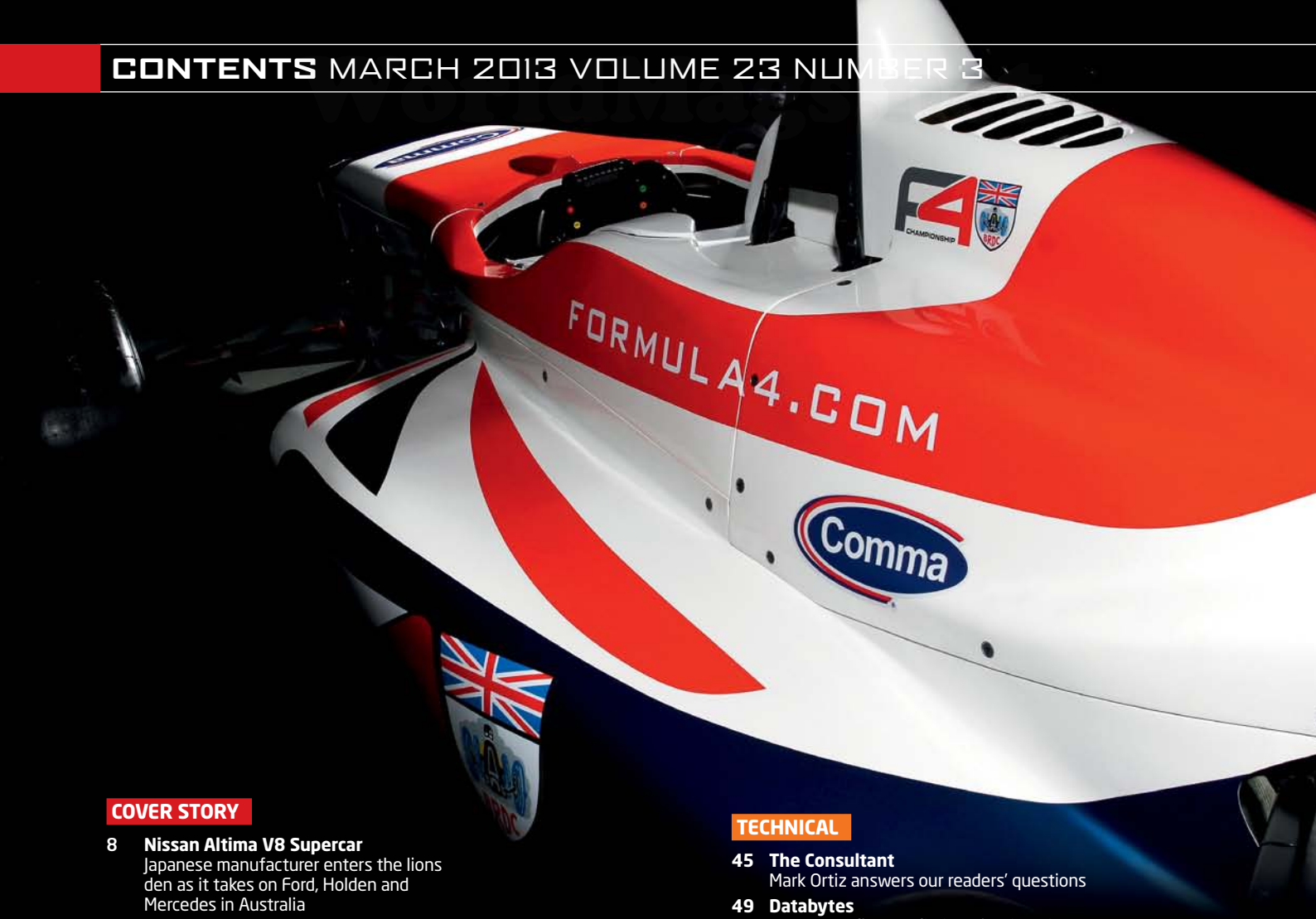

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Memory matters

Knowledge is power. Well, the bits you remember are, anyway...

Earlier today I awoke to find myself hurtling through space at 66,000mph on a smallish rock that was incessantly circling a giant nuclear fireball... And it being that time of year, in the fallow season, not having been to a track in three weeks, there was time left to reflect about where I was, and was going.

The year 2013 sees the 200th anniversary of Wagner's birth, but it does not mean we should expect the Götterdämmerung of racing, despite the problems facing the sport. A troubled financial environment, a dearth of jobs for freshly minted engineers and technicians, lack of sponsorship or income for teams, a struggling way of life.

As Dickens said in The Tale of Two Cities: 'It was the best of times, it was the worst of times, it was the age of wisdom, it was the age of foolishness, it was the epoch of belief, it was the epoch of incredulity, it was the season of Light, it was the season of Darkness, it was the spring of hope, it was the winter of despair, we had everything before us, we had nothing before us....' Looking over previous columns it seems I have expressed a rather dyspeptic view of the present, and of the future. This is, of course, a good indication of getting older – I remember my father saying roughly the same thing, the world was going to hell in a bucket, things were so much better before. But were they?

In my first forays into motor racing in England, in the late-60s, I used to sit in the pub with the mechanics, listening to the tales of racing in the 50s and early-60s, when everything was great. Callow youth as I was, I was enthralled to hear of the drivers, cars and procedures of a bygone age, but the underlying assumption was that racing had gone to the dogs, and was not was it had been. It is often remarked that we live in the past, as even in its unreliable form it is almost all we have. But our perceived past has changed, with endlessly recounted stories magnified into myth, before finally assuming the epic form of unreality.

But O! The aura of that re-invented past. To me the present then was really the interesting time, as I was racing and working with my erstwhile idols, breaking new ground in an innovating period, much as it should be to the new generation of engineers.

SO WHAT ABOUT TODAY?

The brain doesn't gather and store information like a computer's hard drive. Facts are stored first in the hippocampus, a structure in the brain about the size and shape of a shelled prawn. But the information does not rest there. Whenever we retrieve it, our brain writes it down again, and during this rewrite, it is also reprocessed. Over time, the fact is gradually transferred to the cerebral cortex and is detached from the context in which it was originally learned. As proof, you know that the capital of France is Paris, but you probably don't remember how you learned it.

This experience is known as source amnesia, and can also lead people to forget whether a statement is true. Even when an untruth is presented with a disclaimer, it is later remembered as true. With time, this misremembering only gets worse. A false statement from a non-credible source that is at first not believed, can gain credibility during the months it takes to reprocess memories from short-term hippocampal storage to longer-term cortical storage. As the source is forgotten, the message and its implications gain strength. Adding to this innate tendency to mould information we recall, is the way our brains fit facts into established mental frameworks. We tend to remember facts that accord with our worldview, and discount statements that contradict it.

Psychologists have suggested that legends propagate by striking an emotional chord. In the same way, ideas can spread by emotional selection, rather than by their factual merits, encouraging the persistence of falsehoods.

How do you like them apples, Isaac?

According to IBM, every day we create 2.5 quintillion bytes of data, so much that 90 per cent of the data in the world today has been created in the last two years alone. This is big data, and the problem is that the signal-to-noise ratio, the amount of meaningful information relative to the overall amount of information, is declining. We're not that much smarter than we used to be, even though we have much more information, and that means the real skill now is learning how to pick out the useful information from all this noise, and furthermore, the ability to weed out obsolete and mistaken data.

Physics and mechanics do not change, as Chapman used to remind us young engineers: 'You cannot change the basic laws of nature; no one has yet. Let Newton, Charles, Boyle, Bramah and Bernoulli rest in peace.' But the way you work and reason is amenable to review, deeply and often, not least because among all this new information there are applicable new insights.

Innovation means two things. First there's the matter of coming up with new ideas, strategies, and ways of doing work. That's the easy part, and the constructive side. The hard part is the destructive side. That's letting go of what worked for you six months ago, two years ago or for the past five years, bringing forward the fact that your reasoning skills are inherently based on pattern recognition, a powerful tool as seen in the approaches used in chess programming. Brute force and pattern recognition - a study found that the latter is how we (humans) play well. Surprisingly perhaps, brute force beats pattern recognition, but as you are not a computer, that is what you have. Having wrong facts in your store of information makes things worse. You will see erroneous patterns.

One can often think we are living in the most challenging of all eras, and that everything new, everything important, has been created in the last 15-20 years. If you can go back 2,500 years and see what Confucius, Buddha or Heraclitus were concerned about, you can see that today are we are wrestling the same problems. It helps to put a fresh perspective on what we're doing today, and the decisions we have to take. The cornucopia of knowledge available today opens huge horizons, and you kids are ideally placed to exploit it. Life is cyclical, and the next boom will be your oyster. To use a hackneyed cliche: 'Today is the first day of the rest of your life.' So go out and explore new things and new concepts, remembering, 'It was the best of times, it was the worst of times...'

Meanwhile I'll just go back to misremembering.

"The hard part of innovation is letting go of what's worked for you for the last five years"

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GT at the crossroads

Things look healthy on the track, but one false move could derail GT racing

Rather than analysing the reasons for a paucity of entries on race grids, it is pleasing to instead remark on the healthy and continuing growth of one major category of motorsport.

Surely GT racing has seldom been as popular as it is now? This past year there were more than 15 international and national series worldwide, and something like 100 regular entrants. Including one-make Cup machines, I estimate that more than 200 cars were sold last season, the majority for GT3.

Since Stephane Ratel, head of SRO, with the FIA, came up with the idea of balancing performance between cars rather than issuing strict and complicated technical regulations that favoured only a small number of exotica, a much wider variety of production-based cars has become suitable. GT3, as it was titled, stimulated the interest of manufacturers and teams alike. The resultant combination of close racing and recognisable supercars has increased the image, and GT racing has taken off. At the last count, 15 GT models have been homologated, almost all of which can be competitive in the right hands and closely retain their marque identity and roots. Balance of Performance is not universally popular, especially among those with more purist views. It's certainly not perfect, but constant adjusting seems to have attained its main objective – more manufacturers, more competitors, big grids and increased awareness.

Unlike the heady days of the 1950s and 60s, with evocative 250 GTOs and E-Types, GT racing has generally been more in the background, even though this is the area in which old hands Porsche – between forays into sports prototypes – and Ferrari have expended all their endurance racing energies for some years. Little surprise, though, that GT racing has been overshadowed at events such as Le Mans, and the highest-profile endurance series by the battling giants of Audi, Peugeot and more recently Toyota with their LMP cars.

Now, with GT events and championships in their own right, things are changing. The best-supported Europe-wide GT series, Blancpain, has consistently delivered grids of more than 50 GT3 cars which, in a time of austerity, is quite amazing. Most European countries boast GT series or events of some kind as does of course the USA. Asian and Middle Eastern regions are getting in on the act as well, so for the teams the potential for creating income throughout the whole of each year makes running a GT3 operation highly attractive.

GT racing is a huge growth area during this recession, but can it last?

Consequently, Mercedes-Benz, Audi, BMW, McLaren, Corvette, Aston-Martin, Lamborghini, Nissan and now Bentley have joined Ferrari and Porsche in the GT3 manufacturers 'club,' seeing an opportunity to not only keep exposing their brand image while satisfying the requests of their wealthiest and more sporting customers, but also to make a profitable business out of selling race-prepared cars and parts.

There are more wealthy and younger people in the world than ever. Stereotypically, these folk have short attention-spans, expect excellence without excuses, and demand a fair amount of ego-massaging. But, thankfully, a percentage of them like to go motor racing. The inherent safety of modern GT cars and circuits combined with driver aids and professional team standards gives them what they want without too much likelihood of hurting themselves, or looking hopelessly uncompetitive. Thus, the business model that GT3 racing fits, particularly exploited by Blancpain, centres around attracting these wealthy gentlemen drivers to turn up and drive Friday through Sunday at F1 circuits. They can compete against 'name' drivers in exotic cars, socialising and having a fun weekend as a key factor, but be back at their corporate desks on Monday morning.

However, GT racing is not just about GT3, and not all is sweetness and light. SRO's attempt to promote and operate a GT World Championship failed, although Ratel is attempting to replace it with the GT Sprint Series, now re-dubbed FIA GT Series. There is currently a heated debate between the ACO and SRO over the former's proposal that GT3 and the more elite class of GTE (formerly GT2) should be merged into one, most likely a 'GT3 Plus'. SRO fears that this will be to the detriment of the grid sizes, and that the quality of the racing will revert to its status before he had his brainwave.

"Balance of Performance is not universally popular, especially among those with purist views"

Some manufacturers and those teams with higher aspirations than just making living prefer to race more technically-sophisticated cars. They see the 'equivalency' factor at the heart of GT3 as penalising performance and success. While there are waivers granted or taken away in GTE, it is felt that this is done in a less arbitrary way. This is certainly the position of Ferrari and I believe Porsche also, although they both fully support GT3 as well as GTE. They see GT3 as the 'commercial' class, GTE as the important leading-edge showcase for the brand.

Bizarrely, GT3 lap times often beat GTE simply because GTE engines are more restricted and can have up to 100 bhp less. The ACO has problems with GT cars exceeding 300kph at Le Mans in particular, making it hazardous for the LMP2 cars to overtake. Therefore my expectation is that the GTE proponents would like to see GT3 perform at a lower performance level to redress this anomaly and kept out of Le Mans and the WEC, while retaining GTE more or less as it is now, the top rung of GT racing. But, America being the biggest market for most of these manufacturers, the Grand-Am/ALMS merger decision on GT regulations is keenly awaited and may well affect the shape of GT racing to come outside of the USA.

One solution could be to retain two classes but using the same 'core' car and engine etc which can be configured to either class by a suitable kit of upgrade parts. More positive discussion and decision-making must take place to resolve this soon. It would be a great shame for all concerned for the GT bubble to burst prematurely.

Nissan's super Altima

How the Japanese marque's Australian V8 Supercar went from concept to reality

BY STEFAN BARTHOLOMAEUS

"We've had to create some pretty funky scallops in the front bar to find the downforce required"

It's just as well that a change is as good as a holiday, because the V8 Supercar Championship's move to a new set technical regulations for 2013 didn't leave its teams much scope for an off-season break.

All 28 cars on the grid at March's series opener in Adelaide will be of the new Car of the Future variety, as the category attempts to become more cost-efficient as well as more attractive to car makers outside of Ford and Holden.

Despite the COTF concept having been publicly launched as long ago as March 2010, Nissan remains the only new marque to commit to the class. Mercedes-Benz will also be represented this season, but only through a privately funded AMG customer programme that ultimately went ahead despite the reservations of the car maker's Australian division.

Nissan's push to join the championship saw it back former Holden squad, Kelly Racing (now rebranded Nissan Motorsport), in a deal signed last February. This left the Melbourne-based team with 12 months in which to design, build, test and homologate its engine and body package around the COTF's control chassis before the start of the car's first season.

'It's all very well to do a lovely deal with a new manufacturer, but once you walk away from the boardroom you've actually got to implement it,' says team co-owner and driver Todd Kelly, who also holds the role of racing director within his squad's engineering structure. 'Time was not on our side from the start, so we couldn't afford to take the work involved lightly.'

As detailed in REV22N11, Kelly's team has developed a bespoke V8 Supercar version of NISMO's FIA GT1 World Championship-winning VK56DE V8 engine, receiving technical support from the Japanese factory along the way. Although the COTF engine rules were opened up to allow quad-cam, aluminium powerplants to race alongside the existing pushrod, cast-iron units, the need to adopt several key requirements for the ease of parity, including a 5-litre capacity, 7500rpm rev limit and 10:1 maximum compression ratio, ensured the engine programme would be a major task.

DRAWING PARALLELS

The adaptation of the Altima body to the chrome-moly racing chassis was also a somewhat daunting prospect for the team. First and foremost, it required the

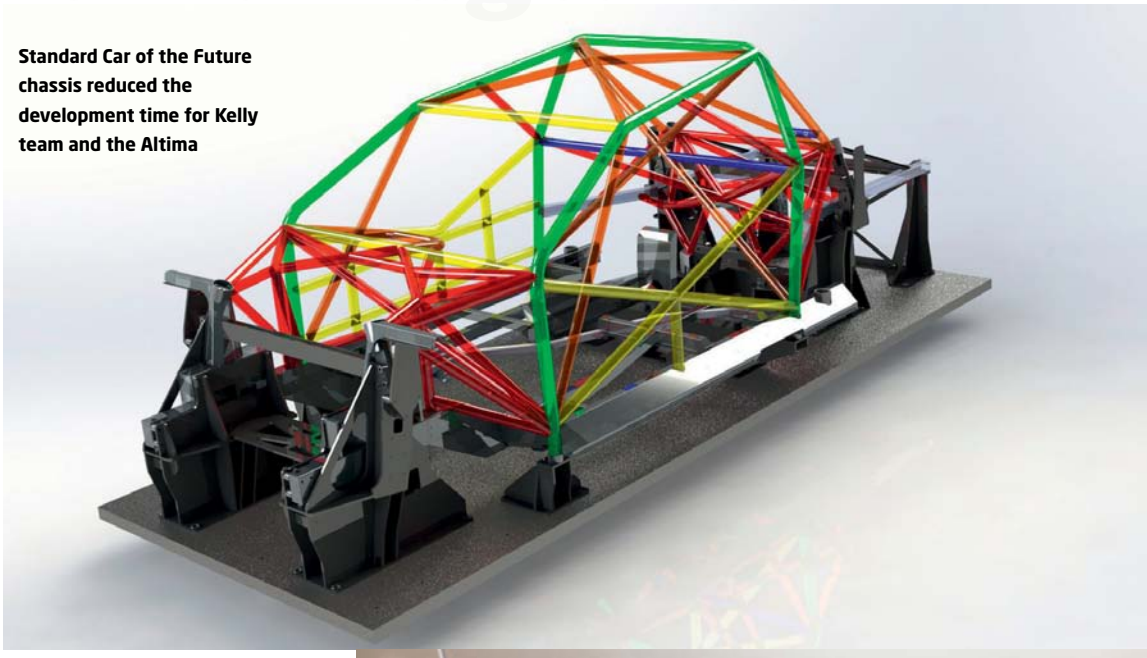
"The windscreen angle is a little flatter and the seat a lot further back, so when you first hop in it feels really weird"

necessary Computer Aided Drawings of the road car from Nissan – a request complicated by the fact that, when the process needed to begin in February, the to-be-raced model was still some months away from production. The Nissan V8 Supercar programme therefore began with a flurry of communication between the race team and the company's headquarters in Australia, Japan and the United States in order to source the relevant drawings.

'Nissan were fantastic in getting us through all the non-disclosure and confidentiality agreements we needed in order to start getting some of the CAD of the car before it was launched,' explains Kelly. 'The whole process was a big job. Firstly we had to describe exactly which files we required, because the CAD of the car comes with door linings and carpet for the floor and so on, and the size of all those files is ridiculous. They had to start getting those files over to Australia and get them to a stage where we could read them on our CAD system.

'Even though the process went really fast to gear us up to get the CAD, actually getting it on our screens so we could work on how to position the bodywork on the cage was weeks of phone calls between Australia, Japan and America. We really started the design of the car with only dribs and drabs of the CAD. We didn't get to the point where we had a full car until well into the design, because we'd focussed on getting all the key files unpacked that were going to hold the process up.'

There was another, fundamental, problem: 'We had outstanding design capabilities before the Nissan switch. We had the FEA, the CFD and all of those bits and pieces that Autodesk offer, but what we didn't have was the volume of everything. We had three suites of it for three full-time design guys. For a while there we were just hammer-and-tongs, ordering new computers and getting on to Autodesk to send more licences through for each suite.'



Standard Car of the Future chassis reduced the development time for Kelly team and the Altima

By early March the team was (digitally) positioning the Altima body on the chassis – a task Kelly says was easier than expected. While the team, as with all Holden squads, previously had to cut and rejoin key items such as the rear doors and roof skins of its Commodores to fit the now outdated generation V8 Supercar platform, the Altima body slides on to the COTF with its door and roof dimensions intact.

'Other than a little bit of scalloping around the roll-cage, it (the Altima body) fitted straight on the car – we haven't had to shorten the car at all. The bootlid, bonnet, roof skin, all that stuff is absolutely stock as per the manufacturer in terms of dimensions. All we've done is widen the rear guards, which is a flare that runs through the rear bumper, the door and the side-skirt, and then lengthen the front guard. But we have to tool up and make that stuff from scratch anyway, so it's no problem in terms of manufacturing.

'We were lucky that the shape of the car fits the rules so well. The only thing that wasn't ideal was that we actually had to raise the body on the chassis a little bit for clearance on particular parts on the roof and the roll-cage where they clashed.'

The 5-litre V8 engine is a development of the GT1 powerplant taken from the GTR, a reducing the cost of Nissan's participation in the V8 series

HIGHER LEARNING

While the position of the engine in the chassis is identical across all COTF vehicles, the extra height of the double-overhead cam engine sees it come perilously close to the bottom of the windscreen. Naturally, this provided an extra challenge for the design of the inlet manifold, while the airbox has been curved and trumpets crossed over to suit.

The airbox being hard up against the screen also means doing engine changes through the bottom of the engine bay rather than the top, although Kelly insists this isn't the drama that it sounds. 'When you actually do it a few times it's probably easier than it has been with the old cars,' he says. 'Without the gearbox and all that hanging off it [the COTF sees a move to an Albins transaxle] you just drop the cross-member and the bottom arms off it. The radiator and the rack of the power steering and the whole assembly can stay intact. So the engine can actually leave the engine shop with the steering system bled and cooling system bled, ready to go straight in the car.'

Nailing down an aerodynamic package that both matched the figures of the Ford and Holden and pleased Nissan aesthetically was, predictably, not an easy job. Despite the best efforts of the design team (led

"For the amount of stuff we've had to design from scratch and make in-house to turn into a part on the car, it's been unbelievably reliable so far"

by Englishman Alex Somerset) with CFD, the inevitable process of physical trial and error was highly time-consuming.

'That was huge,' says Kelly of the effort required to retool and remake different bodywork between open-air tests. 'The side-skirts weren't so bad – we only had three variations of that to get approved both through Nissan and V8 Supercars, but the work involved in the front bar design was massive.

'The way the shape of the car is and the way we've had to position the body is quite unfavourable to match the downforce that the Ford and the Holden produce. We've had to create some pretty funky scallops in the front bar to find the downforce required. To get that right we've done a huge amount of work. We had an extensive list of tuning options we took to the group aero test as well to try and match it. That front bar was probably five months work, nearly full-time, to get to the final version.'

Although the absolute final tick from V8 Supercars won't come until the homologation of the Mercedes is complete, minor trimming of the strip on the back of the front undertray or the rear wing's Gurney flap are all that is expected to be necessary, allowing the team to have already put its bodywork into full production.

The Altima's first track running occurred in early November, just days after the car's public launch. The category's tight testing regulations, however, mean that track work will be limited to just a handful of days prior to the first race meeting. Reliability, therefore, has been highly important to the team's ability to evaluate the car, including gaining an understanding of the independent rear suspension and 18-inch wheel/tyre package that's now standard across all entries.

'For the amount of stuff we've had to design from scratch and make in-house to turn into a part on a racecar it's been unbelievably reliable so far,' says Kelly. 'I was almost expecting to be chasing a lot of dramas at this point with something so new.'

Testing has been completed by Rick Kelly, the original development driver when COTF was first announced

KELLY'S HEROES

Unfortunately for Kelly, the former Bathurst 1000 winner has been unable to undertake any serious testing himself as he continues to recover from shoulder surgery following a training injury last year. The bulk of the running has instead been undertaken by his younger brother and fellow team co-owner/driver, Rick.

Although Rick drove V8 Supercars' own Holden COTF prototype during the category's tyre development process in 2011, he says it's difficult to draw accurate comparisons with the on-track feel of the Nissan due to the amount of time that had elapsed between the two tests. The seating position within the car, however, is rather distinctive.

'The thing that you notice straight away is that the windscreen angle is a little flatter, and the seat is a lot further back, so when you first hop in it feels really weird,' he says. 'Your feet, and the driving position, are about a foot behind the windscreen rather than underneath it. So it's a bit daunting when you first sit in there, but like most of those things, as soon as you drive out of pitlane you don't notice it any more.'

All of the initial running is being completed with a single test car. The remaining three that will make up the team's four-car attack will then come together in quick succession in early February.

'Our process was to make pretty much one of every single thing on the car and then modify all the major components such as the steering rack, uprights, cross-members and so on as necessary,' says Todd Kelly, who also points out that his is one of multiple teams that has had to change from front-steer to rear-steer steering racks due to the new rules. 'Once each one has been ticked off we've started the full production parts. So six to eight examples of all of those components will lob in the build shop within a day of each other

Q&A WITH NISSAN'S DARREN COX

Why the Altima?
We are just launching it out there – it is a brand new life cycle, and it fits with the rules. If you look at a cost/benefit ratio, that is probably the best money we are going to spend this year.

In terms of hardware on track, this project is the best investment. It is what people want to see in the Australian market as well as elsewhere. Surfers Paradise and Bathurst see some great racing, they have a great package. Even if it is on a national basis, it is still value for money, and I can defend that until the cows come home.

They have tried to expand the series to a foreign market. In my view, why take a national championship over the borders when actually most of the people you want to attract won't go to the race? They'll watch it on TV, so get a bloody good TV package, and take that to the people.

Is there a good reason to have a race in the US?
Not for me as a manufacturer looking at the Australian market. You get 10 times the crowd in Australia than in America. If you do go to a different country, it has to be a five-year deal. You have to do the race on the same weekend, same format, same cars, same drivers, and then you see a return. If you do two years, you're wasting your time. We love Australian V8s because they are in Australia and because they are quirky.

Are you worried about the Australian reaction to Nissan?
Absolutely not.

Are you enjoying it? Will you get Jim Richards to call the crowd a pack of arseholes again?
Probably not a good idea to repeat that, but I think the T-shirts at Le Mans summed us up. The best things in life are doing the things that people say you can't do. That was DeltaWing, GT Academy, Qashqai, Juke, Leaf and it sums up Australian V8s. We are going racing and it was a free world last time I checked. We have got a lot of fans in Australia. The current guys watching the championship might not be overly pleased that we are there, but I think it will bring more spectators. I think it will be popular for the series, and they needed it. It has helped the championship, and that has got to be a good thing.

We will promote the championship because of our participation in it. We will spend money in the local economy with the local guys, and in the local championships. Manufacturers will spend money to promote the championship, and we will do the same.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Nissan's arrival has been controversial, and fans have reacted badly on the forums, but Nissan says that it will bring a new fanbase to the series

and we'll finish three cars in a day. But in the meantime there's no real chance of getting one car finished quicker than that.'

Category regulars Michael Caruso and James Moffat will join the two Kelly brothers in the four-car lineup having made the switch from Garry Rogers Motorsport and Dick Johnson Racing, during the off-season respectively.

Naturally, there has been much talk among media, fans and the remainder of the V8 Supercars paddock alike about the results that the Nissan team will be able to achieve next season. V8 Supercars has enjoyed one of the tightest fields in global circuit racing during recent years, with the whole grid separated by little over a second at most circuits. While this spread will undoubtedly increase as teams, regardless of manufacturer, get to grips with the refreshed technical package, the window in which to fall into isn't exactly going to be large for a new player.

Ongoing engine development is likely to have a major bearing on the car's performances during its rookie year. The already homologated motor is currently several horses shy of the 640bhp ballpark figure needed to be competitive. This should be clawed back with development, although a concession, such as increased revs or a camshaft tweak, may be required to ensure a level-playing field in the short term.

EARLY EXPECTATIONS

'We'll go into the first round with a conservative approach,' says Kelly of his expectations, noting that the season-opening event on Adelaide's former Grand Prix hosting streets is traditionally one of the hardest in the championship.

'Priority number one is to have all four cars finish at the Clipsal 500 and start the year with a good points base, but at the moment it's just one massive unknown what sort of pace our car is at compared to others.

'We've been pretty impressed with the car so far in terms of the suspension, the geometry and the whole undercarriage of the car. If we get the engine to where it needs to be, there's no reason why we can't set our goal at the highest level possible. It should just be a matter of how good a job we do tuning the car, and we've certainly got the right people in the right places doing that. We'll start off conservative, but we'll certainly have some pretty big goals that we want to achieve through the course of the year.'

Having described the first Altima as 'the most impressive racecar that V8 Supercars has ever seen' at its launch, one can't help but feel that Kelly is looking forward to showing off his new toy at the first event almost as much as he's looking forward to racing it.

'The technology, the build quality, the attention to detail... everything about this car sets a new standard for V8 Supercars,' he says. 'It's the highest quality I've ever seen in a racecar in Australia and I think you could put it next to any racecar in the world and get complimented on it.'

"Everything about it sets a new standard for V8 Supercars – it's the highest quality seen in Australia"

TECH SPEC

Chassis: Nissan Altima V8

Championship: Australian V8 Supercar

Weight: 1345kg

Fuel capacity: 75 litres

Suspension: Double wishbone, front, four link rear, cockpit adjustable anti-roll bar front and rear

Dampers: Sachs

Clutch: AP Racing triple plate carbon 7 ¼ inch

Brakes: AP Racing

Wheels: Rimstock control 17 inch x 11 inch magnesium alloy

Tyres: Dunlop control tyre

Transmission: Six speed sequential Holinger gearbox, Australian-made

Data Acquisition: MoTeC

Engine

Number of cylinders: 8

Displacement: 5-litre

Power: 635bhp limited to maximum 7,500rpm

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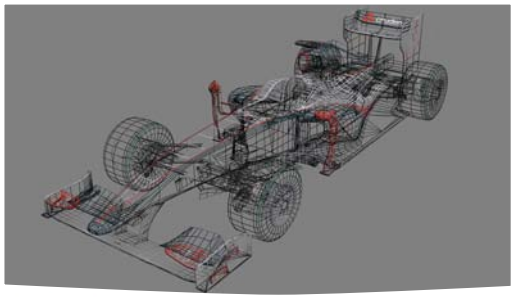

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The next giant leap for diesel?

With SkyActiv at its heart, hopes are high that the GX Mazda 6 will create as many ripples on track as it's making on the test bench

BY MARSHALL PRUETT

Diesel racing technology has become almost commonplace after years of dominance by Audi and Peugeot at the prototype level. Oil burners have also made their way into production-based racing with SEAT in the World Touring Car Championship, but it took the formation of Grand-Am's new Rolex GX class to produce a proper works diesel GT program.

Mazda, in conjunction with the Florida-based SpeedSource team, became the first manufacturer to compete in the new-for-2013 GX class, a category created to house GT3-style cars, and entice alternative models that aren't a natural fit for Rolex GT competition. With production having stopped on Mazda's RX8, the choice was made to bid farewell to its triple-rotor Rolex GT counterparts, and build for the future with its SkyActiv diesel technology at the forefront of the project.

'A little over two years ago we knew that the rotary, as fantastic a history as it has had, was ready for a new presence in Grand-Am,' said SpeedSource owner/driver Sylvain Tremblay. 'It was a new philosophy coming from Mazda, and we had to fully understand what SkyActiv was. It is more than the powertrain. It's gearboxes, the way of building cars, thinner steel, stronger steel, the entire way of looking at a car. It was incredibly similar to how we look at building a racecar. If you look top to bottom, where can they make improvements, where can they make gains on efficiencies, on weight, on strength? That's this entire SkyActiv technology.'

John Doonan, Mazda's motorsports manager, also saw the opportunity to follow its tradition of rotaries with another-less-than-conventional racing powerplant.

'The new SkyActiv Mazda 6 GX programme is more fully integrated with marketing, engineering, and the overall communications of the company than anything we've done before,' said Doonan. 'So when the idea of SkyActiv was introduced, we were challenged by our executive team, which represents marketing, communications and engineering, to produce a motorsport programme that would be a tool in their toolbox.

'Specifically, as we did with the rotary for years – that was Mazda being nonconventional, and this really became the opportunity for us to open up the next chapter and become the first Asian automaker, and frankly any automaker, to bring a truly production diesel racing engine to the racetrack.'

DIESEL CONCEPTS

Tremblay's SpeedSource team had delivered a championship, and numerous Rolex GT wins, for Mazda, and had also taken a lot of the RX8 construction and R&D in-house. With the new SkyActiv racing initiative, everything from designing and building the tubeframe chassis to developing a pool of brand-new production-based racing engines was placed into his care.

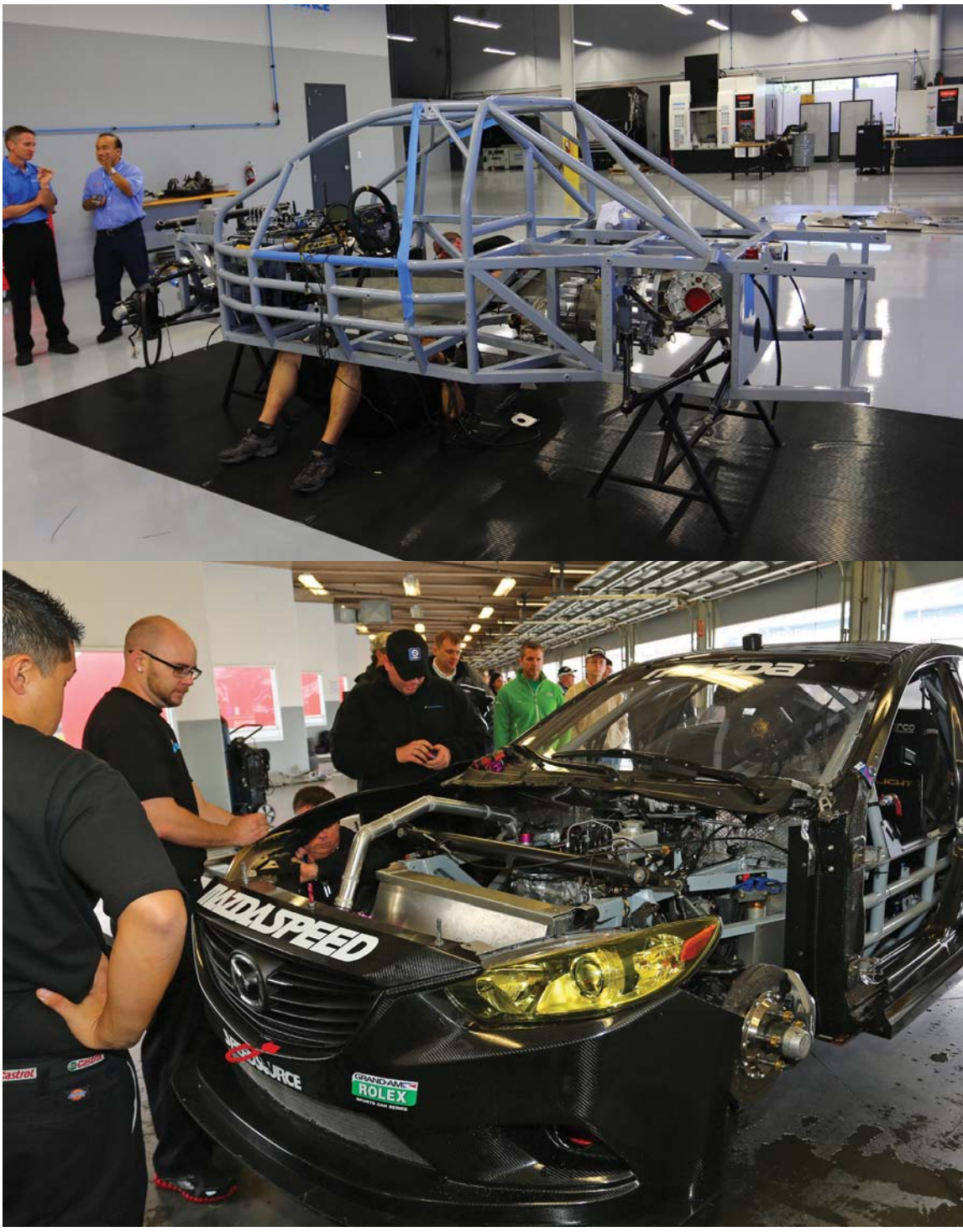
Enter a commission for the silhouette version of the 4-door 2014 Mazda 6 with a 2.2-litre bi-turbodiesel at its heart.

'When I first heard it was going to be a diesel, I was very excited,' said Tremblay, 'but as soon as I caught my breath, I was scared to death. It's a huge undertaking to use a stock block diesel for motorsports. As we did more and more research the potential is amazing. Diesel technology has been proven to still have a huge amount of room in terms of development. The internal combustion engine is a wonderful, highly-tuned machine. But diesel technology, even though it's older than gasoline, is just starting now to reach part of its potential because of the electronics. So it's really been the impetus of why this works now and why this didn't work 10 years ago.'

"As we did more research, we found the potential to be amazing"

Without the luxury of designing a bespoke diesel powerplant for the GX Mazda 6, Tremblay says he was pleased to find how suited the stock unit was for a motorsports application.

'When Mazda engineering told us that they were going to have the lowest compression diesel, we didn't quite understand what that was about,' he said. 'As we looked at what they were trying to do – which is basically a diesel without any after-treatment – then the low compression makes sense. As we started seeing the first CAD drawings of the engine, we were instantly amazed at the huge jump in quality and detail that Mazda did on the casting, on the engineering, on every single aspect – even the length of the capacitors for the engine, they looked at every single thing. That encouraged us that the pieces would be strong.'



The tubular steel chassis of the '6' is essentially the same as the Riley MK XXIV Mazda RX8 which won its class in the Rolex 24 in 2010. The first of the new cars was built 22kg underweight with later versions even lighter, partially due to a lightweight composite body. Note the NASCAR style door bars

DIESEL DEVELOPMENT

Starting with the European spec Mazda 6 2.2-litre diesel as a development baseline, SpeedSource used the 'R2D' diesel unit until Japan was able to seed the GX programme with an initial batch of engines specifically for the GX class.

'We did a lot of development to try to get to the curve of the power that we needed to make,' said Tremblay. 'Initially, we were going to use this for GT, so we had a 450hp target and the 550 foot-pounds of torque was what this was made for. We did some more development, a lot of simulation, obviously, using ANSYS. We brought that process in-house about a year-and-a-half ago and were able to simulate, and do in-cylinder combustion, airflow, mass analysis, transitional – everything that you can do in the computer, at a much faster rate.'

The Mazda factory's commitment to GX was most evident when it came time for Tremblay to get started on the race-engine programme.

'Mazda has such great support for this engine and this programme that engine 001 came here to our building – their very first engine,' he said. 'And then 002, 003, 004 and 005 followed. So when we created the engines in October, we were amazed that the engines themselves were the first five off the production line.'

With Grand-Am looking for the diesel GX Mazda 6 to come in some 70hp under the 450hp GT cars, SpeedSource was tasked with hitting those numbers and tailoring the drivetrain components to match the application. 'We looked at all the particular aspects of it,' said Tremblay. 'The big unknowns to us were the amount of torque that the engine could produce, which came back to the development that we had done on the R2D. So with that, we had some pretty good torque ramps, and enough data to know that the current drivetrain in the RX8 was not going to withstand the torque loads of this new engine. So we went back to EMCO. They had basically a P1-style gearbox, which uses the same internals as the RX8, but the externals have stronger bevels and it has a drop gear because of the RPM limit. So we went from shifting at 8600 to now - we're shifting at 5000.

'We were able to use the same outboards – the uprights and the axles – and based on the changes to the gearbox, we changed the way we do the drive shaft and the clutch housing.' Compared to the low, squat footprint of the

The engine was the real key to the car's development, and indeed is the reason the car even exists (top). A new Alcon brake package was fitted to the car further reducing weight (above)

RX8's triple-rotor engine, the 6's inline-4 required a completely new solution for packaging.

'Once we had the running gear of the car sorted – the new brake package by Grand-Am; the new gearbox – we still had this new engine to develop and to understand how to package it. So cooling is a huge issue and we're still optimising that because with this compound turbocharger, which is the first motorsports application that we know of, with one turbo that turbocharges the other one, you compound both boost numbers from each turbocharger and that gives you your manifold pressure. So we needed to have two intercoolers.

'We tested early on some liquid intercoolers and always came back to this air-to-air ratio. We're still playing with percentages of high pressure and low pressure. So it has an intercooler the size of the radiator.'

Lowering the mounting of the production engine in the RX8-turned-Mazda 6 chassis was another major challenge.

'Luckily for us, the SkyActiv 2.2 is a very small package. It's not a very heavy engine because it has an aluminum block, but we had to make our own dry sump system and try to integrate the front mount and lower pump. We've made the integrated dry sump oil pan/forward mount to mount all of it. That's an in-house designed and built piece here at SpeedSource. So it's a huge chunk of billet to make that particular part, but it also stiffens the bottom end of the engine because this is a split cradle type engine, so the block itself is really a two-part block. This helps stabilise that particular aspect of it.'

PUMP PARTICULARS

'When we looked at motorsports application, we wanted to increase the safety factor and the rigidity, because we still had the plan of using this particular package for an LMP2 possible programme. We looked at different water pumps and, the most efficient was the production pump. We have a relatively nice carbon fibre valve cover to try to keep the mass as low as possible. We looked at relocating the alternator. The alternator now is driveshaft-driven off the rear of the engine – that would able to compensate for the weight.'

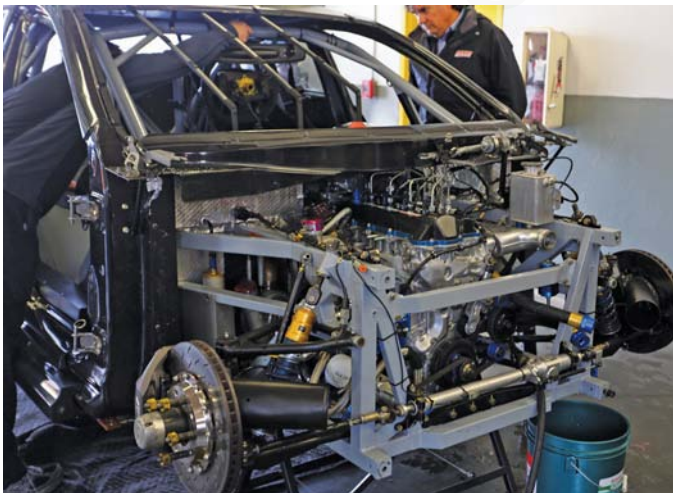
With a more complex fueling system required for the SkyActiv engine, Tremblay sought the help of Bosch Motorsport to provide a few solutions.

'You would be hard-pressed to find a more experienced partner that has more miles with diesel motorsports than Bosch,' he remarked. 'So that being said, we designed with them in mind of what we needed to do. Obviously, the high pressure pump – the heart and soul of this particular engine – is a huge part. It's driven off the exhaust camshaft and is rearward of the motor, which is great for weight distribution, but packaging was a still little bit of an issue.'

The fuel consumption merits of diesel fuel are somewhat mitigated with the use of a series mandated 14.5-gallon cell, but Tremblay's team and Bosch worked hard to maintain an advantage. 'The fuel supply needed actually decreases a considerable amount because this engine is roughly 30 per cent more efficient than a gasoline engine,' said Tremblay. 'The real work went into the fuel rail itself and the high-pressure fuel lines. Our injector pressure right now is at 2400 bar – 30,000-plus psi, feeding these injectors. So it was a huge challenge to find something that would withstand

the vibration and would be repeatable from one engine to the other. We've had to make a CNC fuel rail mount that we feed to the middle port and then each cylinder from either side of that port. To engineer all of that, Bosch's experience was instrumental in us getting it right on the test bench. They made a big difference.'

The final piece of the packaging puzzle came with the placement of the twin Garrett turbos and their accompanying TiAL wastegates. 'The weight difference between this engine and the rotary is about 35 pounds more, because now we have two turbos,' said Tremblay. 'The larger turbo is low and then the exhaust system is much lower. So we looked at not only at the engine, but all the ancillaries. The rotary is a light engine, but it must carry a tank-sized muffler.'



The turbo diesel engine replaces the RX8's triple rotor, a first for Grand-Am. The drivers shift through the EMCO gearbox at just 5,000rpm.

The Mazda 6 production car is front wheel drive, but the GX version drives the rears, a difference you would never find in GTE!

CHOOSING A CHASSIS

Mazda's fleet of factory Rolex GT RX8s started life with rolling chassis provided by Riley Technologies before SpeedSource took the majority of the programme in-house. Due to the number of RX8-bodied GT cars, the choice was made to base the Mazda 6 programme from the Riley-SpeedSource tubeframe cars.

'We wanted to make it as easy as possible for our RX8 teams to convert to the Mazda 6 GX,' said Doonan, 'so we felt working around the current chassis concept was the best solution for everyone. We've already seen a big response.'

In addition to SpeedSource building brand-new chassis, Tremblay's outfit came up with a limited number of modifications needed to update RX8s.

'We had a huge amount of knowledge on the chassis, and we knew that developing a new engine is a huge task, so we didn't want to have to develop a new chassis at the same time. The aero is slightly different, we have some different brake package allowances and we have some different wheels specifications that we can use, but it's very close to the former chassis package. It made calendar sense, also it made overall programme sense that we would convert the cars, so we had to lengthen the wheelbase about six inches. The width, however, stays about the same.

'To get to the proper target weight we used the tried and true tube frame formula, and have a carbon fibre body shell put on top of the frame. We knew we would hit the proper weight target. Unfortunately, we're not as light as the RX8, but we have a target weight of 2450 from Grand-Am, and then we were able to build the first car right at 2428, so we need some ballast, but obviously every car after that will get better.'

Practical changes to the RX8 chassis were required, but SpeedSource tried to keep the surgery to a minimum. 'We tried to keep the survival cell, which is the main hoop and then the A pillars and the B, which is the cage,' said Tremblay. 'The only thing that was changed was the C pillar. So, because of the windshield angle and the actual size of it, the front of the windshield got moved forward. Even though it looks like the driver has been moved rearward, they've not. We kept the firewall from the RX8 to this engine. This engine is much shorter than a three-rotor motor, so once we installed that as ground zero, we could keep the same drive line length because we lengthened the car from the cage rearward. But frontward, everything is the same. However, the cab, because there is a much larger greenhouse area, goes forward more and actually goes rearward too, so now we have full-size rear doors, not the clever half size doors that the RX8 has.'

Looking at the remainder of the GX Mazda 6, a number of familiar items carry over.

'It's Riley uprights, front and rear, so the same DP-style bearing carrier on the rear that we've used. We've used Dynamic's DSSV dampers with the same adjustability that we've built in over the years. We've slowly modified the design and improved it, both at the front and the rear of the car – but it's technology that we're comfortable with.

'We've had to change some packaging issues because of intercoolers. We went from a top-mounted front antiroll bar, and were not at a lower height, but with packaging we couldn't do that. So we went back to where we were when we had the car in 2006-2007. We've changed the antiroll bar location and the blade length to try to lower the C of G of the car. Of everything else, the only difference that's really made for this new GX car is the fuel cell, which is an ATL piece that was designed in-house, fabricated by ATL. It's very small and very low to

"It's roughly 30 per cent more efficient than a gasoline engine"

TECH SPEC

Chassis: Mazda 6 GX

Championship: Grand-Am GX

Body: SpeedSource/Crawford Composites

Weight: 2450lb (min)

Fuel capacity: ATL 14.5 gallon

Suspension: Double wishbone front and rear

Dampers: Dynamics DSSV

Brakes: Alcon 355mm front, 328mm rear

Wheels: BBS one-piece aluminium

Tyres: 285/645 R18 front; 305/660 R18 rear

Data Acquisition: MoTeC, ADL, Bosch

Dimensions: Length 194.3 inches, Height 51.1 inches, width 74 inches

Engine
Number of cylinders: Inline 4 compound turbo diesel

Displacement: 2191cc

Bore: 86mm

Stroke: 94.3mm

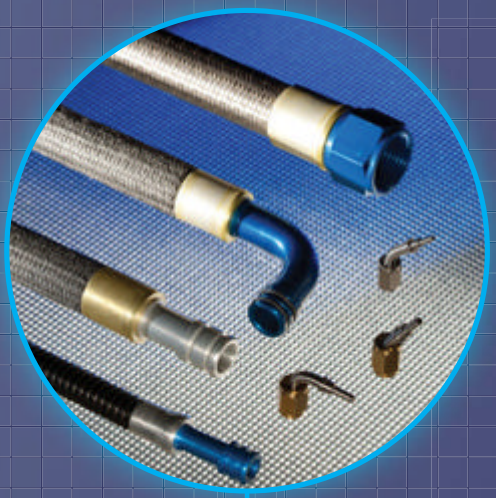
Turbochargers: Garrett

Con rods: Carrillo

Crankshaft: Pankl Racing

ECU: Bosch

CONNECTING INTELLIGENCE



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SKYACTIV P2 DEVELOPMENT

Mazda planned to unveil a customer SkyActiv diesel P2 engine programme to run alongside its Grand-Am GX cars, but the decision was made to delay its entry into the class at the 2013 24 Hours of Le Mans while development continues with a more prototype-specific diesel powerplant.

'One of the big things that we looked at is to make sure that we could do parallel development,' said SpeedSource owner Sylvain Tremblay. 'So we had a high cylinder pressure number for all of the component designs. And we really feel that the bottom end for the GX engine is overbuilt, but we also think it's built to the right specs for an LMP2-style engine. The biggest thing is going to be packaging and that's going to be the biggest challenge in P2. A lot of that is basically with crank height, so the lower the cradle on this particular car does not afford us to have an LMP-style crank height.

With the original goal to supply GX and P2 cars with the same 2.2-litre 4-cylinder bi-turbodiesel having morphed into two separate development streams, Tremblay's company will continue to design and test the components necessary for P2 competition. To aid the fitment and testing requirements with the motor, SpeedSource has also purchased a recent P2 Lola that will serve as its on-track R&D mule.

'The bottom end of the engine will have to be redesigned even though it's a stock block, but the oil pan, the bearing carrier – all of that will have to be changed to get to the right crank line. The rest of the externals, other than the mounting – depending on what valve cover we use – will stay pretty similar. The turbo packaging will change. It may change the intake manifold because now we're going from a forward entry to possibly a side or rear entry to try to package intercoolers.

Really, if you look at it, the internals will stay relatively the same. We believe the crank rods, piston package and valve train package will stay identical from one to the other. But the package on the turbochargers, the dry sump system to lower the crank size and also all the accessory drives will be substantially different on an LMP2 motor. Power-wise and electronics-wise, I think that we will be able to hit those targets without much of an issue. We've been able to do that here on the dynamometer.'

"We want to send a North American team to Le Mans in LMP2 to try and have some success"

Mazda motorsports director John Doonan also confirmed that the manufacturer intends to implement a customer-friendly lease programme with the SkyActiv diesel P2 engines – similar to its previous MZR-R P2 programme – once SpeedSource finishes the units for competition.

'Our intentions are twofold,' he said. 'We've always made a point from our grassroots programmes to our top-level stuff to try to be a customer programme, whether it's engines, cars, packages overall, from spec Miata to Le Mans. And I've always been challenged. If we're going to do something, it's got to support the bottom line. And so the GX car is an example. We've sold some conversion kits already, three of them in fact. Three of the cars that will be competing in Daytona are converted RX8s owned by customers.

'P2-wise, we did take a step back and, with the support of our executives, focused on GX and the Mazda 6 for now. But P2 is moving forward. And we plan to have a car on track probably middle of the year testing. Sylvain invested in a Lola just to get a car out on track and begin testing and development.'

Doonan also confirmed Mazda has designs on a return to La Sarthe with at least one works entry to try and add to the legacy of its overall win with the 787b back in 1991. 'Yes, this is a customer programme, but without a doubt we want to send a North American team to Le Mans in LMP2 to try to go there and have some success.'

And when it happens, don't be surprised if Sylvain Tremblay's team is there leading the charge.

the ground, there's so very little change to the chassis dynamics as the fuel load changes.'

The most distinctive visual aspect of the GX Mazda 6 is its 4-door sedan body shape. With the help of Mazda, SpeedSource and Crawford Composites, a new shell was created to tie the SkyActiv programme together. 'Mazda Design has been involved since the beginning, of what we could do design-wise,' Tremblay explained. 'They were instrumental in helping us really adapting their beautiful shape to motorsports. It's always a battle, form or function – there were certain areas that we had to have and there were certain areas that design had to have. Luckily, there was very little overlap. A lot of the same striking features on the Kodo design language that the 2014 road car enjoys has gone over very well on the racecar.'

Wind tunnel time for the GX Mazda 6 will come after its debut at the Rolex 24 At Daytona in January, but Tremblay is confident on what the virtual testing and limited track testing results have delivered.

'We understand what it's supposed to be doing on the racetrack, but the track and wind tunnels can be pretty far apart,' he said. 'Luckily, with the few laps that we've done with the car, what we've done in ANSYS and in design has translated extremely well.'

TOUGH BAPTISM

With the Rolex 24 approaching, and with three cars to prepare for the race, starting the on-track development portion was reserved until just weeks before its competition debut.

The factory No 70 Mazda 6 encountered issues with its primary accessory belt which required a massive effort to design, test and prefect a new hydraulic tensioner, but few other issues were discovered. However, it served as a reminder that completing the 24-hour race would be a major accomplishment at this point in the car's development.

'It's early days, we still have a lot to learn, a lot of room for growth and a lot of challenges that we don't know we'll have,' Tremblay admitted. 'What scares us every day is what we don't know. But that's what makes it exciting also.'

'We're thrilled to be the pioneers of that type of new class for Grand-Am,' added Doonan, 'but we also know it will involve a lot of learning while we're racing. Finishing races is our first goal, but a year from now, we plan on being ready to show what the SkyActiv philosophy can do in the heat of competition.'

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Willing and able

Last summer's Paralympics in London showed how disability need not hinder an appetite for sport. And one team aimed to make the gruelling Paris-Dakar equally accessible...

BY LAWRENCE BUTCHER

At the 2012 Olympics, there was great debate as to whether runner Oscar Pistorius should be allowed to compete in Olympic, rather than Paralympic, events. Not so much because he's a double amputee, having lost both legs below the knees, but because of the controversial carbon fibre blades he uses, which some claimed gave him an unfair advantage. After much politicking it was agreed that he could race, and so began a blurring of lines between Olympians and Paralympians. In motorsport, there has never been this clear cut divide. There have been many disabled drivers who have competed against, and in many cases beaten, their able-bodied compatriots. Witness Alex Zanardi's wins in the WTCC for BMW between 2005 and 2009. However, these drivers are generally individuals who are an exception to the rule, so the appearance of the Race2Recovery team on the 2013 Paris-Dakar, with a large complement of disabled drivers and crew, is a noteworthy event.

Evidently, tailoring vehicles to cater for the needs of less able-bodied crews presents engineers with an interesting challenge. The Race2Recovery team numbers 28, over half of whom are British and US service personnel who have suffered injuries on active service, with six of the team being amputees. The project is the brainchild of Captain Tony Harris, who lost a leg after an IED blast in Afghanistan, and Corporal Tom Neathway of the Parachute regiment, who lost both legs in the same country after triggering a booby trap.

The two met at the British armed forces' Headley Court rehabilitation centre and between them formed the gem of an idea to compete in the Paris-Dakar event. The intention was to provide a motivation goal, helping them through a long recovery period, while also providing inspiration for other wounded servicemen and women. What started out as a wild idea soon gathered momentum, and drew considerable support from sources as varied as the Duke of Cambridge and Prince Harry's Royal Foundation Endeavour Fund, through to title sponsorship from Land Rover. After much work and intense fundraising, the team honed its skills competing in the British Cross Country Championship before finally reaching its ultimate goal - entering arguably the toughest race on Earth.

WILDCAT FIRE

The Dakar is a punishing event by any standards and has repelled the attempts of many OEM manufacture teams. The vehicles used must combine speed, durability and ease of servicing to be competitive, and so Race2Recovery opted for a proven base vehicle: the QT Wildcat. These machines, produced by QT Services, which is based in Plymouth in the UK, have been a popular choice among privateer competitors thanks to their rugged simplicity and versatile performance. The car has impressive statistics - it can wade through water up to

600mm deep, traverse slopes up to 40 degrees, and climb up to 45 degrees. Though the Wildcat bears a resemblance to a Land Rover Defender, it is a completely bespoke vehicle. However, it is testament to Land Rover's rigorous testing that many OEM parts are still utilised.

The core of the vehicle is a tubular steel space frame, incorporating the driver/co-driver safety cell and the engine/suspension mountings. The frame also houses the sizable fuel tank – the Wildcat is laden with over 375 litres of fuel in Dakar to cope with the incredible distances it encountered during stages. Cloaking this frame is a composite body, designed in sections to ensure it is easy to replace damaged sections, or access the mechanical components. The body also houses all of the spares that the crew required during the race, from engine oil to sand ladders. On the subject of equipment, easy recovery is essential in the desert and it is here that the Wildcat has a joker up its sleeve. The underside of the vehicle is equipped with a high-powered onboard jack system enabling the car to lift itself up from a grounding situation with the minimum of effort. Especially important given that the crews do not necessarily have the use of all of their limbs, coupled with the fact that regular jacks are impractical on soft sand.

The powertrain is based around a 4-litre Land Rover V8 petrol engine, coupled to a Quaife QBE86G gearbox. The Wildcat is available with a diesel engine, but the power and torque delivery of the petrol is considered more suitable to the conditions experienced on the Dakar. One important factor to consider is the high altitude of some of the rally stages, which can have a considerable impact on the power output of the engine.

To counter this, the ECUs have an inbuilt altitude correction map to adjust fuelling and ignition timing in order to extract the best output regardless of altitude. The rest of the drivetrain is also uprated from the standard Land Rover fare. The axles have new high-strength half shafts, and the differentials have been changed to heavy duty ATB units, also from Quaife.

The Wildcat's onboard jack system in action

SUSPENSION DEVELOPMENTS

Development of the Wildcat is ongoing, with the most recent changes focusing on the suspension. By relocating the suspension mounting, the team has been able to increase the size of the spring/damper units, and unlike circuit racing in the world of Rally Raid, bigger is usually better. The Donerre 'Lithium' dampers are dedicated off-road units and while looking externally similar to regular motorsport shocks, have several key additional features to suit the extreme conditions encountered. The damper bodies are a hefty 68mm in diameter while the piston rod measures an equally substantial 25mm. A quick look at footage from the race will explain why such bulk is needed. Great attention has also been given to keeping the dampers cool, a considerable problem given the very high shaft speeds generated by the long wheel travel and the unrelenting nature of the terrain.

The Lithiums also feature hydraulic bump stops for both compression and rebound. These are incorporated into the dampers' internal valving, greatly increasing the damping rate at the extremes of travel. These are preferable to traditional rubber stops for two reasons. Firstly, a rubber stop will feedback the energy absorbed in an impact directly as rebound force, potential upsetting the vehicle stability. Secondly, a rubber stop will react in the

↳

The needs of some Race2Recovery team members are met with specialist hardware and sensors

same way if the damper bottoms out at a rate of 0.1m/s or 5m/s. Although more complex than a simple rubber snubber, the use of a hydraulic bump stop means that these problems can be circumvented by adjusting the setup of the hydraulic circuit. The key advantage of having a rebound bump stop, either hydraulic or mechanical, is protection of the damper itself. If the Wildcat flies over a jump, the suspension reaches full droop rapidly, and the bump stop prevents violent mechanical contact between the internal components.

Extreme terrain in the Dakar calls for a hardcore suspension solution

PERFECT PARTNER

Bosch is a technical supporter and official partner for the team, and has helped kit out the Race2Recovery QT Wildcats to ensure the electrical systems are up to the rigours of the Dakar. The company has considerable experience producing bespoke solutions for the Dakar event, having been the main supplier to VW's multi-year assault on the race. 'Our involvement is more about preventing problems than increasing performance,' says Tim Hare of Bosch Motorsport,. 'We put our DDU7 display in the cockpit and made a bespoke loom to instrument some of the things that we would consider fairly vital parameters that were not present. These include things like transmission temperature and diff temps.' There were also some additional sensors to aid the disabled crew members, notably driver Tony Harris, who has a prosthetic left foot, and therefore no feeling in his clutch foot. During testing it was found this lack of sensation meant he had a tendency to ride the clutch without realising it, leading to high wear on the plates. To counter this, Bosch fitted clutch position sensors linked to the DDU which flags up a stern warning, not suitable for publication, whenever he inadvertently forgets to remove his foot from the pedal.

Where necessary, OEM electrical components have been replaced by Bosch Motorsport items. 'We have fitted out the engines with Bosch motorsport equipment to complement the existing Bosch hardware supplied to Land Rover,' says Hare. 'These include things like ignition coils, crank sensors etc. It was really a case of making sure we didn't interfere with the running of the vehicle. The extra equipment is all an advantage, but if there was a problem with the kit it wouldn't affect the regular operation of the engine. We had come on board after the vehicles were completed so we just laid out bespoke loom on top and there is no interference with the existing loom.'

"We made sure we didn't interfere with the running of the vehicle"

RACE NEWS

By mid-distance, the team had suffered not just at the hands of the notoriously merciless race, but team members travelling in a support vehicle were injured in a tragic head-on collision on day five in which two people travelling in a taxi died.

A total of 451 race vehicles started the Rally - 183 motorbikes, 40 quad bikes, 153 cars and 75 trucks. At the end of the first half, which saw those vehicles travel between 4300-4550km, the number of vehicles out of the race stood at 110 - a drop-out rate of 24 per cent. Of these, 70 were withdrawn, 33 did not make a specific stage start time, and seven were expelled.

By that point, three of Race2Recovery's vehicles had been eliminated following racing incidents and mechanical failure.

However, as *Racecar* went to press, the two-week race finished, and the team's final car, driven by Major Matt O'Hare and co-driven by leg amputee Corporal Phillip Gillespie, made the finish.

TECH SPEC

Engine: Petrol V8, 4000cc double overhead cam with variable valve timing.

Power: 283bhp

Torque: 292lb/ft

Transmission: Sequential six-speed Quaife gearbox, Alcon clutch, limited slip differentials (front and rear)

Brakes: Alcon four-pot calipers (front), two pot calipers (rear)

Wheels & Tyres: Silverline alloy wheels, Cooper Discoverer STT off-road tyres

Suspension: Donerre twin-piston 60mm remote dampers

Fuel tank: FIA specification, 365-litre capacity

Interior: Bosch drivers display, sensors and data logging, Luke harnesses, 3M Peltor intercom, MES fitted fire suppression system and extinguishers

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R for rationalise

The FIA's new Group R headings are designed to help clean up the mess of rules and classifications in rallying. But what are they, and will they work?

BY MARTIN SHARP

Rally car groups have gone from numerical (ie: Group Two) to alpha-numeric (Group A8) and cover a wide variety of different car types. The FIA's initiative to tidy up this situation, reclassifying some existing cars into Group R and writing feeder formula rules into that categorisation is admirable. The stated aims of the new groups are cost reduction and attracting greater entry numbers, but the changes will take time to become fully effective. Some cars fall by the homologation wayside and indeed some car types are no longer valid.

The World Rally Car (Super 2000 and Regional Rally Car) is not designated with an 'R' suffix, but under the general Group R heading there are six categories. These range from R1 to R5, with the sixth called RGT. This last formula is a 'gentleman driver' GT rallying designation in which, so far, only the Lotus Exige has dabbled.

There are, however, sub-categories. R1A covers cars with engines up to 1400cc which must weigh more than 908kg, while R1B is for cars between 1400 and 1600cc with a 1030kg minimum weight limit. R2B is 1400-1600cc and 1030kg, R2C is 1600-2000cc and 1080kg; and R3C is 1600 to 2000cc and 1080kg. All clear?

R1, R2 and R3 cars must be two wheel-drive and normally aspirated, with two turbocharged two wheel-drive exceptions: R3T is for turbo petrol cars up to 1620cc with a 1080kg minimum weight limit, and R3D for turbo diesel cars up to 2000cc and 1150kg. Still following?

In simple terms, R1 is the lowest 'standard with original parts and a few bits' rally car form and increasingly is equating to the showroom stock Group N concept. For the R1, R2 and R3 categories, 2500 examples of a car model must have been manufactured in a period of 12 consecutive months and homologated by the FIA in Touring Cars (Group A).

R2, meanwhile, is a category based on the truism that modern road cars, with their emphasis on occupant safety, are now very difficult to transform into a good rally car within the Group N rules. Essentially R2 offers a cheap option for a rally car which is properly involving for the driver.

R3 is the next step up the feeder formulae towards the top level category of rallying – World Rally Car. Revised freedom levels in the R3 rules enable improved performance, at increased cost.

In the 2013 World Rally Championship the two wheel-drive R1, R2 and R3 cars can contest the WRC-3 Championship. At least six events must be contested, with the best five results from the first seven events counting toward the final points tally.

The admirable FIA Academy young driver initiative continues into 2013, renamed Junior WRC Championship, exclusively using Ford Fiesta R2s. There are three rounds each on gravel and asphalt, with the five best results counting toward the final score.

The consistency of the route to the top level of rallying continues with the penultimate-rung WRC-2 Championship. This is exclusively for four wheel-drive cars, open to Super 2000, N4, R4 and R5 cars and the opportunities offered deserve some investigation. At least seven events must be contested, and the best six results from the first seven rallies entered count.

N4 cars are the old 2-litre 'showroom stock' turbocharged four-wheel drive Subarus and

Mitsubishis, and the R4 cars are developed from later Group Ns to provide quicker, and nicer to drive, rally cars.

There are two Super 2000 varieties; the original normally aspirated 2-litre concept, from which the current World Rally Cars were developed, and the 1.6-turbo versions, which are basically World Rally Cars with smaller diameter inlet restrictors, and few other changes.

SPEC SAVERS

And so we come to the FIA's latest addition to the R series: R5. The rules offer a cheaper alternative rally car to a Super 2000 and the regulations stipulate maximum price cost ceilings for most components, aimed at pegging the price to around €180,000, less than half the price of a Super 2000.

R5s are four wheel-drive cars powered by turbocharged engines in the 1390-1620cc capacity bracket, with a 32mm inlet restrictor. Maximum boost pressure is 2.5 bar (absolute) and compression ratio cannot be higher than 10:1 (a maximum rpm is not stipulated; the former constraints mean rpm is self-limited). In the first edition of the R5 regulations, the FIA reserves the right to change maximum boost and restrictor diameter stipulations depending on the level of developed R5 engine outputs and their effectiveness in achieving R5 performance parity with Super 2000.

Unlike 1.6 turbo S2000 and World Rally Car engines, direct fuel injection is not mandatory for R5 power units, but they must be turbocharged engines from a manufacturer's range, or normally aspirated engines from that range fitted with an FIA-approved turbocharger. Global concept engines are not allowed. R5s must have five-speed units and limited-slip differentials in each axle must be mechanical, with adjustment restrictions. MacPherson strut suspension is mandatory front and rear, with minimum weights and maximum prices.

The formula offers an obvious option to teams and manufacturers and it is no surprise that many are developing cars for this new category, which will poses a question over the long-term future of the S2000 category, in the WRC at least. Skoda Motorsport's Super 2000 Fabia is a normally aspirated 2-litre car. The team will be producing a 1.6-litre turbocharged rally car, but as an R5, not as an S2000.

The PSA Group announced plans at the 2012 Paris Salon for the Peugeot 208 Type R5. The car's 1598cc EP6 CDT engine will run Magneti-Marelli high-pressure fuel injection, and its Peugeot Sport Project Leader Bertrand Vallat explained: 'We are aiming for performance which is slightly higher than that of the S2000.' One month later, PSA will have an R5 version of the Citröen DS3 ready for rallying.

Arguably the most advanced R5 car under development is the Ford Fiesta being prepared by M-Sport. Matthew Wilson has announced his 2013 arrangement to contest the WRC-2 series in a Fiesta R5, the first version of which tested in January.

His father, M-Sport MD Malcolm Wilson, is full of praise for the R5 concept. 'We can use a standard intercooler and many standard parts, and simulation is possible,' he says. 'The R5 car will be cheap and really competitive.'

There are three versions of STI-developed Impreza R4s: the first of the hatchbacks, 5714, the Specification C car and a four-door car built by Toshi Arai. The Mitsubishi R4 was developed by MML and Ralliart Italy, not Ralliart itself, and in 2011 was claimed to be one second per kilometre quicker than the Group N Evo X. There's at least two year's life left in the Impreza R4, yet in its current guise it cannot compete squarely in WRC-2, predominantly because of its weight. R4 regulation minimum is 1300kg, while S2000 and R5 is 1200kg – and 1325kg is the lightest weight possible on the Impreza possible. Subaru are currently considering converting the Group Group R4 car into an R5 car, but this would require almost a clean sheet of paper approach.

For they and many other manufacturers, debate over the various options on the table are currently raging.

CLASS ACTS

In Group R1, aka the 'standard with original parts and a few bits' class, the Citroën DS3, here at last November's Rallye du Var

Over in R2, pitching itself as a cheap option for rally cars that are involving for the driver, you'll find the Peugeot 208

Things get more serious in R3, a step towards WRC. This DS3 is enhanced given the rules' allowance for improved performance at increased cost

An R5 4wd 208 – an example of how the Group faces up against the S2000 spec. Peugeot is aiming for better than S2000 performance

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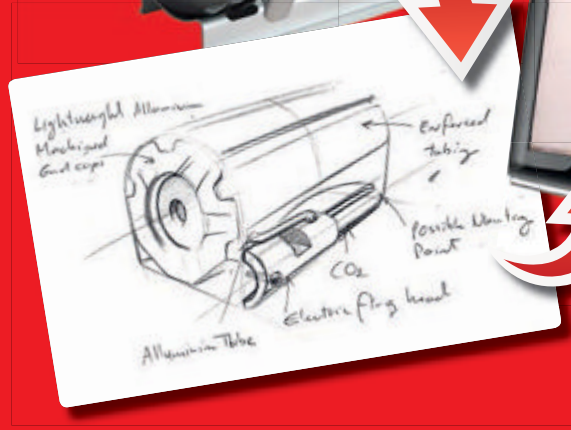

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Formulas for success?

Fears grow that new F4 and F-Ford cars point to a 'racing version of The X Factor'

BY SAM COLLINS

The talk in the aisles at the Autosport International Show was all about two cars, both open wheelers, both attracting enthusiasm and controversy in equal measure. The unveiling of the new BRDC Formula 4 car took place on the opening morning of the show and attracted a large crowd of British racing team owners and young drivers.

What appeared was a modern looking slicks and wings junior formula car, well prepared with some very nice features. Designed and built by the RFR company now headed by Ralph Firman, who founded and ran the legendary Van Diemen operation, the MSV F4-013 features an FIA article 277-compliant tube-frame chassis in order to reduce costs.

Power comes from the seemingly universal 2-litre Ford Duratec engine, tuned by Cosworth and developed to produce 175-185 bhp. Cosworth also supplies the car's electronics systems. The obvious choice of transmission would be a Hewland FTR, but RFR instead opted for French manufacturer Sadev's sophisticated 6-speed sequential ST75-LW box, complete with paddle shift.

But the car's spec was not the real talking point. Indeed, it was generally felt that it was 'a nice piece of kit' and, retailing for just under £30,000, is exceptionally competitive on price. But getting your hands on one may not be that straightforward. 'The car is very unlikely to be made available to anyone not doing an F4 championship,' explains series boss Jonathan Palmer. 'We really only want to sell the car to people who run it in our championship. The price is very much based upon those cars running in our championships, not outside.' The first 24 cars produced have already been sold, though more will become available later in the season.

'I think there is considerable scope for much bigger grids in the UK, before we start to look overseas,' continued Palmer. 'We limited the first batch to 24 to ensure that all of those drivers get their cars and can test them before the first race. We will continue to sell the cars throughout the year if there is demand, and I think that there will be. There are drivers who are about to turn 16 who will then will be able to race, and so I'm sure more cars will be sold. It will swell the UK grids considerably, and very much so into 2014. In Europe we are looking to expand the concept. We would love to see F4 using this car all around the world, but I'm also keen to see dads and lads and traditional club racers get involved as these cars are so easy to run.'

What makes the cars so easy to run was probably the main talking point surrounding the new F4 car. The driver-centric concept of the new

"The more scope for engineering you have, the less contribution the driver makes"

The MSC F4-013 is undoubtedly a good car, but the driver-centric concept worries the engineering community

TECH SPEC

MSV F4-013

Class: BRDC F4

Chassis: Advanced spaceframe chassis construction (4130 material) featuring side impact panels, front and rear carbon crash structures

Body: Fibreglass side pods, side panels, engine cover and nose. Single plane front wing with two adjustable flaps. Adjustable twin element rear wing

Engine: 2-litre Cosworth Duratec (185bhp), race-proven dry sump oil system, specially designed F4 inlet and exhaust manifolds together with fly-bywire throttle. AP Racing sintered clutch

Transmission: Sadev ST75LW six-speed sequential transmission with pneumatic paddleshift actuation system and fixed gear ratios

Brakes: AP Racing 4-piston calipers with cockpit adjustable brake bias

Suspension: Twin wishbone and pushrod arrangement suspension all round with adjustable front and rear anti-roll bars coupled to Bilstein dampers. Front and rear wheel tethers

Dimensions:
Wheelbase: 2679.5mm

Front Track: 1596mm

Rear Track: 1494mm

Weight: 470kg

F4 is too early for drivers to learn to setup and develop a car, says Jonathan Palmer, and the emphasis is on keeping running costs down for competitors

series leaves very little scope for engineering, much to the distaste of many.

'We are in an era of relative austerity, which looks like continuing for some years,' says Palmer, 'and it is essential we provide young single-seater drivers with an affordable path to learn and prove themselves. With F4, we have focused on four key areas; providing the lowest season running costs, the lowest car purchase price, the highest levels of car equality, and highest safety standards.

The costs are dramatically less than anything around, probably less than in Formula Ford 1600 in many ways. Part of the big thing to do to get the costs down is to reduce the amount of labour needed to prepare the car, so having a sealed gearbox is one area where we have done that. You can't fiddle around, you can't buy new ratios, and you can't fiddle with the diff. That will reduce between four to eight hours from a car's preparation time per weekend. Think if four to eight hours is charged at £50 per hour then it all adds up. There are stories in Formula Renault BARC (the UK's low cost version of Formula Renault) of people spending £800 per weekend just on optimising the gearbox. It's madness.'

The new F4 car is also fitted with non-adjustable Bilstein dampers, removing another area of engineering freedom from the new series. Palmer argues, however, that having a more adjustable car simply puts the costs up and doesn't benefit anyone. 'The more technical freedom you give people to develop from a engineering point of view, the more cost goes up and the more significant the engineers you have become,' he says. 'The trouble with that is that at the moment, the people that are paying the bills are the drivers. Drivers do not want to be paying to have engineers develop a car – they just want to pay the least amount of money they can to be able to prove how good they are and to develop their skills as a driver and to move on. The more scope for engineering you have the less contribution the driver makes to the car's performance. Thats not to say the car is not sophisticated, you can adjust ride heights, cambers – almost all of the things you can normally do – but the only thing you can't do is adjust the dampers. In my experience changing dampers is not hugely significant anyway.'

The engines, too, are sealed and can only be worked on by Cosworth. This, Palmer hopes, removes another variable.

'In Japanese F4 you can run whatever engine you want and that is a massive cost inflator. It takes away from the equivalence for the drivers. If you look at GP2, engines are a non-event. You never hear drivers grumbling that they did not have an engine as good as someone else. In F3 or the old Formula Ford, who built your engine was critical. If you got the wrong engine tuner you wasted a season because you won't get the results. In

F4 ELECTRONICS

The new MSV F4-013 is not only equipped with a Cosworth engine – it is also equipped with the same firm's electronics, including a full data acquisition system. A copy of Cosworth Toolbox Lite will be supplied with every car and a pre-season training day will be arranged to familiarise the teams with the software and its full range of capabilities if required.

At every race event and championship test, MSV & Cosworth will provide support engineers to ensure that cars, the engines and all the electronic and mechanical systems, are functioning correctly. In addition to that, the cars are fitted with mounts for both forward- and rearward-facing video cameras. As an optional upgrade, an onboard video system can be supplied that is integrated with the car data set provided from the Cosworth ECU and data logger.

The new car also features Cosworth's new CFW steering wheel. The CAN Formula Wheel (CFW) is 277mm in diameter and is meant for use in open and closed cockpit racing cars. It is constructed from aerospace grade aluminium with moulded rubber grips – technology derived from Cosworth's experience in building F1 steering wheels.

The 320x240 QVGA 3.5" sunlight viewable TFT display is paired with eight clearly visible shift lights. The CFW can be connected to the car via a coily cable, and has two connectors chosen to help keep loom prices cost effective. One connector carries switches and power, and the other enables expansion to a paddleshift system. The wheel has been designed to accept industry standard paddles including Cosworth, Shiftec and Hewland as standard but others may be compatible as well.

Six permanently fitted switches are ergonomically positioned for driver comfort and practicality all six switches are CAN-based, two also being passed through the system connector for uses such as a radio button.

The wheel design also offers the option to have two rotary switches fitted, including a professional sticker pack to allow the end user to easily mark the wheel up to their own specifications, maintaining a sharp, F1-style visual attraction.

Designed to be electrically robust, the CFW277 has reverse-battery, over-voltage and load dump protection built-in.

Japanese F4 I suspect that the same is true. This is about driver development, remember it's them that are paying for it.'

It has been argued by some team owners – but notably no drivers – that a key part of a young driver's development is learning how to setup and develop a car, something that has given some leading competitors such as Fernando Alonso and Michael Schumacher a key advantage. But Palmer feels that for youngsters coming out of karting, it is perhaps too early to develop those skills. 'The drivers can learn how to do those things as they move into F3 – they don't need to learn it at this level,' he says. 'People have to understand that the biggest challenge to the viability of motorsport at all levels is cost, not technical sophistication. If you look at what is going on in motorsport, there's less and less scope for technical development, because it is very expensive.'

It was suggested by many that F4 has moved into a part of the British motorsport landscape traditionally occupied by Formula Ford, which in recent years has suffered from dwindling grids. Unsurprisingly among those who feel that the famous class has had its day is Palmer, himself a Formula Ford graduate. 'I think it has sadly lost its way,' he says. 'It was outstandingly successful in the early days, but it has progressively got less appealing and grid numbers have gone down. I think the adoption of a turbo engine was a mistake. There is a degree of competition there and I believe Formula 4 will be the championship of choice for young drivers.'

The new Formula Ford EcoBoost 200 is hoped to be a step forward, not further evidence that the class has 'lost its way' as Jonathan Palmer claims. Mygale, Ray and Fluid Motorsport have committed to building the cars

THE F-FORD PERSPECTIVE

One man who could not disagree with Palmer more strongly is Ford's motorsport manager Mike Norton, who could be found on the stand next door to Palmer's, where the blue oval was showing off its updated Formula Ford EcoBoost 200 design.

The main change to the long-established concept is the adoption of an aerodynamic package. This is in response to the demands of drivers, says Norton. 'I went to a lot of kart meetings and spoke to a lot of young drivers, and they want a car that looks like an F1 car and they want a car that has aero, as they will not drive another with it in their career,' he says. 'The car was always designed to have wings as an upgrade. We took the decision last year to just have a new engine – the financial climate was much harder then than today. We got a year of running with the new car, and after getting a televised slot on the BTCC bill and talking to the teams, it was clear that all of the drivers we wanted to attract wanted wings, and that we should make the step now.'

As has always been the case with Formula Ford, any chassis manufacturer can take part and Mygale, Ray and Fluid Motorsport have already committed to building bewinged 2013 spec cars. The wing package itself is a spec kit supplied by Ford. The wing profiles and endplates cannot be altered, although there is scope for adjustment on wing angle. The front wing mounts to the mandatory single spec front impact structure, while the rear wing mounts to the mandatory Hewland gearbox casing.

WINGS: THE DEBATE

'Wings make a proper racing car. I don't mind touring cars without wings but a single-seater has to have wings,' says 19-year-old driver Sean Walkinshaw. Both BRDC F4 and Formula Ford felt that fitting wings to their cars was essential to the success of their respective series. Walkinshaw's attitude is typical of young racing drivers who, according to Jonathan Palmer, pay for racing today.

'I want a car with lots of grip – it makes it easier for a driver,' says Walkinshaw. 'You still learn about mechanical grip in the low speed corners because wings only work at high speed. So a car without wings will give you both aspects, but an old Formula Ford will only give you mechanical grip. But you don't learn anything about aero downforce.'

Not everyone agrees. John Kirkpatrick of Jim Russell Management Ltd (and the MIA), has been influential in the careers of many top racing drivers and today still works with young drivers. 'Its a result of the celebrity culture we live in,' he says, 'But the fact of the matter is that when I started out with the Jim Russell school, I went around the classroom and asked those sat there what they wanted to do.

'They all had the simple goal of going racing. I go karting now and there are some eight-year-old kids there and you ask them the same question, they all tell you that they want to be an F1 driver. Consequently they do not want to drive a car that teaches mechanical grip and does not have any wings. Instead they want to drive something that kind of looks like a Formula 1 car. That means any new series has to have wings, it has to have an aero package, and that camouflages any deficiency that they may have as a driver straight away.

'What is happening now is that youngsters simply want to get to Formula 1. Consequently nobody enjoys the journey up the ladder – it's just the racing version of the X-Factor.'

The F-Ford's new wing kit has split opinion, but Ford claim they've merely acted in response to the demands of drivers

'We are very conscious that Formula Ford remains cost-effective. We don't want an aero war – this isn't Formula 3 – it's the first rung on the professional career ladder,' says Norton. 'Having it all made up of mandatory parts gives the economies of scale in terms of the production costs. It also prevents everyone from developing their own and turning it into a mini-Formula 3. Due to the cockpit shape and sidepod duct shape being common to all cars, the frontal area is basically the same for everyone. So, to some degree the aero is much the same. That's to prevent the aero war, but from the chassis perspective and mechanical setup it is still as Formula Ford has always been.'

Ford developed the new wing package primarily using CFD, although it did spend some time in the manufacturer's climatic tunnel in England. However, the chassis manufacturers are already working hard on the aerodynamics, free to run their cars in wind tunnels. Mygale has already done so at full scale according to company boss Bertrand Decoster. One of the English-built cars will feature in a future series of Aerobytes in the pages of this magazine after full-scale tests are conducted at MIRA.

Many however feel that Formula Ford and other junior formulae should not have wings, but Norton thinks that the series has to move with the times. 'When Formula Ford first started, the cars looked like Formula 1 cars because F1 cars didn't have wings,' he said. 'But we stayed where we were and stuck to the Formula Ford ethos. Even with the wing kit, that will remain. The front wing is much larger than the rear, we have a flat floor, but no diffuser – so we're hoping that the tight Formula Ford style racing continues. The aero does not add a huge amount to the car – only around 200kg at around 140mph. The drivers say it is apparent in fast corners, but not on the slower ones. In that environment you need the same old Formula Ford skills, you need the car setup to be right and you need basic driver skills.'

Both Formula Ford EcoBoost 200 and BRDC F4 will kick off in the UK in the spring. It remains to be seen which proves to be the most successful.

F4: THE SERIES OF THE FUTURE?

Formula 4 is nothing new. It has existed in different forms for many years in Japan and the UK. However, there is a new drive behind the F4 concept, perhaps sparked by the growth in series using the F4 moniker. The FIA has got in on the act too, and will will launch its own international F4 concept in 2014.

Former grand prix winner Gerhard Berger was named President of the FIA Single Seater Commission in 2011, and it's fair to say that he has shaken up the establishment somewhat with changes to Formula 3. But he now has his sights set on the level below F3. 'The Commission looks at everything between karting and Formula 1,' he says, 'and I find that the pyramid at the moment is very loose. there are too many championships out there, and attention between them is split too much.

'We are missing something between karts and Formula 3 – call it Formula 4, if you will. We are working on this. It has to be reasonably priced, it has to be safe, and drivers need to learn about aerodynamics. It mustn't be too complex, but it should be a challenge, so that they can learn. It has a modern good-looking car. I think all these side categories disturb the system.

'We should have one formula with one regulation. OK, if a country does not have a strong enough championship then it could join with another, or there can be some kind of final between the top guys in the different national series, but what we have to do it break it all down and provide what is needed.'

The Italian motorsports governing body has already committed itself to the new plan with F4. After a meeting with Berger, ACI-CSAI decided to drop the Italian F3 series so that it could prepare for the new FIA F4 regulations. Italy is well-placed for an open chassis F4, with a number of manufacturers well equipped for this type of racing including Dallara, Mirage & Tatuus, all of whom offer a low cost open wheel car already.

ONLINE LINK: F4 around the world – Sam Collins takes a look Formula 4 racing as it is today.

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AUTOSPORT INTERNATIONAL Engineering Show

In association with Racecar engineering

Brilliance in Birmingham

Looking back over the agenda-setting 2013 Autosport International show

The Autosport International Show once again cemented its reputation as Europe's leading motor sport show, with 79,000 spectators over the four days, and 28,000 registered trade visitors, nearly a quarter of which came from overseas. No fewer than 2000 of these trade visitors also registered to attend the main show.

Before the show even started, the MIA Low Carbon Conference set the tone for the week, with industry leaders and the UKTI discussing how racing could benefit production cars. It is a link that is vital to the survival of the sport, and to the development of the cars that we will drive on the road. It is a link that has not yet been cemented by anyone other than, perhaps, Audi through its Le Mans programme.

At the show itself, there were launches of new products, the presentation of new cars and engines, and new exhibitors, 100 from overseas and 75 exhibiting for the first time.

Radical launched its RXC coupe, the first ever closed car by the British manufacturer, the BRDC took the wraps off the Formula 4 car featured on page 31 this month, ATL Racing Fuel Cells displayed a Formula 1 fuel cell, DC Electronics launched its Motorsport Electronics Engineer Training Progamme and Ford publicly unveiled its 2013 EcoBoost 200, with aero wings and a 1.6 litre EcoBoost engine. That was just on day one!

Linking OEMs to motorsport is vital to its survival

On display were three new gearboxes from Quaife Engineering, for oval racing, the Skyline GTR and the Honda Civic Type R. Titan Motorsport launched its cylinder head and valve train upgrade for the Nissan GTR and VR28 platform, while in the Engineering show, Versarien Limited won the Graham Jones Award for technical innovation at show with its revolutionary new heat transfer material for constrained environments. The company has opened negotiations with Formula 1 teams, as the sport heads further down the road of hybrid technology, and the judging panel felt that it was an entirely relevant and new product.

Short-listed for the award were Ole Buhl Racing, with its PCM2 Electronic Control Unit, and Zircotec, which launched its GOLD products at the show, offering heatshield and variant for composites that offer 98 per cent reflectivity.

Elsewhere in the show, Formula 3 was put into the spotlight once again, with the launch of Neil Brown Engineering's engine, built to the new regulations and featured on Page 74 of this magazine.

With the product launches, the location of the show and the timing, at the start of the new year and with eyes turning towards the season ahead, it is small surprise that a significant amount of business was completed. Show organisers estimate conservatively that more than £800 million worth of business was generated. Overall, it was an indication of the health of motor sport in the UK. There is still a lot to be done, but the NHS can rest easy, for now.

Best in show

Some of the highlights from the Autosport International Show, 2013

Photography by **David Lord**

Radical RXC was certainly eye catching in its stunning yellow livery

Versarien won the Graham Jones Award for best innovation at the show

Gill Sensors is on the verge of finalising the design of their ultrasonic sensor

The Racecar Engineering stand was more popular than ever in 2013

Crankshafts at the Autosport International Show

AUTOSPORT INTERNATIONAL Engineering Show

In association with Racecar engineering

DC Electronics displayed the Mussett Technology Group's 1.5 litre turbo

Subscription manager Will Delmont (left) was kept busy this year

Deputy editor Sam Collins' haircut makes him an easy person to find

STAND AWARDS

Maja Foster receives the award for Best Stand in Manufacturing Technology from our own Tony Tobias

Advanced Fuel Systems won the Best Small Stand in the Autosport Engineering Show, held in association with Racecar Engineering

Greaves Motorsport won Best Overall Stand at Autosport Engineering

THE MIA AWARDS -2013

Jon Hourihan from Goodridge presents the MSA's Colin Hilton with the Service to the Industry award

Williams F1 won the Xtrac supported Business of the Year award. Xtrac's Adrian Moore presents Alex Burns with the award

Interex won the Export Achievement award, presented by Arianna Maugeri, representing the PRI Show

British Touring Car Championship Team Dynamics won the Teamwork award. Edward Grainger from Grainger & Worrall presents Barry Plowman.

Julia Schumacher, NEP, presents Raphael Caille of Swindon Engines with the Small Business of the Year award

DC Electronics expanded into the USA, and was presented with the New Markets award by Desktop Engineering's Geoff Haines

Ricardo's Steve Sapsford presented Millers Oils' Martyn Mann with the Technology and Innovation award

A full lineup of the MIA winners at the awards dinner, held on Thursday night at the Autosport International Show

Eastern promise

Unfortunate timing, but a great showcase for German and East European companies

Cologne is a great place for a trade show, but this year the Professional Motorsport World Expo's timing was not ideal as the Formula 1 season had not yet reached its conclusion, and it also clashed with the end of season Macau Grand Prix. Attendance was still strong, though, and as usual those present were of the highest calibre. 'Preliminary visitor numbers show that over 7,000 motorsport professionals attended the show, which featured over 250 exhibitors from all over the world, each showcasing the very latest race technologies, components and services,' enthused Graham Johnson, managing director of UKIP Media & Events.

One of the real highlights of the show was the Slovakian Praga R1, a car few thought would ever see the light of day. Rollcentre MD Martin Short, who handles Praga's interests in the UK, says: 'I discovered Praga Racing at Spa in August 2011. I was hugely impressed about how such a little car was so near the front of the field in Dutch Supercar, especially at a big, tough circuit like Spa. I got into conversation with the MD Dusan Maly, and we realised we had a lot to offer each other.

Praga's R1 caught the imagination of many at the PMW expo

'They were an emerging car manufacturer from Slovakia with great technical skill and huge innovation, and impressively out of the box ideas. I found this really appealing. A huge bonus to this relationship is that Praga are now developing their own engines, a 532bhp Suzuki Hyabusa-based V8 weighing fully dressed on 89 kilos, and also a four cylinder engine 1500cc producing 265bhp. I can see a really good market for these engines for hill climb, rally cars and indeed more racecars. This is going to be the most amazing car to drive, with huge downforce, incredible power-to-weight ratio, and most importantly a fully enclosed cockpit.'

The Praga R1 has what can only be described as a striking look, but it has really caught the enthusiasm of its suppliers, many of whom were present at the show. A full feature on Praga will appear in a future issue of *Racecar*.

It is becoming rapidly apparent that the PMW expo is the door to the growing Eastern European motorsport industry. Many companies present were really only there to tap into it. But it is also the place to find very high end new products from German engineering firms, many of who do not exhibit elsewhere.

Farewell Florida

Uncertainty over PRI's move to Indianapolis told at a noticeably subdued event

There was something a little subdued about the 2012 PRI show – the buzz it often has was perhaps a bit absent. That is not to say that it wasn't a good show, indeed approximately 37,500 racing business people from all 50 states and 70 countries attended this year's event to get up-to-date with the latest in racing technology, courtesy of the 1000 motorsports companies exhibiting.

Indeed the real reason for the slight change in mood was the uncertainty surrounding the future. This year in December the show will relocate back to its former home in Indianapolis. Many exhibitors spoke of greatly reduced costs, not having to send crews to both PRI and the IMIS show after the latter was recently acquired by SEMA and consolidated with the PRI Show.

'Having the two shows combine together makes all the sense in the world,' relayed Safety Kleen's Drew Pate. 'Cost savings on a dollar basis are probably well north of $50,000 when you consider man hours, travel and accommodation.'

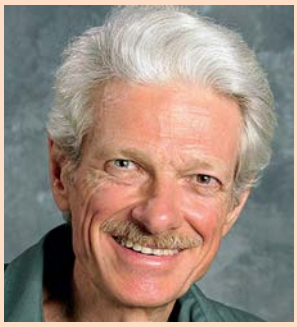
Leading into the show there was a series of events, something that will hopefully be repeated in Indiana. Chief amongst them was the MIA's now annual trip to Daytona, where delegates get a great lunch in the France family suite overlooking the track, as well as a few beers down on the beach – a great opportunity for networking.

Top of the bill were The Advanced Engineering Technology Conference (AETC), Claude Rouelle's Optimum G Advanced Vehicle Dynamics Seminar, the Race Track Business Conference, the International Council of Motorsport Sciences (ICMS) annual Congress, the Winning The eRace Digital Marketing Conference, Winning Setup Strategies for Dirt Late Models, and the FAST EFI University training course on electronic fuel injection in racing applications.

PRI 2012 was busy, but 2013's move back to Indiana muted the usual buzz

In total there were 35 conferences and seminars that ran in conjunction with the show.

Some of the main show highlights have already been featured in recent issues of *Racecar*, but there are plenty more still to come. Preparations are already underway for the 2013 PRI Trade Show, which will run at the Indiana Convention Center, 12-14 December. Don't forget to bring your coat this year.



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155 Wankel Drive , Kannapolis
NC 28083-8200, USA

Small load transfer with low roll resistance

A delicate balancing act is needed to stop cars tipping over...

Q Here's a quote from Ben Bowlby at the World Motorsport Symposium, discussing the Nissan DeltaWing: 'Because the vast majority of the roll stiffness was on the rear, the front tyres saw virtually no change in vertical load.'
Could you explain to a virtual newbie like me how this happens?

Having very little lateral load transfer in cornering is possible with any car – for one end of the car only, and only up to the point where the opposite end lifts a wheel. This is true whether the car has an extremely narrow track at one end or not. The only difference when one end has this, and also a small percentage of the static weight, is that very small load transfer cannot be obtained at the wide end, except for very small lateral accelerations. But it's definitely possible at the narrow end.

For the car not to tip over, the total roll resisting moment for both wheel pairs has to equal the overall overturning moment for the entire car, which is the product of the cg height above ground, and the total ground plane lateral force at the tyres.

Or, neglecting the unsprung mass load transfer, it is the product of the sprung mass cg height above ground and the portion of the ground plane force at each end that reacts the sprung mass inertia. It helps if we ignore the unsprung load transfer. Treating things in this manner, the roll resisting moment at each end of the car is the load transfer at that end multiplied by the track at that end. This is also the change in wheel load difference times half the track (note: adding 100 pounds to one tyre and taking 100 off the other changes the difference by 200.)

The sum of the front and rear roll resisting moments has to equal the overall roll moment. Therefore, we can reduce load transfer at one end of the car by making it softer relative to the other. However, this will increase the load transfer at the other end of the car.

It will be apparent that when either factor (the track or the load transfer) is small, the product (the roll resisting moment for the wheel pair) cannot be large. However, if the product can be small, then neither factor has to be large.

Thus, it is entirely possible to have small load transfer at the narrow end of a near-tricycle four-wheel car. We can even arrange for it to have no load transfer at all, provided that the wide end can resist the roll moment by itself without lifting a wheel. It's also possible for the narrow end to have negative load transfer, provided the wide end can react more than 100 per cent of the roll moment without lifting a wheel.

This requires the suspension system to have negative net roll resistance: when it experiences ground plane force to the left, it tries to roll the car to the right, not resist rightward roll. This can be arranged by having zero or very small elastic anti-roll, and geometric pro-roll. I don't know of any car that has net negative roll resistance at either end, but it is a theoretical possibility.

With a very narrow front track, it's possible to greatly affect the load transfer at the front by adjustment of the front suspension. This allows us to tune the oversteer/understeer balance of the car. However, it is not possible to greatly affect load transfer at the rear by adjusting the front suspension. With very little track to work with, the front can't generate a lot of anti-roll moment even with a lot of load transfer. In a tail-heavy car with a front track similar to the rear, if we add front roll resistance to the point where the inside front is very light or airborne, we get not only an oversteer reduction/understeer increase, but also good loading on the inside rear, helping the car put power down with that tyre. When the front track is extremely narrow, the inside rear will unload dramatically in limit cornering, even if the front end is stiff enough to pick up a wheel.

"A car with net negative roll resistance at either end is a possibility"

When the wide end has a very wide track and well over 50 per cent of the static weight, it's possible to have all the load transfer at the wide end and none at the narrow end, up to maximum lateral acceleration. It may even be possible to have negative load transfer at the soft end.

Any wheel pair can only resist roll by exerting force against the ground. Regardless of how the system generates its roll resistance, it has to act through the tyres, and therefore has to change their loadings.

The front end of the Nissan DeltaWing sees little change in vertical load as the majority of the stiffness is on the rear

Finding the swing axle length in a modern strut suspension

Q A question has been rattling around in my head for a while which you'll hopefully be able to shed light on. From everything I've read regarding finding the swing axle length on strut suspension, they say that you project a line from the top of the strut, square to the centreline of the strut, until it intersects with the line of the lower control arm.

I understand this in relation to the days when struts were in line with the lower ball joint. However I'm confused where modern suspension is concerned, where the strut is bolted to the side of the steering knuckle.

Should the upper line project square to the strut?

Or should it be square to the 'virtual' strut (line between strut top pivot and ball joint)?

For the purposes of analysing suspension geometry, the axis of the strut itself is what matters. The effective upper control arm plane is the plane perpendicular to that axis, containing the strut pivot centre of rotation. However, where analysing steering geometry is concerned, the steering axis is the line containing the ball joint centre of rotation and the strut pivot centre of rotation.

A Peugeot 208 Group R rally car, an example of a vehicle which features strut suspension

Understeer in tight turns, oversteer in high speed turns

A pile-up at the Druids hairpin at Brands Hatch last year – without wanting to point fingers, we're guessing understeer played a part

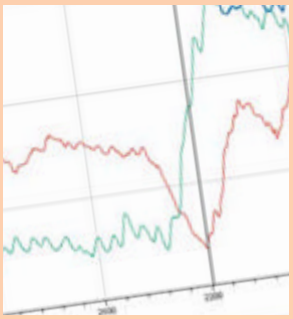
Q Why does the same car understeer in a low speed tight corner but oversteer in a high speed bend? Aero aside, is this just a product of yaw centre location or is it due to other effects (Ackermann, etc)?

It isn't strictly true that all cars do this, but when they don't it's usually because of aerodynamic effects – those being significantly greater downforce and/or less lift at the rear than at the front.

I will confess that I don't fully understand the reasons for this, but I understand some of them.

Ackermann does enter into it. A car needs more Ackermann in a low speed turn than it does in a high speed one, and as a result we have to compromise.

The rear wheels always track more to the inside of the turn, relative to the front wheels, in tight turns than in sweepers for the same amount of understeer. With rear drive, this 'off-tracking' puts the centre of front wheel drag further to the outside of the turn and the centre of rear wheel propulsive thrust further to the inside, relative to the track of the cg, in a tight turn than in a sweeper. This creates a yaw moment out of the turn, adding understeer.



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

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

Fly-by-wire calibration

Following on from last month: how to configure a FBW throttle

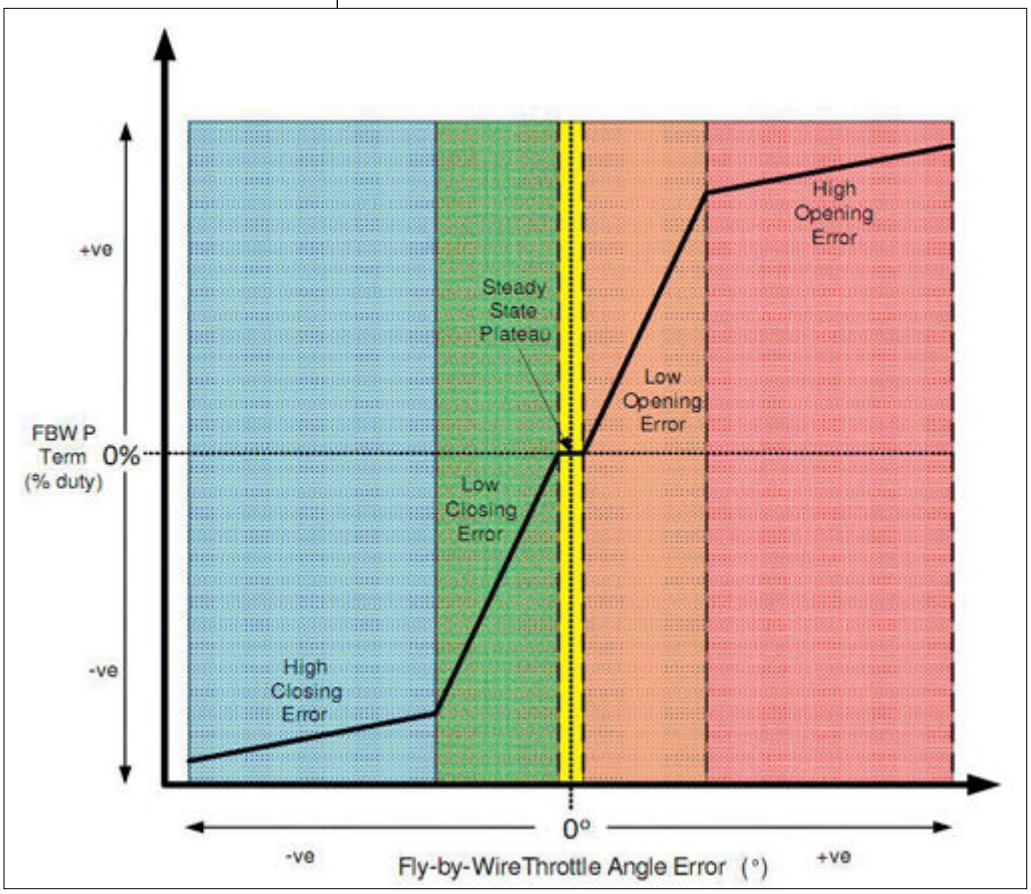
Following on from last month's Databytes, which introduced some of the principles of fly-by-wire throttle systems, this article features one method that can be employed for the initial calibration and configuration of a fly-by-wire throttle. The idea is to focus on methods, rather than go into detail regarding calibration software, so I'm writing under the assumtion that the user knows the calibration software well enough to carry out the tasks.

The procedure I'm detailing here assumes that only one fly-by-wire motor is being used, and that the system allows adequate data logging in order to visualise what is going on. As this is a base calibration with the engine off, it's obviously necessary to be able to start the data logger without the engine actually running. The data logger should also be able to log the required channels at a high enough rate to see small details in the fly-by-wire system behaviour.

The fly-by-wire system uses a PID controller and it is critical that both the I and D terms are zero before starting the calibration procedure. Only the P term will be used to begin with and the I and D terms then used to fine-tune the system. The proportional term is tuned set with respect to the error between the requested throttle angle and the actual throttle angle. The relationship between the P term and the error value can be seen in the diagram below.

There are five different regions shown here. The areas with the highest error values result in the greatest duty demand of the FBW motor. This ensures that the target is met as fast as possible. As the error value goes down, the gradient of the P term duty steepens, reducing the amount of motor duty demand as it approaches zero. To prevent oscillation around the zero value point, there is a plateau which allows the motor to sit at steady state without any demand for duty in either direction.

There are two variables in the matrix used to control the fly-by-wire P term: the X-axis has the angle error value and the Y-axis the throttle position. This allows a fine tuning of the calibration in specific areas of throttle opening. A throttle system that incorporates two springs – one for returning the throttle to close and another soft spring to hold the throttle open at 8-10 degrees – demonstrates where this is important. This can be described as having a 'limp home' feature, as the engine will keep idling if there is a failure in the throttle system. The P term matrix will vary slightly depending on what type of spring is incorporated in the throttle system. Page 50 shows two examples – one for a single uni-directional spring, and another for two opposing springs. Note the different values on the Y-axis where in the two spring solution there are finer intervals around the spring switching point to give sufficient control. The two images over the page also show how calibrations can differ between different systems.



Matrix: FBW Position Based Proportional Term A (%)

fbwErrA (°)

TPSA (°)	-20.0	-17.5	-15.0	-8.0	-4.0	-1.0	-0.5	-0.2	0.0	0.2	0.5	1.0	4.0	8.0	15.0	17.5	20.0
10.0	-80.0	-76.2	-72.4	-61.7	-55.6	-51.0	-40.0	-35.0	-30.0	20.0	34.7	41.3	51.6	60.0	74.6	79.8	85.0
15.0	-80.0	-76.1	-72.3	-61.5	-55.3	-45.0	-35.0	-25.0	-4.0	20.0	34.7	41.3	51.6	60.0	74.6	79.8	85.0
20.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-20.0	1.0	27.0	36.9	46.9	60.0	64.3	71.7	74.3	77.0
30.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	27.0	36.9	46.9	60.0	64.3	71.7	74.3	77.0
40.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	27.0	36.9	46.9	60.0	64.3	71.7	74.3	77.0
50.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	27.0	36.9	46.9	60.0	64.3	71.7	74.3	77.0
60.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	28.3	37.7	47.7	60.0	64.4	72.1	74.9	77.7
70.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	28.3	37.7	47.7	60.0	64.4	72.1	74.9	77.7
80.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	28.3	37.7	47.7	60.0	64.4	72.1	74.9	77.7
90.0	-60.0	-56.2	-52.4	-41.8	-35.8	-31.2	-25.0	-15.0	5.0	28.3	37.7	47.7	60.0	64.4	72.1	74.9	77.7

Figure 1: data from a single uni-directional spring

Matrix: FBW Position Based Proportional Term A (%)

fbwErrA (°)

TPSA (°)	-20.0	-17.1	-14.3	-11.5	-8.7	-5.8	-3.0	-1.0	-0.0	1.0	3.0	5.8	8.7	11.5	14.3	17.2	20.0
1.0	-8.0	-8.0	-6.2	-4.3	-4.0	-3.7	-3.4	-3.2	-12.5	50.0	52.1	55.1	58.1	61.1	64.0	67.0	70.0
5.0	-8.0	-8.0	-6.2	-4.3	-4.0	-3.7	-3.4	-3.2	26.1	50.0	53.1	57.6	62.2	66.6	71.0	75.6	80.0
7.0	-8.6	-8.3	-6.6	-4.3	-4.0	-3.7	-3.4	-3.2	29.5	62.5	65.0	69.1	73.4	77.5	81.6	85.9	90.0
10.0	-9.8	-8.9	-7.4	-5.5	-4.8	-4.1	-3.4	-3.2	32.9	66.9	68.8	70.6	72.7	74.6	83.0	91.6	100.0
15.0	-48.0	-40.0	-34.0	-31.0	-28.0	-25.0	-22.0	-20.0	33.3	66.9	68.8	70.6	75.0	79.2	83.4	91.8	100.0
30.0	-48.0	-40.0	-34.0	-31.0	-28.0	-25.0	-22.0	-20.0	33.6	60.0	64.0	69.7	75.7	81.4	84.3	92.3	100.0
50.0	-48.0	-40.0	-34.0	-31.0	-28.0	-25.0	-22.0	-20.0	34.0	48.9	64.0	69.7	75.7	81.4	84.3	92.3	100.0
60.0	-58.0	-50.0	-44.0	-41.0	-38.0	-25.0	-22.0	-20.0	34.3	43.2	64.0	69.7	75.7	81.4	84.3	92.3	100.0
80.0	-87.0	-83.0	-78.0	-64.2	-46.7	-33.0	-25.5	-20.0	34.7	43.2	64.0	69.7	75.6	81.4	84.3	92.3	100.0
100.0	-87.0	-83.0	-78.0	-68.0	-55.0	-35.0	-25.5	-20.0	35.0	43.2	64.0	69.7	75.6	81.4	84.3	92.3	100.0

Figure 2: data from a system featuring two opposing springs

The first step in calibrating the fly-by-wire system is to configure the steady state conditions. This effectively gives us a base calibration that sets the P-term up to oppose the throttle return spring. This procedure is based around a throttle system with a uni-directional return spring and an engine map with a base pedal to throttle position map (PPS to TPS map). This can be as simple as a one to one map, and a base fly-by-wire position-based P term map which will be used to calibrate the throttle behaviour.

The first step is to fix the value of the PPS to TPS map in order to demand a steady state value from the throttle. Then go back to the P term map to observe what TPS error is present. There are three likely outcomes at this stage:

1. There is a small error present but the throttle has reached its target and is stable. This means the calibration is satisfactory at this point. This means its possible to go to the next incremental step of steady state – normally the steps are 10 degrees from zero to 90.

2. There is a large error (more than 2 degrees) and the throttle cannot reach its target with the current level of duty. This means there is either too much, or too little, duty being given to the motor. Adjustments need to be made to the map to either increase or decrease the duty until a satisfactory result is achieved.

3. The throttle can reach its target but the angle and error are oscillating. This means that at low error the P-term is too aggressive and a plateau needs to be created by adjusting the cells either side of the zero-error value. Note that the zero-error cells may require a positive value in order to overcome the return spring of the throttle.

Once all steady state values are tuned, it's advisable to re-check

Once all steady state values have been tuned, it is advisable to re-check through the entire TPS range and also check a few values that were not specifically configured. If a plateau has not already been created, it is advisable to do so at this stage to make sure that the throttle can sit in the zero-error position without being driven in any direction.

In the next Databytes we will continue with the fly-by-wire calibration, looking at step changes and finally tracking the throttle by simulating normal conditions, and also how the I and D terms can be used to further fine-tune the installation.

COSWORTH

Produced in association with Cosworth
Tel: +44 (0)1954 253600
Email: ceenquiries@cosworth.com
Website: www.cosworth.com

Subaru studies

In the first of a new mini-series, our aero expert takes a look at a popular car: the Impreza. Here, a model from the UK's Euro Saloon and Classic Thunder championships

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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Tel: +44 (0) 24-7635 5000
Email: enquiries@mira.co.uk
Website: www.mira.co.uk

We begin a new project this month with a close look at a favourite among racers all over the planet, the Subaru Impreza. This one is the 2006 UK specification WRX STi of clubman racer Danny Precious, nicely prepared by Scoobyclinic of Chesterfield in the north of England. The team had implemented a number of aerodynamic developments on the car during 2012, but limited running due to other technical issues during the season meant that little information had been gleaned on the benefits (or otherwise) of the aerodynamic work. However, some sterling preparation work and half a day in the wind tunnel soon put that situation right, and it also generated some really useful, back to basics data for us to study in these pages.

FROM LIFT TO DOWNFORCE

We'll start with a look at the overall benefit of the 'wing and splitter kit' that formed the basis of the Impreza's aerodynamic package, and attempt to relate the maximum potential downforce observed in the wind tunnel to the positive lift generated without the downforce inducing appendages. **Table 1** shows the coefficients of the best, near-balanced configuration achieved during the session, and the coefficients with all downforce-inducing appendages removed for comparison, with the differences (Δ or delta values) also shown. It is worth noting that even in 'appendage-less' trim the car sported a small STi splitter at the front, and would probably have been generating positive lift at both ends of the car had this not been fitted, so this is not quite a complete comparison. Nevertheless the differences are illuminating.

In the most simplistic terms then, by converting the positive lift into downforce, the aero kit provided 387 'counts' of downforce (a count being a coefficient change of 0.001) for just 22 counts of drag, which seems like a very efficient return. And in this best configuration, the kit turned positive lift (with most of that lift at the rear in the baseline configuration evaluated) into a pretty well balanced amount of downforce for a car with a 61 per cent front static weight percentage with driver aboard.

A key question then: how significant was that change from lift to downforce? We can calculate that by applying the aerodynamic force equation to the change in the overall lift coefficient value (0.387) at various speeds, and then relate that to the car's actual weight. The frontal area estimated for these tests was 2.19 square metres, and the force equation is as follows:

Force = ½ x air density x frontal area x coefficient x velocity squared
or $0.5\rho ACLv^2$

Using a value of 1.225kg/cubic metre for air density, and converting speed to metres per second, the aerodynamic load at the following speeds can be tabulated.

Table 1: comparison of coefficients with and without aerodynamic appendages

	CD	CL	CLfront	CLrear	%front	L/D
'Best'	0.402	-0.222	-0.140	-0.082	62.6%	0.55
'Worst'	0.380	0.165	-0.028	0.193	-	-
Difference	0.022	0.387	0.112	0.275	-	-

Our new subject this month: the Nippon Challenge Subaru Impreza STi

Did this roof vane provide any aero benefit? See over the page...

Looking at the percentages in the right hand column of **Table 2** in the most simplistic terms, these are approximately equivalent to the amount of extra grip provided by the aero kit at the speeds shown, compared to the 'no aero kit' configuration. And while this car isn't going to develop the kind of downforce that could see it adhere to the ceiling at normal race speeds, nevertheless that extra grip will be available for braking and cornering at the speeds shown. Furthermore, the car would also feel more stable and balanced at speed, giving the driver increased confidence as well as greater grip. In a nutshell, this is the benefit of downforce on a racecar, even if it is relatively modest here. We'll revisit exactly how the best overall configuration came about in a future issue.

Table 2: equivalent aerodynamic downforce at various speeds

Speed	Equivalent downforce, N (kg)	% of car's weight incl. driver
70mph (31.3m/s)	508.6 (51.8)	3.6%
100mph (44.7m/s)	1037.2 (105.7)	7.4%
130mph (58.1m/s)	1752.3 (178.6)	12.5%

Table 3: the effect of the roof vane

	CD	CL	CLf	CLr
With	0.385	-0.043	0.059	-0.102
Without	0.382	-0.044	0.058	-0.103
Difference, counts	-3	-1	-1	-1

This was the standard location of the rear wing

Position 3 had the wing at its highest, directly above the starting location

ROOF VANE

A common aftermarket fitment on Imprezas is what might be called a roof vane. The most probable intended purpose of this was to help the airflow to remain attached to the rear screen, and to divert a better feed of air to the kind of low mounted wing more typically seen on Imprezas, at least in WRC-style guise. The standard wing location in this instance was perhaps slightly higher than a WRC wing, but did the roof vane have any benefit? **Table 3** shows all.

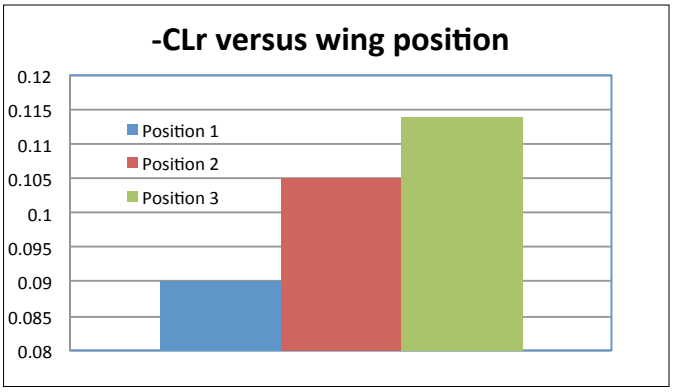
In short, the effect of the vane was almost negligible, with a 0.8 per cent reduction in drag but changes in lift coefficients that were smaller than the typical margin of error. Earlier versions of the Impreza saloon had steeper rear screen angles and it is possible that in that case a vane like this might have had some benefit. But in this case it was removed for the rest of the session.

WING LOCATION

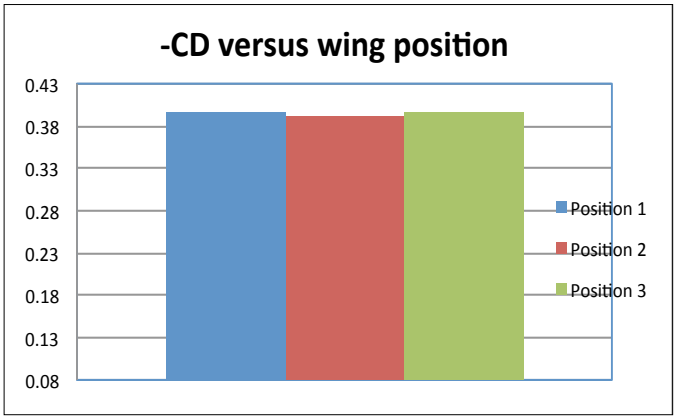
One of the trials carried out in this session was to evaluate the effect of the rear wing in three different locations. The standard location had the wing's central leading edge 220mm above the rear deck, with the centre of the trailing edge of the wing, which was slightly curved in plan view, just overhanging the rear deck. Position 2 saw the wing 90mm higher and also about 90mm further rearwards. And Position 3 was in the same fore and aft location as the standard position, but was 155mm higher. As a quick method of assessing which was the best location for this wing, **Figures 1** and **2** show the rear lift and drag coefficients with the wing at 4 degrees (measured near the tip) each time. Clearly moving the wing rearwards and up helped to an extent, and the highest position of all produced the greatest negative lift coefficient at the rear, and it seems reasonable to presume that this was down to the wing receiving a better feed of air. So while many racing categories specify limits to the height and reward location of a wing, it's pretty clear from this little trial that it pays to exploit any freedoms available in this respect.

Next month we'll look at some variations in rear end treatments and ponder future developments on this car.

Racecar's thanks to Jonathan Fletcher, Danny Precious and the crew at Scoobyclinic.



Rear lift coefficient versus wing position at a wing angle of 4 degrees



Drag coefficient versus wing position at a wing angle of 4 degrees

Basic interlinked suspension

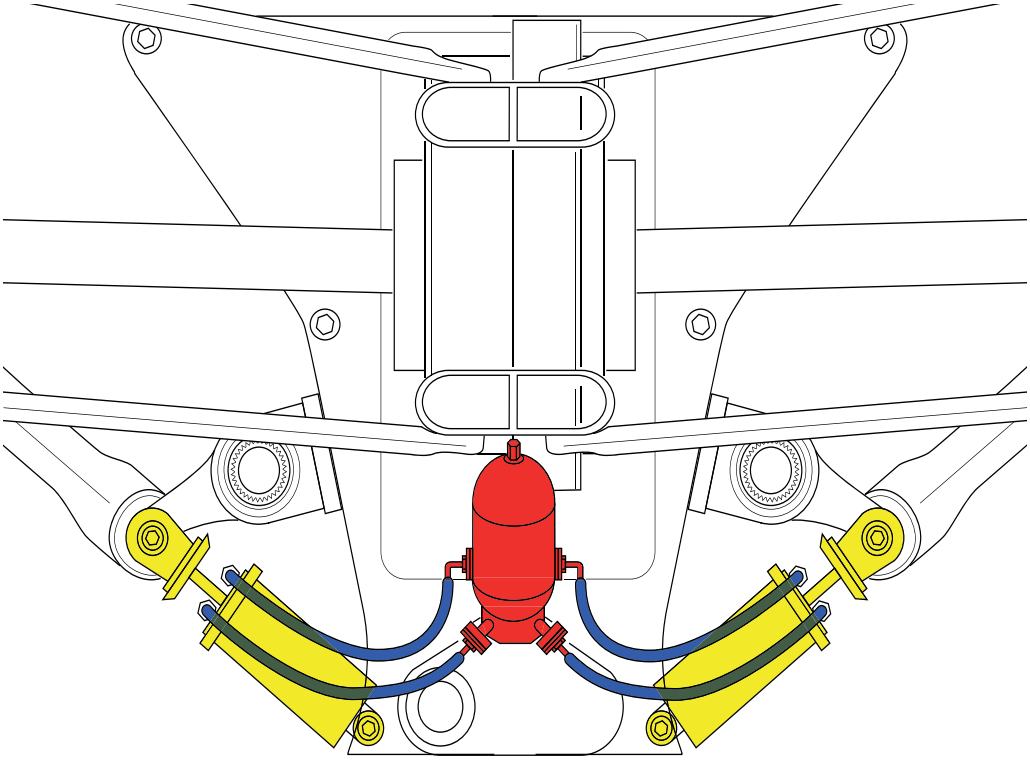
Could you conquer ride height troubles with minimal modification? Read on...

BY MANUEL GREINER

Racecars with very complex and refined aerodynamics can be sensitive to disturbances and become 'peaky' in their performance. As a result, the suspension of a car has to resist the aerodynamic loads in order to prevent significant ride height and rake angle variations.

It is critical for aerodynamic performance that a car is run at its optimal ride height. Dive during braking can choke the airflow going under the car. Conversely a rise in rear ride height changes the expansion ratio of the floor leading to a stall of the diffuser. The result is an immediate drop of downforce and braking performance. The aerodynamic load distribution can also vary with speed, which causes variations of axle load essentially resulting in rake angle changes.

Spring setups for aerodynamic load at high speed are too stiff to provide mechanical grip at low speed, while soft springs better compensate for road disturbances, resulting in a smoother ride. Stiff springs also cause oscillations and tyre normal force variations. But it is not quite as simple as that. Tyres have hysteresis effects, meaning lateral force builds up after a certain delay in response to tyre normal force. Therefore, oscillation of tyre normal force has to be prevented in order to improve mechanical grip. Soft springs do not provide enough roll and pitch support to stabilise the vehicle body during cornering and braking, which is required for handling and response. The different modes a vehicle can experience have to be damped as well, meaning the damping ratio has to be compromised because the dampers control several different modes. Roll, pitch and heave have different demands on the masses, spring ratios and moments of inertia, This results in some of the modes, typically roll and pitch, being over damped.



This type of suspension is nothing new, but this method is now increasingly finding its way into Formula 1

Racecars, such as the TTR-1300 sports racing car we are using as an example, use a six spring-damper arrangement with antiroll bars in order to help separating the modes. Each wheel has individual low stiffness corner spring. Heave, dive and squat are controlled by the heave spring. The antiroll bars are used to control roll as well as load transfer during cornering.

The idea of interlinked suspension is to do for pitch control what the sway bar does for roll control. A compression of the front axle should cause a compression of the rear axle to prevent pitch movements, by converting them into heave movements. Furthermore, a portion of the spring load acting on one axle is transferred to the springs of the opposing axle. Compression of the loaded axle is then reduced, which results in a reduction of ride height and rake angle variation. This helps in decoupling aerodynamic load distribution from the suspension setup. In theory it makes finding a setup easier because a change in wing angle does not necessarily require a change of spring stiffness, as the aerodynamic loadings have been decoupled from the suspension setup to an extent.

As was revealed by Bob Bell in a recent issue of *Racecar,* interlinked suspension is becoming common place in Formula 1, but little detail of these systems is known. Mercedes GP has developed a hydraulic suspension which connects the left and right side of the vehicle or the front and rear, depending on how the system is configured. The pull-rods act directly on hydraulic actuators, which are connected to a central device. The system then acts as an antiroll bar which is interconnected with the front as well. This allows distributing roll moments between front and rear axle.

A system developed by Lotus which uses the brake pressure to prevent dive was banned by the FIA before the beginning of the 2012 season, but that team is thought to have an alternative in place already.

Interlinked front and rear suspensions are nothing new – they have been tried not only in Formula 1 but also in rallying and sportscar racing. The Kinetic and Creuat systems show that it can be advantageous to use

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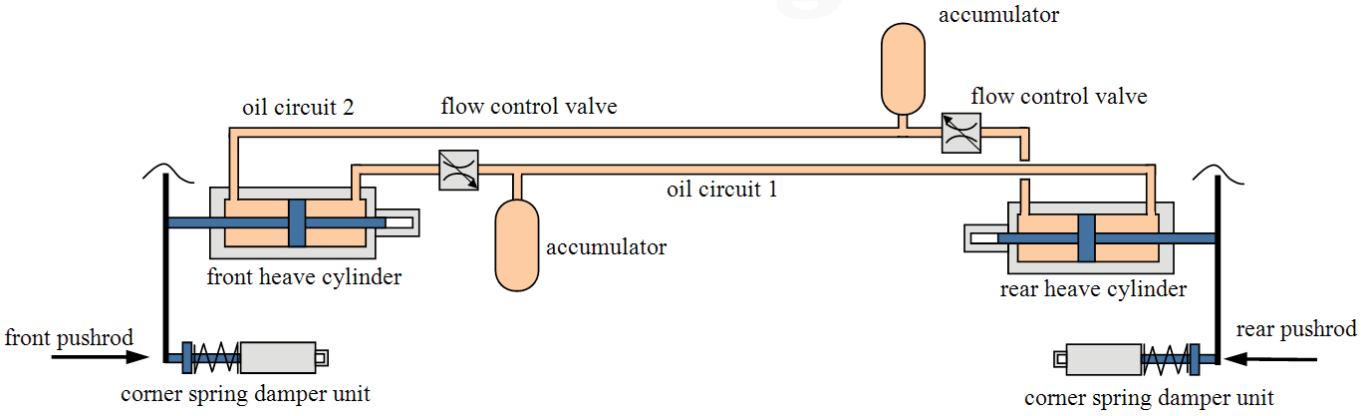

Schematics of the proposed hydraulic system. The presence of flow control valves in the circuits offers the potential to fine-tune the pitch velocity

interlinked suspensions in racecars. The systems illustrated have one thing in common – they connect all four tyres to each other. The approach followed in this article is different in that aspect as it utilises the special design of a six-spring damper suspension, which allows replacing of the heave dampers only. This represents only a small modification to the original suspension, which allows for easy interchanging of the system as well as retrospective integration into an existing car.

Interlinked suspension with a cable or a torsion bar – as it is done in the 2CV – is not the most suitable solution for a racecar. This is especially the case when the system is supposed to be an add-on solution instead of being implemented in the design from the outset. A torsion bar requires a straight connection path between front and rear which needs to be taken into account when the vehicle is designed. A cable is more flexible because it can be run around corners. However, this can cause high losses due to friction and it creates a certain safety hazard when the cable snaps. Therefore, a hydraulic solution – similar to one found on the Morris 1100 – was found to be the best concept.

The interlinked suspension is simulated based on data of the TTR-1300, which was designed to compete in the British Bikesports championship. It is a tube frame racecar fitted with a Suzuki 1300cc Hayabusa engine developing around 135kW. It runs on any Formula 3 tyres, and has a flat floor which leads into a very big diffuser. It develops a significant amount of downforce based on the CFD work conducted by TTR. It has a double wishbone suspension, with a pushrod actuated triple damper layout front and rear. Its sophisticated suspension design and its high downforce potential made this the ideal base car with which to investigate the application of interlinked suspension.

The suspension proposed replaces the heave dampers with hydraulic cylinders, which are connected to each other to generate two separate oil circuits. The hydraulic pipes cross over such that compression of one axle will also cause a compression on the other axle. This means the cylinders will mimic each other's movement. Oil is transferred from one cylinder chamber into the other. The magnitude of movement depends on the spring stiffness of the two axles because a movement can only be realised by a compression or decompression of a spring. Therefore, the interlinked system generates a transfer of spring load between front and rear axle and offers an additional load patch. Essentially the system should reduce a compression of the individual axles because any vertical load, which acts on the vehicle, is spread among both axles. Which in turn should improve aerodynamic performance.

The illustration above shows what the hydraulic circuit could look like. It is possible to place flow control valves into the circuits, which will resist the movement of the oil according to the oil velocity. This offers the possibility of fine tuning the pitch velocity. In addition, an accumulator can be placed into each circuit, allowing fine-tuning of the spring stiffness. But the design of such a system is far from straightforward.

Regular hydraulic cylinders have the con-rod connected to the piston on one side, which creates different piston surface areas and different oil displacements. The difference of oil displacement causes a problem which can be illustrated in a hypothetical example. If the piston surface area on the con-rod side is half the size than on the other, when the front cylinder compresses 1cm and displaces 10cm^3 of oil to the con-rod side of the rear cylinder, the rear piston then has to move twice the amount – 2cm. This already shows that the rear piston is not moving the same amount as the front. In addition, the force generated by the rear cylinder is smaller due to the difference in surface area. The 2cm movement of the rear piston then displaces 20cc of oil from the big cylinder chamber of the rear cylinder to the smaller con-rod side of the front cylinder. However, due to the 1cm movement of the front piston, there is only a volume of 5cc available. This means

INTERLINKED SUSPENSION ON THE CITROEN 2CV

One of the first vehicles featuring a form of interlinked front to rear suspension was the Citroen 2CV from 1948. The purpose of the system is to keep the car in a level ride when going over rough terrain and bumps. The front wheels are attached to a leading arm, the rear wheels to a trailing arm. On both sides of the car is a cable running lengthwise, which connects the arms. The cable transmits forces between front and rear to cause opposing movements. The cable is split in the middle, with each side pulling on a spring which is housed in a floating cylinder unit and rests against the casing. These springs generate the heave springing of the car. The cylinder casing transmits the forces between the two sides. The cylinder unit itself is able to move lengthwise in order to allow for compensation of road disturbances and to allow for pitch movement. It is restrained on both sides by auxiliary rubber springs which are connected to the chassis. Differences in front and rear sprung mass are compensated by different leverages of the cable attachment point. The attachment points also generate a rising rate. The vehicle is sprung very soft in heave because the purpose of the suspension is to improve ride over bumps.

As a result of that, the suspension is very soft in roll. Dive is not prevented by this design as an upward movement of the front arm causes the rear arm to move down. This amplifies dive movements, which requires compensation by anti-dive and anti-squat suspension geometry. The 2CV inspired Alex Moulton to develop the Hydrolastic suspension, which was then used in the Morris 1100 Car.

the system contains 15cc of excessive oil which has to be dissipated, otherwise the system is locked in one position. One solution for this is to place an accumulator in both circuits which can compensate for the volume difference. However, this creates further difficulties because the accumulator itself acts as a spring. Fluid going into the accumulator causes a pressure rise in the circuit, which will act on the different sized surface areas of the front and rear cylinder. This causes a force which acts against the movement. The cylinders will be able to move but the system is intended to return to its original position.

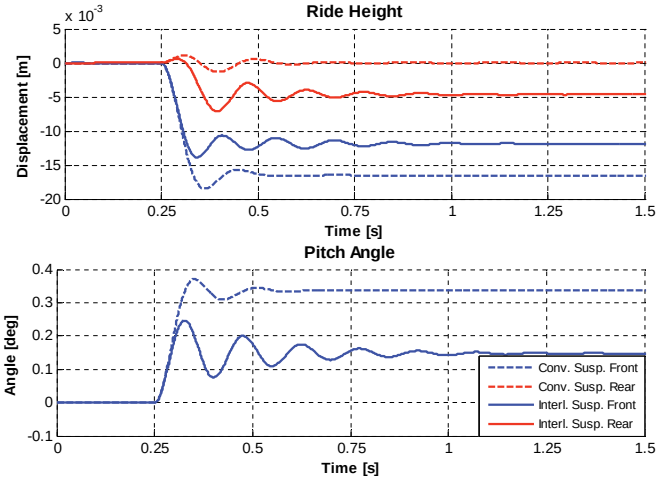

Figure 1: the comparison of load response between independent and interlinked suspension

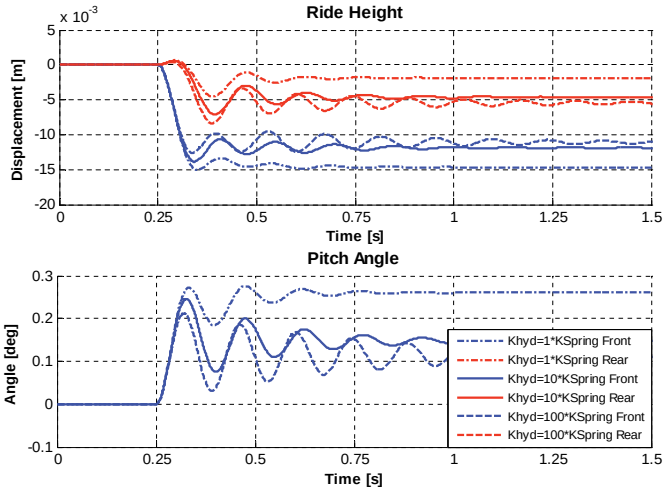

Figure 2: load response with increasing stiffness of the hydraulic connection

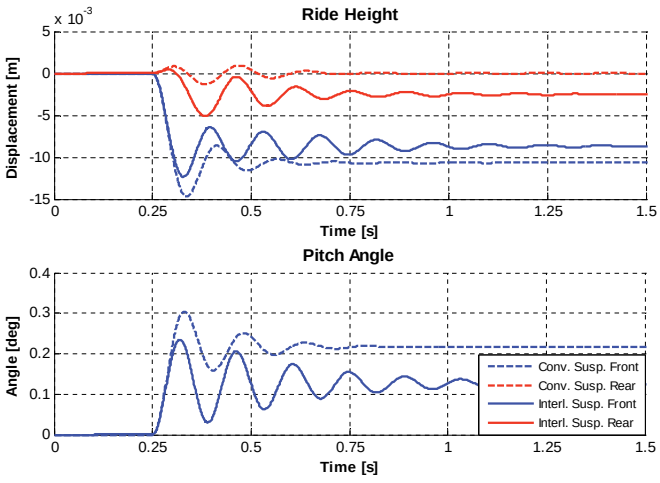

Figure 3: effect of the interlinked suspension for the TTR-1300 racecar

Another solution is the use of cylinders which have the con-rods going through the piston, so that the piston surface area is equal on both sides. The oil can then be displaced in any position without generating any restoring force. It is further required that the front and rear cylinder have the same displacement. As the TTR-1300 was still on the drawing board when this project was conducted, the only way to work out the best solution to these issues was using simulation. That process will be detailed in full next month, but here we'll discuss the implications of the system.

In the tests run for vertical load response, the front axle of a conventional independent suspension compresses according to its spring and tyre stiffness, which essentially causes a positive rake angle. After the suspension has settled down, the rear ride height should not be affected by the load on the front. **Figure 1** shows this behaviour in comparison to an interlinked suspension. The simulation was undertaken with a symmetrical vehicle, which means CoG was set to 50 per cent. Front and rear spring stiffness was set to 90 kN/m, tyre stiffness was 185 kN/m for both axles, and the damping ratio was set to 0.9 on both axles.

A higher stiffness causes more oscillations on the system which take longer to settle down

It can be seen that the compression of the front axle is reduced with the interlinked suspension. The rear axle compresses more according to the transferred spring load. The change in pitch angle is therefore reduced. Apart from the transient time, the wheel load is not affected by the interlinked suspension. However, the variation in pitch angle is not totally reduced as only a fraction of the front compression is reproduced by the rear. This can be explained with the deflection of the tyres which cause a big fraction of the ride height change. This shows that the effect of the system is reduced with low tyre stiffness and very stiff suspension springs.

CONNECTION STIFFNESS

The stiffness of the hydraulic connection also affects how much the rear axle compresses. **Figure 2** shows the deflection with increasing hydraulic stiffness. Hydraulic stiffness was set in relationship to the previously mentioned spring stiffness of the suspension. It becomes apparent that an increase in hydraulic stiffness reduces the deflection of the front axle further, and increases the deflection of the rear axle. This keeps the deflections of the two axles closer together, which reduces the pitch angle variation. However, it also becomes apparent that a higher stiffness causes more oscillations of the system, which take longer to settle down. Front and rear axles oscillate 180 degrees out of phase, which means they bounce off the hydraulic link by compressing it. This causes oscillations in wheel load which reduces mechanical grip. On the other side, the 100x stiffer hydraulic connection does not result in an significant improvement of pitch reduction compared to the 10x stiffer connection. This means that it is not required to make the hydraulic connection more than 10x stiffer than the suspension spring stiffness. It seems to be a good compromise between reduction of pitch angle and minimisation of oscillations.

Figure 3 shows the effect of the system on the car. The suspension was setup to give ideal ride height variations when the vehicle is running on the track. This requires high spring stiffness in order to resist the downforce which is generated at high speed. Spring stiffness of the front suspension is higher than on the rear to prevent dive. The hydraulic stiffness is set 10x higher than the front spring stiffness. The plots show that the effect of the interlinked system is reduced with such a setup in comparison to the symmetrical suspension setups which were used in the previous plots.

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SYSTEM BEHAVIOUR

The simulations showed that the interlinked suspension worked largely as expected and was able to transfer load from the front suspension to the rear, and the other way around. The hydraulic connection offers an additional load path between front and rear for spring load. The system does not manipulate the wheel load in a steady state situation. Load on one axle can be carried to a certain extent by the hydraulic cylinder – this reduces the spring load on that axle, meaning the spring will extend slightly. The additional load caused on the opposing axle then compresses the springs there accordingly. Variations in rake angle remain possible with the system. When the vehicle gets lowered on its springs it will converge to a specific rake angle, defined by its spring stiffness and CoG location.

Simulations show the interlinked system to be 0.03 seconds faster through each corner

The simulations revealed that the suspension is not able to keep the car absolutely level to the ground when load is added to one end, because the compression of the tyres cannot be prevented. It is common to have the spring stiffness in the same magnitude or higher than the tyre stiffness. The stiffness of the hydraulic connection contributes to the difference between front and rear axle deflection – the stiffer the hydraulic connection, the closer the axles follow each other. So, the hydraulic system should be stiffer than the suspension springs. A good compromise was found, with a hydraulic stiffness 10x higher than the spring stiffness.

A higher stiffness gives little improvement in terms of body pitch control, but caused a significant increase of oscillations in the system. The front and rear wheels oscillate with a 180 degree phase shift to each other, which pressurises the hydraulic connection. The connection is loaded and unloaded from both sides synchronously, similar to the impulse transfer in a Newton's cradle. The flow control valve is non-effective in such a scenario because the oil flow is too marginal. It is clear that a solution is required to generate damping for a hydraulic pipe connection, otherwise any sudden distortions to the system will trigger oscillations. These will cause fluctuations in wheel load which essentially reduce mechanical grip. Conventional dampers are not able to control these because of the higher stiffness of the hydraulic system. This type of interlinked suspension is really only suitable for smooth tracks, as running over bumps results in an increase of pitch angle as the compression on the front axle also causes a compression of the rear.

The track simulation of the system showed that the behaviour of the system helps to keep the vehicle closer to the ground without having too much dive during braking. It was possible to lower the rear ride height, especially in corners, by 2mm, which helps to keep the rear closer to the ground, giving less pitch angle and essentially improved braking stability due to the increase of downforce. The lower ride height can present a further advantage by the lower CoG. Dive under braking can be further reduced when the system is able to sense longitudinal accelerations of the vehicle. The track simulations show that the interlinked system is 0.03 seconds faster through each corner. Extrapolated to a full track, this is worth a time improvement of approximately 0.15 seconds.

The highest advantage can be achieved for a racecar which is very sensitive to ride height variations. The aero maps of the vehicle examined here may not have been sensitive enough to demonstrate its full potential.

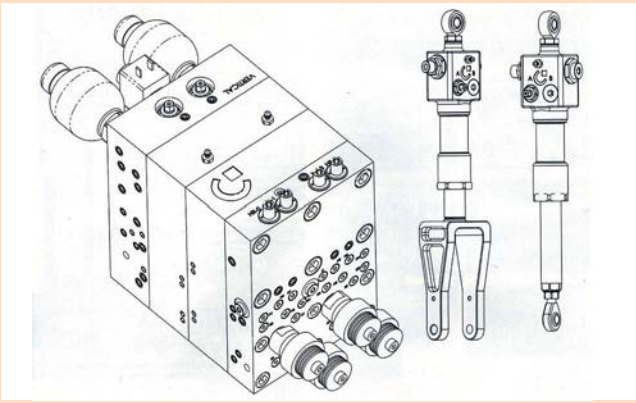
For the TTR-100 market, the interlinked suspension adds an additional element of complexity to the vehicle. Its behaviour can be very unusual for amateur drivers and finding an ideal setup can be complicated. However, the system does provide a certain performance advantage and it is a unique selling point. But in reality such a system is more relevant to F3 type cars or Le Mans Prototypes.

This article is an edited and reformatted version of the thesis the author completed while at Cranfield University ***Next month****: evaluating the concept using simulation software – and why it might not be that easy to install.*

INTERLINKED SUSPENSION IN MOTORSPORT

The Spanish company Creuat developed a hydro-pneumatic interconnected suspension system with the aim to use it in a racecar. Instead of conventional springs and dampers, it uses hydraulic actuators which are fitted to each wheel. These are connected with high pressure oil hoses to a central device which houses all the performance relevant elements. Damper and spring rates can be adjusted with this device, which is placed next to the driver. The springing is achieved by four gas chambers. However, instead of allocating each chamber to one corner of the car, they are responsible for each mode of chassis behaviour. The stiff modes are able to blow off pressure to weaker ones when required. The purpose of the system is to allow for better control of roll, pitch and heave movements independent of the other modes. This gives more flexibility in setup and improves load distribution. It allows for stiff damping in roll and pitch, which improves stability and generates soft damping for heave. This improves traction and grip, and also offers the option to tune diagonal load transfer (warp), which can be beneficial when the system is used in a car with low stiffness or to control understeer. The system can be pre-setup with different configurations which can be switched when for example the track conditions change. The system also offers an easy possibility to change ride height, simply by removing oil from the system. Ride height variations caused by fluid temperature changes are low enough not to cause any problems.

A similar system was developed by the Australian company Kinetic. It replaces the dampers of all four wheels with interconnected hydraulic cylinders. The system provides very high roll stiffness while keeping the individual stiffness of each wheel low. Different constructions of the system, passive and active, are available. A design where the front and rear antiroll bars are connected is also available. It got successfully used by Citroën Motorsport in their Xsara WRC rally car and helped the team to win the championship three times. Mitsubishi Motorsport used it in their Pajero Rally Dakar car and managed to win with it 2004 and 2005 until it got banned by the FIA in 2006.



The Creuat suspension comprises four hydraulic cylinders, connected to a central block with four spring chambers where the spring damping occurs

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A sense of speed

Onboard sensors are becoming smaller, lighter and ever more vital to track performance

BY DR CHARLES CLARKE

In the last issue we looked at data loggers and data acquisition equipment. None of these systems would work if they didn't have sensors all over the car feeding them data.

Just in case you're having a 'how hard can it be?' moment, the online sensor retailer, Autosport Sensors, lists 54 different types of in eight different categories, from engines to weather stations.

Such is our appetite for data these days that, if it moves or changes orientation or state, then there will be a sensor for it, and that sensor can be measured with incredible accuracy and at high frequency.

Because virtually anything is possible, the limitations coming only from your wallet and the space available, it pays to have a sensible sensor strategy. The more data you collect, the more you have to analyse. It's pointless kitting out your track day Mazda like an F1 car unless you have equally sophisticated logging and data transmission equipment, and serious computer hardware and software to analyse it.

Hard-wiring of sensors is difficult to avoid for exhaust temperature, mechanical load and range of motion-type sensing. The trend is definitely towards wireless, non-contact, non-moving parts, 'bolt-on' sensing where possible, making use of the inductive and capacitive characteristics of the environments or materials as much as possible.

"NASCAR is opening up opportunities for sensor designers and manufacturers"

Perhaps the most beguiling of modern developments is the Surface Acoustic Wave (SAW) sensor. These devices make use of the capacity of certain materials to turn physical effects or changes (chemical, optical, thermal, pressure, acceleration, torque and biological) into electrical signals that can be transmitted wirelessly. This technology is a necessary component in touchscreen displays.

By exploiting the piezoelectric effect of certain materials – like quartz and lithium niobate – sensors can operate without batteries, which makes the technology even more attractive.

Stack's TPMS (Tyre Pressure Monitoring System) uses a batteryless, wireless sensor that utilises SAW technology. The absence of a battery cuts down on the maintenance cost and it can also be fitted in places that eventually become inaccessible, like the inside of tyres. The TPMS sensor is just a bit bigger than a tyre valve cap. A SAW pressure and temperature sensor can weigh less than 3g, with a resolution of 0.1psi, and it can be easily integrated into a racing wheel. It fits on the inside of the wheel valve and transmits signals wirelessly to the data logger, which lets you know with precision how the tyre pressures are varying. It can also sample at higher frequencies without affecting its performance. This was developed internally at Stack UK and it's now fitted to cars across the motorsport world.

It also has an RFID function that can be interrogated. The TPMS sensor tells you where the tyres are at the rack or the factory, so for the bigger teams it's very useful for tyre management.

Each wheel sensor comprises a 2mm thick x 12mm diameter SAW pressure/temperature sensor and an antenna, in a 21mm diameter x 16mm cylindrical housing weighing only 15g – it is claimed to be the smallest and lightest sensor on the market.

Stack uses patented SAW sensor technology under licence from Transense Technologies, which offers wireless, batteryless, compact operation. SAW sensors are passive (no power required), wireless, low-cost, rugged and extremely small and lightweight, making them well suited for measuring pressure, temperature and torque (strain) in moving objects (eg tyres, drive shafts etc). These characteristics offer significant advantages over technologies such as capacitive and piezoresistive sensors, which require operating power and additional electronics to make a wireless connection.

Race Technology's Speedbox Mini, an non-contact speed sensor using GPS and inertial tech

One of the various Texense sensors available from Texys

An ultrasonic fuel flow sensor from Gill, which also offers fuel level sensors and gauging solutions

Germany's 2D Datarecording provide data loggers, sensors, CAN-modules and more

The SAW pressure and temperature sensor can be integrated easily into a racing wheel. These systems enable the user to measure the pressure in each tyre up to 20 times per second. Higher sampling rates can be used to improve chassis setup, as well as providing an early prediction of tyre failure. The Stack TPMS system allows higher sampling rates without fear of shortening sensor life.

The higher sampling rates allow you to see the dynamic effects of wheel and tyre loading through individual corners, rather than just over a lap, and from lap to lap.

The whole TPMS project was driven by Stack UK and the manufacturing design and manufacture is all done in the UK. The TPMS sensors can now be used in competition - you can race as well as test with these sensors.

Each wheel sensor is mounted internally on the wheel rim or valve, or externally on the valve stem. The Interrogator Module is mounted in a convenient location on the vehicle, and four patch antennas are each mounted locally to each wheel (within approx 500mm of the wheel), and connected to the Interrogator module by an RF cable. The CAN data output can be connected to any standard CAN-based data acquisition or driver display system.

The Interrogator Module takes readings of tyre pressure and sensor (air) temperature from each wheel sensor continuously at a pre-defined rate between 1Hz and 10Hz. Pressure and temperature data for each wheel is output on CAN bus, with user configurable CAN-ID messages.

Similar wireless SAW technology, again licensed from Transense Technologies, has allowed McLaren Electronic Systems to develop a non-contact, SAW torque sensor for their Formula 1 Kinetic Energy Recovery System (KERS).

MORE FROM SAW

Other SAW-based applications include torque measurement systems for Electrical Power Assisted Steering (EPAS), IC engine control and driveline management.

"It's pointless kitting out your track day Mazda like an F1 car unless you have equally sophisticated logging and data transmission equipment"

One of the recent projects was to develop a torque sensor for KERS, capable of operation in the extremely harsh environment of F1 vehicles. The sensor was capable of measuring torque generated by the KERS motor or the car engine at a very high rotation speeds, up to 18,000rpm. In addition it survived very intense engine vibrations, of around 100g, while the temperatures ranged from 70 to 170degC.

As part of the Joint Development Agreement (JDA) with McLaren signed in August 2011 and following on from the success of the KERS project, Transense is now manufacturing torque sensor shafts for Indycar.

The driveshafts and input shafts are fitted with SAW torque sensors, which are then supplied to McLaren for integration with the sensor interrogation electronics and shipment to the customer. Modifications to the Indycar shaft for sensor compatibility, the SAW torque sensor and the interrogation electronics all contain Transense-patented intellectual property.

Texsys has a variety of sensors for measuring critical temperatures of tyres and brake discs. All this is involves non-contact temperature measurement. The other important area of measurement is what is commonly called the aerodynamic sensor. Texsys has been developing a small multichannel pressure sensor for aerodynamic applications. These are very small discreet sensors that you can put underneath the racecar to measure aerodynamic flow. They can also be embedded in wings or any aerodynamic part and they can be moulded to the shape of the component.

Texys has developed high technology temperature sensors for various embedded temperature monitoring applications such as carbon and steel brake discs, tyre surfaces and clutches. Special solutions have been designed to measure the temperature distribution of the complete tyre footprint.

Over the years, Texys has gained a strong reputation in non-contact measurement expertise with different technologies to answer customers' specific requirements for temperature ranges, short response time solutions, and/or special field of view applications. Infrared optical fibre has been developed to match very harsh environmental requirements. Texense patented thermocouple amplifiers are widely supplied to testing facilities and laboratories in all forms of the automotive and industrial marketplace.

Dynamic vehicle analysis requires a mix of acceleration and angular speed measurements to assess levels of tyre grip, braking and efficiency. Texys provides low and high frequency miniature acceleration models to cover the spectrum of automotive testing demands as well as single- and multi-axis gyroscopes. They have also introduced some modular combinations of accelerometers and gyroscopes, and offer integrated measurement solutions with four- and six-channel inertial boxes.

The company has also developed a range of miniature micro controlled amplifiers with integrated protection, to allow an easy setup close to or remote from signal measurement. They have designed a range of adaptable products with analogue and/or digital amplifier with programmable features. Texense too has designed an electronic amplifier for high speed acquisition. The company has expanded its range of products to match with customers requirements, such as internal and external temperature compensation, filter options,

and input and output voltages. Robust and fully programmable analogue-to-CAN and CAN-to-analogue interfaces are available for multiple applications.

Aerodynamic sensors have been a significant part of their automotive sensor range, with the development of low and very low pressure sensors for multiple applications such as wind tunnel analysis and, most recently, sailing applications. The reduction of testing has led Texys to develop Formula 1 on-car aero sensors that are easy to package and highly adaptable. Texys has developed a range of multi channels solutions available with both analogue and CAN output options.

Texys has worked for many years on strain gauge bonding applications, to components such as pushrods, linkages, dampers, steering columns, track rods and rod ends. This has also led to the development of miniature programmable strain gauge amplifiers.

Variohm is now manufacturing its own range of temperature probes in the UK, targeted at the motorsport industry. These are mainly designed for full exhaust gases temperature measurement using thermistor-type probes (PC 100 type), not infrared.

Variohm has an in-house design facility, which has designed this type of temperature sensor, and they are working with suppliers of some higher response time epoxy resins. These products are being developed in conjunction with their existing motorsport contacts.

Variohm has a range of off-the-shelf sensors and they can offer custom design services. They can take a customer housing and integrate the sensors within the housing. These can either be permanent fixtures or clamped in place for ad hoc measurements.

For a more permanent installation, the sensor would be threaded in place. In these instances the thermistor would be immersed in the gas flow.

"Race series such as Porsche Supercup are providing good opportunities for sensor designers and manufacturers"

The technology is relatively simple and consequently it is easy to integrate into virtually any data logger.

Often Variohm's motorsport customers are looking for custom designs and they're very happy to accommodate a custom approach as long as they can see the prospect of medium volume production for a particular design. Variohm are known for their rotary sensors, rotary potentiometers, rotary Hall effect devices, linear transducers and linear potentiometric devices.

Their contacts and customers throughout the motorsport industry helps them to tailor their products to their customer's requirements.

A higher percentage of their sales is tending to come from Europe, and they are building relationships in the US by working more closely with companies such as DC Electronics and Texsys, who have setup facilities in the US. They also partner in Japan to address the worldwide sensor market.

On their rotary sensors, which are generally used for gearbox and throttle positioning applications, they're seeing a variety of requirements for different angle devices. Rather than customers taking a standard product, which may be losing resolution by applying it to a particular application, Variohm have a new Hall effect device, which is programmable on site. The part itself is a 360-degree part, but one customer has a requirement for a 345-degree device and one from 130 degrees. Variohm can program the 360-degree part and give the customer exactly what it wants. The thermistors are UK-manufactured, the rotary sensors are made by Germany's Novotechnik. Veriohm is a worldwide design partner of Novotechnik.

NASCAR seems to be opening up opportunities for sensor designers and manufacturers and the individual race series like Porsche Supercup are providing good opportunities. Companies such as Radical are using Variohm sensors in their various race series, while all the Formula 1 companies in the motorsport triangle have various Variohm products on their machinery.

There is a major push at Gill Sensors to perfect its ultrasonic flow sensors The FIA has decided to impose fuel flow restrictions on engines in 2014, which means that the fuel flow needs to be very accurately measured to ensure that the cars comply with the new regulations. But it also means that the engine developers and manufacturers have to go back to the drawing board and redevelop their 1600cc turbo engine to be as fuel-efficient as possible so that they can get the maximum power.

LIQUID MEASUREMENT

Aside from the fuel flow measurement devices, Gill also produces fluid level sensors that cover all racing fluids. These are sophisticated devices which use an inductive technology and are gaining popularity across numerous formulae.

'We haven't really offered products to lower formulae, but we have addressed this with our latest non-contact position sensor,' says Mike Rees of Gill Technology. Gill supplies almost all the Formula 1 teams in terms of liquid level sensors.

'Some of the time teams will run a fuel collector level sensor which tells them when they're getting down to the last litre,' says Rees. 'The teams that are keen on fuel level sensing will also run a fuel cell level sensor, which will monitor the whole fuel cell and report on fuel consumption during the race. The fuel collector level sensor will reveal when they're about to run out. We've seen a few instances in 2012 when there wasn't enough fuel in the collector and some high-profile drivers had to stop on track to ensure there was enough fuel for a test sample.'

An example of a clutch sensor from Lymington, UK-based Gill Sensors

The TPMS wheel sensor from bf1systems has decreased in size, down from 36g to 30g and have a pressure resolution of 12.5mbar/bit, 14.7mbar/bit or 25 mbar/bit, according to demand

Example of an F1 throttle sensor from Gill

The Gill Sensor's level sensors are capacitive, they don't have any floats or moving parts. They basically turn two tubes into a capacitor in the fuel call – as the fuel moves up and down and fills the void between the tubes and the capacitance of the device varies. Because there are no moving parts it's an excellent solution for Formula 1 in situations where the car is subjected to relatively high g forces.

Gill has been supplying Formula 1 for the last nine years, and the technology has developed impressively during this period. 'We've now moved on to more micro-level sensors in an attempt to reduce the weight of every part and increase the resolution where we can,' says Rees. 'A lot of teams are now using carbon fibre and titanium construction for sensors to reduce the weight and size. Each team has a custom designed fuel level sensor because each fuel cell is slightly different, so we rarely build the same sensor twice.'

The fuel flow sensor uses ultrasonic technology, which is solid state and again has no moving parts. This is been developed specifically for measuring fuel flow rates, which come into the rulebook for Formula 1 and WEC in 2014. The idea of this regulation is to promote fuel economy the FIA is looking to cap the rate at which the engine consumes fuel. But there is no complementary restriction on power, just flow rate. The underlying agenda here is to try and make Formula 1 more relevant to everyday cars and vice versa, as well as more than a passing nod to eco matters.

'We've done about 20 full car tests within Formula 1 and endurance racing and initial feedback is very positive,' says the company. 'As well as testing the device we are also testing robustness and how it will cope with temperatures and the accelerations involved in F1.'

This flow sensor operates using two ultrasonic transducers at a fixed distance apart in the flow line. A pulse is fired from one to the other and the time it takes for the pulse to travel is measured. A pulse is sent back and measured again. Because the speed of sound is known and the distance is known you can work out the effect of the flow in terms of delaying the pulse. The flow rate can be calculated very accurately from this.

The FIA has specified that the sensor should have a maximum error of +/- 0.25 per cent in a flow rate of 8 litres per minute. 'With this sensor fitted to a V8, we can actually identify problems with individual injectors,' says Rees. 'It's possible to pick up, in the low rpm ranges, every injector pulse so it's possible using this technology and a reasonable data logger to identify misfires and where they happen.

"Some high-profile drivers had to stop on track to ensure there was enough fuel to provide a test sample"

'We have also done quite a lot of work this past year in F1 on position sensing. We have our own patented induction technology, which has been around in the company for about 10 years, but we've just taken it to the next level where it's faster, smaller and a lot higher resolution than the old technology it replaced. We've been producing position sensors for clutch actuation. We did one earlier in the year monitoring the position of the DRS rear wing, and we developed a non-contact position sensor for monitoring throttle pedal, which mounts to the outside of the axis of rotation of the throttle pedal.

'The big selling point we found with these kinds of sensors, particularly for clutch sensors, is the stability at high temperatures,' says Rees. 'With Hall effect devices the magnets change properties at very high temperatures which can affect readings. And it's very difficult to calibrate for temperature.'

With inductive devices, where you're relying on a piece of mild steel rather than a magnet, it's much more robust at high temperature and frequency. The clutch sensors are monitoring clutch actuation, and because the technology is so accurate, Gill can monitor clutch wear to the micron level. The throttle pedal sensor is linked to the fly-by-wire throttle used in modern F1 cars.

The technology is not changing dramatically – more the size, the accuracy and the affordability. Load sensors, pressure sensors, accelerometers, laser distance sensors, linear position sensor are becoming more affordable for the grassroots racer. This is coupled with the general availability of relatively low-cost data loggers and ECUs.

The more traditional 'resistive' technologies are giving way to capacitive and inductive approaches with the trend being towards non-contact measurement with the minimum of moving parts and using wireless transmission where possible. SAW technology seems to be the 'next big thing' with a number of companies making SAW-based sensors.

As is always the case in racing, the sensors are getting smaller, lighter, more robust and significantly more capable. The good news is that they are no longer the preserve of the rich and famous – they are moving into areas that complement the new ranges of affordable data loggers and data acquisition equipment.

Smaller is better

Wiring companies are investing in the reduction of weight for their products, while maintaining performance targets set by teams

BY GEMMA HATTON

The number of sensors on modern race cars is ever increasing, as the need for monitoring and controlling every possible variable is becoming essential to achieve a race car with optimum performance. Consequently, the development of wiring harnesses and connector designs are advancing rapidly.

An electrical connector is defined as an electro-mechanical device for joining electrical circuits as an interface using a mechanical assembly. Wiring harnesses and looms are an assembly of cables which transmit electrical signals.

As ever with motorsport, the most important factor is weight reduction, and this has resulted in the motorsport connector industry tending towards miniaturization – a concept that Fischer Connectors quickly realised. 'Electronic devices are getting smaller and smaller and, at the same time, more input and output contacts are required and less weight,' says Arjen Meijer, Content Editor and Project Leader at Fischer Connectors. This instigated the creation of their MiniMax Series which is a unique rugged push-pull interconnecting solution with an all-in-one 20 signal (0.5A) and 4 power (5A) connector with 24 mixed contacts.

The continuous need for reduced weight, but more contacts, is spurring further innovation and, if designed well, can be the make or break of a manufacturer, as Deutsch Connections demonstrates. 'Our most popular product is the ASL (Microlite) sensor connector because we have managed to squeeze in one extra contact,' says a company spokesperson. 'We now offer a 6 way ASX, which allows for true sensor redundancy – power, signal, ground x 2, or the option of running 2 sensors via the same connector.'

The most popular type of connector within motorsport is the Souriau 8STA high density range, which is derived from military specifications seen in the Eurofighter, and are designed to withstand high levels of shock and vibrations. Souriau are the market leaders in the smallest, lightest, most reliable, highest density per shell size and largest power connector 'The High Density range is proving popular across the board in motorsport, but we have seen the biggest uptake in endurance racing, rally and F1 where it allows teams to reduce the connector size, but keep the pin count the same, resulting in smaller and lighter wiring harnesses,' explains James Shingleton, Business Development Director for bf1systems.

The biggest challenge when supplying motorsport teams is conforming to the regulations, as Boguslaw Budzioch from

Tekdata's Multiway Distribution Box, left, while below, a connector from bf1systems,

Weald Electronics explains: 'Motorsport requires a lot of new connector design as rules change. However, only small volumes are needed, as each team has different requirements, which can cause problems for funding. The biggest issue with supply is the lack of forecast and the demand for development, but this is where our VAD connector assembly comes in to play as we hold large stocks of piece parts, and can assemble hundreds of connectors within three days.'

To stay ahead of the game, some manufacturers attempt to predict future trends, such as Deutsch Connectors. 'It takes teams time to assess new ideas and technologies, so we are working on parts which may only become useful if the regulations permit using different materials for cable and connectors and more use of fibre-optic connections,' says the company. 'However the good news is that we don't see any drop in the demand for very harsh environment products.'

Unsurprisingly, supplying motorsport teams puts manufacturer's under huge time pressures as bf1systems describes: 'With the elongation of the racing seasons, the time when teams are not racing is becoming shorter. The wiring tends to be one of the last items finalised on the car because it has to integrate with so many other components. Therefore, the date when wiring can be mocked up on a car is later, yet the date required for the first harness remains the same. Previously, timescales from mock-up to first builds were months, now they are weeks and sometimes even days.

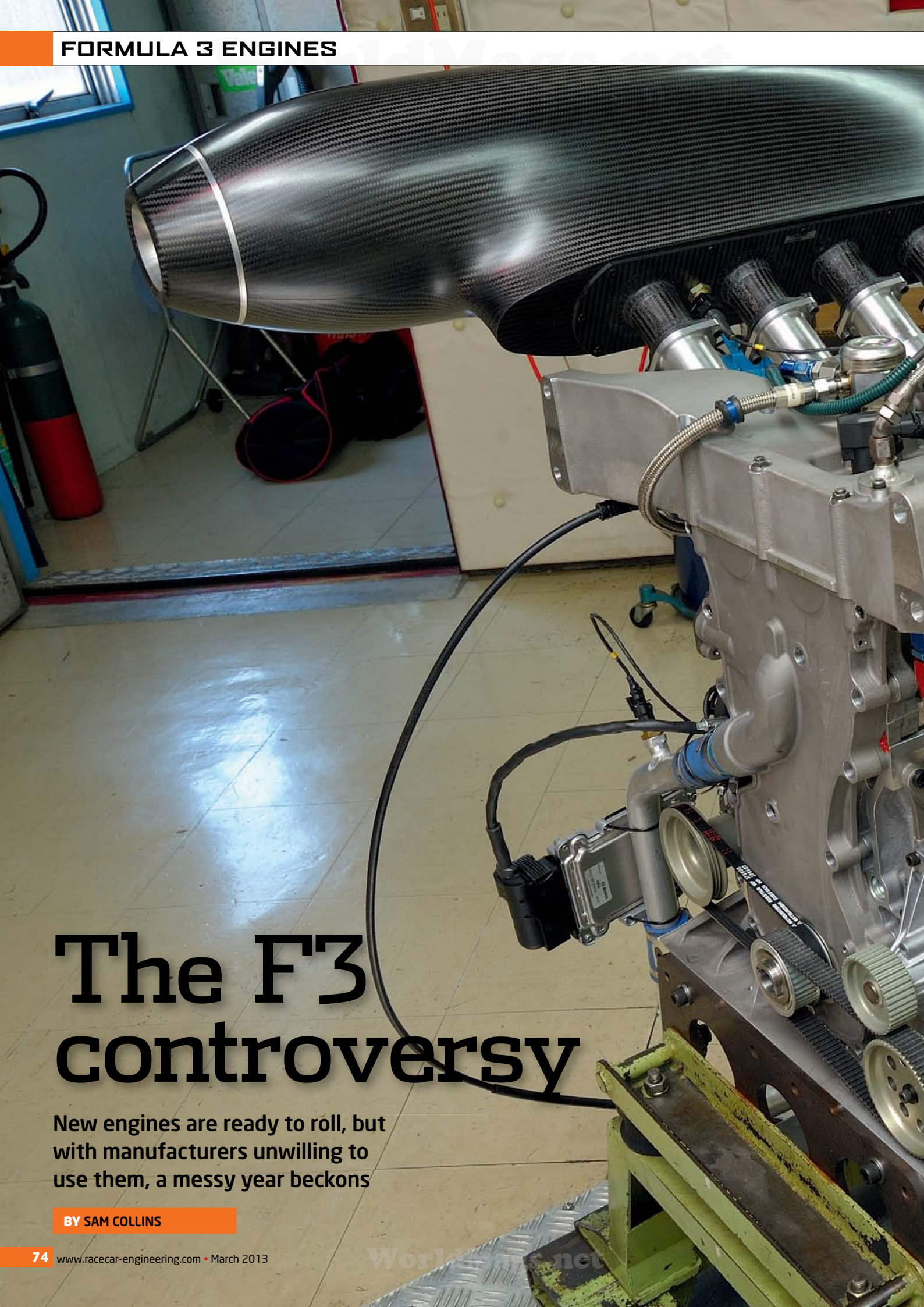
'Wiring harnesses have evolved significantly over the last couple of years, which has led us to develop Wiring in Composite (WiC) Technology, which allows the complete integration of wiring harnesses into composite structures. This has massive benefits for teams, as the overall weight and size of the wiring decreases significantly. This technology is early in development, and requires a step change within the design process.' Rapid prototyping has further advanced the technology, The use of rapid prototypes for semi-structural components which integrate the wiring has been a big change because they replace expensive, long lead time parts with a more cost effective solution. The structures which incorporate the wiring are also being used for other purposes such as retaining ECUs.'

The use of rapid prototypes replaces long lead time parts with a cost-effective solution

Tekdata explains the further potential of effective wiring harness design. 'Developing harness solutions is an area which can offer not only packaging advantages, but also opportunities to reduce weight via using smaller core wires, as the weave offers structural integrity and also allows the opportunity to bond wiring into the chassis of the car.'

The future of connectors and wiring harnesses looks bright as teams have an insatiable appetite for data. Furthermore, the continual introduction of hybrid systems is providing new challenges for manufacturers, as demonstrated by Fischer Connectors which has recently collaborated with the GreenGT H2, the first prototype of an electric/hydrogen competition racing car that will participate in the 24 Hours of Le Mans this year. Fischer Connectors will supply the GreenGT H2 with more than 30 connectors to secure safety and performance.

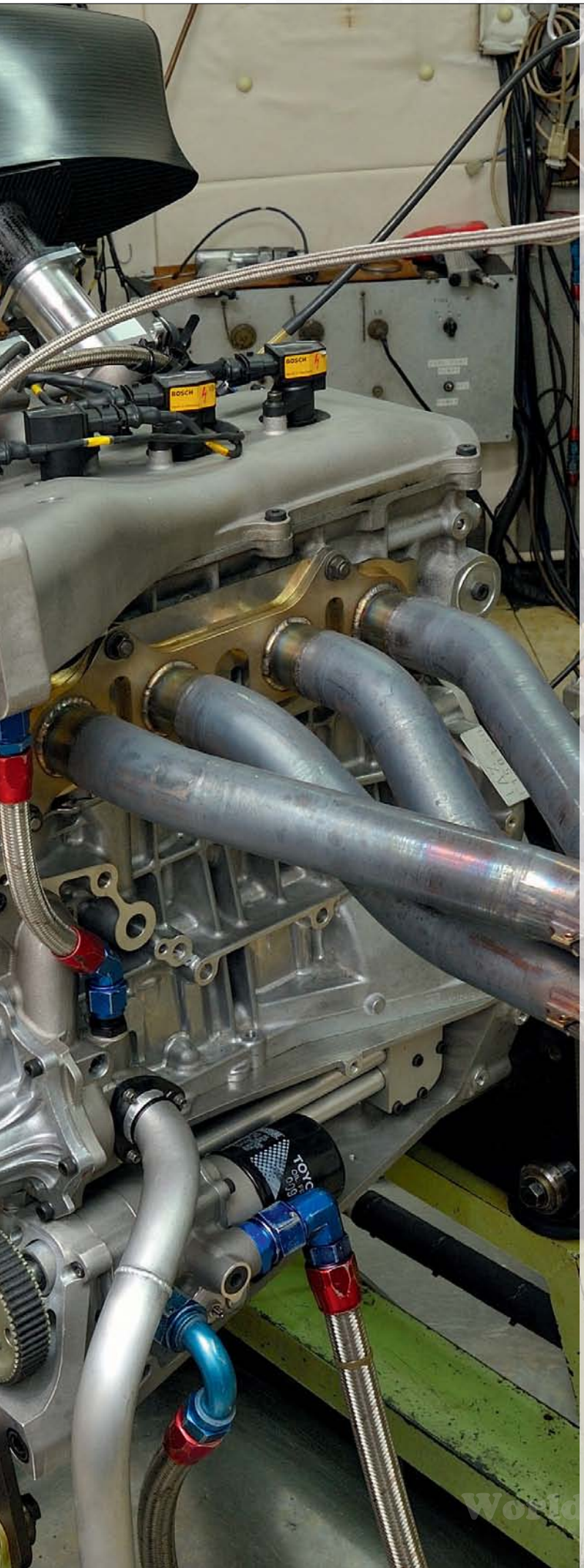
Weald electronics concludes: 'For connectors, motorsport is all about weight, volume, density and size. Quality is a given and service/availability are key.' Electrical connectors will become smaller, more advanced and more efficient. The question is just how far can this technology develop and what is in store for the future.



The F3 controversy

New engines are ready to roll, but with manufacturers unwilling to use them, a messy year beckons

BY SAM COLLINS



TOM'S and Neil Brown Engineering have shown off their new engines for Formula 3, amid ongoing uncertainty about the regulations for the struggling junior category. A new rulebook for the powertrain in the class was meant to have been introduced at the start of 2012, along with the new chassis regulations which were implemented. The new engine rules were postponed by a year due to the precarious economic state of many F3 teams, but they are in place for the 2013 season. However, it is not clear if any of them will be used on track.

The new engines are a traditional Formula 3 in that they are 2-litre, 4-cylinder normally aspirated units breathing through air restrictors, but unlike the previous set of regulations they do not have to be based on a production block.

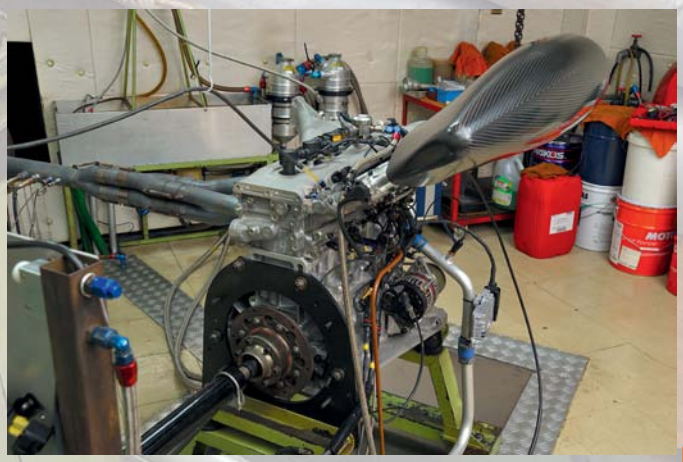
Overall, the 2013 engine configuration is tightly controlled. It must be a four stroke inline four with a maximum capacity of 2000cc. It must run clockwise with a firing order of 1-3-4-2. Pistons must be circular – no Honda R&D-style ovals here – and the dimensions of most of the major moving components have minimum sizes. Each cylinder can only have a single injector, throttle and spark plug. The total engine weight must be no less than 87kg with no more than 5kg of ballast. This weight does not include any of the flywheel, intake system, exhaust manifold, alternator, clutch, oil filter and mounting studs.

Even the use of coatings is restricted to certain areas. DLCs, for example, can only be used on the tappers, camshaft, piston ring and the gudgeon pin. The piston skirt can be coated but only with Graphal or molybdenum-based products found in mass production vehicles. However, in general the regulations give scope for manufacturers to introduce coatings used in mass production to many parts of the new engines.

Crucial to the rulebook, and very much a sign of the times, is the fact that the engines are cost-capped, as Gavin Harrison, manager at Neil Brown Engineering (NBE) explains. 'The engine has to cost €50,000 per season, but that did not limit the development,' says Harrison. 'We have produced an engine that is the best that we could produce. You have to keep that budget in mind, but you also have to consider that the budget is per season, and that the life of the engine is four seasons or more. A full year's running is 10,000km, including testing. On top of that, you can charge for overseas track support.'

The engine budget must include the actual engine, wiring harness and engine mounted sensors, the flywheel and lease, the mileage and a rebuild, as well as local track support.

For many years, NBE was closely aligned with Honda in Formula 3 and its engines won multiple championships. Today that relationship has come to an end (on amicable terms) leaving NBE to develop its new engine, and as all the new engines have to feature direct injection it was a steep learning curve for the English firm. 'It is totally bespoke, which is the first in F3 for us,'



TOM'S new F3 engine is unveiled for the new season. However, new units are unlikely to be seen in any meaningful competition until November

Neil Brown Engineering's 2013 F3 engine, on display at Autosport International in January, could be as much as 1.5-2 seconds a lap faster than the old units

says Harrison. 'It was also the first time we have done a direct injection engine, which was a major challenge. Its very different. The injectors are specifically designed for our engine by Bosch, who supply all of the electronic components. They did a study for us along with one of our designers to work out what was required from the injector.

'The original intention was that you could take a production injector, but due to the non-disclosure agreements Bosch has with its customers the guys there could not tell us what the injectors were, so we got them to make a bespoke injector for us. It's more expensive, but at least you know you are getting what you want. So you can pretty much do what you like with the injectors, though fuel pressure is limited to 200bar. Beyond that, there is a spec ECU and wiring. The injector drivers are separate but everyone still has the same.'

NBE showed off the new engine at the Autosport Engineering Show on the Cometic Gaskets stand, keen to make the point that they were fully ready for the 2013 season. 'It's done 30 hours on the dyno already, and the performance is significantly better than the old engines. Power and torque are increased and the engine revs are higher. It has a bigger restrictor, and peak power is about 7000rpm, compared with 6000 on the old engines.'

This performance increase is at the heart of the controversy surrounding Formula 3. In Japan, three 2013-spec engines have been built, with TOM'S, Mugen and Toda Racing all ready for the start of the season, but in Europe only NBE committed to the new rulebook. TOM'S considered an engine supply deal via TMG in Cologne, but could not meet the cost cap due to the strength of the Yen against the Euro. Notably absent from the list are Mercedes and Volkswagen, who currently supply the bulk of the engines raced in Europe.

"We are disgusted with how the situation has been handled, it has turned into a farce"

'The reason nobody wants these engines is political,' says Harrison. 'In Euroseries, every team is supported by the manufacturers so they won't go over to the new engines. In the British championship there are two big teams, both tightly linked with a manufacturer. It has been suggested that if anyone runs a new spec engine in British F3 they will leave the series for Europe and it will kill the British championship dead. We are not a factory – we cannot give teams subsidised engines and chassis developments – so the manufacturers have a stranglehold.'

While the German OEMs had initially supported the new engines, they then decided to push for Formula 3 to adopt 1.6-litre appendix engines. 'We had the idea of using the engines from WRC or WTCC and passing them to suppliers to tune for F3,' explained Donatus Wichelhaus of Volkswagen, 'so we would give our old engines when we've finished with them to Speiss who could tune them for F3. This would allow many more manufacturers into F3 and give the tuners opportunities which maybe they do not have if we supply directly.'

The situation is now unclear. While the regulations of the European championship allow the new engines to race at any time, the old engines will also continue through 2013 to give the German OEMs time to develop engines to the new rules in time for 2014. This would, according to Harrison, give anyone using a 2013 engine a huge advantage. 'The new units could be about 1.5–2 seconds a lap faster so its a significant gain,' he says, 'but due to the political furore in Formula 3 at the moment we have no idea when the engine will run. We would like to run it at some point this year.'

'We are disgusted with the situation and the way its been handled, it has turned into a farce. There seems to be a lot of self-interest in the way the regulations have been put together. Now Formula 3 is in a rather weak position as a result. Drivers are not willing to commit, because they do not know what the rules are. Because there was so much confusion, the FIA allowed the old engines to continue, and you now have this situation where both are available.'

Anyone who wants to homologate an engine for the 2014 season must do so by the end of March, so that they are ready to race at the Macau Grand Prix in November, which is likely to be the first mass usage of the new engines. But late entries will be available after the March deadline subject to the approval of the suppliers who have already homologated engines. Once the spec of the engine is homologated by the FIA it will be subject to a design freeze which will run up until the end of 2017.

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Refining aeromaps from pitch data

Interpreting the stats could make the difference between first and second...

In the absence of manufacturer info, pitch data can provide valuable insights

Over the last couple of months I have been working with a number of customers and colleagues on refining their simulations on a number of different car platforms. This has spanned open wheelers, GT cars and touring cars. The major problem we have been dealing with is non-existent, or very poor, aeromapping data supplied by the racecar manufacturer. However, you can derive a lot from looking at pitch data.

BY DANNY NOWLAN

This is when we combine the front dampers and the rear dampers together in one channel. I realise what I'm stating borders on the ridiculously obvious but let's define the front pitch and rear pitch as the following equation:

We have:

FL_Damp = Front Left damper
FR_Damp = Front right damper
RL_Damp = Rear left damper
RR_Damp = Right rear damper

The beauty about these channels is that unless you are running some horribly asymmetries they are fantastic sanity check for the anti-dive and anti-squat and more importantly the aero information. The thing about these pitch channels is they eliminate the roll information. What this means is that they are a brilliant tool for figuring out what's going with the aero.

You know you are dealing with an aero-related modelling problem when you have a clear discrepancy in the pitch data. You are looking for something that looks like **Figure 1** (overleaf).

This has been taken from actual data, so I've had to blank out scalings and data numbers. However, I can walk you through the channels.

The top trace is speed, the second trace is steering, the third trace is front pitch the fourth trace is rear pitch and the final trace is acceleration. In rough terms what we are seeing

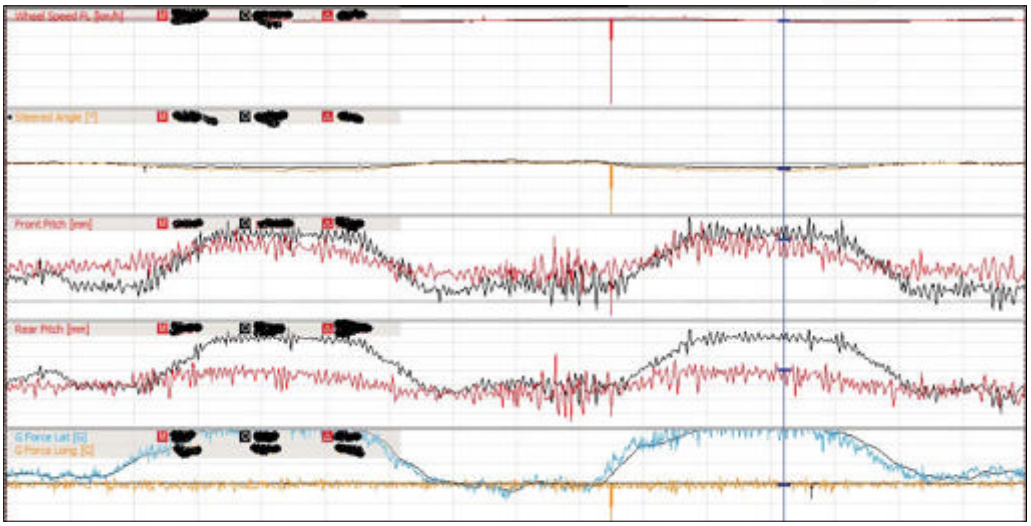
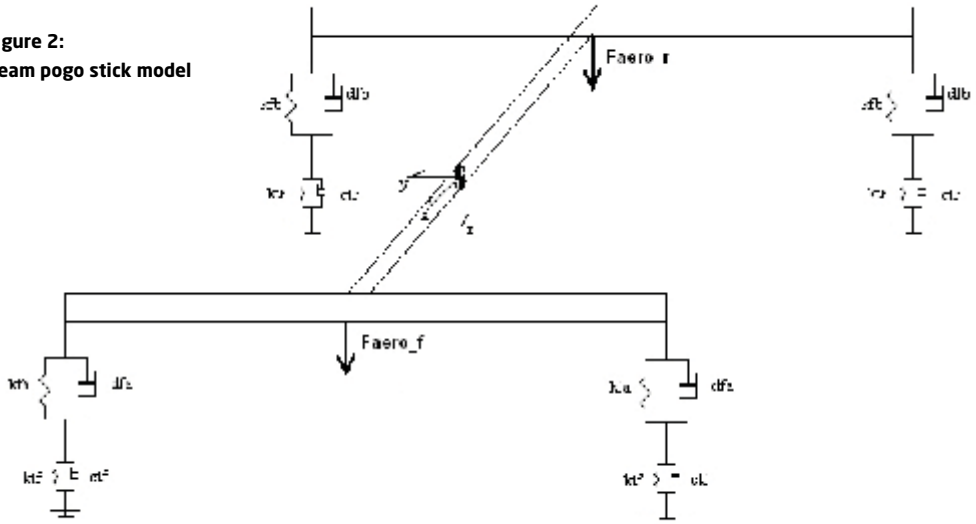


Figure 1: Pitch data which indicates we have some aero modelling work to do

Figure 2:
Beam pogo stick model



here is, down the straights, the correlation is OK, but in the corners, the simulated pitches indicated by the black traces diverge significantly. When most people see this, they would throw their hands in the air and simply conclude that the simulation is rubbish. However, when you are seeing this, you have an aeromap that isn't performing as advertised. This is your signal to fix the aeromap.

But before we discuss how to fix **Figure 1**, it would perhaps be wise for us to reflect on what it's telling us. It's saying that when the rear ride height drops below a certain value, it actually stops producing downforce. This screams out at you when the simulated rear pitch keeps on going when the actual pitches level off. Hopefully young data engineers reading this will be pointing and screaming on this point. Typically, what is happening here is that the rear diffuser is becoming choked and its effectiveness at producing downforce has diminished. It is with great regret that I say this, but I have seen this happen far too often with many of the current generation-spec racecars.

That being said, the fix for this is a lot easier than you'd perhaps think and revolves around a proper consideration of the beam pogo stick model. To refresh everyone's memory, I've presented the beam pogo stick model in **Figure 2**.

The key points here are as follows. In order to generate our downforce, we can represent as a downforce front and rear that is acting on the car, and we have a spring rate moving on the body, as well as a tyre spring rate acting at the tyre. What this all means is that if you have a good idea of the tyre spring rates acting on the car, quantifying the ride heights and the downforce being generated actually becomes really easy.

Table 1: F3 sample parameters

Item	Quantity
Front motion ratio	0.9
Rear motion ratio	0.8
FL damper/FR damper	10mm/10mm
RL damper/RR damper	15mm/15mm
Front spring	140.1 N/mm (800 lbf/in)
Front spring	140.1 N/mm (800 lbf/in)
Torque at RPM	200 Nm
Rolling tyre radius	0.28m
ax	0g
Vx	220km/h
Gear ratio value	3
mt	500kg
h	0.3m
wb	2.6m
Initial front ride height	20mm
Initial rear ride height	40mm

BACK TO SCHOOL

Regular readers will know that I've described the mathematics for this all before, and any 14 or 15-year-old that's well-versed in algebra should be able to work it out. To refresh everyone's memory, the force on the spring is given by **Equation 2**. Where F_s is the force of the spring damper unit at the wheel, and x_s is the movement and velocity of the spring, k is the spring rate or function and c is the damper rate or damper function specified at the damper, while MR is the motion ratio of the spring expressed as damper/wheel movement.

It is assumed that the zero of the spring function is when the car is on the ground. In most cases the spring function, k, is a spring rate. If bump rubbers are used, the spring function k can be easily deduced by a lookup table. If you're fortunate enough to have strain gauges fitted to the car, then all the hard work in **Equation 1** has been done for you.

Now that the spring force has been determined, we need to determine tyre deflection. In the absence of laser ride height sensors, the tyre deflection is given by **Equation 3** where k_t is the spring rate of the tyre. This is where things can get a bit tricky. As you hopefully know, tyre spring rate is a function of wheel speed, tyre pressure and camber. However, to get started I would suggest that you use a single approximate figure to get you going. While not strictly accurate, it will

EQUATIONS

Equation 1

$$FrontPitch = \frac{FL\_Damp + FR\_Damp}{2}$$

$$RearPitch = \frac{RL\_Damp + RR\_Damp}{2}$$

Equation 2

$$F_S = \left(k(x_s) + c(\dot{x}_s)\right) \cdot MR$$

Equation 3

$$w_m = \frac{F_S}{k_t}$$

Equation 4

$$d_i = \frac{x_{s_i}}{MR} + w_{m_i}$$

$$rh_f = rh_{f0} - \frac{d_1 + d_2}{2}$$

Equation 5

$$rh_r = rh_{r0} - \frac{d_3 + d_4}{2}$$

Equation 6

$$\begin{aligned} FtDownforce &= MR_f \cdot k_f \cdot (FL\_Damp + FR\_Damp) \\ &= 0.9 * 140.1 * (10 + 10) \\ &= 2521.8N \\ RrDownforce &= MR_r \cdot k_r \cdot (RL\_Damp + RR\_Damp) \\ &= 0.8 * 140.1 * (15 + 15) \\ &= 3362.4N \end{aligned}$$

$$C_L A = \frac{FtDownforce + RrDownforce}{0.5 * 1.225 * (220/3.6)^2}$$

$$= 2.57$$

$$AeroBal = 100 \cdot \left(\frac{FtDownforce + \frac{mt \cdot g \cdot a_x \cdot h}{wb}}{FtDownforce + RrDownforce} \right)$$

$$= 100 \cdot \left(\frac{2521.8 + \frac{500 \cdot 9.8 \cdot 0 \cdot 0.3}{2.6}}{2521.8 + 3362.4} \right)$$

$$= 42.9\%$$

$$C_D A = \frac{gr * T / r_t - m_t \cdot g \cdot a_x}{0.5 * 1.225 * (220/3.6)^2}$$

$$= \frac{3 * 200 / 0.28 - 550 \cdot 9.8 \cdot 0}{0.5 * 1.225 * (220/3.6)^2}$$

$$= 0.937$$

EQUATIONS

Equation 7

$$w_m = \frac{F_S}{k_t}$$

$$w_{mf} = \frac{0.5 * 2521.8}{200} = 6.3mm$$

$$w_{mr} = \frac{0.5 * 3362.4}{200} = 8.4mm$$

Equation 8

$$d_i = \frac{x_{s_i}}{MR} + w_{m_i}$$

$$d_f = \frac{10}{0.9} + 6.3 = 17.4mm$$

$$d_r = \frac{15}{0.8} + 8.4 = 27.15mm$$

Equation 9

$$rh_f = rh_{f0} - \frac{d_1 + d_2}{2} = 20 - 17.4 = 2.6mm$$

$$rh_r = rh_{r0} - \frac{d_3 + d_4}{2} = 40 - 27.15 = 12.85mm$$

then form a basis on which to get going and you can add a more complex analysis later. Also, in my experience if the appropriate value of k_t is chosen this can actually get you very close.

Once the deflection of the tyre is known, the user can deduce how much the corner of the car compresses under this load. This deflection can be deduced by **Equation 4** where d_i is the compression of the corner of the car for corner i, x_{s_i} is the spring deflection for corner i, and w_m is the wheel movement for corner i. The convention for the car corners is at the discretion of the user. The convention that I use is **1** for the left front, **2** is the right front, **3** for the left rear and **4** is right rear.

Once the user has deduced the corner deflections, the ride heights can be calculated. The front and rear ride heights rh_f and rh_r are given by **Equation 5** where rh_{f0} and rh_{r0} are the initial ride heights. I acknowledge that I've just repeated verbatim a section from an article from a couple of years ago, but in **Equations 2-5** I've just given you all the tools you'll ever need to calculate what's going on in the individual components of the aeromap.

Let's put this into practice using our F3 example. Again let me illustrate our parameters in **Table 1**. Let's crunch through our numbers to establish our aero parameters, **Equation 6**...

GRAB A PENCIL

At this point you might be thinking so what? At the risk of quoting Heath Ledger's Joker from The Dark Knight, I'm going to show you a magic trick. Let's presume the tyre spring rates are 200 N/mm front and rear. So consequently from **Equation 3** the wheel deflections are going to be as we see above in **Equation 7**.

The wheel movement at the front is 6.3mm and the wheel movement at the rear is 8.4mm. The reason we halved the forces is that we're assuming the car is

Figure 3: plot of speed, front pitch and rear pitch

THE CHASSISSIM COMPETITION

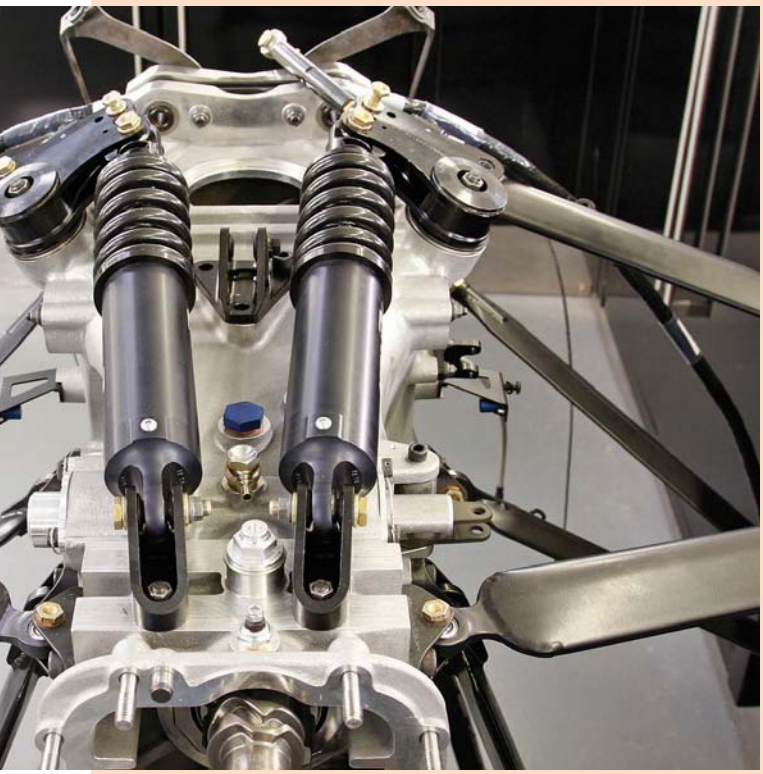
It dawned on me recently that I have been writing for *Racecar Engineering* for over five years. During this time I have written a great deal on the nuances of vehicle dynamics and how they apply to racing. That being said, I've never got you – the readership – involved. Well this is about to change.

With the launch of ChassisSim Professional Online you now have a vehicle to apply what I've been writing about over the last five years, so what better way to kick this off than with a competition! I'll be asking you to model and find the optimum setup for a twin shock F3 car.

Register at **info@chassissim.com** with the subject of 'F3 competition'. You'll be provided with the following:

- A setup sheet
- A monster file that is the data corresponding to the car

Further instructions will be provided when you register.



The competition will be broken down into two tasks: the first task is to achieve correlation, and the second is to achieve the fastest possible lap time.

All of this will be used using ChassisSim Professional Online.

The goal will be to submit a finished car model and circuit files, with a report telling me what you did. All reports limited to a maximum of 10 A4 pages!

To throw some sanity into this I am not necessarily looking for the fastest possible lap time. Yes, I want the car quicker, but more importantly I want to know how you got there and why.

Registration is open until 1 March, and final submissions need to be in by 21 March. Winners will be published in the May issue of *Racecar*.

Entrants are limited to a maximum of 300 simulations.

There will be no customer support – this is a test of intelligence and initiative! Don't worry, if you follow the instructions you'll be fine.

The prize is as following,

- A cash prize of AUD $500
- 6 months free use of ChassisSim Professional Online

The competition is open to everyone except current ChassisSim users and competitors. I look forward to your entries.

symmetrical. Using **Equation 4** we get as shown in **Equation 8**.

And consequently the ride heights from **Equation 5** will be as detailed in **Equation 9**.

While this might seem bordering on the trivial, what this all means in plain English is that when you're presented with a situation in **Figure 1**, you now have the ability to calculate the aero coefficients for each particular ride height – you can now populate the ride height map.

It also provides you with the the tools to figure out whether or not the racecar manufacturer is telling you a bunch of fibs. I can tell you from direct experience that this can be the difference between winning and losing, so you ignore this point at your peril.

One other perspective I'd like to add is in using pitch data to pick pitch sensitivity. Consider **Figure 3** the plot of speed, front pitch and rear pitch from a GT car.

While I'm not at liberty to tell you what car it's from, I can tell you that this car has absolutely ridiculous values of anti-dive and anti-squat. When you see something like this, it positively screams pitch sensitivity. If anything, this trace tells me this car produces its downforce under braking.

Consequently, I have some homework for the reader. The techniques we discussed here can be readily applied. That being said, they do need some work. Your job is to figure it out. Hint: think about load transfer.

DEVASTATING TOOL

In closing, then you should now appreciate what a powerful tool is it to be able to interpret pitch data. The beauty about it is that it gives you an instant picture about what the longitudinal load transfer and the aero of the car is doing.

Where it becomes very powerful is when you overlay actual to simulated data, because this will quickly highlight what bits of the aeromap need to be fixed.

When used properly, these techniques can be employed to pretty devastating effect.

Lotus Cars files record losses

The true extent of the financial woes facing Lotus Cars has emerged, with latest accounts showing that the sportscar builder, which has interests and connections in a number of motorsport series, lost a whopping £115.3m in the year to March 2012.

Lotus' record loss dwarfs its oft-quoted £21m loss of the previous year, and while revenues were £77m, this was down 37 per cent after a big slump in sales for the Norfolk-based manufacturer.

The accounts also show that the company breached banking covenants on a £270m financing facility, with lenders freezing funding to the firm in January of 2012.

Since then, DRB-Hicom, the Malaysian group of companies which now owns Lotus, has agreed to put more funds into the company, but the impact of the crisis has already hit its motorsport projects, most notably with its withdrawal from IndyCar – where it was one of three engine suppliers – at the end of 2012.

In the year to March 2012, Lotus Cars lost £115.3m following a slump in sales

Another casualty of the crisis has been former Red Bull and Ferrari man Dany Bahar, who was sacked from his £1.2m a year post as chief executive in June of 2012. Since then Bahar has filed a £6.7m lawsuit for unfair dismissal.

Meanwhile, the owner of the Lotus F1 team, Gerard Lopez, has put an end to speculation that it was up for sale, following rumours that former Lotus Cars owner Proton was interested in buying it. Speaking to Italian publication *Gazzetta dello Sport* Lopez said the ownership of the team will remain in the hands of his company, Genii Capital, and he is pleased with the way Formula 1 is working for them. 'I have never wanted to sell the team because for me, for Genii Capital, F1 is a fine platform to develop business,' he said. 'With the sponsors we talk not only of the advertising that goes on the car, but wider business too.'

Lotus goes into 2013 in fairly good shape on the sponsorship side, for while it's not known how much money it gets from Lotus Cars – most believe it's simply an agreement to use the name with no money changing hands – it has scooped a blue chip backer in the shape of the Burn energy drink, a Coca-Cola brand. It is also believed to be in talks with American industrial giant Honeywell, which might come onboard as title sponsor.

Lopez said: 'We are close to the top teams. We are financed by Microsoft, Unilever and Coca-Cola. This demonstrates the value we are recognised as having.'

Prodrive sells crack Australian V8 Supercar outfit

British-based motorsport and engineering company Prodrive has sold off its highly successful Australian V8 Supercar team, and says it is now back on track after a less than stellar financial showing recently.

Ford Performance Racing (FPR), one of the only two teams to win races in the premier Australian motor racing championship last year, has been bought by Rod Nash and Rusty French, with Ford Australia – the team's primary sponsor – fully supporting the move. The team will keep the FPR name and Tim Edwards will remain on the books as team principal.

Ford Performance Racing will retain its name despite changing hands

While Prodrive would not be drawn on the reason for the sale, a glance at the most recent accounts for the company (for 2011) shows that it made an operating loss of £6.9m for that year, and a £2.3m operating loss for the previous period. A spokesman for Prodrive admitted: 'We got a significant income from the sale, because it was a successful team.' Prodrive's sale of FPR comes a year after it also sold the company's sister operation, Ford Performance Vehicles – the road car arm from which the team sprang in 2003.

New owner Nash says he is delighted with the purchase: 'Rusty and I are pleased we've been able to acquire a business as strong as FPR, which is not only an icon of Australian sport, but one of this country's leading specialist engineering firms.

'In the last few years I've watched FPR grow from strength to strength and to see so many talented people from so many different industries working together is a real credit to the entire team.'

There will still be strong links between FPR and Prodrive, however, and the latter's chairman and chief executive, David Richards, said: 'FPR continues to be part of the Prodrive family and we retain our close technical and commercial relationship going forward. I will personally continue to follow the team's progress with great interest.'

Prodrive lays much of the blame for the poor 2011 figures in the lap of its high-profile LMP1 and WRC projects: '2012 is much better, we are in profit,' said the spokesman. 'But 2011 was a tough year. We had the massive investment in the [Aston Martin] AMR-One programme, and in the Mini programme. There was a massive amount of expenditure, so that was the reason that was such a poor year for us. But we've managed to turn that round – things are back on track now.'

BRIC-built future for OEM motorsport, says survey

Motor manufacturers are most likely to want to take part in motorsport based in, or visiting, the emerging markets of Brazil, Russia, India and China, commonly known as the BRIC countries, the findings of a respected global survey suggests.

According to the findings of KPMG's annual Global Automotive Executive Survey 2013, which is the result of questions put to executives from the world's top automotive companies, market growth in emerging markets is seen as the most important trend, with 86 per cent of respondents saying its either 'extremely important,' or 'very important'.

John Leech, UK head of automotive at KPMG, told *Racecar* that with this in mind, it's highly likely that motor manufacturers will want to compete in motorsport within these markets.

'Frankly that's where all the growth in the car industry is going to come from in the next two to three decades really,' Leech said. 'The car manufacturers absolutely appreciate that it's really important for them to get their brands established in these countries, and a great way to get their brands established is through the motorsports arena.

'When you think of how some brands – like Subaru in the past – penetrated overseas markets with a strong motorsport theme, the industry is extremely aware of the power of that link, and the halo effect that can cover all the products launched by manufacturers. So they want to be out in the emerging markets supporting motorsport.'

Other findings in the survey include a trend to concentrate on the downsizing and optimisation of the internal combustion engine (73 per cent saying this was extremely or very important). While electric powertrains are still cited as extremely or very important (76 per cent), Leech was struck by the industry's new focus on the combustion engine.

'If you go back five years, the industry didn't expect the benefits from the more modern turbochargers and direct injection petrol engined vehicles would be so great, allowing them to reduce the size of petrol engine cars,' Leech said. 'That was one thing that came through very strongly this year, and that's going to be a big trend over the next few years.'

When asked if, on the basis of the survey, Formula 1 was right to opt for 1.6 turbocharged units as its new engine formula for 2014, Leech said: 'Yes. But it's no coincidence. Motor manufacturers are quite keen to extol the sporty virtues of smaller engined vehicles.'

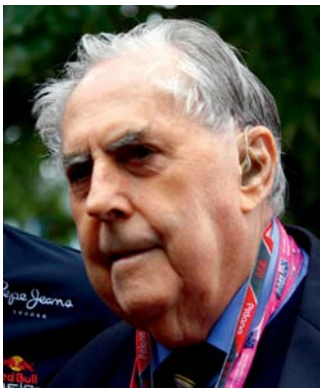
Brabham trumps Trick in German name game

The Brabham family has won the right to protect the commercial use of its name following a legal battle in the German High Court.

David Brabham, son of Sir Jack Brabham, has successfully sued Michael Trick in relation to his use of the 'Brabham Racing' name to market modified BMWs in Germany. The result of the action is that Brabham's EU trademark registration now belongs to the famous racing family and cannot be used without its agreement.

The battle in the German High Court in Koblenz originally began in 2009, when Formtech founder Franz Hilmer lodged an entry for the 2010 Formula 1 season using the team name of Brabham Grand Prix. Although the Hilmer application was not successful, it brought to light car dealer Trick's use of the name, which sparked another legal battle.

The Brabham family was very pleased with the German court verdict: 'I'm delighted that this situation has finally come to an end,' said David Brabham. 'It's been a long and tiring battle, but this was something I felt we needed to do to protect the Brabham name. The global brand stands for success and innovation bolstered from 60 years of racing heritage, and deserves to be protected.'



F1 legend Sir Jack Brabham

Part of the reason for the legal action was to protect the interests of the third generation of the racing dynasty, says David. His son, Sam, has competed in Formula Kart Stars, while his nephew, Matthew, won the USF2000 championship last year. 'This ruling will not only help future plans for the Brabham brand, but also protect the third generation of drivers, in Sam and Matthew, coming up through the ranks,' Brabham said.

Sir Jack Brabham teamed up with designer Ron Tauranac to set up his eponymous Formula 1 team back in 1962, going on to win two world titles before it was bought out in 1973.

Qatar Fiesta WRC revealed

M-Sport has unveiled its 2013 WRC Ford Fiesta, featuring an all-new livery in deference to new sponsor Qatar. The Middle East state stepped in following the withdrawal of Ford as the team's primary sponsor last year. Speaking at the unveiling of the new partnership, M-Sport boss, Malcolm Wilson, said that finding a replacement for Ford had been tough, but that while there are still funds to source, he is confident that the team now has a bright future. 'The last three months of last year were the most difficult of my business life,' Wilson said.

'The reduced investment from Ford obviously put a lot of pressure on the team to find added investment. We've got Qatar on board which has filled a big hole. We've got some way to go but I'm confident that we can challenge for some good results and that will bring more interest.'

PEELING BACK THE STICKERS. NUMBER 11: TOONED

An organisation can have a character just as surely as an individual can. Take McLaren, which from the outside epitomises cleanliness, efficiency and precision – and to some observers a demeanour that's perhaps a tad on the cold side.

But does it really matter that an F1 team seems cold and austere from the outside? Evidently it does, for last year the organisation gave up valuable sponsorship real estate on the back of its rear wing (the sort of patch that can cost a sponsor an estimated $10m a year) to plug its efforts to prove to the world that McLaren is in fact, well, fun.

Tooned is a joint venture launched in partnership with the Oscar-winning visual effects and animation studio Framestore. The idea was to run a series of cartoons featuring the McLaren drivers, with the stated aim of attracting a younger fanbase to the team while lightening the grey image associated with McLaren, as team principal Martin Whitmarsh explained. 'We see that it's important to try and bring younger demographics,' he said. 'I think also for McLaren to demonstrate that we're not taking ourselves so seriously. We're still very serious about motor racing, we still want to win and we do everything we can, but I think you also have to show a slightly lighter side.'

Whitmarsh also believes that this sort of initiative is not just beneficial for McLaren, but for Formula 1 as a whole. 'We've got to buy more people into the sport,' he said. 'This is fundamentally a great, great sport. The more you understand, the more you get involved in it, the greater it is. We've got to now try and sell that proposition to as broad an audience as we can and Tooned, the McLaren animation, is part of that process.'

While McLaren's clinical image has sometimes been seen as a reflection of former team boss and now executive chairman of the McLaren Group, Ron Dennis, it's interesting to note that he claims a stake in at least the seeds of the idea, stating at last year's launch that: 'Tooned is the result of extensive market research carried out by McLaren, which John [Allert], our group brand director, and I then analysed carefully together. It's an exciting and creative concept that addresses the insights gleaned from our research in a very innovative way.'

'I'm confident that the opportunities it presents will be extensive. Creating a more demographically accessible face for McLaren will help our brand appeal to a wider audience whilst also fostering increased brand loyalty.' Incidentally, Dennis appears in episode 12, along with his talking parrot 'Cosworth'.

Drayson signs up to Formula E

The first of the 10 teams to compete in the all-new FIA Formula E Championship for electric vehicles has been announced.

Drayson Racing Formula E Team is a wholly owned subsidiary of Drayson Racing Technologies, the company set up in 2007 by Lord Drayson, former Minister of Science for the UK Government, to develop green racing initiatives. The company has also been acting as scientific adviser in terms of sustainability to the FIA Formula E Championship.

The Oxfordshire, UK-based outfit is the first team to commit to the zero-emissions series and will run in the inaugural season of the Championship in 2014. Formula E will feature cars racing on city street circuits powered exclusively by renewable electric energy.

Drayson will field a two-driver team and is already talking to a number of leading drivers about filling its seats. During 2013, it will work with Spark and Formula E Holdings to test the Formula E customer car and to promote the championship around the world in the 10 host cities planned for the first season.


Lord Drayson and Alejandro Agag

Drayson Racing will run the new Formula E customer racing car in 2014, which will be supplied by the promoter Formula E Holdings and is currently being developed by Spark and McLaren but, from 2015, the team plans to be a constructor in its own right, fielding a new drivetrain developed from the advanced DRT 4X2-640 electric system featured in the Lola-Drayson B12/69 EV car.

Lord Drayson said: 'We are hugely excited about the prospect of competing in the opening season of FIA Formula E. We aim to be one of the front-runners from the start, leveraging the know-how we've built up over the past two years working on electric drivetrains and developing our 200mph electric Le Mans prototype. We believe that FIA Formula E has very significant commercial potential, it will attract new fans and new sponsors to motorsport and is on track to become the world's leading environmentally sustainable global sporting event.'

New Ferrari Formula 1 facility

Ferrari has begun work on a new factory in Maranello, where it plans to house the working area for the team, plus offices for the engineers, management and administration staff. Ground was broken for the new build in early January, and work is progressing on the foundations of the building.

Ferrari said of its new construction project: 'The aim is to create an environment that has been well thought through for the people who will work there.

'We have been working on a programme of reorganisation along with the introduction of new methodologies, especially concerning the wind tunnel,' said team principal Stefano Domenicali. 'The Maranello facility will be closed until August. Until then we will use the Toyota wind tunnel in Cologne.

'We have also adopted a better method of splitting up the work between those who run the wind tunnel and those who should concentrate more on the creative side. This year, we saw that when we do too many things at the same time, maybe we are not efficient enough.'

Pescarolo Team goes into liquidation

The company owned and run by Le Mans legend Henri Pescarolo, most recently known as Pescarolo Team, has gone into liquidation.

The concern was liquidated by a French court after a six-month 'back-up' period when it was protected from its creditors under French law. However, at the end of the period a survival plan had to be presented to the Le Mans court, and Pescarolo failed to find the backing to support that plan.

Henri Pescarolo said that while he was naturally disappointed with the decision he fully understood it. 'As difficult as it is to accept, this decision is quite justified. The commercial court simply applied the law. Having been put under back-up for a period of six months, I had to offer a credible solution for continuation of the activity of Pescarolo Team. That was not possible.'

Pescarolo, who is now 70, says he does not feel the failure of the company is down to past management decisions, but rather the actions of a former potential sponsor.

It may not be quite the end for the Pescarolo name in motorsport or at Le Mans, however, as he says he still has the facilities to run a team and hopes to do so some time in the future. 'I have a superb workshop, located on the 24 hours Technoparc at Le Mans, and nothing prevents me from continuing activity in a personal capacity,' he said. 'I am disappointed for my team, and that counts for me. But even if we cannot hope to engage our own cars in the next Le Mans 24 hours, there are other possibilities and I hope to be able to offer the team members a beautiful project, enabling them to once again demonstrate their potential.'

Last year the team withdrew from the WEC after a disastrous Le Mans 24 Hours, but its record at Le Sarthe, in its various guises, is excellent, and for much of the 2000s it was the most successful private entry, scoring two seconds, a third and two fourths against works opposition.

Pescarolo has also won four Le Mans 24 Hour races as a driver, as well as starting 64 Formula 1 grands prix.

Grand-Am and ALMS claim new classes are 'designed to welcome all'

Those behind the new-for-2014 unified Grand-Am and ALMS US sportscar championship have said they worked hard to make sure that all existing machinery will be catered for when devising its new class structure.

The new class structure will see LMP2 cars and Daytona Prototypes vying for overall honours, with a slot for production versions of the Nissan DeltaWing also in the premier class. The ALMS one-make LMPC prototype class for the ORECA-Chevrolet FLM09 will continue, while the ALMS GT (previously GTE) division will be separate from the Grand-Am GT class.

Meanwhile, the Porsche 911 GT3 Cup cars that form the GTC class in the ALMS will be amalgamated into the Grand-Am GT category and Grand-Am's new GX category for experimental cars might be absorbed into this group or run as a separate class.

ALMS chief operating officer, Scot Elkins, said the main priority for those setting up the new class structure was to make sure existing equipment from either of the current series would not be left without a place to race. 'Numerous important partners and stakeholders have been invaluable during this process. We could not have reached these decisions as rapidly as we did without that assistance,' he said. 'Many factors were taken into consideration for this initial conceptual lineup, but the priority was to enable as many current competitors as possible to continue racing with their existing equipment.'

Grand-Am managing director of competition Richard Buck agreed. 'This is a best-of-both-worlds approach that reflects the fact we have a true merger evolving on a daily basis,' he said. 'This announcement is only a first step in solidifying our class structure. Our organisations' respective competition departments are working diligently on balance of performance for the top prototype class, plus overall class specifications across the board.'

It remains unclear just how the DP and LMP2 cars, the latter of which are much faster on most circuits, will be performance balanced.

BRIEFLY

Lola LMP updates

Multimatic Motorsport, which is part of the group that is now providing engineering support to teams fielding Lolas, is working on aerodynamic upgrades for the manufacturer's LMP1 and LMP2 cars for this year.

The Canadian company now employs some of the key personnel from Lola Cars International, including chief engineer Julian Sole, and they are continuing the developments from where they left off when Lola Cars International went into administration last May. Multimatic has teamed up with the long-time Lola distributor in the USA, Carl Haas Auto, to support Lola teams and provide spares.

SEEN: RADICAL RXC

Powered by a 3.7-litre Ford V6 producing 380bhp and tipping the scales at just 900kg, the Radical RXC accelerates from 0-62mph in 2.8 seconds, and is capable of a top speed of 175mph.

A space frame chassis is couples with an aggressive, Le Mans-styled body including a full-width, carbon bi-plane rear wing and gullwing doors.

It's sure to prove popular with North American track day specialists, and will go toe-to-toe with cars such as the Riley MkXXII. Road and race versions will be available this summer.

INTERVIEW: MATTHEW MORRIS

Matthew Morris is the MD of SPAL's UK operation. He's been with the firm since 1993 and has held his current post since 2008. The SPAL group of companies is based in Italy, and is one of the world's biggest manufacturers of fans and blowers. On the automotive side SPAL supplies Ferrari, GM/Opel, Ducati and BMW, among many others. It is also active in the motorsport sector in the UK.

Q. How did the UK arm of the company come about?
We took over the distribution of the fans and the blowers, which was previously handled by an agent. We bought the business from the agent and moved his operation to Worcester. We've got 700sq.m of warehouse here, and an office block. We don't manufacture here, we're just distribution.

Q. How much of your business is motorsport?
Motorsport is probably 10 per cent of our turnover, but we're growing into it every year, and I think it will become a bigger part of the business. Where we can really help is with quick turnaround. High volume orders are supplied direct from our Italian facility, but race teams in a hurry need a product off the shelf rather than a pre-ordered item with a delivery lead time. We are equipped to provide that fast turnaround service and enable those customers to keep their cars competing at the highest level.

Q. Who do you supply in motorsport?
We supply one of the works WRC teams, and that's probably our highest profile client, and we also supply to a lot of the people who prepare vehicles for motorsport.

Q. What's the main product that you sell into motorsport?
Our sales into the motorsport sector really are quite varied, especially when you start to consider brushless motors, which is something SPAL is very heavily involved in. These are software driven, so you can manage the cooling very accurately. It's not really new technology, but it's been refined by SPAL for the automotive sector.

Q. What advantages does brushless technology bring?
Brushless is the big leap forward at the moment. It incorporates high-energy rare earth magnets and I suppose that the biggest advantage is that they have 'soft start', which means that you avoid the big current spike when they start up. This means that you can use smaller batteries, alternators and possibly less harnessing, all saving precious weight.

You can manage the fan speed very accurately, which means that you can keep the engine temperature at the correct level for maximum performance. There is also a diagnostic input and output for performance data. Finally, with brushless fans you get considerably longer life, because there are far fewer moving, wearing parts.

Q. What material are the fans made out of?
Plastic: plastic shrouds, plastic blades. SPAL makes three and half million fans a year using high-quality injection moulding. SPAL also uses rapid prototyping, so it can take somebody's 3D drawing and it can throw up a 3D model in 24 hours, and then you can actually see if the thing is going to fit where you want it to fit, and that cuts a lot of time out of the design process.

Q. How thorough is the testing regime?
There is a great deal of testing involved, it's a huge part of the process. They do all sorts of tests: airflow, temperature tests, thermal shocks – where you take it down to minus 20 and then kick it straight back up to plus 100 – life tests, vibration tests, water tests, salt spray tests, and all the rest.

Q. How is a fan designed?
It depends on what sort of airflow you want. Ideally we like to work with customers. We need to find out what they need by way of cooling. It's not just a matter of sticking a fan on: the fan's got to overcome restricted air intakes, it's got to overcome the distance between the fan and the radiator, it's got to overcome the radiator – pushing air through the core. So you get different blade profiles: you get straight blades, curved blades, thin blades, fat blades. It's actually quite complicated; just how you design a blade which will give you the right amount of cooling.

Q. How effective is the sealing of the fan motors?
We have a fish tank in the office and we have a brushless fan running in the tank completely underwater, doing about 70rpm! The motor is completely sealed. SPAL has always been very good with this sort of thing – the latest product is totally sealed and certified IP6K9K. It is therefore impervious to water ingress, salt and other pollutants, as well as being incredibly safe in operation – there is so little oxygen within the sealed unit, that fire risk is close to zero.

Williams scoops MIA's top business award

Williams has capped a successful year both on and off the track by picking up the prestigious MIA Business of the Year Award at the Motorsport Industry Association's (MIA) Business Excellence Awards. First presented in 1995, it is the only awards of its kind within the industry, and the judging panel consists of industry and MIA members who are invited to vote in seven categories.

Last year was particularly successful for Williams. The F1 team returned to winning ways, with victory at the Spanish Grand Prix, while Williams Advanced Engineering saw its technologies introduced into a number of high-profile applications in the fields of energy efficiency, road safety and education.

Chris Aylett, CEO of the MIA, said: 'Williams F1's race heritage is beyond question, with 114 victories in Formula 1. But things have evolved over the past few years, with Williams Hybrid Power supplying the first hybrid car to win Le Mans in 2012, and Williams Advanced Engineering widening technology supplies into many sectors. With a Technology Centre in Qatar, and a leading Conference Centre, this MIA member is a vibrant company going places fast and one of the few Formula 1 teams to successfully diversify.'

Commenting on the award, Williams CEO Alex Burns said: 'Our diversification strategy into new markets is ambitious in its scope and 2012 has seen our technology transfer from Formula 1 gain excellent momentum. We're focusing our attention on Formula 1-based technology that can make a real societal benefit and it's fantastic that the judges recognised this.'

Other MIA awards went to the Motor Sports Association (Service to the Industry); DC Electronics (New Markets); Interex Motorsport (Export Achievement); Millers Oils (Technology and Innovation); Swindon Engines (Small Business of the Year) and Honda Yuasa/ Team Dynamics (Teamwork).

OBITUARY

Guido Forti

Former Formula 1 team owner Guido Forti, often referred to as F1's last true private entrant, has died at the age of 72. Forti, whose Forti Corse organisation competed in 27 grands prix in the mid-90s, set up his team in partnership with fellow Italian Paolo Guerci towards the end of the 1970s and it enjoyed success in Italian Formula Ford before graduating to Formula 3.

F3 also proved to be a happy hunting ground for Forti, the outfit picking up four Italian titles – running such notables as Gianni Morbidelli, Enrico Bertaggia and Emanuele Naspetti – while a move to Formula 3000 in 1987 saw it taking nine race wins before it decided to step up to Formula 1 for the 1995 season.

But Forti did not enjoy any real success in Formula 1 and after losing major sponsor Parmalat at the end of its first year – when it followed driver Pedro Diniz to Ligier – the remainder of its time in Formula 1 racing was marked by a constant struggle for backing.

The team finally called it a day when a bitter legal dispute with a potential sponsor forced it to pull out of F1 midway through the 1996 season, which was seen as a great shame at the time as its second car, the FG03, was a great improvement over its debut offering, the FG01. Sadly, Forti failed to score a point during its short time in F1.

Guido Forti made a brief return to motorsport in 2002 and 2003, as a team manager in Euro F3000, the forerunner to Auto GP.

Guido Forti 1940-2013

Pedro Diniz in the Forti Ford F1 at Interlagos in 1995

BRIEFLY

Ratel and roll

Ten teams have signed up for the new FIA GT Series, which well-known racing promoter Stephane Ratel has devised to replace his GT1 World Championship this year. Among the confirmed entries for the sprint race format series are former world championship-winning team Vita4One, which will run BMWs, and Audi squads Phoenix and Novadriver. Other teams include ProSpeed (Porsche), Rodrive/Lamba (Ford), Sebastien Loeb Racing (McLaren), Heico Gravity Charouz (Mercedes) and Reiter (Lamborghini). The six-race series kicks off at Nogaro in France at the beginning of April.

Smiles per gallon

If there were ever any doubts about the knock-on effect of a grand prix on a local economy then take a look at this far from sobering statistic from the Texas Comptroller's office, which reveals that events relating to the Austin-based US Grand Prix in November accounted for a staggering (perhaps literally) $2.8m worth of sales in beer, wine and mixed drinks. Meanwhile, the Austin American-Statesman has claimed that overall sales of alcohol in the Texan capital for the month in which the race took place were up 23 per cent on the same period in 2011, at $48.4m.

RACE MOVES

Michel Nandon has been signed up as team principal for Hyundai's World Rally Championship effort. The Frenchman is a WRC veteran, and was director of Peugeot Sport from 1999 until 2005. Hyundai is currently developing a WRC version of its new i20 for its return to the championship in 2014.

Ron Otto has joined NASCAR K&N Pro Series East outfit Precision Performance Motorsports as crew chief for the No 46 Toyota driven by Brandon Gdovic. Precision Performance, which is headed by team manager **Charles Denike,** is based in Gloucester, Virginia.

Luca di Montezemolo looks likely to remain in his position as president of Ferrari for the foreseeable future after he announced he will not now be switching to politics. It was widely thought he would relinquish his role with Ferrari if he won a seat in the Italian parliament because of various conflicts of interest. Montezemolo has been president at Ferrari since 1991.

Steve Nielsen has left the Caterham F1 team, where he filled the role of sporting director. Nielsen joined the team from Renault in 2011. In a long career in Formula 1 Nielsen has also worked for Arrows, Benetton and Tyrrell. At the time of writing it was reported that he would now be taking up the position of technical director at Toro Rosso.

Mark Gillan has left the Williams Formula 1 team. Gillan was chief operations engineer at the Grove-based outfit, and before joining Williams he was head of aerodynamics at Toyota during the marque's final season in the sport. He has also worked at McLaren and Red Bull, originally joining the latter when it was still known as Jaguar.

NASCAR Nationwide Series team Kyle Busch Motorsports (KBM) has promoted **Eric Phillips** to the post of crew chief for the No 77 Toyota driven by **Parker Kligerman**. Phillips previously oversaw KBM's No 18 entry in the NASCAR Camping World Truck Series.

Harold Holly is to take the place of Phillips as crew chief on the No 18 KBM Toyota. Holly will oversee the truck driven by **Joey Coulter**, who he has crew chiefed for the past four seasons, both in NASCAR trucks and ARCA.

Three-time F1 world champion and former Jaguar F1 boss **Niki Lauda** has stepped down from his management role at Air Berlin in order to fully commit to his new position as non-executive chairman at the Mercedes Formula 1 team.

Allen McDonald, who was technical director at the championship-winning Andretti Autosport IndyCar team last year, has now rejoined rival outfit Schmidt Hamilton Motorsports. At the time of writing it was not known what position McDonald will take at the team, at which he last worked in 2011.

Just a week after McDonald's departure, **Tino Belli** – who was race engineer for **James Hinchcliffe** at Andretti Autosport last year. Prior to that he worked for Pagan Racing, Forsythe and also for former IndyCar constructor March.

Lee Dykstra has joined Indy Lights outfit Juncos Racing as its team manager. Dykstra has spent the past five years as a very successful race engineer in the second division US single-seater series and has previously been director of technology in ChampCar and president of both Special Chassis Inc. and Dekon Engineering during a varied career in motorsport.

Harry Scott Jr, a long-time minority owner of NASCAR Nationwide Series and reigning Camping World Truck Series champion team Turner Motorsports, has expanded his involvement in the organisation, becoming co-owner alongside **Steve Turner.** The team is now known as Turner Scott Motorsports and Scott will manage its marketing, public relations and business development efforts, while Turner will oversee the competition side of the operation.

SPONSORSHIP

The Lotus Formula 1 team has signed a long-term deal with British clothing manufacturer Henri-Lloyd. As part of the partnership the race team personnel will wear Henri-Lloyd gear while travelling, and a Lotus F1 Team range of clothing will be launched.

Above: One of the UK's top Mercedes truck and van dealerships, Ciceley Commercials, is to be title sponsor on the Toyota Avensis of Adam Morgan in the BTCC. Additional backing for Morgan's family-run squad, which is to be known as Ciceley Racing, comes from Fuchs Titan Race, PM+M, ModelZed, Snickers Workwear, Graphix and White Wave Web Solutions.

Great Clips Inc, said to be the world's largest hair salon brand, has signed a primary sponsorship agreement with JR Motorsports in the NASCAR Nationwide Series. It will also continue to back JRM driver Kasey Kahne's World of Outlaw Sprint Car outfit.

NASCAR has extended its long-term partnership with Featherlite Trailers. The six-year extension ensures that Featherlite will be the official trailer of NASCAR until the end of 2018. Now entering its 13th year as an official partner, Featherlite built its first racecar transporter for team owner Richard Childress some 20 years ago.

Force India signs 3D technical partnership deal

Formula 1 team Force India has signed an agreement with printing company 3D Systems to help speed up its in-house development capabilities.

In what is said to be a multi-year agreement, the deal sees the extension of an already active relationship between the companies. Force India says it will now be able to reduce the manufacturing time of wind tunnel models and therefore speed up its in-season development.

Vijay Mallya, team principal and managing director of Force India, said of the deal: 'We've been working with 3D Systems as a customer for many years, so we are delighted to forge stronger links with a company that is the market-leader for rapid prototyping technology. We use their technology on a daily basis to manufacture wind tunnel model components, and this new relationship will hopefully allow us to get performance to the car faster.'

3D Systems is a provider of 3D content-to-print solutions including 3D printers, print materials and on-demand custom parts services for professional organisations and consumers alike.

Kevin McAlea, senior vice president and general manager of 3D Production Printers, which is a division of 3D Systems, said: 'We are excited to launch this technical partnership with the first ever Indian Formula 1 team. The opportunity to partner with emerging innovators like Sahara Force India provides tangible customer benefits that extend well beyond motorsports.'

RACE MOVES

Turner Scott Motorsports has signed **Scott Zipadelli** as crew chief for the No 31 Chevrolet, driven by **Justin Allgaier.** Zipadelli is a Nationwide Series veteran with nearly 200 races to his name and he has chalked up 11 top five and 46 top 10 finishes in his time as a crew chief. Most recently Zipadelli was at RAB Racing, where he oversaw the No 99 car.

John Crossle, the founder of the racecar manufacturer that bears his name, was awarded an MBE in the Queen's New Year's Honours list. His award was for services to engineering and manufacturing in Northern Ireland, where he set up his firm in 1957. Crossle retired from the business in 1997 and it is now in the hands of **Paul McMorran,** who bought it towards the end of last year.

MSA general secretary **Rob Jones** has been elected to the FIA Ethics Committee, a new body which has been established to safeguard the integrity and reputation of motorsport, and of the other activities within the FIA's broad motoring-related remit.

Bobby Rahal, Skip Barber, Bill Noble, Carroll Shelby and **Andy Porterfield** are all to be inducted into the SCCA Hall of Fame. Their formal induction will take place at the US racing club's national convention in Las Vegas at the beginning of March. The SCCA Hall of Fame was created in 2004.

Richard Childress Racing has promoted **Phil Gould** from car chief to crew chief on the No 2 Chevrolet Camaro which will be driven by **Brian Scott** in this year's NASCAR Nationwide Series.

Mike Bumgarner is now the crew chief on the No 5 JR Motorsports Chevrolet in the NASCAR Nationwide Series. Bumgarner has spent the last 18 years at Hendrick Motorsports, in both the Sprint Cup and Nationwide Series.

John Balash, who has worked as the NASCAR Nationwide Series director since 2004, has now assumed a new position as international competition liaison. His new role is to be the NASCAR point of contact for competition-related matters in the Toyota (Mexico) Series, Canadian Tire Series, the Euro Racecar Touring Series and other international competitions. Balash will report to Richard Buck, who has been promoted to managing director, competition Grand-Am and managing director, Touring Series, NASCAR.

Wayne Auton, who has served as the Camping World Truck Series director since 1995, is now the NASCAR Nationwide Series director. **Chad Little,** formerly Whelen Modified Tour Series director and director of racing development, Mexico, will now fill Auton's former position as Truck Series director.

NASCAR has announced the promotion of four senior executives across the company. **Ed Bennett** has been promoted to senior vice president, with **Kim Brink, Jim Cassidy** and **Zane Stoddard** promoted to vice president. Bennett also retains his roles of chief administrative officer and president/chief executive officer of Grand-Am Road Racing. Cassidy, Stoddard and Brink lead key areas of racing operations, entertainment marketing and NASCAR's brand marketing initiatives with integral roles in the implementation of its five-year Industry Action Plan.

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

BRIEFLY

Fans switched off

The popular FanVision sets will probably not now be a part of Formula 1 in 2013 after the company that looks after the handheld devices could not agree terms with Formula One Management (FOM). The technology provided spectators at the grands prix with the ability to watch the broadcast coverage of the race, including in-car camera footage and race data. It was originally marketed as Kangaroo TV.

FanVision will continue to provide its sets for NASCAR and the NFL in the US, and for golf. FOM would not comment on whether it has plans for a replacement service for Formula 1.





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GEARBOX

Xtrac 1113 transmission

Xtrac's 1113 R5 4WD transmission has been designed specifically to cater for Rally cars competing under the FIA R5 regulations. The gearbox specification meets all the requirements of the FIA R5 homologation regulations and has been approved for use by the FIA. The 1113 transmission utilises Xtrac's championship winning experience in S2000 and WRC applications to deliver a technically reliable and lightweight solution, built to its normal industry-leading quality standard.

The transmission is a five-speed manual with a sequential shift, coupled with a mechanical plate front differential and a fixed 50/50 torque split front and rear. The box weighs in at 55kg and is capable of handling up to 500Mn of torque.

For more information visit www.xtrac.com

CYLINDERS

AP's new CP5898

Developed to increase braking efficiency and enhance performance in racing applications, this new differential bore master cylinder from AP Racing is already in use in the NASCAR Sprint Cup Series, and will be available to other categories including F1, sportcars, touring cars and rallying. Its advanced design improves braking consistency, by reducing unwanted low pressure pedal travel and operating at high pressure throughout brake actuation. It is also fully adjustable, allowing for a wide range of applications across different car setups and race series.

The principle relies on a relatively large bore taking up all the low-pressure, long travel within the system, including caliper piston retraction, knockback, trapped air compression and seal squash. At a set pressure, a smaller bore cylinder is then switched into use for the higher-pressure, short-travel part of the braking event.

Check out www.apracing.com for more details

HEAD STUD KIT

Cosworth cylinder head studs

Uprated Cylinder Head Stud kits are essential for high performance engine builds. Heavy duty head studs reduce cylinder head movement in high boost or high compression engines, optimising cylinder head to block sealing. These Cosworth high performance head studs are manufactured from H11 tool steel with 240,000+psi tensile strength and also feature roll formed threads. The studs come complete with nuts and washers. The studs are manufactured with hex broach ends for ease of installation. Additionally, the head studs utilise a base seating feature to evenly distribute maximum load on the stud and not the threads.

See www.cosworth.com for more information

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COATINGS

Zircotec thermal control

Coating specialists Zircotec recently released two new thermal control products to market, aimed at providing exceptional heat resistance for minimal weight gain.

The first is Zircotec Gold, a plasma-sprayed ceramic coating incorporating 24 ct gold. The new coating can be applied to a wide range of materials from steel to composites. Gold is highly reflective of infra-red radiation, providing 98 per cent reflectivity at upto 600nm. When applied, Zircoflex Gold weighs less than 750g/m2.

The second product is Zircoflex Gold – a very thin 24 ct gold plated, ceramic coated aluminium heat shield material. This combines the effectiveness of a the regular ZircoFlex heat shield material with the aforementioned reflective properties of gold. The new material is highly flexible and can be formed into complex shapes to protect areas, for example composite bodywork in close proximity to heat sources such as turbochargers.

For more information on either of these products visit www.zircotec.com

THROTTLE

Titan throttle body system

UK-based manufacturer Titan has released a new throttle body system designed for the omnipotent Ford Duratec engine, found in everything from Formula Fords to sports prototypes. The new system is intended to be the definitive ITB solution for the engine with highlights including optimised port profiles to improve flow volume and direct compatibility with existing fuel and ignition electronics. Additionally, the bodies are supplied as a single, complete component, with all trumpets, linkages and sensors pre-fitted, making installation a simple affair.

Check out www.titan.uk.net for more information

3D PRINTING

EOS plastic powders

Ecological compatibility, high technical performance and low manufacturing costs are the main attributes of two new powder materials introduced by rapid prototyping specialists EOS, for layer-by-layer 3D printing of plastic components in its additive manufacturing machines.

The first, PrimePart Plus (PA 2221) is said to represent a breakthrough in polymer development, as significantly more of the material can be recycled after use. Conventional plastic materials are usually refreshed for the next build cycle with 50 per cent or more new powder, whereas for PA 2221, the figure is 30 per cent. The result is a considerable saving in the amount of powder that has to be scrapped. The technical performance of the finished plastic parts is not diminished and the overall key performance indicators achieved are only slightly lower than those of the established EOS powder, polyamide 12-based PA 2200.

The second plastic material, PA 1101, is a natural-coloured polyamide 11, characterised by high elongation at break and good impact resistance. Less non-renewable resources are used in the production of this material compared with polyamide 12. The material is particularly suitable for applications where the finished product contains functional elements that require high material ductility, such as integral hinges, as well as for parts that need high impact resistance.

Visit www.eos.info for more details on both products

PLUMBING

Viper catch tanks

Viper, the UK producer of a prodigious number of new plumbing components, has recently added these useful small alloy tanks to its range of aluminium fabrications. The tanks are available in anodised black or polished natural aluminium and come with mounting brackets and six outlet/inlet -8 ORB female ports. Unused ports can be blocked off with blanking caps. The tanks can be used in a number of applications such as reservoir tanks, breather tanks and fuel surge tanks. The tanks are robotically TIG welded and come in three sizes ranging from 1.4-3.1-litre capacity.

More details can be found at www.viperperformance.co.uk

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Photography
LAT, WRi2, David Lord
Deputy managing director
Steve Ross
Tel +44 (0) 20 7349 3730
Email steve.ross@chelseamagazines.com
Head of business development
Tony Tobias
Tel +44 (0) 20 7349 3743
Email tony.tobias@chelseamagazines.com
Advertisement Manager
Lauren Mills
Tel +44 (0) 20 7349 3740
Email lauren.mills@chelseamagazines.com
Publisher Simon Temlett
Managing director Paul Dobson
Editorial
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700
Advertising
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
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The MIA's low carbon conference at the Birmingham NEC, held on the Wednesday before the Autosport International Show, threw up some interesting questions. The event was used to launch the first Formula E team, showing Lord Drayson putting his money where his mouth is, but how to deliver enough power for the cars? One suggested solution involved Russian nuclear submarines.

The conference largely focused on how motor manufacturers could speed up the development of new technology using their racing divisions. Racing teams are able to adapt faster to changing conditions, which helps when dealing with new technology.

One issue that sprang to mind was: If racing concentrates on technology, what happens to the sport?

Take Formula 1, which has just finished a popular season in 2012. A new engine formula will provide uncertainty to the results – if one manufacturer gets it right, and another does not, teams will find themselves in uncustomary sections of the grid. Similarly, in sports cars, privateers have needed a balance of performance to at least challenge the manufacturers if they have an off day.

"If you could tap that knowledge, expertise and skill, and reduce emissions, that is far more important"

Balance of performance has become an integral part of modern motor racing, as effective as a wind tunnel programme or a season of testing in terms of producing outright results, provided the person arguing the toss a) shouts loudly and b) knows his onions. Cynics would suggest that item c) would be that said person also has deep pockets. I am not that cynical.

The clear message from the conference was that, as manufacturers concentrate on producing high volume cars, they need disruptive technologies to figure out what is the future.

'It is transferable knowledge,' said Darren Cox, head of Nissan Motorsport, Global. 'You listen to Audi's Ulrich Baretzky, he is genuinely driving innovation on the road cars, and that needs to happen. The theories, the rapid prototyping and the decisions, have to happen quicker. The motor racing community could do it if the rules allowed them to. Blowing body parts, bigger wheelnuts that will help with airflow. Really? How will that benefit the motor industry? That is a complete waste of resources. If you could tap that knowledge, expertise and skill, and reduce emissions, that is far more important.'

This is an interesting point, one that Baretzky also raised at the conference. It is not long now until emission targets for new cars start to bite. Compared to 2007 figures, by 2015 motor manufacturers in Europe will have to have cut emissions of new cars by 18 per cent, and by 2020 by 40 per cent, to just 95g/km. That is 5.6-litres of fuel for 100km for petrol, dropping to 4.1-litres in 2020. And the deadlines are looming.

As for the sport, if the technology is concentrated around Formula 1 and Sportscars, which has embraced hybrid systems into their regulations, the sport should see the rise of production car-based racing, single-seat series, rallying and X-games, as detailed by Ricardo Divila in his much commented-upon column last year (REV22N12).

On a related topic, according to KPMG's Automotive Executive Survey, issued in January, vehicle purchase decisions made by the general public are increasingly driven by financial concerns. Fuel efficiency is the number one priority for consumers. Plug-in hybrids will account for 36 per cent of the market in 2018. In the TRIAD countries, including the European Union, Eastern Asia and North America, Mexico and Canada, increasingly the population will look to buy small cars. In BRIC (Brazil, Russia, India, China) countries, the SUV market is expected to hit 66 per cent of the market.

Efficient SUVs?

Weight is the enemy, and there isn't a single government that has a minimum weight requirement for a production car. For simplicity's sake, and for the sake of discussion, what say you that, while safety standards remain constant in racing, the minimum weight limit is struck from the regulations. Then let's see what happens.

EDITOR
Andrew Cotton

PAGIDRS

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