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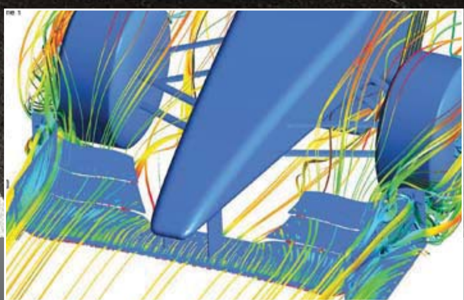
BMW Z4 GTE

How the American Le Mans Series contender evolved

VW Polo WRC

Volkswagen's guided tour of its latest rally contender



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TECHNICAL

Batteries not included

It's only a matter of time until electric trumps petrol. But we're not there yet...

Gene Cernan has the unofficial lunar speed record with the electric Lunar Roving Vehicle chassis 03 at 11.2mph (18.0km/h), actually above its design speed of 8mph (13km/h). On Earth, it is a bit higher – 307.6mph (495.14km/h) for electric-powered cars, so obviously the idea of electric racing cars beckons, in the name of green image and world salvation, which will nudge manufacturers towards alternative renewable and green energy sources.

Manufacturers are investing into the future production of millions of electric cars, on one hand, and hybrids on the other, such as the Toyota Prius hybrid car, first sold in 1997. By October 2012, the Prius had reached sales of 4.6 million, 2 million of them in Japan, cutting 30 million tons of CO2 and saving 11 million litres of petrol.

There is a long way to go still, as the daily consumption in the US alone is upwards of 10 million barrels of oil per day for motorcars. Hybrid technology is a method of improving fuel efficiency mainly through the recuperation of braking energy, worth it to eke out our energy needs with less pollution, but it's not a game-changer.

We constantly form unjustified expectations about the future. To what extent can we trust predictions? If the future is less predictable than we imagine, how do we plan for it? I am not wanting to frame the discussion in terms of Hume's Problem of Induction. (He argued that belief that the future will be like the past is grounded neither in experience nor reason, expressing scepticism at our ability to predict the future.) I shall endeavour to pull back the curtain...

In the real world, the natural laws of physics, installed capacity and free market economics drive the vast majority of the world's use of internal combustion engines burning hydrocarbon fuels, rather than chemical batteries and electric motors, because of the superior cost/performance ratio that hydrocarbon fuels currently provide. This situation will likely remain true for at least another 20 or 30 years. The need for an alternate power source is a environment-driven political need.

The technological boost of reluctance motors and new battery types will improve this ratio, but let us be frank about it – any use in motor racing will be rules driven, much as diesel and hybrids are today in endurance racing. It provides manufacturers an excuse to go racing to reap public perception kudos, keeps teams in business, and might just provide the drive to improve the technology rapidly.

And there is a fundamental problem with electric engines, as electricity is not an energy source – it is a means of transmitting (or storing) energy. Electrical town cars shift the pollution generated upstream, outside towns, and induction-powered cars without batteries can be a coming technology, possibly showcased in an inductive track. This would be cheaper to implement than redoing the road network – a craft known since 1894 – when Nikola Tesla demonstrated resonant inductive coupling also known as 'electro-dynamic induction'.

Electricity can be generated in several ways: hydroelectric, wind, nuclear, geothermal and not excluding hydrocarbon fuels. Maybe hydrogen-powered cars will be the future, be it fuel-cell technology or internal combustion, as the probably in-car storage challenge for hydrogen will be solved way before we see electric cars with a useful range.

So much for the general, but what about the particular case of racing? Batteries will have to improve by an order of magnitude before they weigh acceptable values and have credible range.

Electric is invigorating the consumer market, but racing could be another matter

In order to make an electrical racing series attractive as a spectator sport, the rules would need to be wide open. This would permit high levels of technological development and allow the cars to be very fast, as Formula 1 once was, which was why it garnered a wide audience. The downside would be the same problem that F1 ran into: rapidly escalating and unsustainable costs.

Personally, I have my doubts about electric car racing, not least because it would also be too quiet – one would not feel the same adrenaline rush from the screech of tyres. The nerve in motor racing is in the hysterical scream of 18,000rpm through tuned exhaust pipes, engines expiring in flames or clouds of smoke – the visceral impact of thermodynamics in action. It's man taming the monster, and winning through the smart use of the Carnot cycle. Will Icarus make it, running so close to the edge of meltdown?

Electricity is too sophisticated and elegant for racing – we need heat and loudness

Alas, electricity has none of this charm. It's too sophisticated and elegant, with electromagnetic fields being too extrasensory compared to man's primitive needs of facing the bleeding obvious monstrosity of heat and loudness.

Don't get me wrong – I love disruptive technologies, whether in life, computers or cars. Anything that shakes the traditional slothful 'same old, same old' with a different slant is worthwhile. That's why the electric car and plug-in hybrid technology will revive a boring industry, but not necessarily racing – it has other problems. The introduction of hybrid, electrical or hydrogen racing cars have only the interest of the car manufacturers and of the engineers that will work on them – but probably not of the public that should watch it.

F1 cars look the way they do due to regulations, just as electric automobiles are a product of government regulations that distort market economics for a good cause. The way trends are going, battery cost and performance should improve to the level necessary for it to compete with hydrocarbon fuels. We have mentioned hybrids at the start.

So there you have it. An opinionated, provocative prediction and about as comfortable as a wire-wool jockstrap, dependent on economics, geopolitics, and therefore a science of complex, nonlinear systems – systems that are chaotic in the technical sense, and not susceptible to detailed long-run forecasts.

One can only say, 'Gentlemen, plug your batteries', and quote Jane Austen: 'Let other pens dwell on guilt and misery, I quit such odious subjects as soon as I can, impatient to restore every body, not greatly in fault themselves, to tolerable comfort, and to have done with all the rest.'

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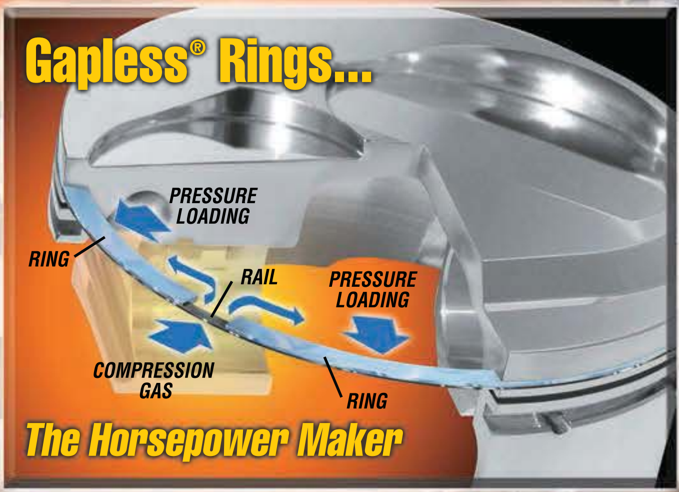

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F1: preserve of the rich?

Once again it seems that not all top tier drivers are there on merit...

There has been much comment recently about 'pay drivers', especially in F1. Let's analyse the term 'pay driver' and not be naive. Any young and aspiring driver advancing beyond club racing has to have backing beyond most average families' financial capabilities, so at what point does this somewhat pejorative term kick in? For me, as I suspect for most racing people, it's when a driver obtains his or her seat in a professional team over other, more obviously qualified candidates, by paying to occupy it, rather than by being paid.

It has always been difficult for a driver to get to F1, or its grand prix equivalent of earlier times, on merit alone. Even Juan Manuel Fangio would have almost certainly remained a legend just in South America without the Perón government backing that financed the Argentinian to start racing in grands prix at the beginning of the 1950s – and much the same can be said of other great drivers of the period. Had Stirling Moss, for instance, not had sufficient family wealth to at least buy his first racing car, he may not ever have placed a foot on the ladder. A couple of generations later Ayrton Senna – from a wealthy family – came to Britain to race with significant sponsorship behind him. Michael Schumacher, Kimi Räikkönen, Lewis Hamilton, Fernando Alonso and their peers may not all have been rich, but they managed to get crucial financial backing at an early stage. But that's OK, because they all had the skill and determination that marked them out from the beginning, and that's what earned them the support.

The 1960s through to the 1980s probably saw the most opportunities for drivers to make their way primarily through talent. The over-riding reason was the relatively low cost – even by the values of the time – of creating an effective F1 car and team. British innovations brought to the sport the affordable 'off-the-shelf' Coventry Climax and following Ford Cosworth DFV engines. Much of the operating funds came from tyre and fuel companies, along with start money from the race promoters and sometimes a degree of wealthy patronage. When commercial sponsorship was introduced, it was in its infancy and relatively easy to obtain – the sums involved and the competition for it in sport was generally unsophisticated and undeveloped. Bernie Ecclestone's virtual takeover of F1 and his hard-nosed business approach resulted in teams receiving dollops of TV money way beyond what they had experienced before.

All this meant that F1 teams were generally able to employ drivers of choice based on their results in the junior formulae, which in turn were considerably more accessible than today. A substantial amount of a driver's earnings was still based on prize money and bonuses. And there was a quite high turnover of available seats too, racing being far less safe than now...

The Formula 1 world has come full circle since the 1950s

As stars became superstars and pay demands accelerated accordingly, government bans on tobacco advertising brought increasingly generous sponsorship to F1 on a plate. The re-engagement in the top level of motor racing by automotive manufacturers added free powertrains and greater resources, plus many millions of dollars to team budgets. Even as F1 embraced vastly expensive technology in all its forms in the 1990s and into this century, inventive marketing and promotion strategies hooked into the increasingly global TV coverage to such an effective degree that the ability to pay 'real' drivers kept pace.

The global economic near-meltdown has burst the bubble. Sponsorship is now very hard to find, with so many alternative ways in which major corporations can be persuaded to spend their reduced marketing budgets. Attempts to substantially cut teams' real operating costs have not been effective. Thankfully some young driver development programmes (eg Red Bull) do exist, but despite this there are a truly worrying number of pay drivers in F1 now – and tellingly not just in the poorer teams.

Had Stirling Moss not had a wealthy family, he may not have got a foot on the racing ladder

If you think I'm exaggerating, then let's not kid ourselves and acknowledge that surely for the first time in its long history McLaren have taken a pay driver – a quick one, with a very big budget, admittedly – in the form of Sergio Perez. Otherwise, why not on form alone have chosen Nico Hülkenberg or given a second chance to the now matured and fast Heikki Kovalainen, for example?

This is a world away from when Williams were able to turn down free engines from Honda because they didn't want the Japanese driver that came with the deal!

If you take three of the five new drivers in F1 this year, they have only a few dozen race wins and fewer than half a dozen championship victories in their combined careers to date. This does not stack up to genuine F1 material. Only Valtteri Bottas and Jules Bianchi have had the success in their careers so far that deserves an F1 seat.

So have we come full circle from when – between the world wars and even in the early-1950s – grand prix racing was the province of the wealthy and only a few gifted drivers might be hired to drive by manufacturer teams? Pay drivers may be playing a crucial role in teams surviving and making up the F1 grid, but I doubt that most followers of the sport want to see F1 in future as the playing field of moderately competent youngsters whose greatest ability is sourcing huge amounts of money instead of the epitome of driving skill, determination and sheer race-winning ability that we have long taken for granted it represents.

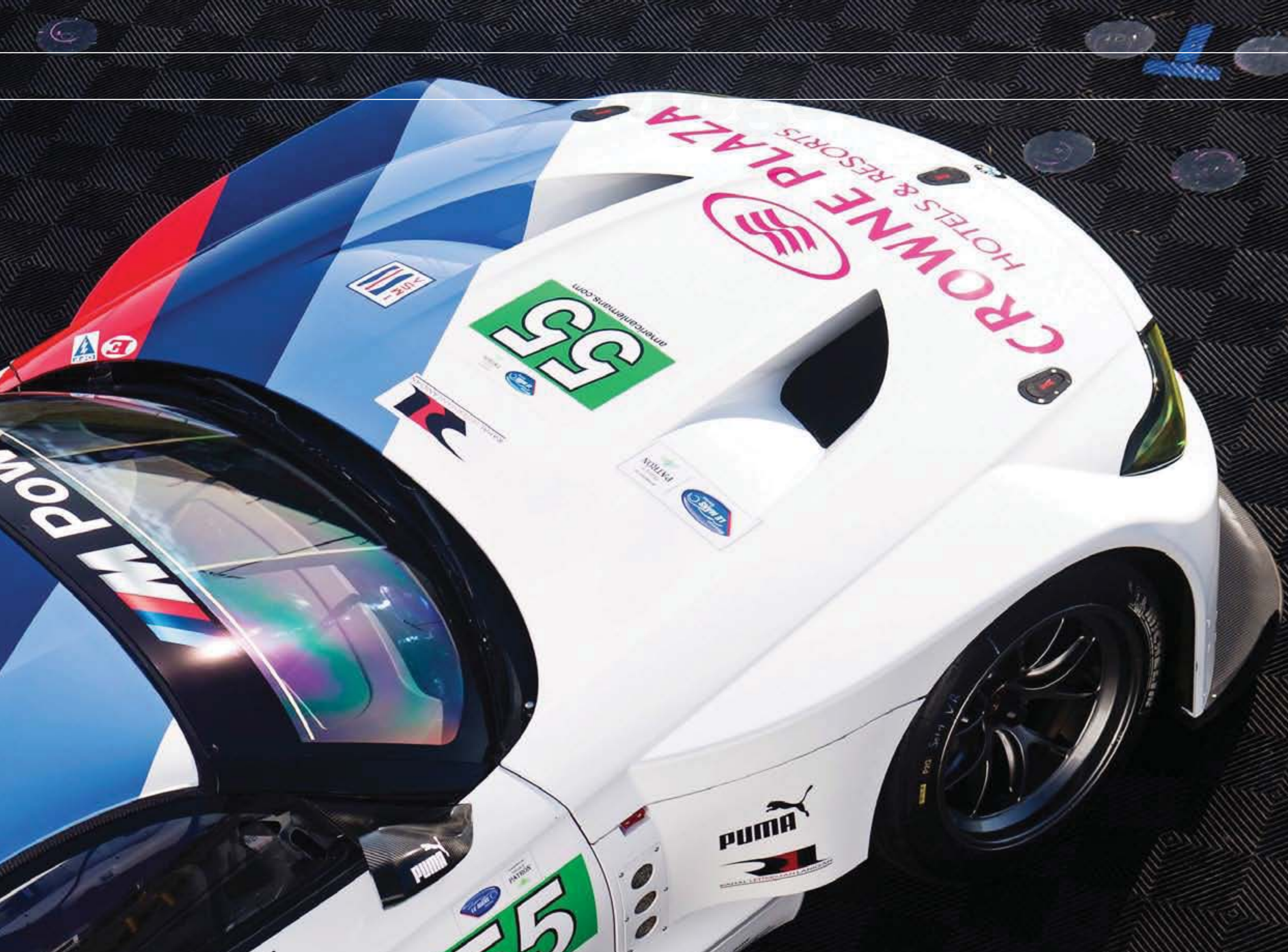
Perhaps F1 car development should be aimed at making them a hell of a lot harder to drive at the limit, to make employing drivers gifted with great talent a necessity rather than an option?

The same, but different

BMW is switching from M3 to Z4 for its ALMS 2013 campaign, and used the GT3 car as the base model

BY ANDREW COTTON

"We know that there is a technical difference, especially with the aero. The rulebook is a whole new world"



BMW returned to the North American racing scene with its new GTE car, the Z4. In line with its previous GTE models, its debut at Sebring, the opening round of the American Le Mans Series, caused something of a controversy.

Some described it as a mini DTM car, with outlandish aerodynamics that meant that the car looked nothing like its road-going counterpart. Others complained that there was no road-going Z4 with a 4.4-litre, V8 engine, although as the car was developed from the GT3 car with the same engine, these were quieter voices. All agreed, however, that it was in BMW's tradition to turn up with something unexpected.

FIRST PRINCIPLES

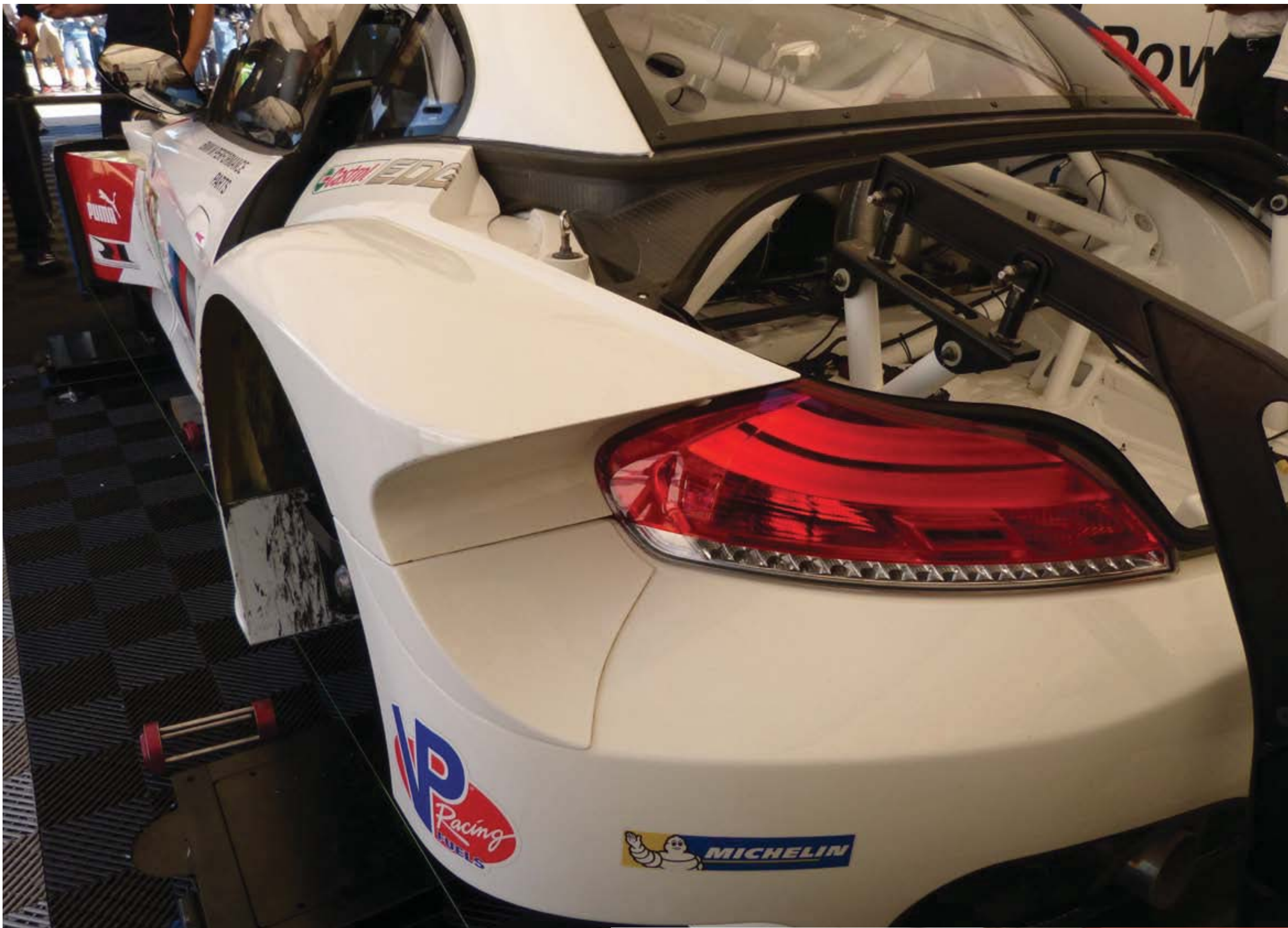
The decision to switch away from the M3 programme is based on the regulations, that state the car must be in production. The outgoing M3 won the ALMS title for teams, drivers and manufacturers in 2011 before it was retired at the end of 2012, in favour of the Z4. The Z4 was upgraded from GT3 specification over the late summer and winter in a race against time for the manufacturer, which admitted that it had underestimated the amount of work needed.

According to figures in the BMW end of year report, sales of the Z4 have fallen in 2012, and the GTE programme aims to make the most of the facelift Z4 introduced mid-cycle.

'For us, the ALMS project is vital. It's very important for BMW to have a factory-backed programme in this market,' says BMW's motorsport director Jens Marquardt. 'We need to really look at the future in the US. With the M3 we felt we had reached the peak in 2011 when we won the championship, maybe a bit beyond the peak, and in 2012 we realised that there was nothing more to extract out of the car.'

The old M3 did not go to the larger front tyre, as others in the category had achieved, and was also considerably narrower. It was a sporting family car, racing against the likes of Porsche, Aston Martin and Corvette, and needed a wealth of waivers to make it competitive.

There is no doubt that the Z4 is a more suitable racing car and, with the base model already competing in customer hands in Europe, BMW decided to make that its headline car in the US.



Rear wheel arches look more like a TransAm car than a GTE

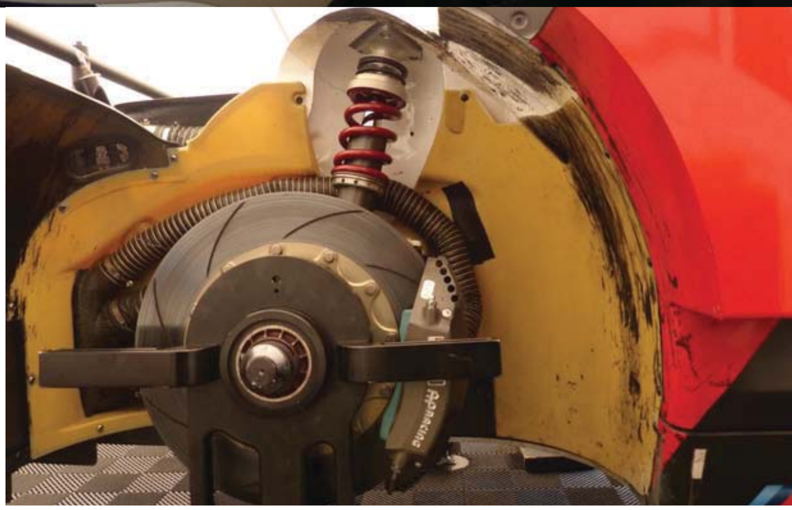
'As we had the Z4 running in European GT3 championships, the decision was taken,' says Marquardt. 'We have the GT3, and we knew roughly what it would take to make a GTE out of the GT3. We maybe underestimated that a bit, but that was the natural step.

'The M3 races in the DTM, and as we know, it is quite far away from a GT or a proper GT car. We still have some M3s that are in GT4 class, but the Z4 is for customer racing in Europe, long distance racing in Europe, and now in the ALMS campaign. On the European side, with the M3 and the M cars, we take our sporty icon to the racetrack. At the same time we have launched a production version of the Z4 with a facelift, and we felt to support this campaign with the emotion of the M3 would help. The Z4 is a sporty car, which is why we felt the relationship works in the US.'

WHAT RULEBOOK?

In the middle of 2012, work started on converting a GT3 car, which runs in a series without a technical rulebook but works on balance of performance, into a GTE car that has a strict technical rulebook, but also has the facility to help performance through balance of performance where required.

'All the experience was taken from the GT3 car when we laid out the GTE,' said technical director Jan Hartmann. 'We know that there is a technical difference, especially with the aero, and the rulebook is a different world. The target was to get to the base performance of the M3 and then develop the car further from there. We looked at the aero, CFD simulations, what we could take from the GT3 to the GTE, and then looked deeper into the regs to see what we can recover in the downforce level.



MacPherson strut was used, but regulations allow a change to a double wishbone set-up later in the season

'We had to look into the details for the suspension, the chassis itself, the exhaust and the engine. We wanted to be as close to the GT3 engine as possible. We have the sonic restrictor in the GTE and a restrictor plate on the GT3.'

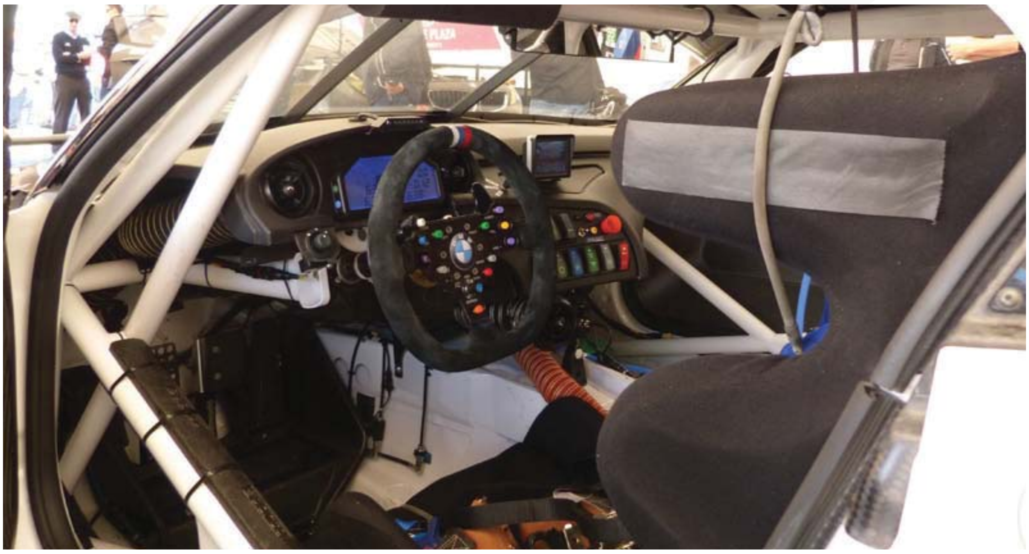
The engine was a known quantity, taken from the production M3 and coupled with a 6-speed transmission. The wheel arches were reprofiled, there is a smaller front splitter, a removal of the front diveplanes, a single element rear wing and a new rear diffuser was devised, leading to an estimated 30 per cent reduction in downforce compared to the GT3 car.

The changes to the engine concerned the switch to a sonic restrictor

The Z4 is 75mm lower than the M3, but is considerably (98mm) wider, overcoming one of the major hurdles faced by the M3. The wheelbase is 267mm shorter than the champion car of 2010 and 2011.

'When we first looked at it, it didn't seem to be as much work as it turned out,' said Hartmann. 'During the process of development we saw that it was more work, but it was a challenge. We made all the design and development in autumn, and in the winter we built up the first car. We had some input from the Rahal team. The timeline was short, and we had to teach the car to the team on one side, and develop, so it made sense to have them help us to develop it. The Sebring test was in February, so the car tested in Europe to give us 90 per cent development. We had roughly seven months to develop it.'

'In the end we took the M3 GT2 and ran some simulations on American tracks with it,' says Marquardt. 'That gave us the baseline. Then we took the GT3 as it was and ran the same simulations and looked how the two performed against each other. Then we took the GTE regulations, and put them one to one over the GT3 car, dropping everything that was outside of the regulations, and realised that we were two seconds off.



BMW had to change the driver seat to aid quicker pit stops, and introduce air conditioning to meet regulations

Time was spent in BMW's full scale wind tunnel to develop the aerodynamics, which have proven to be controversial

'That was when we set the targets of where we needed to go with the development. Then you consider if I don't get a waiver, if I stay within the regulations, I am not making a step ahead. If I take the rear wing back 20mm or the front splitter is extended, what do I gain? What is the proper balance? And you run the simulation again to see where you have lost. You talk to the ACO, and they feed back that you cannot move the rear wing by that much, but you can move it a bit, so it is an ongoing process.

'To go from a not-so-regulated series GT3 car to a strictly regulated GTE car, from the engine side it was easier, because you want to come back to where you have been, through the intake and exhaust system. It was only the air exchange that we wanted to change.'

Most of the bodywork has changed. In fact, only the roof and the doors are carried over from the GT3 car.

FRENCH SWITCH

Unquestionably one of the biggest changes to the programme is the switch from Dunlop to Michelin. With Dunlop, BMW won ALMS titles, as well as the Nürburgring 24 hours overall in 2010, but the team felt that it could get more from the Michelin tyre despite an incredible amount of work by Dunlop. 'You would turn up to a race and have a choice of eight different types of tyre,' said driver Dirk Müller. Michelin has just two. A suspension development later in the season will see a switch to a double wishbone suspension, as permitted by the regulations.

The 6-speed gearbox was carried over from the GT3 car, while the suspension was developed for the American circuits. 'If you look at Sebring, it has a surface that you don't have in Europe,' says Hartmann. 'There are rough bumps. If you look at the details, you have time-consuming analysis and calculations. In the current GT3 car, we had a different differential for better reliability, and a different diff function – here hopefully we would gain something from GT3 to

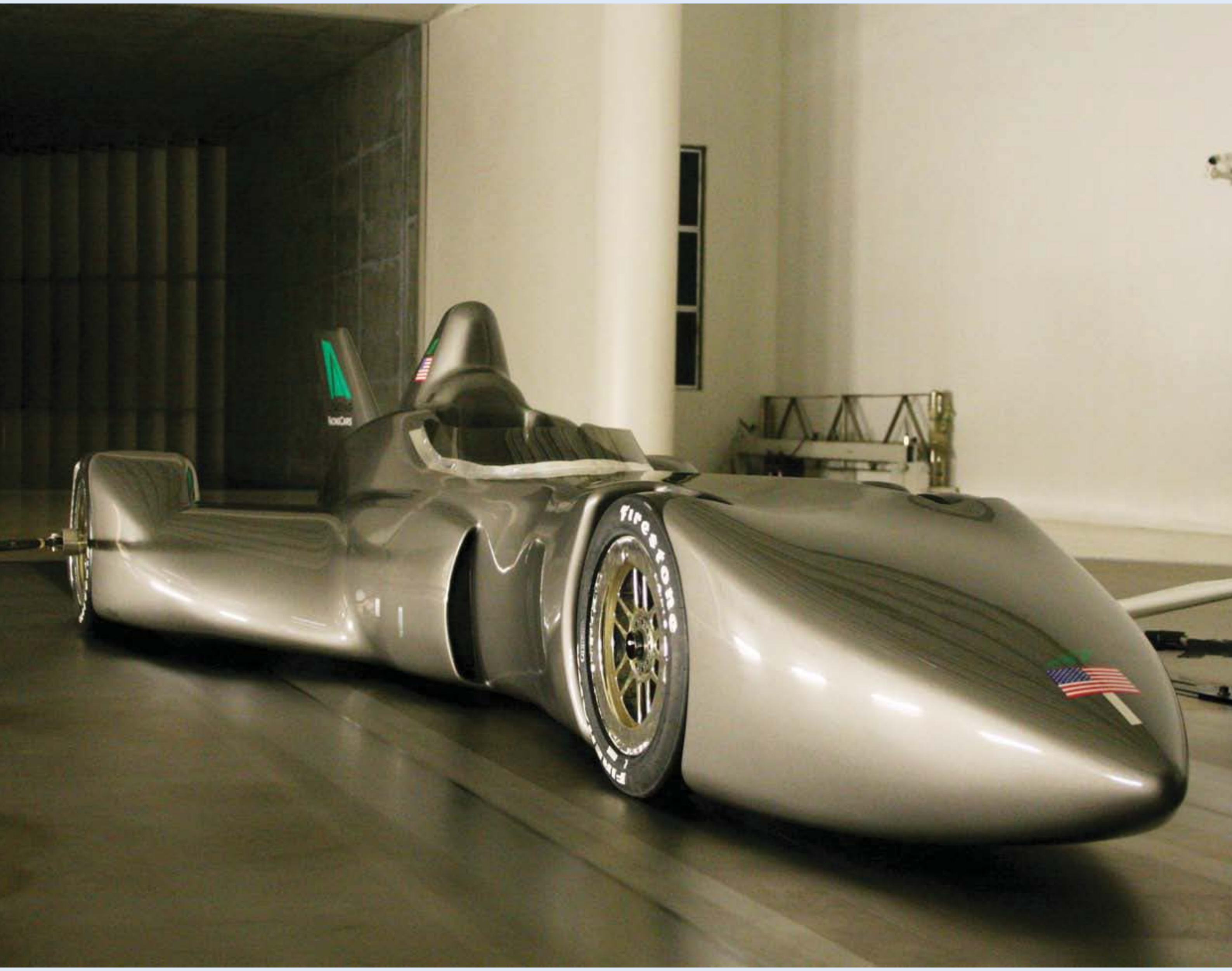
OUTSIDE ALMS?

The BMW Z4 is currently homologated in the US, and motorsport director Jens Marquardt was not exactly effusive about the Z4's chances of racing in Europe, or in the World Endurance Championship next season.

'We felt that we should concentrate on the ALMS with that car, and the time schedule was tight,' he said. 'We did our first proper test early this year, and maybe underestimated the effort of turning a GT3 into a GTE. But for us, it felt that with everything new that we are putting together, with the ALMS and allowing RLL to concentrate on understanding the car deeply, getting to grips with the tracks here, rather than doing a logistic effort – particularly as at Le Mans you need a special car setup and aero package – that's why we said for 2013 we leave it to the ALMS. We targeted the car for the ALMS. With the team and the new tyre partner, we really wanted to concentrate on this season to get to the winner's circle, and concentrate on this rather than to take our effort in all directions.

'Le Mans is a fantastic race, but the prototypes are the dominating class, and the GT class gets overlooked. With the ALMS, the GT class is what is looked out for and watched, so the platform is right. We have a good relationship with Rahal, and we share operating and engineering resources. We have a good exchange with them and it was done in a close relationship with those who are operating the cars. The DTM programme and the ALMS programme are independent. We wanted to continue a strong campaign in the US with a strong team and strong drivers. DTM we are going into a second season, and the cars are kept in a tight homologation envelope, so it was easier to add a fourth team without putting a mega effort into that.

'At the moment we have no plans setup in that respect. We have to concentrate on the ALMS and become competitive as quickly as we can, but at the moment our plan is to re-establish where we belong in the ALMS. Let's concentrate on 2013 and be competitive here.'


firestone

GTE. The waiver on the chassis was to make more clearance on the diff. The diff is more efficient and we could cover some better angles in the driveshaft and prop shaft area.

'The airbox changed to fulfil the requirements for a sonic restrictor,' continued Hartmann. 'Timing was adapted for the new aspiration side, and this was mainly the work to do. Also here a lot of simulation was done before we got into hardware. If you do a change on the engine, you have to do an endurance run and check mechanical reliability. We wanted to get the best out of the airbox, and we had our targets of what we could gain, and we had to stay as close to the GT3 engine as possible.'

COOL RUNNINGS

While the headline changes were under way, the smaller details required by the ACO and IMSA were also causing something of a headache. The cars are required to run with air conditioning systems, and there are no waivers available for running too high cockpit temperatures.

Converting the GT3 car was more work than anticipated

fuel system needs to be redone because some of the vitons swell in too much ethanol, so you have to make sure you have thought through every bit from getting the fuel into the car to the injector,' says Marquardt. 'If you look at the fuel lines, in the GT3 car they are to FIA regulations, but not valid for the ACO – it is these details that we underestimated.'

Whatever the strategy for bringing the Z4 to headline competition in the US, there was a lot of work undertaken to make it happen. From the development of the suspension, the hours spent in the wind tunnel with a full-scale model,

"The fuel lines in the GT3 car are to FIA regs, but not valid for ACO – we underestimated these details"

'It is small things that you underestimate,' says Marquardt. 'The ALMS requires an air conditioning system while GT3 does not. It is not a small system and you realise that it needs cooling also, otherwise it doesn't work, and then it costs power. You are adding components, so you need to find space so that it doesn't interfere with anything else, and in that confined space that you have given it, you have to get it to work properly. They are at the very bottom of your list of priorities, but they can catch you out. Then you go testing in Europe and it is 10 degrees or something, and it is not stressed, but then you go to the first test in proper conditions and you need to improve it.'

The fuel system needed to be changed to run with E85 fuel from the E10 run in Europe. 'The whole

the development of the shift mechanism and the engine and exhaust, the car was rushed through in record time.

The suspicion is that this is a holding pattern for the company, and with the announcement that the DTM and GT500 cars are planning to race on the sports car programme, the future of BMW's Z4 GTE programme does not look to be long term.

There is no plan at present to race the car in Europe, or even at Le Mans *(see sidebar, p12)* as the company targets the North American market.

There is no doubt that the Z4 is a better base model than the M3 for racing but, as one rival put it: 'They have never shown up with the right car. This is better than the others, but doesn't look like a road car, like the Aston Martin or Corvette, and we need to protect that.'

TECH SPEC

BMW Z4 GT3

Length: 4,387mm

Width: 2,010mm

Height: 1,210mm

Wheel base: 2,510mm

Weight: 1200kg

Tank capacity: 115 litres

Chassis/body: Steel body with welded safety cell

Transmission: 6-speed sequential sport transmission, operated via shifting paddles mounted on the steering wheel, multiple ZF Sachs clutch

Front axle: MacPherson axle with pushrods and wishbone, additionally with adjustable shock absorbers, H&R coil springs. Will be changed later in the season to double wishbone.

Rear axle: longitudinal links with wishbone, adjustable shock absorbers, H&R coil springs

Brake system: hydraulic dual circuit brake; monobloc multi-piston light alloy brake callipers, inner-vented steel brake discs

Engine type: 8-cylinder, V-configuration

Capacity: 4,361cc

Max output: approx 515bhp (depending on air restrictor regulations)

Bore x stroke: 92x82mm

Max engine speed: 9,000rpm

BMW Z4 GTE

Length: 4,395mm (excl rear wing)

Width: 2,010mm

Height: 1,205mm (depending on setup)

Wheel base: 2,512mm

Weight: 1,245kg

Tank capacity: 110 litres

Chassis/body: Steel body with welded safety cell

Transmission: 6-speed sequential sport transmission, operated via shifting paddles mounted on the steering wheel, multiple ZF Sachs clutch

Front axle: MacPherson axle with pushrods and wishbone, additionally with adjustable shock absorbers, H&R coil springs

Rear axle: longitudinal links with wishbone, adjustable shock absorbers, H&R coil springs

Brake system: hydraulic dual circuit brake; monobloc multi-piston light alloy brake callipers, inner-vented steel brake discs, seamless brake balance adjustment (front and rear) by the driver

Wheels: BBS forged aluminum wheels, front axle: 12.5×18", rear axle: 13×18"

Tires: Michelin, front axle: 300-680-18, rear axle: 310-710-18

Engine type: Eight-cylinder, V-configuration, four valves per cylinder, mandatory air restrictor (2×29.4mm)

Capacity: 4,400cc

Max output: approx 480bhp (with mandatory air restrictor)

Max torque: approx 480Nm

Cylinder block: Aluminum cylinder block construction

Engine management: BMW Motorsport ECU 408, without fuses, central display

"Development incorporated 20,000km of testing, covering the conditions of every rally"

Jari-Matti Latvala takes flight in a VW Polo at Rally Sweden in February, where French team-mate Sébastien Ogier won

Time for lift-off

Volkswagen Motorsport has produced Dakar winners between 2009-2011. Now, with the Polo R WRC, it is targeting the World Rally Championship title

BY MARTIN SHARP

There is nothing untested at the Volkswagen Motorsport programme. Parallel to a 17-month development of the Polo R WRC, which incorporated 20,000km of testing covering the conditions of every rally in the 13-round WRC – with double champion Carlos Sainz as consultant and development driver – the team also ran a comprehensive season in the 2012 World Rally Championship with normally aspirated 2-litre Skoda Fabia Super 2000s, cars with identical floorpans to the Polo.

Although the team did not physically test any rival car during this period, it assessed its rivals logically. 'Racing the Skoda with a known driver, we could have some kind of reference as to where the Skoda is compared to the world rally cars last year, and we know where the Skoda was compared to our Polo,' says technical director Willy Rampf. 'So with this "triangular" relationship, we tried to see where we are compared to the cars in 2012.'

Despite the Fabia and Polo having the same floor pans, not one component carries over from the Skoda Super 2000 car. Experiments were made with relevant areas of the chassis of the Fabia during its 2012 WRC campaign, as highly experienced rally engineer, VW technical project manager François-Xavier Demaison explains: 'In the last two or three rallies of 2012, we tried solutions looking at these cars. If you look, the damper angle is the same and its arrangement is the same as in the Skodas, so for sure there is something related.'

VW Motorsport has a fledgling schedule for its five technical 'jokers'. In essence, the 2013 Polo R WRC is pretty much 'conventional' with few unusually complicated technical solutions, a tactic aimed at aiding a smooth debut WRC year. Yet the team is already working on aspects of technical progress for the 2014 homologation, a car which, in its first homologation guise, came second on its first-ever WRC event, won its second outright… and – at press time – entirely dominated its third world event, Rally Mexico.

VW's Wolfsburg wind tunnel was available to the team, and it made wide use of the facility. All aspects – downforce, cooling and drag – have been investigated at length. Yet ex-Formula 1 technical director Rampf does not rate downforce as a high priority in a rally car: 'You can create some downforce with the rear wing, but you will always struggle on the front because there's no aerodynamic device there.'

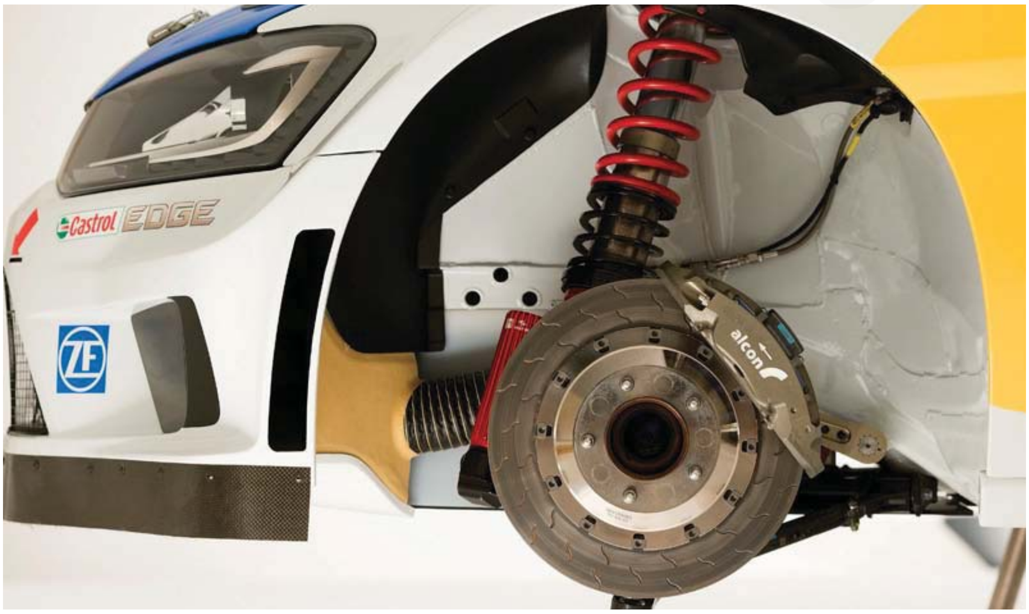
BALANCING ACT

'You're limited with the rear wing,' he continues. 'A bigger rear wing at one stage doesn't really improve the car performance because the car balance is getting worse – you only have an aerodynamic device on one end of the car. It's more of a conceptional thing – even if you create more downforce at the rear, if you can't balance it, you end up with a car which creates more downforce, but balance-wise it's not a benefit.'

The Sachs dampers reflect current rallying practice in that the MacPherson strut tubes take the side loads while the damper sits independently within the tubes. Initially the remote canisters were on the uprights, a method preferred by some rival teams, but after tests VW decided on the latest iteration of locating them on the body. 'Each concept has its advantages and disadvantages,' says Rampf. 'The unsprung mass is higher with the canister on the upright, and airflow to the brakes can be blocked. But if the canister's up at the top end, you need to put it somewhere in the car and then you need a tube to connect it. It's more difficult to handle because it's basically more components than one. You could run either system – I don't think there's a particular advantage to one of them.'

Engineers at Mini JCW WRC designer/builder Prodrive believe the extensive amount of wheel travel used on rival rally cars is not necessary. Rampf agrees with the majority – the more the better: 'I think it gives more grip. You have a bit more freedom on the mechanical setup. The only disadvantage where wheel displacement is concerned is that you have bigger changes in the kinematics. More is better, but to reduce it is easy; to make more is almost impossible. We have developed as much as we can our suspension concept, as the limit is the suspension concept itself. If you have huge travel you might end up with very strange kinematics, for example, as we have to use the MacPherson suspension and all the other components like the

Back on terra firma, a peek under the bonnet of the Polo R WRC, boasting a straight four with turbocharger



Wheels off view of the Polo R WRC, hinting at VW Motorsport's suspension concept for the car

driveshafts. They don't have unlimited angles, so above a certain angle they might be less efficient or they might end up with some strange designs which you don't want.'

Volkswagen Motorsport initially decided to use the French Sadev transmission in the Polo R WRC, as Citroën Racing did for the DS3 WRC. When this equipment became 'not available' to the German team, however, it plumped for the British Xtrac option as chosen by Ford/M-Sport and Mini/Prodrive.

There is a difference. While the latter two teams employ master and slave hydraulic cylinders to drive the handbrake lever-activated rear drive axle disengagement to facilitate negotiating hairpin bends, VW's Xtrac rear-drive disengagement system is aided pneumatically. This is technology which has carried-over from the Dakar Race Touareg. Compressed air is stored in a small bottle and supplied via an accumulator to charge the hydraulically actuated disengagement.

The movement in the system is small, compressed air consumption is not high and so typically the bottle supply lasts a day depending on the rally. However, just before Rally Mexico, Volkswagen Motorsport homologated a Variant Option, replacing the compressed air bottle with an electric motor-driven pump. This later system was not used in Mexico, and at press time it was under consideration for appearance at the next rally in Portugal.

At the outset of VW's WRC engine programme in February 2011 the team, under head of engine development Dr Donatus Wichelhaus, studied whether to go for an 'engine of the make' or an 'appendix engine' – or Global Race Engine. All Volkswagen engines have a cylinder distance of 88mm, yet the appendix engine rules specify a minimum cylinder distance of 93mm.

The team could have selected any relevant unit from the Volkswagen Group. However, as Wichelhaus explains: '[The Polo R WRC engine] is a unique block. We made it from a white sheet of paper – the whole engine – so it has nothing to do with any production unit. It is completely separate.

'I think the intention of the GRE is completely right – to do a proper race engine which costs a reasonable amount of money – a reliable, powerful engine and that's it.' Discussing rival team's engines, Wichelhaus makes the point that Ford/M-Sport was fortunate to have a competition-proven and rugged production cylinder block with the correct dimensions for the Fiesta RS WRC, but that its cylinder head is GRE, while the Mini JCW WRC's BMW unit is a purely production 'engine of the make'. 'It's a long stroke with a 77mm bore, I never understood why they took this engine. But at the end of the day it's more expensive to spend some money for an engine which is worse from the beginning and you never get right, instead of paying once for a good engine which you can then use for years.'

"The intention of the GRE is right – to do a reliable, powerful race engine that costs a reasonable amount"

Volkswagen's crankshaft is machined from steel billet by SP Crankshafts in the USA. The steel is high in purity with no debris and therefore the cranks are reliable. Motorsport teams from NASCAR to Formula 1 to WRC use the same materials. Such materials are expensive, however, and were provided for VW's WRC engine by Aubert & Duval, a French technology company which developed these steels for spaceships. It has a limited production capacity, and therefore long lead times, but the benefits of using these materials overwhelm the problem of having to order the steel for delivery in 12 months time.

The engine team already had experience of motorsport-orientated direct injection power plants with a four-cylinder built for a 24-hour race Scirocco. There was also a five-cylinder direct injection-engined Golf which produced up to 600bhp. The team learned much from the latter, as did direct injection specialists Bosch. It was the first time an engine in development had more than 100bhp-per-cylinder – all previous high power output direct injection engines had eight or 10 cylinders and ran with around 80bhp-per-cylinder.

'There we learned a lot about injectors, spray pattern and so on, experience which we could then more or less take over to the WRC engine,' said Wichelhaus. 'And, to be honest, because direct injection has been in production for 10 years, all the development is done by others.

'I think they first started with direct injection in 2000. The first direct injection motorsport engine was the 3.6 litre V8 by Ulrich Baretzky from Audi, which was running in at Le Mans in 2001 in the R8 chassis. Bosch had started already with all the race development. And, to be honest, the race injectors are no different to the production ones. It's only this metal sheet on the bottom of the injector with the holes. But the rest of the injector is a standard road car part. It must be a standard road car part – it's written in the WRC regulations.'

Fuel pressure must be maintained in the fuel line during injection, which demands the fuel rail to be of a certain volume. Then, to minimise the volume of fuel system carrying 200 bar, the fuel rail should be as close to the injectors as possible. Equally, the fuel pump should be as close as possible to the fuel rail. Ideally for such a rally application, the injectors should be easily accessible. Naturally, all these features are engineered into the Volkswagen Motorsport WRC engine.

The latest regulations allow dry sump lubrication systems, which have been taken up in various forms by all current WRC cars. Similarly to its rivals, the Polo R has a water/oil heat exchanger to avoid chances of

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The Polo R cockpit. Drivers have a four-position map switch to help VW engineers to tailor the car to rallying conditions

total lubricant loss which might occur in the case of a failed/punctured air/oil cooler.

However, the Polo's sealed heat exchanger is in a rectangular casting on the forward-facing flank of the engine's cylinder block, below the fuel rail. Other teams use Laminova heat exchangers, located away from underbonnet heat sources. The legal maximum fuel pump-to-rail-to-injector pressure is 200 bar. This is self-limiting, as much over 200 bar will create enough pressure behind the pintel in the injector to stop the injector opening – even when 60 volts are deployed to power the injector.

High-pressure fuel pumps in WRC cars have one-way valves to stop the fuel retuning to the pump, and until an injector opens, no fuel can be evacuated from the fuel rail. Even with 'just' 50 bar in the fuel rail – for example with the engine at idle – when switching the engine off, the associated heat soak can cause the pressure of the incompressible fuel to rise by a few degrees of temperature, which increases the fuel pressure in the rail dramatically. M-Sport/Ford tests have seen an increase to 180/185 bar under such circumstances with the Fiesta RS WRC engine, and that engine's heat exchanger is away from potential heat soak areas in the left-front corner of the car's engine compartment.

With the heat exchanger immediately below the fuel rail, and with the high altitude, thin air and low oxygen content on Rally Mexico, the Mexican-spec Polo R's engines were equipped with a cooling jacket over its fuel rail and injectors to avoid any danger of the above heat soak-induced possibilities.

Wichelhaus confirms that the Polo R engine is affected by the altitudes of Rally Mexico more than any other part of the car. Another associated issue is decreased air resistance in the turbocharger, meaning the turbo will run at higher rpm than at any other WRC rally. Climate and altitude chamber tests were carried out before Mexico to guarantee turbo stability and to create engine maps which will lose as little performance as possible.

A 2009 to 2011 hat-trick of Dakar victories for the Race Touareg at high altitudes in South America almost certainly ensures Wichelhaus and his engine boffins are no strangers to optimising high-level running, however.

While the Volkswagen Motorsport-designed engine software maps must be tailored to suit the specific requirements of each WRC rally, Wichelhaus is adamant that the primary issue is to adjust the anti-lag system to suit the particular needs of each driver. 'This is because the drivers are different whether they are running on dry or wet or gravel – or whatever conditions – and they are different in their driving styles, or they prefer different solutions for the anti-lag. We learned from the beginning that with the anti-lag you can do everything you want for the problem. With all the functionalities it's quite simple – it's more important for the engineer to understand the wish of the driver. Then everything is good – it doesn't matter what the data is saying, or maybe what the engineer feels about the performance. When the driver is happy with what you've got, he'll be quick. I told the guys they really have to be focused on that, not on the data – I don't care about data.'

"When the driver is happy with what you've got, he'll be quick. I don't care about data"

Drivers have a four-position map switch. At events with changing conditions, they can report back to engineers which map they feel is the best and request a different range to be programmed into that map. That way they can quickly adjust the anti-lag to their driving style for the specific conditions during an event. As Wichelhaus explains: 'You must do it during events because you never know the weather conditions. In Monaco it was terrible, and whatever you adjusted before the event was wrong, so you have to adjust it before the rally.'

STARTER'S ORDERS

While Wichelhaus rues the fact there's 'no playaround', or scope for innovation with his engine, he's certainly thought things through. The FIA's latest R5 regulations are based more closely on road cars – some of which incorporate combined starter motor/alternator units – so such equipment is allowed in R5. But it is expressly not allowed in World Rally Cars. Would Wichelhaus like to be able to use one? 'It would be nice, for sure,' he says.

A computer-controlled engine with direct injection can be started by injecting into the cylinder with its piston ready for the power stroke and firing the sparking plug, so did Wichelhaus consider doing away with the starter motor entirely?

'Yes, you can work without any starter if you are clever – but you have, I think, a 95 per cent chance of well-done starts and I think for rally drivers that's not enough – they get desperate when it won't start!' he says. 'I think rallying is 75 per cent the driver and you must give him a reliability and a certain competitiveness. Then he will be quick, and he will win races. When you start to put technical dreams in your car which are maybe not reliable enough, then you are never successful. So it's purely a matter of giving the driver the right thing that he can be quick and that's it.'

With variable valve timing not allowed, at the design stage three gear-driven camshaft design iterations were investigated for the inlet cam. These are of more importance to the output of a turbocharged engine than the exhaust 'shaft. Using Design of Experiment (Doe) calculation tools, a variable is changed and a computer crunches the numbers until it has found the best solution. Hence the part can be optimised before dyno testing. In practice, VW's camshaft design was first computer calculated as the best


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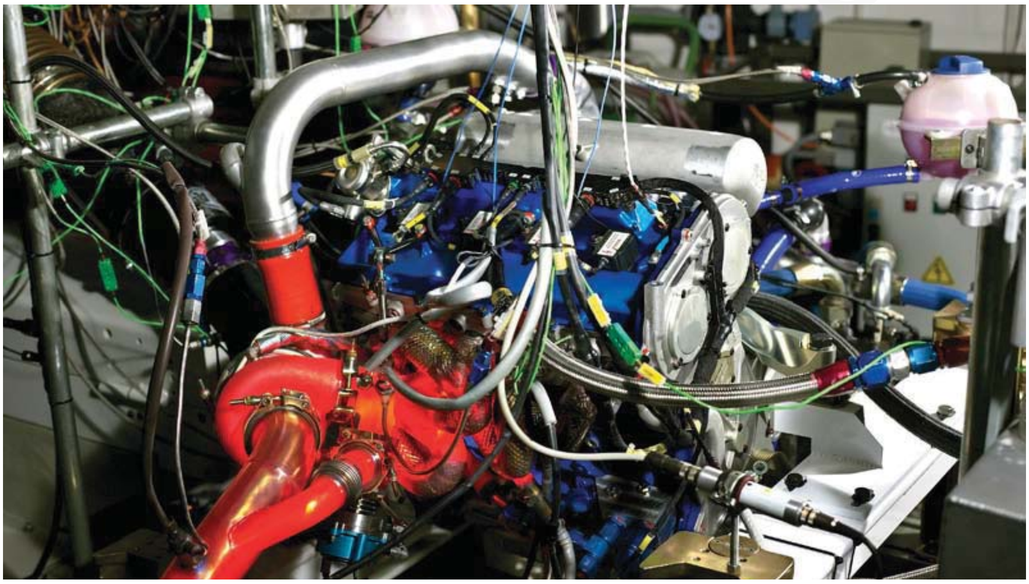


Dr Donatus Wichelhaus says that 100bhp-per-cylinder is impossible with the imposed 33mm restrictor hole

solution, and has proven to be the best solution in the engine. The computer indicated that its calculated alternative variants were worse, which was also proven in reality.

Wichelhaus's engine team has not investigated stratified charge so far, although an ECU modification would make this possible. Such technology is very uncommon for full-load running and is generally used for idle and part-load, where the turbulence in the combustion chamber is too low. However, would the FIA's consistent emphasis on perceived fuel economy and limiting fuel quantities for competition cars in various formulae mean stratified charge technology might be worth investigating in rallying?

'So, in the FIA discussions – Formula 1, Le Mans, everywhere we are – let's say in the purely technically driven challenges the fuel consumption is the biggest issue. But in rallying at the moment it's getting a reliable car to acceptable costs and getting the show right. And all the manufacturers are not so much in favour of introducing fuel consumption limits for rallying. Because – say with ALS – we all know it's a waste of fuel, so if you switch it off you save as much fuel as possible already.'

could World Rally Car engines ever reach 100bhp-per-cylinder outputs? 'No, never. We could do it with the 5-cylinder Golf engine because the air was much larger. But with this small [33mm diameter restrictor] hole, no way. Congratulations when you get 100bhp-per-cylinder from a WRC engine, but then you must have a drilling machine to drill the hole a little bit bigger!'

Wichelhaus believes that, as friction and power-related dimensions are restricted by the regulations, in three or four years all World Rally Cars will

"In rallying the biggest issue is getting a reliable car to acceptable costs and getting the show right"

RALLYING THE PUBLIC

Wichelhaus's opinion here is encouraging, and typically pragmatic: 'For sure on road sections we're already trying to be as efficient as possible – the car just drives and the driver is happy how it drives. But I think rallying first must get more of a marketing approach. Before that you can start playing with fuel and things like that, because the show must be right. At the moment the biggest effort you have to have for rallying is to get it in people's minds, so they're aware of it. I don't know whether it's so good when you have cars running very slowly on road sections and – maybe – running out of fuel.

So, what would be the alternative to not having anti-lag? 'Have turbo lag – the driver has to handle it. But you know the show would not be right, so to me rallying today is first getting the marketing side right, and then when it's really in the public's minds then you can start fiddling with some technical stuff – people don't care at all. Even when you go to Formula 1, ask the spectators what is in these cars – maybe 30 per cent might know.'

Wichelhaus points out that the specific fuel consumption of Formula 1 cars and World Rally Cars is nearly the same – yet concedes that Formula 1 cars 'have a bit more power!' But

have the same power. He is aware that the individual engine concepts are all different, but today that difference is less than 10bhp: 'Maybe 5bhp/6bhp, not more,' he says. But then a high bhp figure is not the most important thing for a rally engine. 'No – driveability and reliability and so on... that was the intention of this regulation: you have to have a reliable engine which gives everybody the same chance to have the same performance and not to be related to any road car design. This may be good for fuel consumption, but it's bad for power output. So this was the intention of the regulation and I think it works. It definitely works.'

TECH SPEC

Volkswagen Polo R WRC

Engine

Type: straight-four engine with turbocharger and intercooling, transversally mounted in front of the front axle

Displacement: 1,600cc

Power output: 232kW (315hp) at 6,250rpm

Torque: 425Nm at 5,000rpm

Bore/stroke: 83,0 mm/73,8 mm

Air restrictor: 33mm (FIA regulation)

Engine control unit: Bosch

Gearbox: sequential, 6-speed racing gearbox, transversally mounted

Final drive: permanent four-wheel drive with fixed drive between the front and rear axles, multi-plate limited-slip differentials, front and rear

Clutch: hydraulically actuated double-disk sintered metal clutch from ZF

Chassis/suspension: MacPherson struts, dampers from ZF

Suspension travel: approx 180mm on tarmac, approx 275mm on gravel

Steering: servo-assisted rack and pinion steering

Braking system: ventilated disc brakes (front 355mm on tarmac; front and rear 300mm on gravel) aluminium brake calipers (four calipers, front and rear)

Wheels: Size 8 x 18in for tarmac, 7 x 15in for gravel

Tyres: Michelin competition tyres tarmac: 20/65-18 (235/40-R18), gravel: 17/65-15 (215/60-R15), spikes: 15/65-15 (195/70-R15)

Chassis/bodywork

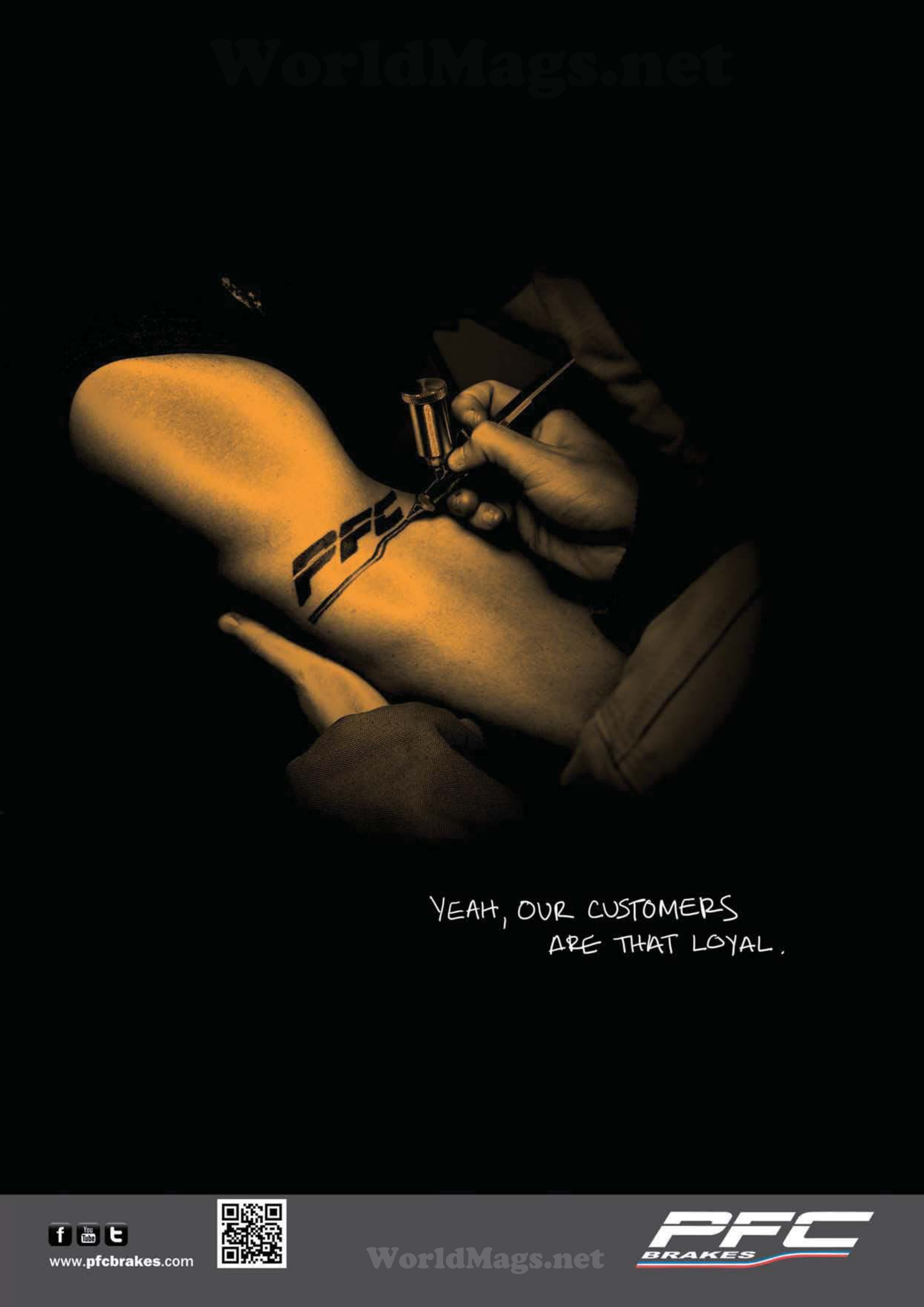
Build: FIA-conformant reinforced steel body

Dimensions and weight
Length/width/height: 3,976/1,820/1,356mm
Track width: 1,610mm
Wheelbase: 2,480mm
Minimum weight: 1,200kg

Performance

Acceleration: 0-100km/h in approx 3.9 seconds

Top speed: up to approx 200 km/h (depending on gear ratio)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Start your engines

A holding pattern for engine development in IndyCar was planned for 2013. So, an ideal time for some mild tinkering...

BY MARSHALL PRUETT

IndyCar Series engine providers spent 2012 learning about their brand-new, 2.2-litre turbocharged V6 powerplants with an understanding that limited changes would be permitted during the off-season.

The progressive, year-by-year rules structure that came from the IndyCar Engine Committee (IEC) was a direct result from input by the series' three manufacturers - Chevrolet, Honda and Lotus. From those IEC meetings, the decision was made to treat 2013 as much like the second of a two-year development freeze as possible.

Chevy, with its Ilmor-built twin-turbo engine, dominated the first year of the new-look series with prodigious power and reliability, claiming 11 wins, the manufacturers' title and powering Andretti Autosport's Ryan Hunter-Reay to his first championship.

Honda, by stark contrast, won the IndyCar's crown jewel, the Indianapolis 500, with Chip Ganassi Racing and Dario Franchitti using its single-turbo powerplant, and three other events with Ganassi and Dale Coyne Racing, but suffered too many engine failures to accelerate its development program to offer sustained challenge against Chevy.

The general reckoning was that by the season finale on the 2-mile oval at Fontana, Ilmor and Honda Performance Development were equally matched on pace, but both manufacturers looked to the long six-month off-season to ignite robust development plans.

The greatest opportunity for advancement came with the allowance of a complete redesign on fuel systems. With Lotus having exited the series in December, Chevy and Honda were left to alter any aspect of the combined port- and direct-injected architecture found with both engines, as well as commissioning workflows to improve reliability and performance within the boundaries of homologation guidelines.

'When we were first sitting down and drafting the regulations, we originally weren't thinking much of an update for 2013,' said HPD technical director Roger Griffiths. 'But what we all agreed on was particularly in the area of direct injection - it was all pretty new for all of us. And we felt that it would probably be a wise thing to allow us the opportunity to make a change on the fuel system because that area was very new. We didn't know quite how it was going to work and we wouldn't want to be stuck with carrying a bad decision over two years on the fuel system, because it was an area that was evolving so fast.

'We felt that it would probably be prudent to allow us to go back and have a second look and make sure we had made the right decisions a year earlier. So that's the background as to why there's an interim step there, rather than the major changes that are coming in 2014.'

Comprehensive changes await Chevy and Honda once the 2013 season concludes, with new cylinder heads and induction systems including plenums, piping and a change in the number of turbos used. Honda can move to twin turbos if desired, while Chevy can reduce to a single BorgWarner unit, and new camshafts are permitted. For now, manufacturers have zeroed in on fuel systems as the primary target for innovation, and according to Chevy's IndyCar programme manager, the Bowtie felt confident in its 2012 system to carry over elements of its design.

"We're taking advantage of the fact that anything the fuel touches is allowed to be changed"

'We certainly didn't throw it away and start over,' said Chevy's IndyCar manager Chris Berube. 'We had decent performance, but we were learning quite a bit throughout the season last year. Now we're taking advantage of the fact that anything the fuel touches was allowed to be changed.'

Griffiths and his team at HPD spent 2012 monitoring high-pressure DI developments that will soon grace Formula 1's turbocharged engines. Like Chevy, HPD opted to retain some of its existing fuel system while searching for new advancements to incorporate. 'As you talk to the various fuel systems suppliers, they're coming up with new ideas,' he said. 'One of the big things that's happening is the F1 regulations. They've committed to a V6 turbo direct-injection engine operating at a 500 bar limit, and we're at a 300 bar limit. What it means is that they now have much more experience operating at these higher pressures. When we first went to manufacturers a couple of years ago, we mentioned 300 bar - that's way higher than

where we are today on road cars. And particularly with the ethanol fuel and the demands of the flow rates required to get the performance we're looking for, we were in uncharted territory.

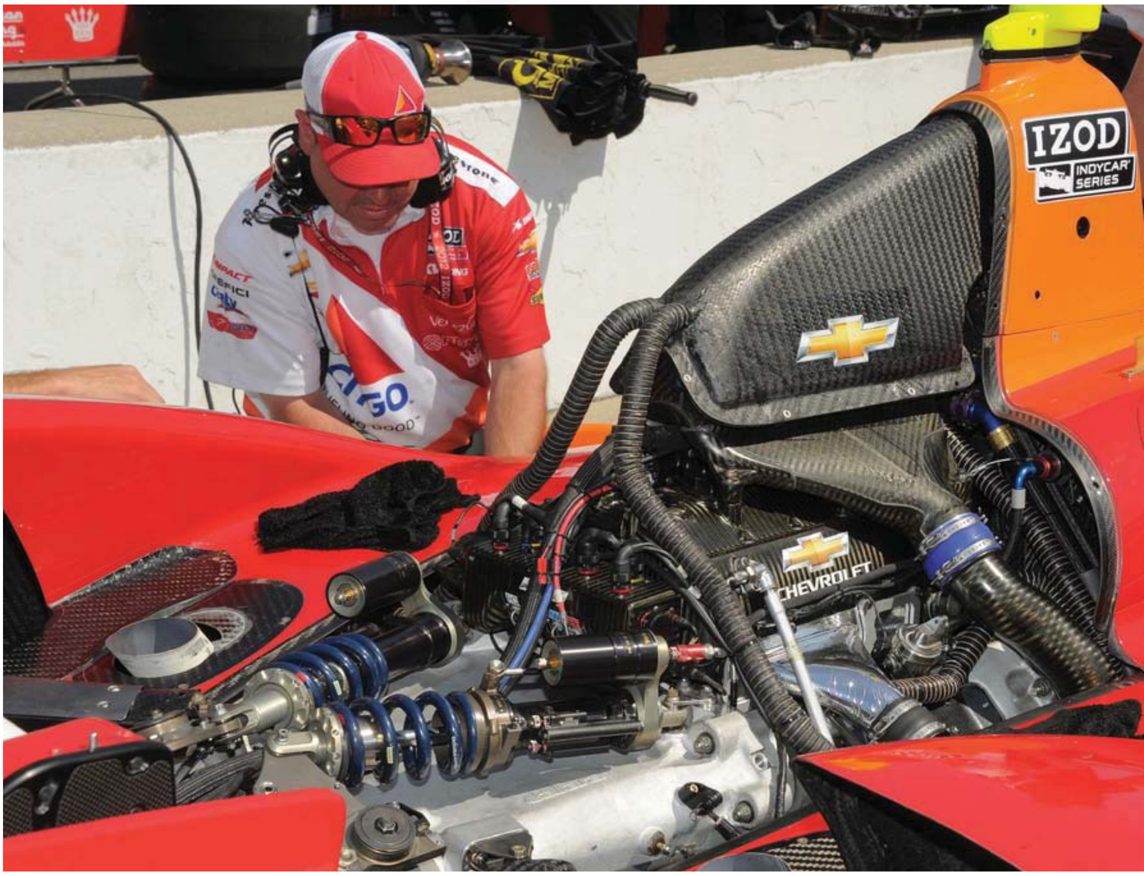
'It didn't matter whether you were talking to Bosch or Magneti Marelli, or Hitachi, or to any of these people – they were all coming back with the same kind of comment: "this is very new for us. We've got some stuff we're looking at for Formula 1, but it's pretty early." We've all had the opportunity of a year's worth of the development. Now we can go back and see what they've learned in the past year and see if that is applicable to what we're doing.'

Working with Hitachi, Chevy took the opportunity to move away from having its injectors working at different pressures. 'We've gone from low-pressure to high-pressure port injection for 2013 – that was a big change that we made,' said Berube.

'Now we are running at a DI pressure level, so the feed is consistent with the DI injectors and the port injectors now,' added GM Racing powertrains and advanced projects manager Russ O'Blenes. 'We're running off the same pump and fuel system.'

One of the most important decisions Ilmor and HPD had to decide upon during their respective fuel system re-homologations was how much further to skew towards using DI. With the rules limiting the use of a single port injector and a single DI injector per cylinder, plus a maximum of 300 bar to flow the spec E85 fuel, both marques struck a safe balance between achieving outright performance through port injection and fuel efficiency through DI in 2012.

The manufacturers would not be drawn on the percentage shift from port to DI for 2013, but both conceded a move was made. However, the ratio of port vs DI fuelling will continue to differ from track to track. 'We look all the time what the best combination of the two is,' explained Griffiths. 'Depending on the particular speed range that you're running on the engine and that particular demand that you've got on the engine, you'll make adjustments to the percentage that you use from one or the other.



For the 2013 season, Chevrolet have moved over from low-pressure to high-pressure port injection

'In certain areas you can get good driveability by having more of one than the other, and then in other areas you're chasing performance. So it's something we focus on greatly. I would say that each of the specifications of engines that we've brought to the racetrack have had a slightly different balance between the percentages of direct injection or the port injection. So it's not something where we said we need 60 per cent of this and 40 per cent of that and never will we change. It's something we look at continuously.'

F1-grade technology, as Griffiths notes, comes with F1-level costs. And with a restrictive price structure for IndyCar engine leases and mileage – $695,000 for five engines lasting 2000 miles apiece between rebuilds – a financial governor of sorts limited how aggressive he could be with 2013 DI developments.

'I think we made some sensible decisions,' Griffiths said. 'You also have to be mindful of how much money you're spending because the lease price still comes back to bite you. As soon as you start talking to people about Formula 1 components, you have Formula 1 prices and then you look at it and think: is it really the right place to be putting this type of fuel injector in or this type of fuel pump? The cost of it will make it more expensive than everything else that you've just looked at.'

"When you start talking to people about Formula 1 components, you have Formula 1 prices"

ALWAYS OPEN

The IndyCar Series leaves the high consumption engine internals open for constant development, with valves, valve springs, retainers, spring seats, pistons, rings, wrist pins, circlips and bearing shells free for manufacturers to explore. Externally, wastegates are also free, and coatings are also open for revision at any time.

'We probably had every single coating manufacturer on the planet contact us with the latest and greatest in technology that they had,' laughed Griffiths. 'I think they must've seen that line item in the rules and everybody came out of the woodwork with some kind of spray-on coating or some cryogenic treatment. We obviously looked at them and then made a decision as to whether or not it was a technology that we wanted to apply.

'You have to be very, very cautious when you look at some of these things. Some of them actually work very well and others are, well, it's a bit of black magic.'

Ilmor chief engineer Steve O'Connor says the firm found more value in tuning its current wastegates through calibration developments than sourcing all-new hardware. 'The wastegate unit is not a major development item for us,' he remarked. 'We are always working on trying to ensure we run maximum boost without over-boosting the engine and suffer a (ECU controlled) boost penalty which will cost us time and track position. The wastegate and engine calibrations are both primary inputs for this. I would say the engine calibration is at least as important as the wastegate in this regard and it would be easy to get

IndyCar is taking advantage of the progress made by fuel companies seeking 500 bar pressure for F1 to increase DI pressure to 300 bar in 2013

this wrong, so this is something we're continually developing and trying to avoid happening.'

It's also safe to assume that in the quest for additional performance, every permissible development item was evaluated.

'As far as everything else, the open areas of development, – whether it's pistons or valves – obviously we're looking all the time for what we can we be gaining,' said Griffiths. 'Is it friction reduction or is it better combustion, for example. Those kinds of areas are the bread-and-butter of our engine development.'

Chevy confirmed it produced a new specification of exhaust headers to start the 2013 season, and also revised aspects of its engine wiring loom to address some of the reliability issues of 2012.

Honda used header bag enclosures with its exhausts in 2012, citing a slight improvement in internal airflow, while Chevy did not. Berube added: 'We looked at that, but it's not the current path we're choosing to go down.'

A number of early engine failures were traced to control issues with the spec McLaren ECU, while others fell into the category of parts failures and even fuel-related issues, mostly fuel line and/or fuel injector fires. The reasons varied from straight failures to crash damage to teams/manufacturers intentionally swapping engines before the 1850-mile usage minimum – to prevent a possible high-mileage failure or to gain access to the most recent engine specification. The end result was 27 Chevys being changed early and 36 Hondas. Lotus, which ran with a single entry for two-thirds of the season, had 15.

Tackling the general topic of reliability was a priority for Chevy and Honda, but those durability initiatives were also dealt a wildcard with the fast-paced 2013 engine developments in mind. Between the revised fuel systems and engine internals, solving the issues that 2012 brought is only part of the challenge.

'We used the GM transient dynos very heavily and it's really your only outlet,' said Berube, referring to the heavy restrictions on track testing. 'Chevy had a decent advantage there. I can only assume how they react to problems and I'm going to assume it's on a very high level, but I'm very impressed with the way our team identified a problem and came up with a fix and implemented the fix to kill issues as soon as they came up. I didn't kill everything. And we had some problems that lingered.'

IN THE LOOP

GM's O'Blenes, who leads the IndyCar dyno testing, described the cyclical nature of developing their engines without the luxury of unlimited track days. 'From my side, the interesting thing with the whole deal is that it's such a tight tie-in,' he said. 'Any time there's a component change, it drives calibration and software development, which then drives a revalidation. It's just like anything that's in that whole development loop where you do traditional dyno type power pulls, power testing kind of stuff on components and then a base calibration is developed for those components so that you can redo the validation side of it. Then in the background you're working on the transient side to develop your at-track driveability. Making sure that any system changes close that loop up.

'So you really have both wheels going at the same time because you're running durability on the components, and also you're also taking those components on the transient side to work on drivability and that sort of thing, so that when you go to the test you're able to spend time working on the car, rather than working on all the nuances of the drivability.'

HPD has also kept its dynos running steadily in search of greater reliability, but like Chevy, there are limits to the process. 'When we looked back on our season, it was the reliability of the engine that let us down more than anything,' said Griffiths. 'Is that something where you could say, OK, our transient dynos are going to be glowing red, running 24 hours a day throughout winter

"We're always working on trying to ensure we run maximum boost without suffering a penalty"

as we try and look for everything and wear these things out to absolutely verify everything we want to verify to improve and increase our reliability? It sounds good, but it's not reasonable. But we've made a huge effort towards fixing it.'

Both manufacturers offered an estimated three to four per cent increase in power for the 2013-spec engines, which could mean as much as 50-70hp more, depending on the circuit and boost levels. No major issues were experienced prior to the season opener at St Pete in March, but reliability will continue to be a source of intrigue as more power is found.

McLaren's TAG-400i engine controller received frequent software upgrades throughout the 2012 season as engine manufacturers provided the firm with useful feedback and suggestions for improvements. Once Ilmor and HPD found a state of trust and comfort with it, the calibration race intensified.

'For calibrations, we're not changing McLaren's code and we're spending lots and lots of hours on dynos working on driveability, working on shift quality,' said Berube. 'Those types of things that can result in loss of time on the track.'

Honda played it safe with the 400is prior to the 2012 Indy 500, and along with other internal engine developments, unveiled a major leap forward with fuel mileage and boost control through the ECU that powered Franchitti and teammate Scott Dixon to a 1-2 finish at the Speedway. Now HPD and Ilmor are working to maximise the electronic updates sent through by McLaren.

'McLaren are also introducing new features and we had a fairly big revision to the way the knock control strategy works late on in the season,' said Griffiths. 'I think both parties identified some issues with the way the original strategy was working. We both pushed pretty hard to get McLaren to re-write the software, and we now have a much clearer understanding of what's going on within the engine. Whereas before we were fairly sure about what was going on, now it's something we feel a lot more confident in using.'

Honda won the Indianapolis 500 in 2012, but following a string of engine failures, there's been an increased focus on reliability for 2013

In addition to knock sensing capabilities, McLaren has implemented a few other updates and functionalities for 2013 according to IndyCar director of engine development Trevor Knowles. 'The major change is the new Push-to-Pass where the driver has a set number of pushes, each of which lasts for a set time,' said Knowles. 'There have been some minor changes to improve the action of the rev limiter and transient throttle response.'

The pace of development differed for Chevy and Honda last year due to the rate of problems encountered by both manufacturers. Honda, as noted, was a lightning rod for engine failures, and those breakages started once pre-season testing began in January of 2012. Chevy also encountered engine failures, but at a lower frequency, which allowed Ilmor to work through its planned list of updates and upgrades with limited interruption.

For Honda, the setbacks derailed many of its development plans through the first four rounds, leaving HPD a number of carry-over items to explore during the off-season.

'We had a lot of good ideas queued up and ready to go, but you were never able to get to them,' said Griffiths. 'And then you make the decision to hold fire and save things for 2013. It's a strategic decision. You have to say, OK, at some point you need to fix the real development focus to the next engine, rather than the current one. It's hard. You've got to keep pushing as hard as you can for the race that you've got the coming weekend, but you've also got to think, well, if I go flat-out all the way to the end, you're going to run out of time with your 2013 engine. You're not going to be able to do the things you want.'

PARALLEL PLANNING

'You've got to almost have this parallel path of one group of people working on the current engine and another group of people working on the future engine,' continued Griffiths. 'And sometimes when you're having problems with your current engine you have to pull people off your future development. so it kind of throws you off a bit. What we were able to do as soon as we got to the end of Fontana was say, OK, now it's full steam ahead for 2013 for everybody. That's how it's worked out.'

It's far from sexy and the average fan doesn't care about it, but with a year of combing through each budgetary line item, Chevy and Honda also spent the winter looking to curb excess spending wherever possible.

"Sometimes when you're having problems, you have to pull people off your future development"

With every engine lease requiring a significant subsidy, reducing fixed costs and operating expenses would allow for more time and money to be poured into development.

'At the end of the day, there is only so much money that we can spend on this project,' added Griffiths. 'And when you are effectively subsidising each of the leases to the tune of half a million dollars or something like that, that comes out of your bottom line.

'There's two aspects to it: the physical cost and the materials cost. How can we produce a component with the same functionality and the same quality but make it cheaper? And secondly, it's the operational cost. Can we make a cylinder head last two rebuilds? Can we last three rebuilds? Can we reuse a set of connecting rods? Can we reuse a flywheel? If our rebuild costs $100,000 one year, can you get down to $80k? $70k? Can we take five hours out of building an engine? All those things that we look at and say: how do we reduce the rebuild cost of the engine so you're not throwing away parts or time?'

Berube seemed to indicate its rival might have taken a deeper dive into the balance sheets.

'I guess I would first to admit to being in that same subsidy boat,' he said. 'First and foremost, our priority's on winning races so where we can – where we're inefficient with money – certainly we take it out, but we're not in a thrifting mode on the engine. Where it makes sense, will it look wasteful? Sure, but nothing dramatic.'

Chevy's primary job is to maintain its form, while Honda is tasked with catching and passing the reigning champions. Testing leading up to St Pete offered a glimpse of the significant progress made by Griffiths and Co., but with the rapid response times from both manufacturers, the 19-round championship will likely be a repeat of the back-and-forth battles seen in 2012.

Better by design

We meet the former motorcycle triallist and aviation engineer who went on to be the brains behind some of the most successful and influential racers of all time

BY IAN WAGSTAFF

IMAGES: LAT PHOTOGRAPHIC

"When Bruce McLaren died, half the workforce didn't believe we could continue. I was in the other half"

(Above left) Gordon Coppuck today, with his model of the M23; (top) the real thing; (above) Al Unser Jr at the 1992 Indy 500 in a Galmer G92

Gordon Coppuck's attitude shines through in both his words and his actions. 'I think motor racing should be fun,' he says. Then witness his love of Formula 2. Yet this is a man who designed a famed, double World Championship-winning grand prix car, an Indianapolis 500 winner and one of the greatest line of sports racers ever seen.

A trained aviation engineer, Coppuck recalls that he was the 13th employee at Bruce McLaren Motor Racing, having been recruited by the team's designer, Robin Herd, from the National Gas Turbine Establishment. He had also been a fine motorcycle trials rider, winning a gold medal in the 1961 International Six Days Trial riding a Triumph and a silver medal the year before with a Cotton. Years later, he was to discover that he had competed against a very young Jacky Ickx in one of these. He worked as draughtsman with Herd on the M5A and M7 F1 cars, and the M6 Can-Am cars. With new recruit Jo Marquart, he designed the immensely strong M8A that was to continue the 'Bruce and Denny Show' in the US. An apocryphal story says that, as the pair felt that they were not yet quite ready to design a complete car, Marquart took on the front, Coppuck the rear. Gordon certainly had the task of mounting the Chevrolet V8 engine and hanging the rear suspension on the Hewland LG500 transmission. The earlier M6A had its engine located between two pontoons, and he believes that the M8A was the first sports racer 'to use the engine as a structural member as in a Formula 1 car'.

The first F1 cars attributed solely to Coppuck were the M7C and Alfa-Romeo-engined M7D. He was also responsible for the M10A, which was designed to be a production Formula 5000 car. 'The M10A was the first car for which I had complete design responsibility. I was starting to know what I was doing,' says Coppuck. 'That first year in F5000, we really did think we had the best car.

'In those days, intuitive Bruce always knew what each of us was doing. When he was killed [in 1970] about 50 per cent of the workforce didn't believe that we would be able to continue. I was in the other half that thought we had learned enough to keep going. Jo Marquart was in the other 50 per cent, so we took

(Top) James Hunt in an M23 at the 1976 German GP; (above) Bruce McLaren in an M7C leads Jack Brabham and Jacky Ickx at the Dutch Grand Prix in 1969

Alain Prost driving the shortlived M30 at the Canadian Grand Prix in 1980. This was Gordon Coppuck's final car for McLaren before he left to join March

on Ralph Bellamy to do the F1 and F2 while I did the Indy and Can-Am cars.'

Coppuck's first foray into Indianapolis was the M15, which was remarked upon at 'the Brickyard' for its high standard of construction. The RAC awarded the 1969 Segrave Trophy – given for 'the most outstanding demonstration of the possibilities of transport by land, sea, air, or water' – for the work on this car, something of which Gordon is particularly proud. Sadly Denny Hulme was burnt in practice for the 500 and McLaren was killed testing an M8D at Goodwood. The programme was, unsurprisingly, disrupted. Coppuck had seen how well the Lotus 56 (Indy) and 72 (Formula 1) wedge cars had run and decided to adopt this shape for the M16, reasoning that aerodynamic forces are pretty constant at Indianapolis. So in 1971, the McLaren drivers dominated qualifying, Mark Donohue stating that the M16 made every other car at the track obsolete. There was talk about too much of the engine being exposed and about the wings being illegal, but Coppuck had ensured that they were incorporated into the bodywork as per the regulations. Circumstances led to just a second place that year for Peter Revson but in 1972 Donohue took the Indy 500 with a Penske entered M16B. Johnny Rutherford won two years later with a M16C. In 1975, Coppuck's then-new assistant, John Barnard, helped develop the car into the M16E which gave Rutherford another Indy 500 win the following year.

The success of Coppuck's designs in North America meant that, when Ralph Bellamy left the company, it was obvious who should take over the grand prix cars. 'They had confidence in me because we had done all right,' is his masterly understatement.

As far as grand prix cars are concerned, it is for the 1973 and 1976 championship-winning M23 that he is best remembered. 'For the next Formula 1 design after the M19 we wondered whether we should build another 'Coke bottle' shaped car or should we build one like the M16 Indy car. The basic principal of the M16 with a Cosworth DFV engine would be a much lighter package than the M19, so we thought we'd make it like that.'

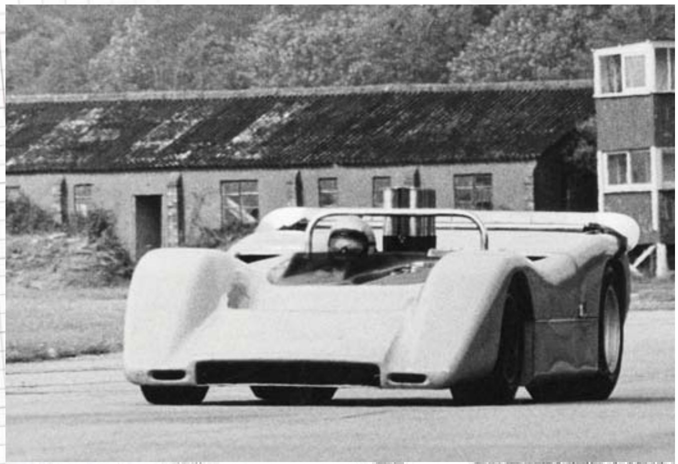
It is perhaps not surprising that the side radiatored M23 bore a passing similarity to the older Lotus 72. 'We recognised that the Lotus 56 jet engine car had been very successful, and we could see that the packaging of the Lotus 72 was that taken to a conventional engine,' recalled Coppuck. 'So, we decided that the next car we did would be a side-mounted radiator inspired by the Type 56. However, pencil did not get on to paper for some months after Bruce had been killed.'

New regulations for 1973 had mandated that the entire fuel tank area of the car in direct contact with the open air stream had to incorporate a crushable structure. Coppuck says that a deformable structure could have been added to the existing M19, but it would have been a difficult job, a bolt-on effort just to meet the regulations. Lotus, conversely, chose to convert its type 72s. Thus, it was decided to create a new car, with fully integrated deformable structure, that followed the spirit as well as the letter of the regulations. The car was right down to the weight limit when it first started racing. It did grow slightly heavier over the years, but Coppuck reports that this was kept in hand. 'The ethos of the M23 was that it was a very simple car – there was nothing at all complicated about it,' says the then McLaren team manager Alastair Caldwell. 'Relative to my contemporaries, I was a bit more concerned about the structural integrity of things,' adds Coppuck.

During the 1973 season, Coppuck also engineered at the track. While Teddy Mayer ran Denny Hulme, he was responsible for Peter Revson. 'I was very pleased to be involved in Peter's two wins.'

The M23 was to go on to greater success. McLaren was to hire what Coppuck recalls as 'a Brazilian with an English temperament and an Englishman with a Brazilian temperament.' The first of these, Emerson Fittipaldi, took the 1974 world championship with the car. James Hunt repeated the feat in 1976 after a controversial battle with Niki Lauda. Fittipaldi's undoubted enthusiasm for testing meant that many small changes were made to the M23 during his two seasons with the team. Improvements, or perhaps otherwise, were still being made to the M23 during its final competitive season, 1976. Repositioning of the oil coolers at one point destroyed its competitiveness, almost costing Hunt the championship.

New regulations that year set down specifications for mounting oil containers on the car. Prior to



(Top) Bruce McLaren driving an M8A CanAm at Goodwood, a similar car to the one in which he died at the circuit; (above) Peter Revson and Coppuck sit on the M16. It was a car that Mark Donohue stated made every other look obsolete

the Spanish Grand Prix, small oil coolers had been fitted below the rear wing aft of the transmission. The latest rules required the wing to be moved forward slightly, which meant that McLaren moved the oil radiators to a new position just inside the water radiators on the right-hand side of the car. There was concern that this might contravene the regulations, but team boss Teddy Mayer persuaded the authorities that there was a difference in definition between oil containers (or tanks) and the oil coolers that circulated the oil to cool it. Even then doubt remained, and the plan was to return the oil coolers to almost their former position after the race, particularly as the oil had overheated in Spain. In the end this was carried out between practice sessions for the Belgian Grand Prix. Because the wing had been moved forward, the coolers were about an inch away from their old placing. This upset the sensitive pressure area under the rear wing and spoilt the airflow with a resultant detrimental effect on the handling. 'It was horrible,' recalls Coppuck. For the next few races, the team struggled until the oil coolers were remounted at the side of the car in time for the French Grand Prix. Having been relegated to almost midfield runner, it was again a race winner. Coppuck says that criticism arose over Hunt because of the above. 'When we put the oil coolers back after Spain, we got James to test the car. He could not recognise any difference. But then for two races we were not competitive. The frustration was that he could not tell the difference.'

A car derived from the M23 was the John Barnard-detailed M25 F5000. Coppuck is wistful about that. 'What happened to the M25 was sacrilege. None of us within the company were interested in the production cars but it would have been very strong if somebody could have done something with it. Denny Hulme said it was so lovely to drive with that big, old Chevy engine.' In the event only one was built, racing just twice in F5000 before Emilio de Villota had it rebuilt for Formula 1 to almost M23 specification.

"I liked the 1970s, but I am not necessarily more pleased with the M23 than the M16 or M8"

'I liked the 1970s but I am not necessarily more pleased with the M23 than the M16 or the M8,' continued Coppuck. 'They were in three different classes.' He went on to design the M23's successor – the M26 – which initially had to be withdrawn because of teething problems, but was reintroduced in 1977, giving Hunt a further three grand prix victories. The next F1 car is the one of which Coppuck is arguably least proud. 'I wasn't very happy about the M28, although is wasn't really that bad.' Teddy Mayer criticised this large, ground effects car at the time, saying that it ignored the crucial design precepts that a car should be as 'light, agile and compact as possible'. Coppuck reckons that it was superior to the previous year's championship winning Lotus 79, pointing out that John Watson came third in its first race, but not as good as the Ligiers during the early races of the 1979 season. The M28 lasted only until the British Grand Prix when it was replaced by the more compact but stopgap M29. Coppuck's final car for McLaren was the shortlived M30. With McLaren now merging with Ron Dennis's Project Four Racing, he left to be reunited with Robin Herd at March.

'In 1981 March had a job for me in Formula 2,' Coppuck says. 'I didn't design the F2 car that year but I ran Corrado Fabi. I thought Formula 2 was fabulous.' His love of F2 can be traced back to the Ralph Bellamy-designed M21 run for Jody Scheckter in 1972. Following a poor start to the season for the car, Coppuck was asked to engineer it at the May Whitsun meeting at Crystal Palace. Scheckter triumphed, but it was to be the M21's only win. That same weekend Mark Donohue drove

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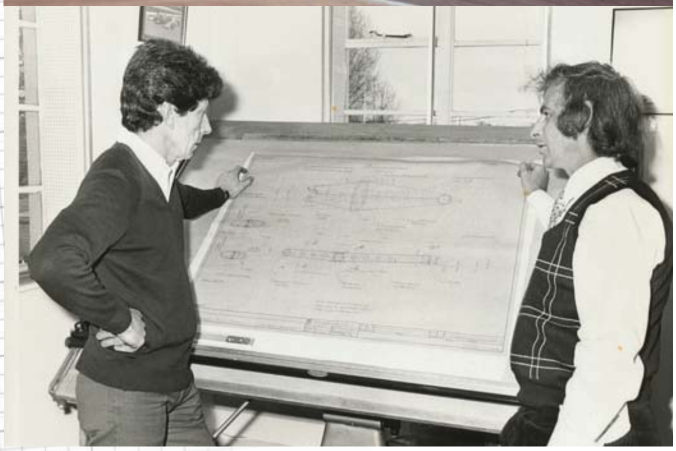
Coppuck's M16 design to victory in the Indianapolis 500. Hulme also won with an M19 at Oulton Park. 'It was good for our egos,' he says.

'When the opportunity came to be part of the Honda project later in 1981, I felt very much that was what I wanted to do,' he adds. So Gordon and John Wickham left March to form Spirit Racing, initially running a new Coppuck-designed car in F2. 'It was a nice car. We didn't win the championship, but that was more to do with Bridgestone, who weren't as competent as Michelin. They were using radial tyres for the first time in serious racing and these were tending to let go. We then had to race with cross-plies, which had a one-inch larger diameter and that screwed up the settings.

'At the end of the year Honda asked us if we would convert one of the cars to take the turbo-charged Formula 1 engine. It was a bit of a monster, to say the least. Honda also didn't really understand our Formula 2 drivers, Stefan Johansson and Thierry Boutsen. Stefan impressed Honda because he was quick, but Thierry impressed me. He was the tiniest bit slower, but he knew what the car was doing everywhere. Time and again he would anticipate a problem for race day that we could do an in-the-field fix for. That meant that Thierry ended up winning three F2 races and Stefan none. With the F1 turbo engine, the lag was unbelievable. In my heart I believed Thierry would have been of more help to Honda. However, they wanted Stefan.

'We knew all along that either Tauranac or Williams had the inside line at Honda, but they'd given us the opportunity to start a company. In truth, we didn't have the credibility to attract the sponsorship for F1. F2 had also now stopped and that had been what I really liked.' Coppuck sold his shares in Spirit to Wickham and returned to March, initially to design the Group C 86G. 'That involved a new way of working at March. We sub-contracted a company to do all the CAD on that car. It was hard keeping an eye on inexperienced CAD designers who were working on two shifts.'

With March, Coppuck was able to return to Formula 1. Robin Herd was later to write of this period:



(Top) Denny Hulme in an M19A at the South African Grand Prix in 1972; (above) Gordon Coppuck – pictured right – at the drawing board with Don Beresford

'I was lucky enough to get Gordon Coppuck and Tim Holloway.' Given insufficient time to create a completely new car for the F1 season, Coppuck adapted March's latest F3000 design that had been penned by Andy Brown.

'I worked for March again in various guises until we were in South Africa in 1993, and Ilmor would not start the engines unless we paid, I think, £500,000. When we got back, the factory was all locked up.

'The 1989 [Porsche-engined] CART car was a very kind one. We only won one race, but we were hopelessly underpowered as we were with the 1990 car, although not by as much. When it left the Bicester factory it was just above the weight limit, but it got to be 30 to 40lbs overweight, which was frustrating. I liked the Porsche project. It was relatively unusual for March, but Porsche was always going to go Formula 1. Still, it gave me confidence when March folded and we were stuck out in South Africa. I enjoyed the American racing: I loved the sociability. There had been a great camaraderie in Formula 1 in the 1970s but that had gradually been eroded.'

Underlying this camaraderie, former March colleague Andy Brown, by 1992 assistant technical director at Galmer, recalls how Coppuck helped him out. 'We had an issue with the front wing of the Galmer. We could not balance any degree of rear wing. I called Gordon up – he was still at what was then called Leyton House – and said, "We had had a pretty good wing on the 1990 Leyton House. Do you think I could have the drawings?"' Coppuck obliged and Galmer duly won the 1992 Indianapolis 500.

In 1993, Coppuck moved to the USA to work in CART, initially running Mark Smith for Frank Arciero, then becoming technical director for the joint Frank Arciero/Cal Wells operation – Arciero-Wells – two years later. During this time Coppuck recruited 13 Brits to travel to the USA join him in CART.

In 2000 the team moved into NASCAR with Gordon effectively retiring from motor racing. There was, though, one final fling. 'Dale Earnhardt had just been killed. We knew when we looked at the cars that the things were really death traps. They could have been so much safer. We decided that they ought to take the inside of an F1 or ChampCar monocoque as a safety cell. So Cal found finance for me to do something in the UK with Reynard. We took the inside of an IndyCar – which we naturally had to widen – fiddled about with it and then crash tested it with a monitored dummy at Detroit University. We built five and had meetings with NASCAR who were impressed, but they only wanted it if it could be made in South Carolina. We said that there was a British industry where we would have a choice of suppliers, and all the correct facilities. You cannot use carbon fibre as fibreglass, for example, but that also fell on deaf ears, so the project died.'

Looking back it is easy to see how Coppuck enjoyed himself in the then perhaps less rigid world of motor racing. 'I never minded the hours,' he says. 'There's something wrong in my disposition that even as an apprentice I was always last in in the morning and last out at night. I'm not time conscious. Even in the civil service I got enjoyment from my work.'

Coppuck was, however, a child of his time. Observing F1 today, he says, 'I'm glad that Adrian Newey is still the force to be reckoned with. He's still doing things in a way that he has probably been doing since the 1980s, using a drawing board, even if his back up is 10 times as large. You are hard pushed to name somebody doing it quite as he does.

'There are now people concentrating on every component on the car. There is probably somebody putting more effort into the area around the front wing than I was on the whole of the car. If I was that much younger I don't think I would have taken to motorsport in the same way that I did.'

"There's something wrong in my disposition – even as an apprentice I was always last in and last out"

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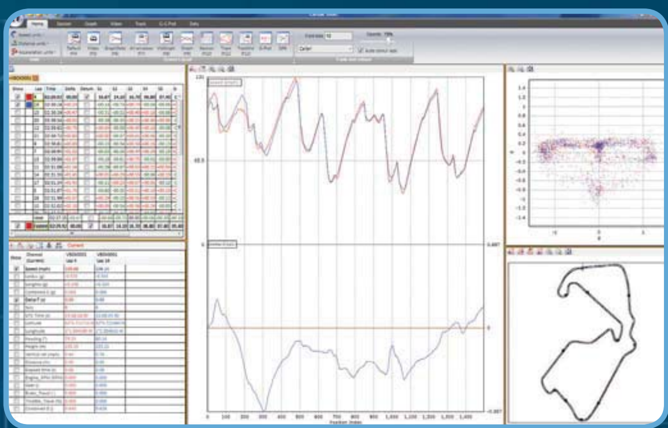

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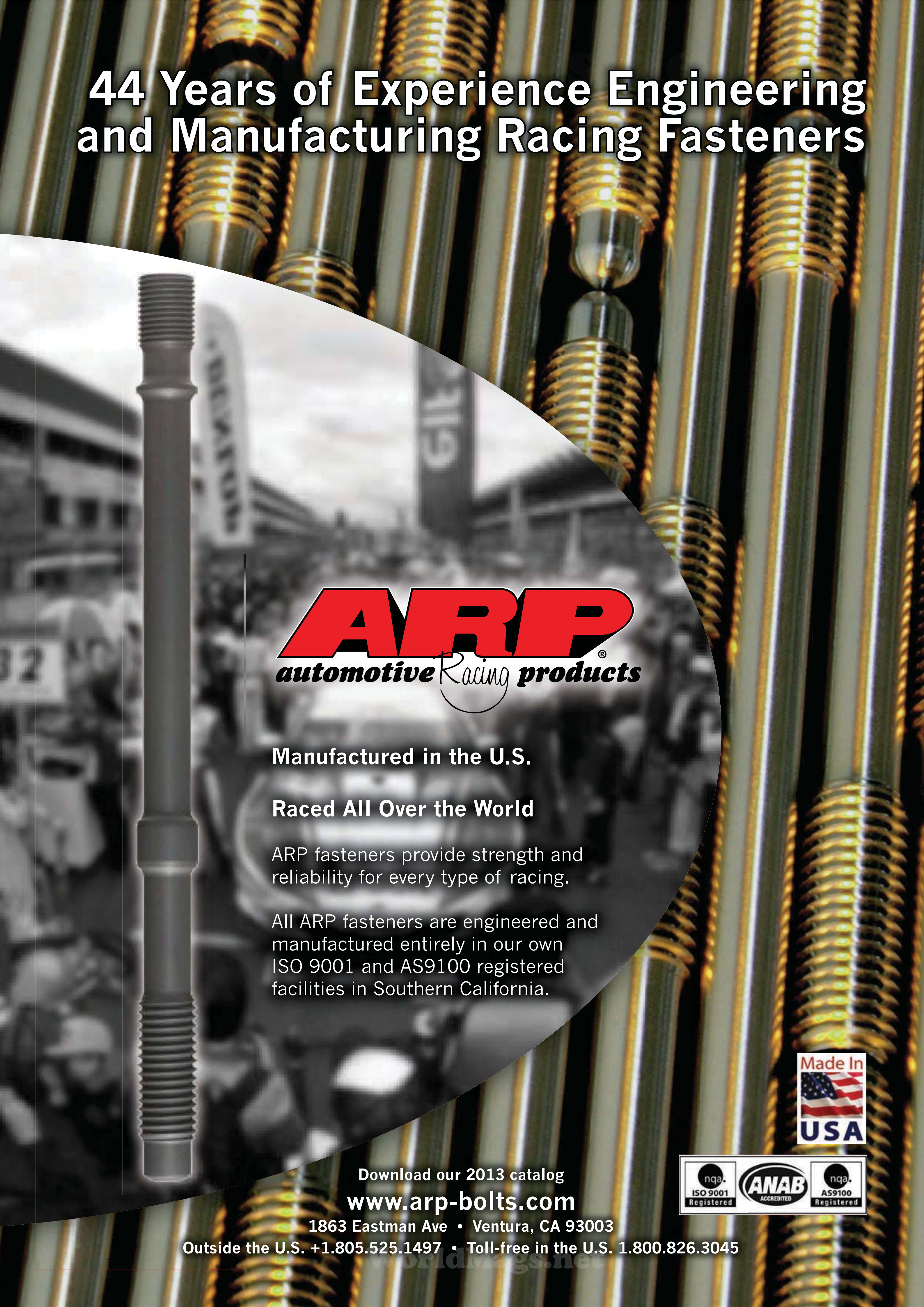
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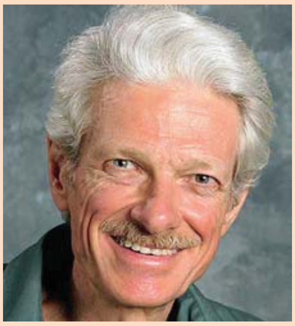
Getting to grips with the Dallara F312's suspension

Deciphering the reasoning in attaching the pushrod to the upright



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A: Mark Ortiz, 155 Wankel Drive, Kannapolis NC 28083-8200, USA

Q I am trying to understand the operating principle of the F312 Dallara front suspension. Rather than attaching the pushrod to the lower control arm, it is attached to the upright.

This would certainly reduce the loads on the lower bearing, but from a geometry perspective the only benefit I can see is to jack weight into the outside tyre when turning into the corner. This jacking effect would vary depending on caster angle, kingpin offset, wheel offset and the pushrod mounting position. Am I understanding this correctly? Or is there another reason for this system?

I seem to remember that I first came across this in the late-1980s, on either a Formula Ford or Formula Continental. Compared to having the pushrod attach to the lower control arm, it may or may not reduce the overall magnitude of the load on the lower ball joint or spherical bearing. However, it eliminates axial loading of the spherical joint, and that's good.

Assuming the spherical is mounted 'flat', so the bolt through the middle is roughly vertical, then if the spring acts through the lower spherical, the force holding the car up acts axially on the ball in the spherical. Sphericals are not very strong or wear-resistant in that direction – they like to be loaded radially instead. They can be loaded axially, but they have to be sized generously and replaced relatively often. Large sphericals tend to have meagre misalignment capacity compared to smaller sizes, and consequently may not allow sufficient suspension travel in some applications. Long control arms help with this.

I have seen cars with the lower spherical mounted 'on edge' instead, so the bolt is horizontal, running front to rear. That makes the support load radial. However, the joint will still see axial loading in braking. This design also limits steering lock or travel, approximately to the misalignment capacity of the spherical.

Assuming the ball joints are somewhat inboard of the wheel centreplane, the lower control arm sees a tension load when the car is sitting still or running straight. If the pushrod is attached to the upright near the lower ball joint, that tension load is increased.

In cornering, the load on the lower control arm can reverse, depending on the y and z position of the joint. In the Dallara F312, the lower joint is very high: close to hub height. This is due to the nose and the entire suspension linkage being high for aerodynamic reasons. In such a case, having the pushrod attached to the upright probably does reduce loading on the lower joint in hard cornering, perhaps even keeping it from reversing.

The questioner is correct that there is an effect on steer jacking (suspension jacking as we steer, which changes wheel loads and also ride heights). If the pushrod is ahead of the steering axis, the effect tends to roll the car into the turn (or reduce the usual outward roll from caster jacking), and add load to outside front and inside rear tyres (ie wedge the car). If the pushrod is behind the steering axis, the effect is reversed: it de-wedges the car, adding to the effect from caster jacking.

Or, it is possible to position the pushrod attachment point exactly on the steering axis, and have no such effect at all. It would even be possible to position the pushrod mounting point inboard or outboard of the steering axis, and have the car jack the same direction – either up or down – at that corner in both directions of steer, similar to the effect we get from front-view steering axis inclination. If equal on both sides of the car, such an effect does not change wheel loads as we steer, but it does induce a self-centring or de-centring force in the steering.

The nice thing about this is that with the pushrod attaching to the upright, we can to some degree separate steer jacking effects from the actual steering geometry. This potentially offers the opportunity to better optimise the overall system for steering feel, wheel loading and camber control.

The pushrod going to the upright on the Dallara F312

Rear roll centre heights

Are they higher at the rear purely for the sake of ride quality, stability and ease of packaging – or is it simply force of habit?

Q Why is the rear roll centre in production cars always higher than the front? This is primarily a feel issue as the driver always wants the rear to catch up to the front. However in an ideal situation, shouldn't they be the same?

Actually, it isn't quite true that the rear roll centre is always higher than the front in production cars. This is so in the vast majority of cases, but not all. The exceptions are mostly rear-engined. Also, among the majority where the rear roll centre is higher than the front, the amount by which it's higher varies greatly.

One explanation frequently offered is that having the rear roll centre higher than the front makes the car feel directionally stable, or inclined to understeer, in transient manoeuvres. The idea is that the car yaws out of the turn a bit as it rolls, because the front of the sprung structure displaces laterally a bit more than the rear with respect to the contact patches as the car rolls, and that makes the car feel stable rather than twitchy.

Another explanation one sometimes encounters is that geometric load transfer has more effect early in corner entry than other components of load transfer, and therefore a higher rear roll centre frees the car up – or moves it toward oversteer – on entry, making it feel more responsive. Those both make a certain amount of sense, but they can't both be true at once. A higher rear roll centre can't be good because it makes the car looser on turn-in, and at the same time be good because it makes the car tighter on turn-in. I think the real reasons are more prosaic, or more practical and historical than purely theoretical.

The biggest differences in rear roll centre height are between independent rear suspensions and beam axle rear suspensions. With independent suspension, jacking starts to become noticeable when the roll centre gets much above four inches. With a beam axle, that's not a problem. Also, with a beam axle it takes a bit of cleverness – and complexity – to get the roll centre lower than about seven inches while maintaining adequate ground clearance for street use.

For racing, ground clearance can be reduced, and beam axles can have roll centres as low as three or four inches with simple designs, or a bit less if we get tricky. So we can pretty much say that the usable range of roll centre heights for independent suspension ends where the usable range for beam axles begins.

> **"Nowadays cars tend to be front-engined and nose-heavy"**

The same constraints apply at the front of the car, except that beam axles at the front are seldom seen on modern cars. This is partly because beam axle front ends are more prone to various kinds of undesirable oscillatory and steering feedback effects than independent front ends, but really it's more just a matter of packaging – the engine is in the way.

At the rear, there are also generally packaging advantages with independent suspension, but a beam axle can be accommodated, and it saves a lot of money. It will also generally have more modest maintenance and repair requirements. For these reasons, beam axles remain a popular choice for the rear. Since the usable range of roll centre heights for beam axles roughly begins where the range for independent suspension ends, any car with an independent front suspension and beam axle rear unavoidably has the rear roll centre higher than the front, unless something very unusual is done at the rear.

In trucks, the engine is usually higher, and often there is room for a beam axle. Even then, the axle usually has a bit of a drop in the middle, and the leaf springs or Panhard bar will necessarily be a bit lower at the front than they can be at the rear, for reasons of packaging. A lower front roll centre also reduces lateral tyre scrub on one-wheel bumps. That minimises the aforementioned undesirable oscillatory and steering feedback effects. With parallel leaf springs, having the springs a bit lower reduces spring wrap-up in braking.

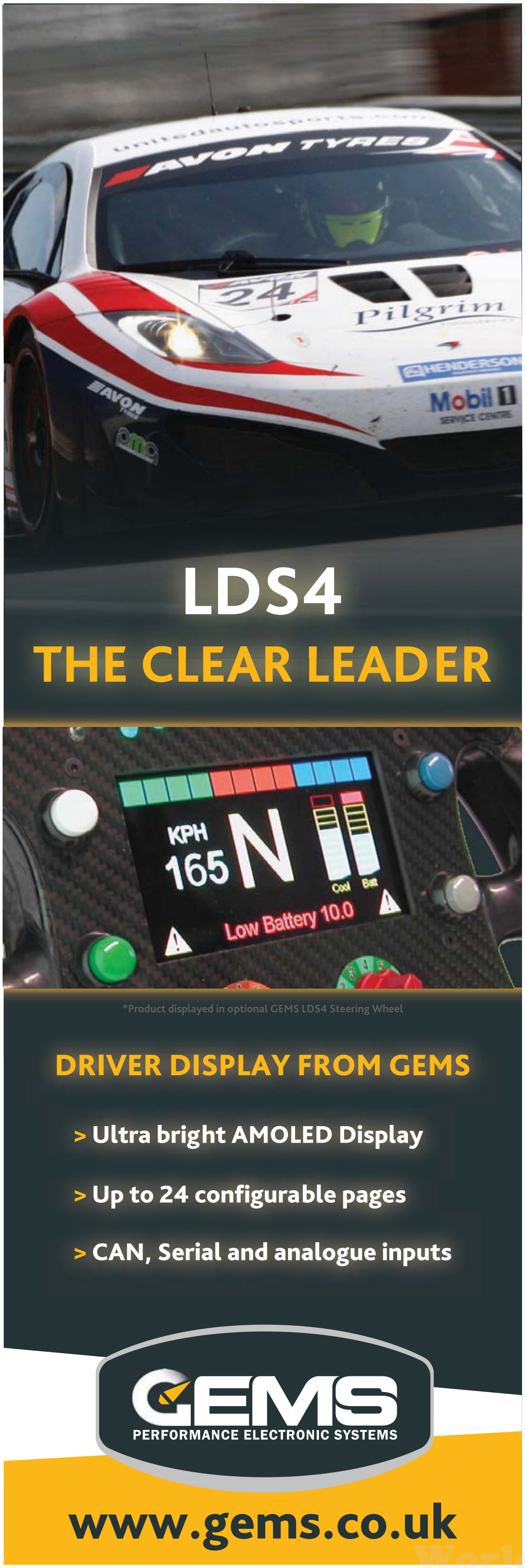
Nowadays, most cars are front-engined and nose-heavy. Those with rear-wheel drive seldom have less than 55 per cent front weight. Those with front-wheel drive seldom have less than 58 per cent. With rear drive, it is better for traction and handling to have at least 50 per cent rear. However, in most cases this requires an amount of engine setback that cannot be obtained without making the front of the car longer, or giving up engine accessibility and passenger space. Also, there are advantages in ride quality if the car is nose-heavy and has the engine roughly between the front wheels.

The front and rear tyres will generally be the same size. Occasionally rears will be bigger than fronts, but the reverse tends to look a bit odd and is never seen. To avoid excessive understeer, the rear suspension needs to have more roll resistance than the front, at least relative to the weight it carries. This can be obtained elastically – with springs and anti-roll bars – and/or geometrically, by using a high roll centre.

If the rear suspension is independent, we may have the roll centre a bit higher than the front, but we will have to use an anti-roll bar in most cases. With a beam axle, we have a choice. The higher we make the roll centre, the less anti-roll bar we'll need. We may be able to use none at all. Having little elastic roll resistance at the rear makes the car soft overall in warp. This reduces torsional loadings on the sprung structure on irregular surfaces. That, in turn, allows the sprung structure to be less torsionally rigid, reducing weight. With lots of elastic roll resistance at both ends of the car, we have to stiffen up the body/frame to avoid having cowl shake or torsional oscillation on bumpy roads, and to avoid having the car twist to the point where door operation is affected when the car is parked on a surface that causes a large warp displacement.

Having the car soft in warp also improves traction on uneven surfaces, especially with an open differential. With a live axle, one disadvantage of having little rear elastic roll resistance is that we get more torque wedge due to driveshaft torque, assuming we don't have rear suspension that's designed to geometrically compensate for driveshaft torque. So, for road racing or high-performance street use, there is some advantage to having the rear roll centre as low as possible, and using correspondingly more rear spring and bar.

Even with independent rear suspension, more often than not we see the rear roll centre higher than the front, but not by much. The difference between that and having both roll centres at equal height will not be very significant in terms of car behaviour or feel.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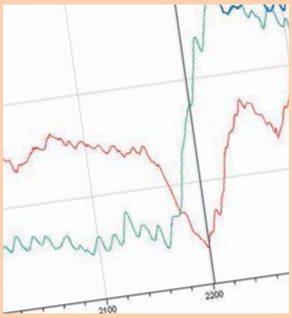


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

Coming onboard

Doing the maths onboard provides a whole host of advantages

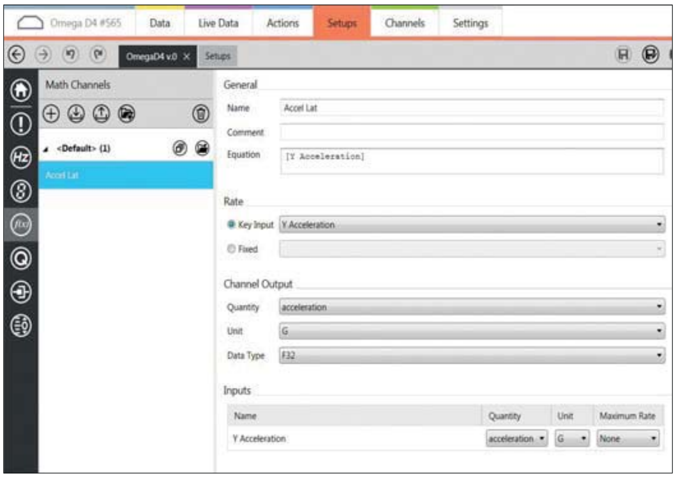
Maths channels are powerful tools for data engineers and are used widely in data analysis software. By performing mathematical operations on logged channels, large amounts of information can be extracted from even the most basic instrumentation. With the ever increasing processing power of data loggers, maths channels can now be calculated onboard, opening up many opportunities for data engineers to be innovative with displays for the driver and reduce post-session analysis time. This article will demonstrate various applications of onboard maths and highlight its benefits to both the team and driver...

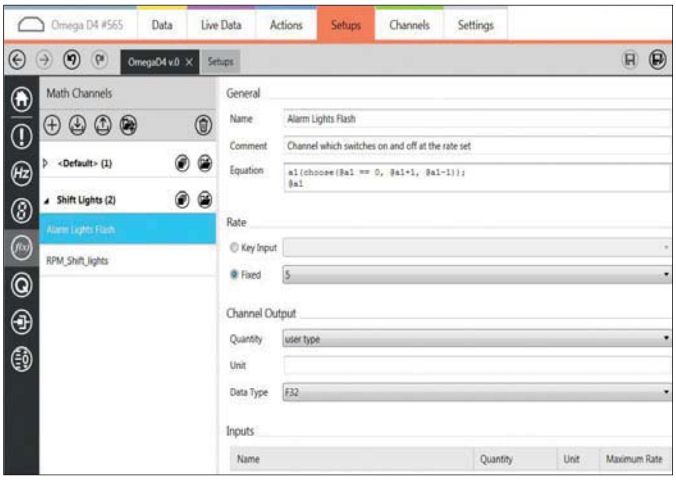
CHANGING CHANNELS

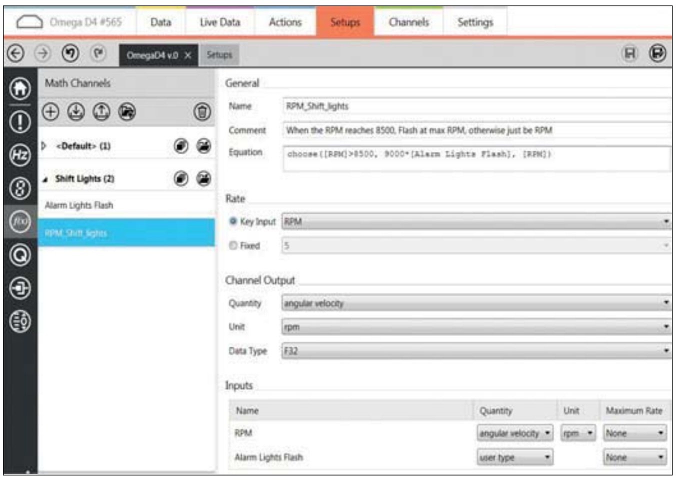
This may not necessarily be the most glamorous application of onboard maths. However, it can be incredibly useful to savvy data engineers with highly refined analysis workbooks. In order for post-processing workbooks to work, they must reference channels correctly. When changing to a new car – or a new team – a data engineer may find that their channel naming convention does not match that of the new car, and therefore their analysis workbooks no longer work correctly. By simply renaming the channels onboard the logger, this enables engineers to stick to the naming convention they are used to and means that the lengthy process of editing a workbook for a different naming convention can be avoided.

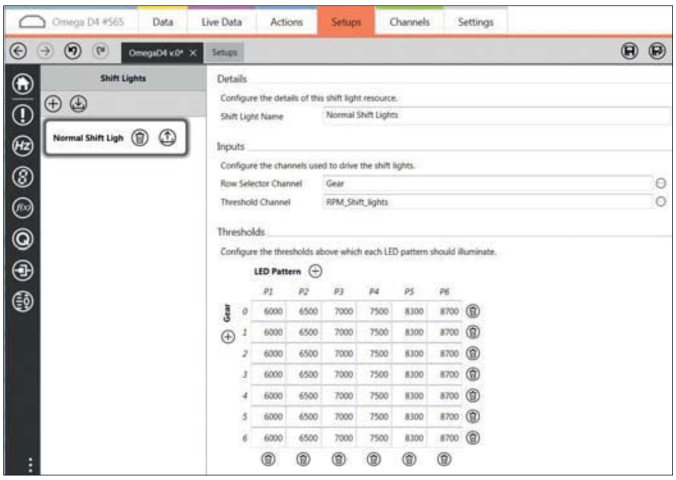
By combining the already standing shift light infrastructure with onboard maths, shift lights can be made to do more or less whatever engineers wish. One of the main uses for driver displays is to add a shift light flash, when the car approaches the limiter, to force the driver to shift up. This can be done quite simply by creating an onboard channel which is alternating between 1 and 0 at a fixed rate and then applying that to the shift light channel when the RPM reaches the chosen limit.

Taking shift light maths further, they can be made to flash on more than one occasion, for

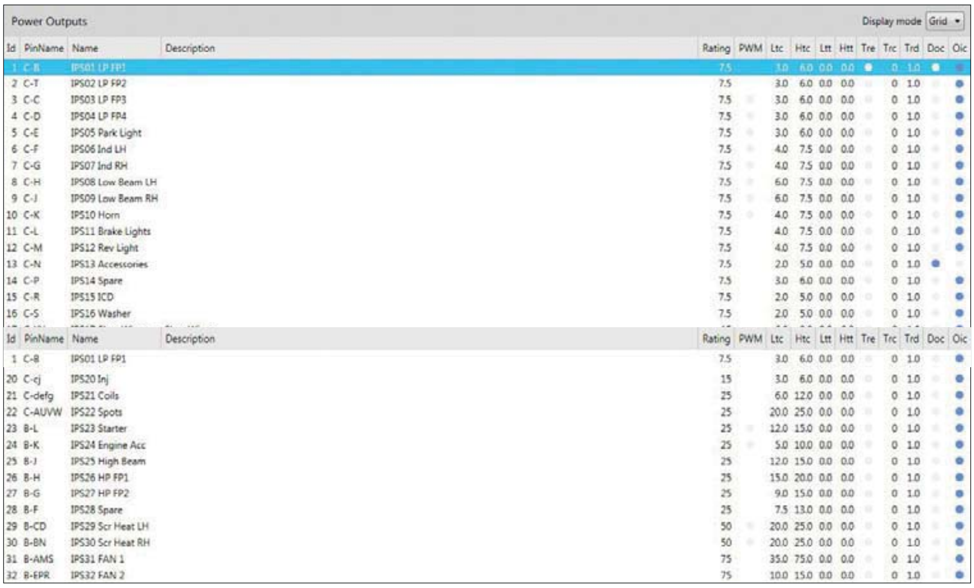




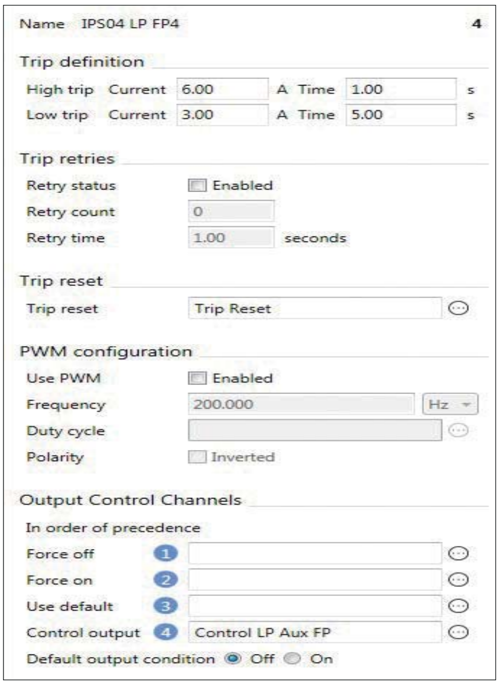




choose([RPM]>8500 || ([Pit Limiter Active]==1 && [Speed]>60) , 9000*[Alarm Lights Flash],
choose([Pit Limiter Active]==1 , 9000,
choose([Water Temp]>100 , [RPM] + 75*([Water Temp]-100),
[RPM])))
The shift lights will flash, when the Pit Limiter is Active and the car is speeding (>60kph)
and, when the RPM > 8500
The shift lights will hold at full value, when the Pit Limiter is Active and the car is not speeding
The shift lights will be increased by 75 for every degree >100, when the Water Temp exceeds 100degC.


Power Outputs — Display mode: Grid

Id	PinName	Name	Description	Rating	PWM	Ltc	Htc	Ltt	Htt	Tre	Trc	Trd	Doc	Oic
1	C-B	IPS01 LP FP1		7.5		3.0	6.0	0.0	0.0		0	1.0		
2	C-T	IPS02 LP FP2		7.5		3.0	6.0	0.0	0.0		0	1.0		
3	C-C	IPS03 LP FP3		7.5		3.0	6.0	0.0	0.0		0	1.0		
4	C-D	IPS04 LP FP4		7.5		3.0	6.0	0.0	0.0		0	1.0		
5	C-E	IPS05 Park Light		7.5		3.0	6.0	0.0	0.0		0	1.0		
6	C-F	IPS06 Ind LH		7.5		4.0	7.5	0.0	0.0		0	1.0		
7	C-G	IPS07 Ind RH		7.5		4.0	7.5	0.0	0.0		0	1.0		
8	C-H	IPS08 Low Beam LH		7.5		6.0	7.5	0.0	0.0		0	1.0		
9	C-J	IPS09 Low Beam RH		7.5		6.0	7.5	0.0	0.0		0	1.0		
10	C-K	IPS10 Horn		7.5		4.0	7.5	0.0	0.0		0	1.0		
11	C-L	IPS11 Brake Lights		7.5		4.0	7.5	0.0	0.0		0	1.0		
12	C-M	IPS12 Rev Light		7.5		4.0	7.5	0.0	0.0		0	1.0		
13	C-N	IPS13 Accessories		7.5		2.0	5.0	0.0	0.0		0	1.0		
14	C-P	IPS14 Spare		7.5		3.0	6.0	0.0	0.0		0	1.0		
15	C-R	IPS15 ICD		7.5		2.0	5.0	0.0	0.0		0	1.0		
16	C-S	IPS16 Washer		7.5		2.0	5.0	0.0	0.0		0	1.0		
Id	PinName	Name	Description	Rating	PWM	Ltc	Htc	Ltt	Htt	Tre	Trc	Trd	Doc	Oic
1	C-B	IPS01 LP FP1		7.5		3.0	6.0	0.0	0.0		0	1.0		
20	C-cj	IPS20 Inj		15		3.0	6.0	0.0	0.0		0	1.0		
21	C-defg	IPS21 Coils		25		6.0	12.0	0.0	0.0		0	1.0		
22	C-AUVW	IPS22 Spots		25		20.0	25.0	0.0	0.0		0	1.0		
23	B-L	IPS23 Starter		25		12.0	15.0	0.0	0.0		0	1.0		
24	B-K	IPS24 Engine Acc		25		5.0	10.0	0.0	0.0		0	1.0		
25	B-J	IPS25 High Beam		25		12.0	15.0	0.0	0.0		0	1.0		
26	B-H	IPS26 HP FP1		25		15.0	20.0	0.0	0.0		0	1.0		
27	B-G	IPS27 HP FP2		25		9.0	15.0	0.0	0.0		0	1.0		
28	B-F	IPS28 Spare		25		7.5	13.0	0.0	0.0		0	1.0		
29	B-CD	IPS29 Scr Heat LH		50		20.0	25.0	0.0	0.0		0	1.0		
30	B-BN	IPS30 Scr Heat RH		50		20.0	25.0	0.0	0.0		0	1.0		
31	B-AMS	IPS31 FAN 1		75		35.0	75.0	0.0	0.0		0	1.0		
32	B-EPR	IPS32 FAN 2		75		10.0	15.0	0.0	0.0		0	1.0		



example when the pit limiter is activated or when an alarm occurs. On top of flashing, shift lights can be scaled up when temperatures rise to notify the driver to shift earlier and therefore help cool the car.

A more advanced use of onboard maths for shift lights is shown left.

ENHANCED DISPLAY

Displays can offer various benefits to the team and driver, and with the added resource of onboard maths they can be used very effectively. For example, wheel slip can be calculated onboard and displayed on a launch page for the driver. This can be used to aid race starts and prevent excess wheel spin being induced. Brake bias can also be calculated onboard for display to both the driver and mechanics.

As well as display benefits to the driver, onboard maths can be combined with power systems for advanced control capabilities. For example, a data logging system – connected to a power control system via CAN – can be used to control various outputs based on other conditions. This is commonly used for brake light control, allowing the brake light to only be turned on when the brake pressure exceeds a certain value. Other applications include warning lights which can be switched on when a car has stalled or headlights to be switched on when the detected brightness drops below a certain limit.

CONCLUSION

Onboard maths capabilities open up a whole host of opportunities for engineers within data logging systems. It increases flexibility of displays and alarms and allows advanced control to be achieved with relative ease.

Overall, onboard maths offers benefits at any level of motorsport and should be considered when specifying any new system. Its power is only limited by the capabilities of the engineers who use it meaning that advantages can be had over rivals by utilising this effectively.

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Tale of the tape

It's the final instalment on this Subaru Impreza from the UK's Euro Saloon and Classic Thunder championships, and this month we put some rolls of race tape to good use...

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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Popular across the globe, the Subaru Impreza runs in many different competition categories. We took the UK specification 2006 WRX STi of clubman racer Danny Precious for a challenging back-to-basics session in the MIRA full-scale wind tunnel. Preparation experts Scoobyclinic had produced plenty of modifications to try, but sometimes a few rolls of race tape can provide important answers too...

Early on in this session, the car was set to the configuration in which it had raced in 2012. Technical issues during the season had prevented much running and the driver had not had the chance to really assess the aerodynamics. However, he did comment that one on-track incident, that saw the car running without its splitter, demonstrated that it didn't make any tangible difference. This seems unusual, so it was useful to evaluate the front of the car in various guises. First the car was run with its small STi splitter as a baseline setup. Then an airdam extension approximately 50mm deep was fitted to this. Then these items were then removed, and the larger splitter made by the team for 2012 was fitted. The coefficients obtained are shown in **Table 1**, while the changes (Δ or delta values) to drag and front lift are shown in **Table 2** in counts (1 count = a coefficient change of 0.001).

Looking first at **Table 1** we can see that the car started with front lift and rear downforce, a stable condition, if one not generally conducive to fast lap times. Fitting the small airdam reduced drag slightly, but only reduced front lift by five counts, and rather curiously also reduced rear downforce by 19 counts. Replacing these items with the large splitter saw – unusually – a 15 count increase in drag and a very modest 43 count decrease in front lift. We have seen much better gains from splitters of a smaller size than this previously in Aerobytes, and generally with very little effect on drag. So this was quite thought-provoking.

Meanwhile, following a range of rear end experiments that saw a new baseline established, some of the usual ideas for gaining some front downforce were applied. First, vertical fences were attached to the outer ends of the splitter. Then the rear ride height was increased by 10mm. And then the splitter end fences were extended and sealed to the

Table 1: the effects of front end modifications

Configuration	CD	CL	CLfront	CLrear
Small STi splitter	0.382	-0.044	0.058	-0.102
Plus small airdam	0.374	-0.030	0.053	-0.083
Large splitter	0.397	-0.075	0.015	-0.090

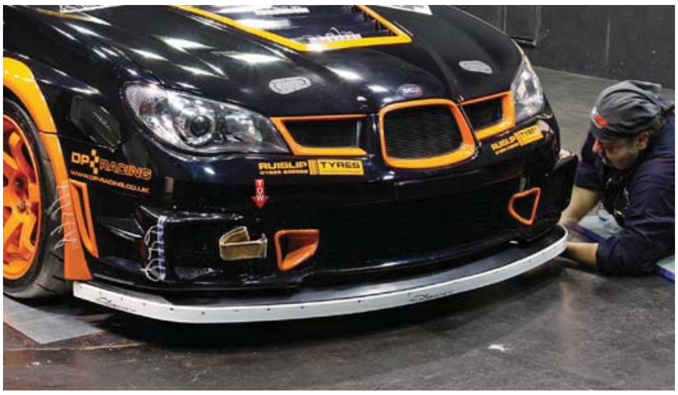
Table 2: the changes to the front end from modifications relative to the baseline

Configuration	ΔCD	ΔCLf
Plus small airdam	-8	-5
Large splitter	+15	-43

Table 3: the effects of further front end changes relative to the new baseline configuration

Configuration	CD (ΔCD, counts)	CLf (Δ-CLf, counts)
New baseline	0.413	0.040
Add splitter fences	0.420 (+7)	0.023 (+17)
RRH up 10mm	0.421 (+1 = +8)	0.007 (+16 = +33)
Splitter fence extns	0.431 (+10 = +18)	-0.003 (+10 = +43)

The car started the session with a small STi splitter (below); (below right) a small airdam was added to the standard STi splitter



This larger splitter had been raced, but its effect was being hindered

Blanking off the front apertures had a significant effect on front downforce

Sealing the end fences to the wheel arches increased the effect

Air entering the front lower aperture was exiting under the car

Table 4: effects of restricting flow through front apertures

Configuration	CD	CL	CLfront	CLrear	%front
New baseline	0.431	-0.163	-0.003	-0.160	1.84%
Tape all inlets	0.402	-0.223	-0.140	-0.082	62.64%
Untape outer scoops	0.405	-0.217	-0.114	-0.103	52.53%
Untape lower main inlet	0.422	-0.177	-0.040	-0.138	22.60%

wheel arches. The results are set out in **Table 3**. None of these changes significantly altered the coefficient at the rear, so the front end coefficients and delta values only are given.

At last a small amount of front downforce was seen, but it was barely better than neutral, meaning the car was still a long way from being balanced. And the latest gains these modifications made at the front were not especially efficient, a total of 43 counts of lift cancellation having been achieved for an increase in drag of 18 counts.

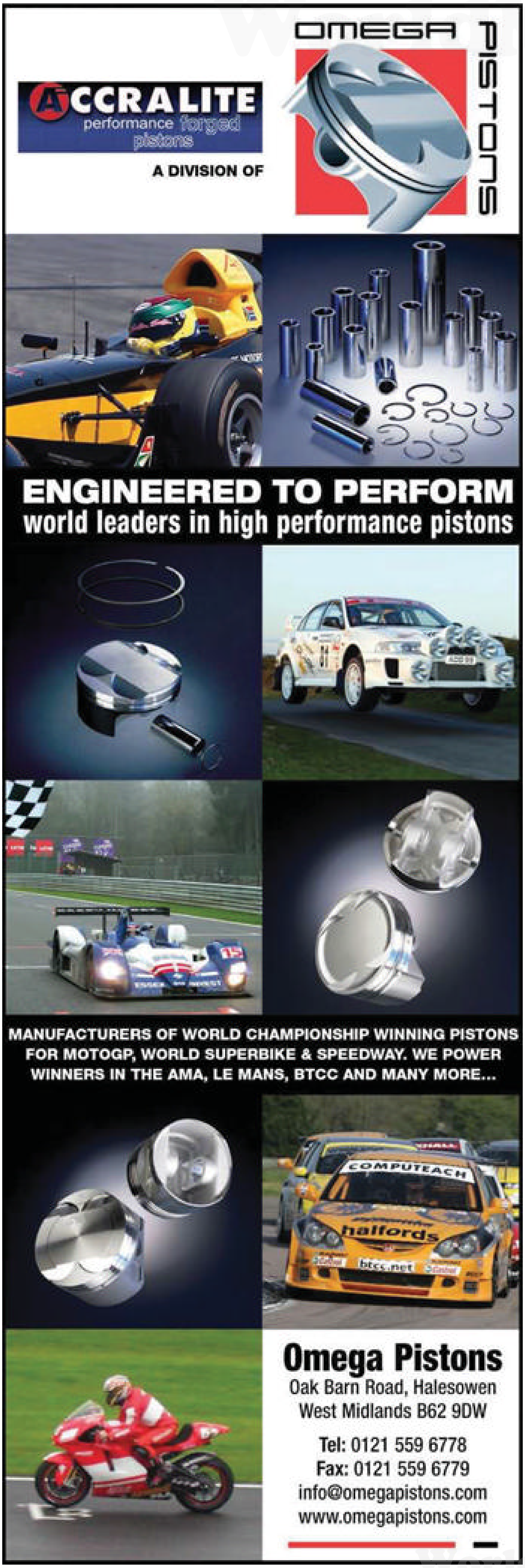
It was concluded at this point that the most likely reason for the difficulty in getting adequate front downforce was that, with the large area of inlet apertures in the front – feeding the radiator, intercooler, front brakes, engine inlet and oil cooler – front lift was probably being generated. Although the underside of the engine compartment was not completely panelled over by the splitter, and although there was also a large vent in the bonnet's upper surface, could there have been a big enough increment of lift to virtually cancel out all the other ideas tried on the front end? In order to find out, *all* the forward facing apertures in the front panel were taped over, and the car was run again. For completeness and to help with diagnosis, sections of tape were then removed in two stages. The results of these last three trials are shown in **Table 4**, along with the previous configuration.

So taping over all the front apertures not only reduced drag by 29 counts, it also released the 'missing' front downforce. Or more accurately it enabled the front downforce that was previously being generated to actually manifest itself by removing the front lift that was being simultaneously generated within the engine compartment. Now, 137 counts of genuine front downforce had appeared, and while not a massive amount, the mechanical unloading of the rear end caused by the increase in downforce ahead of the front axle produced an aerodynamic balance that was very close to the car's front to rear static weight split of approximately 61 per cent. We can also see from the final two rows of data that all the inlets were contributing increments of front lift, with the large, lower intercooler aperture accounting for just over half of it. And it also seems likely that the unusual increase in drag caused by the large splitter was the result of more air being directed into the drag-inducing engine bay.

Now, clearly the car could not perform with all these inlets taped over – apart from anything else, in this example the engine wouldn't start! But this crude experiment points very clearly to the need for ducting cooling air so that air that is to pass through cooling matrices – especially very large ones such as are used on turbocharged cars – should be ducted carefully to and from these matrices, with no air being allowed to leak into the front compartment. Not only would this eradicate the front lift that we have clearly seen being developed here, it would also improve cooling efficiency and possibly permit smaller coolers to be used as well. Production cars like the Impreza do not make ducting easy, typically with little room available and lots of hardware in the way. But the aerodynamic gains should now be very evident from the results of this simple trial.

Next month: new cars – and new challenges.

Racecar's thanks to Jonathan Fletcher, Danny Precious and the crew at Scoobyclinic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Vortices – friend or foe?

What are they and what do they do for us? We head into the vortex for a brief spin…

BY SIMON MCBEATH

On a damp or humid day we sometimes see vortices emanating from the upper rear wing tips of Formula 1 cars. Such fleeting visualisations of vortices not only highlight the rotating flow structures involved, but they also hint at the properties within the vortices. In the racecar aerodynamics context, these can either cause inescapable penalties, or they can be used to exert powerful effects to improve performance. This article will explore some of the pros and the cons.

Photo 1: up close with the wing tip vortex on a Benetton B199

THE BASICS

A vortex is a region within a fluid where the local flow rotates about an axis, and typically the velocity within the vortex is greatest near the axis, reducing in inverse proportion with distance from that axis. Bernoulli's Equation tells us that local pressure reduces as velocity increases, so in the fast rotating cores of vortices, the local pressure is reduced relative to ambient pressure. Thus, on humid days, the pressure drop in the core can be sufficient to condense the moisture in the already nearly moisture-saturated air, rendering the vortex – or at least its core – temporarily visible.

In fluids, vortices occur in many situations, from a planetary scale (hurricanes, typhoons, tornadoes, whirlpools and dust devils), down to features such as those around racecars. So, in the context of racecars, what causes a vortex? What is needed initially is for something to induce an angular change in the velocity of the airflow, perhaps only in a very small region, or perhaps on a larger scale. Then, if the local pressure conditions encourage it, some degree of rotation may be induced that then becomes a vortex. Not all changes of flow direction will create vortices, but certain instances will do so. Take the example we started with, wing tip vortices, to see how those are created, and what their effect is.

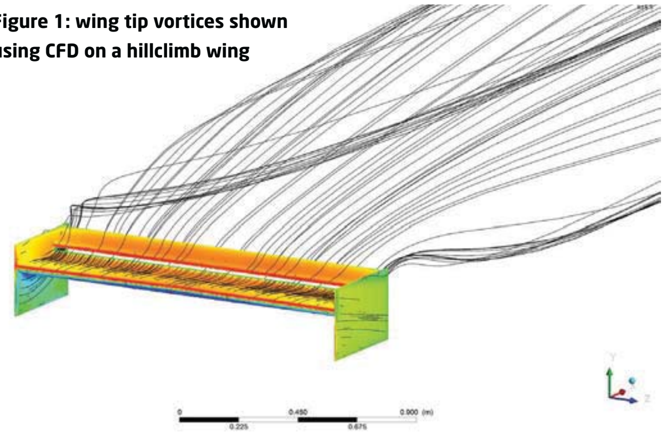

Figure 1: wing tip vortices shown using CFD on a hillclimb wing

WING TIP VORTICES

Photo 1 shows a wing tip vortex on a Benetton B199 visualised with smoke in the MIRA full-scale wind tunnel during an Aerobytes session, while **Figure 1** shows a CFD simulation with 3D streamlines revealing a similar pattern at the tips of a hillclimb wing. Using other views of this hillclimb wing we can gain a clearer view of what happens.

Figure 2 shows the pressure distributions on a transverse plane halfway along the wing; low pressure is established under the wing (green and blue regions are below ambient pressure), with high pressure above (orange to red). And, at the top and bottom of the end plates are small rounded regions of reduced pressure (green). **Figure 3** sees velocity vectors superimposed on this plane, showing there is rotational flow developing at these points.

Figure 4 shows the pressures on a plane level with the wing's trailing edge; the pressure differences above and below the wing have lessened, but the roughly circular low pressure regions near the top and bottom of the end plates have become more pronounced. And **Figure 5**

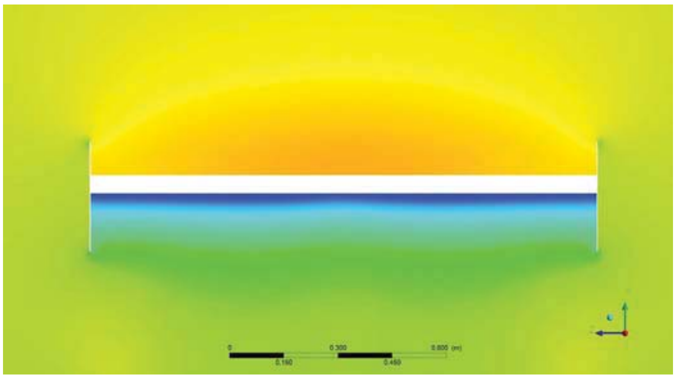

Figure 2: halfway along the wing, small low pressure cores have formed at the top and bottom of the end plates

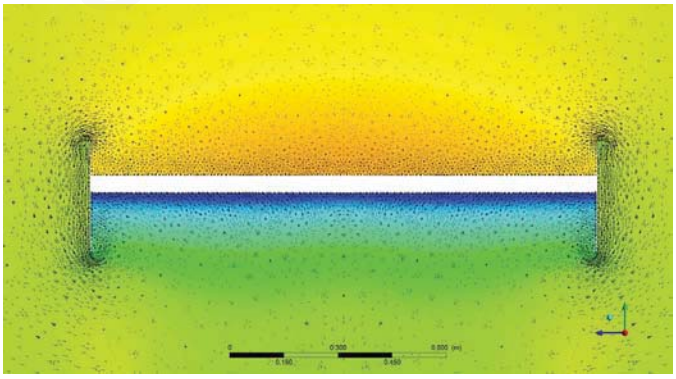

Figure 3: vectors show the rotational structured forming

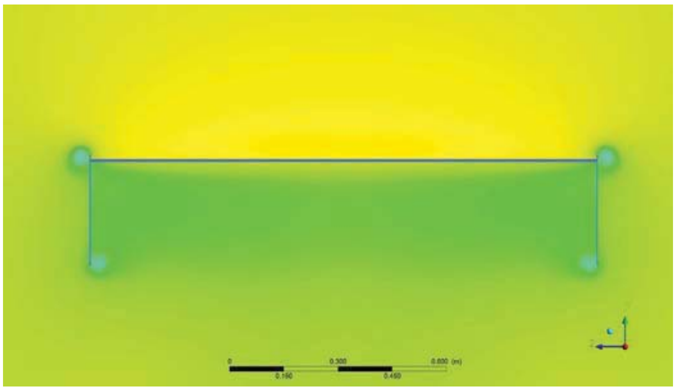

Figure 4: in line with the wing's trailing edge the low pressures cores at the end plate tips and more pronounced...

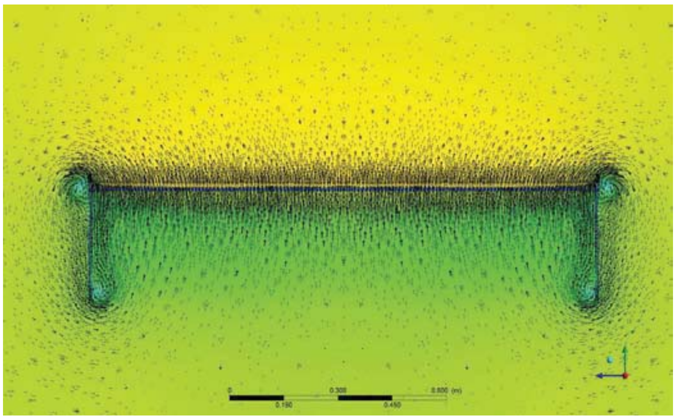

Figure 5 ...as is the rotational motion

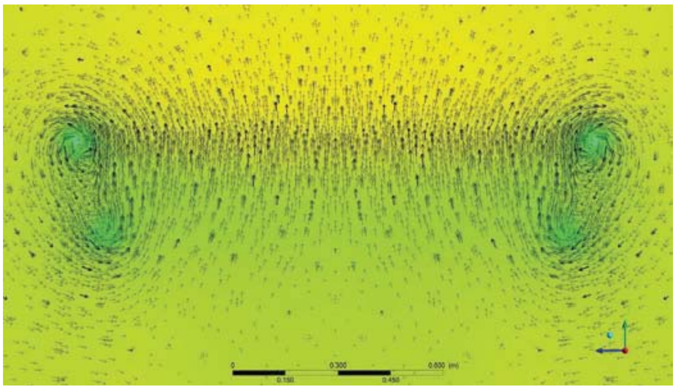

Figure 6: downstream the vortices begin to merge...

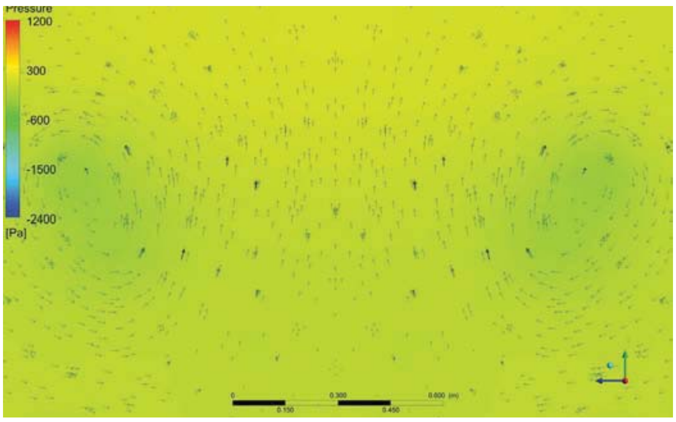

Figure 7: ...and become a single larger diameter vortex from each wing tip

highlights the vortical flow with velocity vectors. **Figure 6** shows the flow pattern 200mm further downstream, and although there are still two distinct low pressure cores, the rotational flows are merging into a single larger vortex. And another 300mm further downstream in **Figure 7** we can see just one vortex with a less pronounced core.

So the pressure differential either side of the end plates has impelled some air to flow over the top and under the bottom of the end plates, spilling outwards from the top surface and spilling inwards under the bottom surface. So, the pressure differentials have imparted the necessary change of direction alluded to earlier. But the additional factor required to generate vortical rotation is that the end plate edges are sharp, and the air has been unable to remain attached to the surfaces of the end plates. Nevertheless, the direction change and the 'attempt' at staying attached have jointly imparted the momentum change required to establish two pairs of vortices. The rotational flow continues downstream, but as viscosity within the vortices reduces the kinetic energy of the flow, so the velocities and pressure reductions within the vortex decline.

Wing tip vortices are an inevitable consequence of generating lift, either positive (on aircraft for example) or negative (on racecars) because of the differences in pressure above and below the wings. And the same applies to any body or surface that generates lift. End plates endeavour to reduce the movement of air from the high to the low pressure areas, and in so doing they increase the efficiency of a given lifting surface, but they obviously do not prevent the formation of vortices – they merely shift those vortices slightly.

Being regions of reduced pressure, and occurring as they do primarily downstream of the object that created them, vortices are sources of drag in this manifestation. Indeed, vortex drag, or induced drag as it used to

Vortex drag – or induced drag as it used to be known – becomes increasingly significant on high lift or high downforce wings

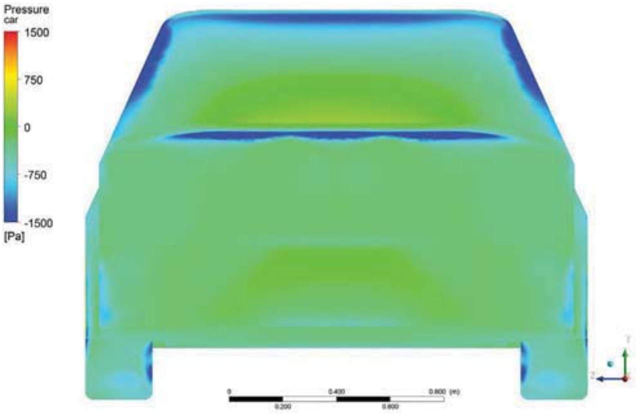

Figure 8: surface pressures on the rear of a saloon/sedan model

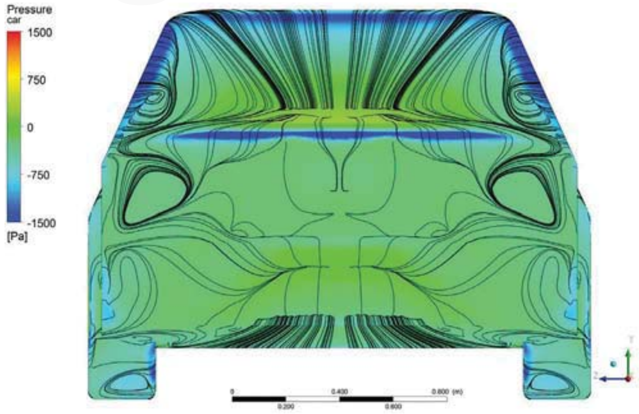

Figure 9: surface streamlines reveal some time-averaged flow structures

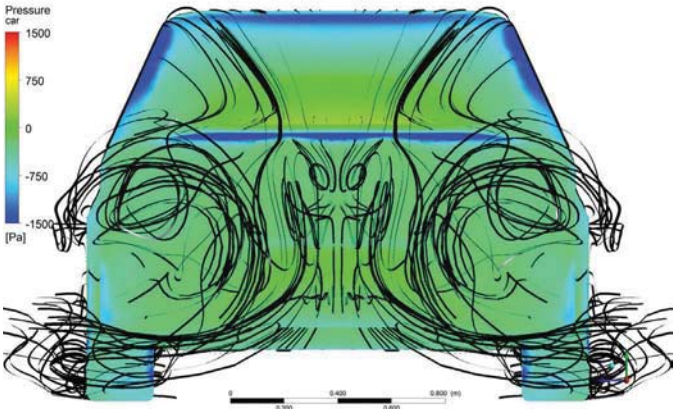

Figure 10: 3D streamlines emphasise the vortices

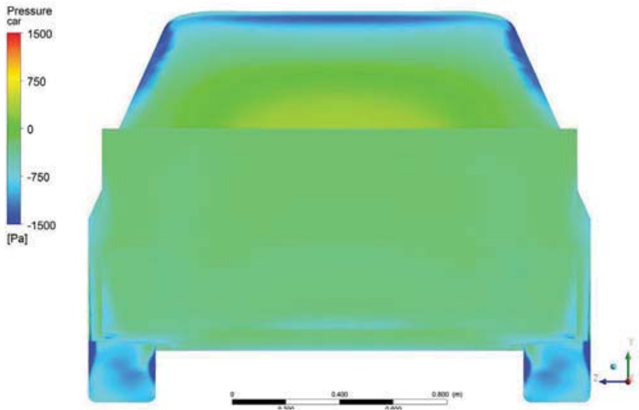

Figure 11: with a small rear spoiler, pressure distributions are different...

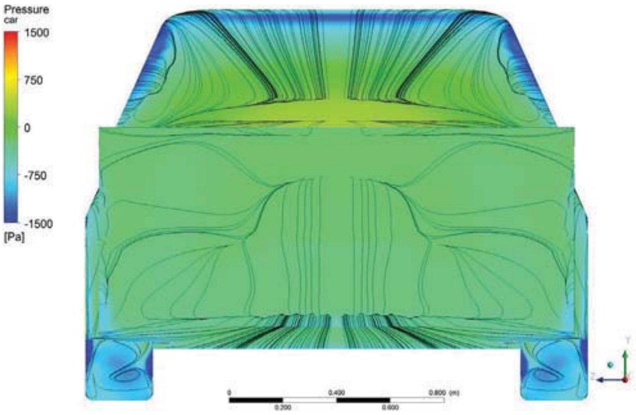

Figure 12: ...as are the flow patterns revealed by surface streamlines

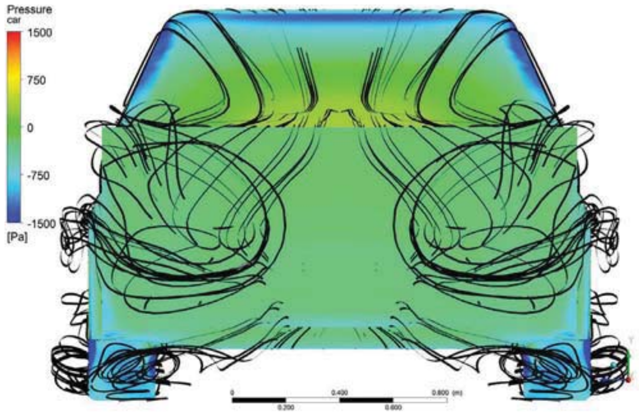

Figure 13: ...and 3D streamlines show much reduced vortical flow

be known, becomes increasingly significant on high lift or high downforce wings. So this first case is one that might be called a 'performance reducing' example of vortices around a racecar. Let's look at some other performance reducing examples...

WAKE VORTICES

The wake is typically thought of as an unsteady, highly disturbed flow region behind a racecar. But rotational flow structures are also present, and when looked at with time averaged CFD, some of these can become apparent. As they contribute to the low pressures in the wake they can be thought of as accounting for some of the car's drag. **Figure 8** is a rear view of a simple generic saloon (sedan) model in CFD, showing surface pressures, scale adjusted to highlight where the pressures are lower than ambient (zero). The lowest pressures are on the margins of the rear screen and the rear lip of the boot lid, but the pressure is also quite low across the rear panel. **Figure 9** shows surface streamlines overlaid, and two pairs of rotational structures become visible, aft of the rear screen pillars, and on the rear panel. **Figure 10**'s 3D streamlines make the large vortices behind the rear panel very apparent.

It is known that small, shallow rear spoilers can not only reduce or reverse the rear lift often generated by saloon cars, but that they can simultaneously reduce drag as well. **Figure 11** shows how a 30 degree spoiler that measured 60mm length in the centre of our sedan not only removed the low pressure region from the boot lip and modified the pressure distribution over the rear screen, but it also more subtly altered the pressures across the rear panel. In **Figure 12** the surface streamlines reveal very different flow patterns to the no-spoiler case, with the lower pair of vortices no longer visible, although **Figure 13**'s 3D streamlines do show a much modified and generally weaker rotational flow pattern now that rear lift has been eradicated. Drag was also reduced compared to the no-spoiler case.

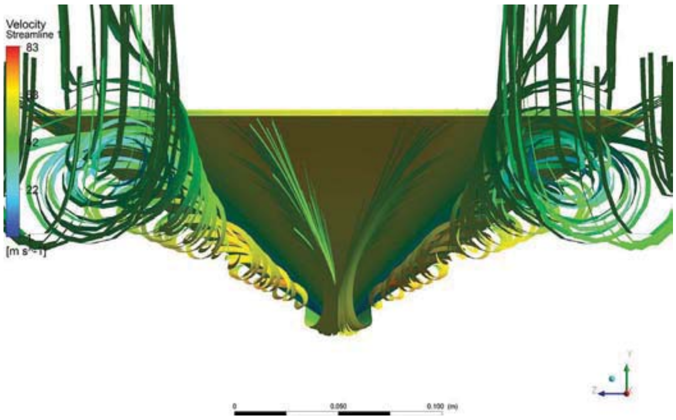

Figure 14: rear view of a simple inclined delta wing; 3D streamlines show the path of the leading edge vortices that formed

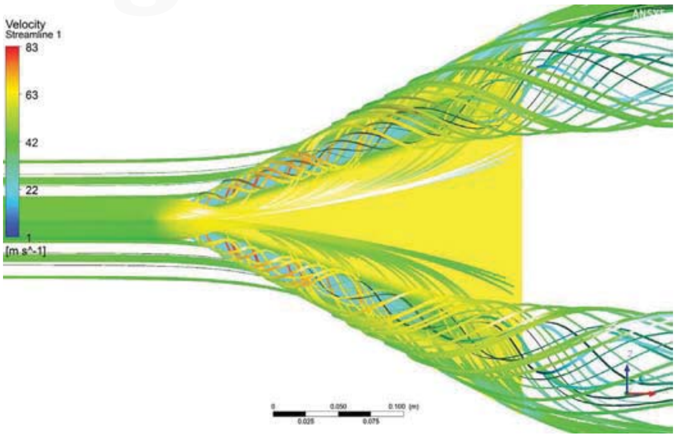

Figure 15: the view from underneath of the inclined delta wing

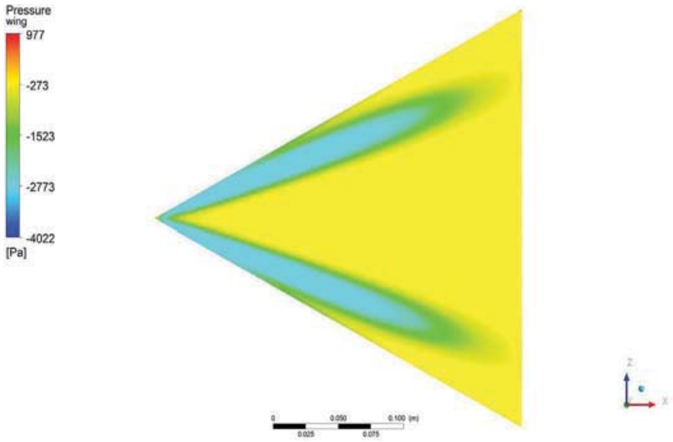

Figure 16: with streamlines removed, the low surface pressures induced on the delta wing are visible

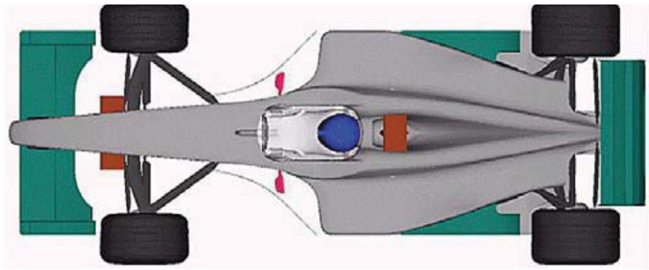

Figure 17: the BAR Honda model with bargeboards

BENEFICIAL VORTICES

So we've seen how vortices are intrinsically connected with the generation of both downforce and drag. However, they are not necessarily just an inconvenient and inevitable consequence of downforce generation – they can be used to actually generate or to amplify downforce, and in some applications to reduce drag. Let's look at more examples...

VORTEX LIFT

One of the better known uses of vortices is in the generation of lift at high angles of attack on delta wing aircraft (think Concorde). Though superficially irrelevant to our cause, bear with this because it will soon become apparent that there is overlap with racecar aerodynamics.

The simplest manifestation of a delta wing at high angle of attack is a triangular plate pointing into the airflow. A model of just such a device with an aspect ratio of 1 (that is, length and width were equal, at 300mm in fact) was set at a range of angles from 10 degrees to 40 degrees and run through CFD to simulate and visualise how such a device generates lift. The devices were placed at negative angles of attack (nose down) in order to generate downforce and make us feel more comfortable!

Figure 14 is a rear view of the delta wing inclined at 20 degrees, and shows the leading edge vortices that have been created. The streamlines are coloured by velocity, and those near the front are at raised velocity (freestream was 44.7m/s or 100mph) while towards the rear the streamlines are showing reduced velocity, and the vortices have expanded in size. **Figure 15** is the same model viewed from below, while **Figure 16** has the streamlines removed to reveal the pressure distributions on the lower surface. It's clear that the proximity of the vortices has produced lowered pressure on the underside of the delta wing, which coupled with the inevitably raised pressure on the inclined upper surface has generated downforce. The data from the four models is summarised in **Table 1** for interest.

Table 1: the forces generated by an inverted delta wing in freestream at 100mph

Angle, degrees	Downforce, N	Drag, N	-L/D
10	24.9	5.4	4.63
20	49.6	18.6	2.67
30	63.1	36.6	1.72
40	57.8	48.6	1.19

So a device that sets up vortices can itself generate downforce, and in the case of the shallower angled delta wings, efficiency (lift over drag, -L/D) was actually not bad when compared with a high downforce wing. But the absolute values of these forces were modest relative to total car downforce. How can they be better exploited?

BARGEBOARDS AND MORE

When bargeboards appeared in Formula 1, it didn't take long for them to proliferate rapidly among all the teams, and into other categories. The initial intention may simply have been to manage the front wheel wakes and the flows into the radiators. If this was so, then their function as vortex generators that added significant underbody downforce may well have been – if you'll forgive the awful pun – a convenient spin-off.

We've looked at two variations on the 'bargeboard as a vortex generator' theme in these pages before, one from F1 and one from Indycar. Both

A device that sets up vortices can generate downforce, and shallower angled wings compared well to a high downforce wing

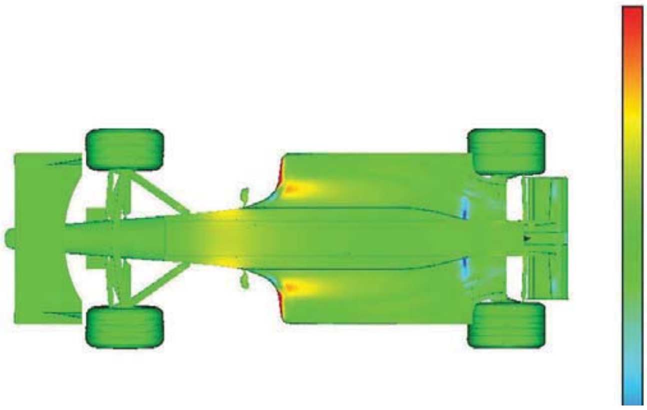

Figure 18: 'delta Cp' plot shows where pressures change with bargeboards removed. Red means pressures increased, blue means pressures decreased

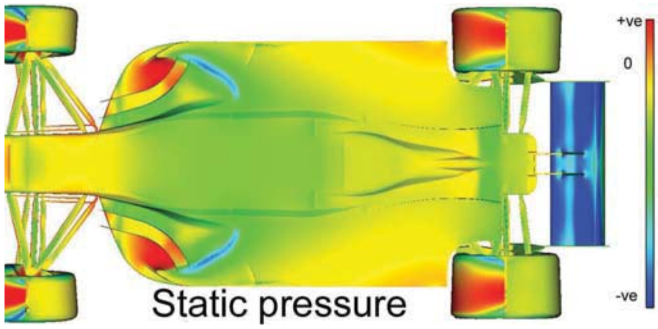

Figure 19: the pressures in this Reynard Indycar's underbody show where the vortex generators in the underbody inlets had an effect

Photo 2: removing the bargeboards from the Honda RA107 had a massive effect on downforce

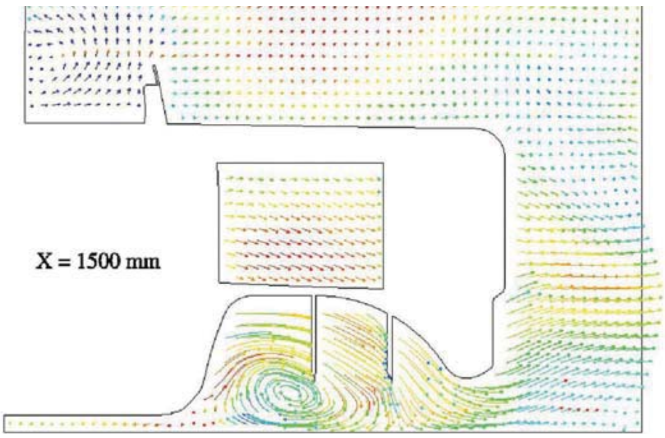

Figure 20: vectors show the effect of the vortex generators in the Reynard's underbody

cars were of 2001 vintage, but the mechanisms were clear. In each case curved vertical vanes turned the air, and vortices were triggered from the lower edges (and upper edges in the case of the F1 bargeboard, though this was of less significance). And the downstream effect was to establish greater reductions in underbody pressure than would have been achieved without the vortices, so adding downforce.

Figure 17 shows the BAR Honda F1 model with bargeboards, while **Figure 18** shows the effects of pressures in the underbody, and where the pressure was seen to increase with the bargeboards' removal, so it reduced with their fitment. **Figure 19** shows the underbody pressures on the Reynard Indycar model, and the low pressures downstream of the vertical turning vanes under the sidepod inlets are apparent. **Figure 20** shows velocity vectors on a transverse slice through half the car, level with the start of the underbody, and the vortex inboard of the inner turning vane is clear.

But these were early examples of the art, and by 2008 the plethora of devices that F1 cars in particular had sprouted ahead of their underbodies was evidence that there were really significant benefits to be had from exploiting vortices. Our recent foray into the MIRA full-scale wind tunnel with the 2007 Honda RA107 revealed just how potent these devices had become, as described in February's Aerobytes. The combined effect of the two pairs of bargeboards that the car featured (see **Photo 2**) amounted to an amazing increase of 39 per cent in total downforce relative to the bargeboard-less car, with 86 per cent more front downforce and 21 per cent more rear downforce.

This total downforce contribution is borne out by an ex-F1 contact who reported that a 40 per cent reduction in downforce was found when the vortex generators ahead of the underbody were removed. This was carried out prior to development for the 2009 rules that banned a lot of these devices, so our data seemed to match this quite closely. And these very substantial downforce increments came for just 3.9 per cent more drag on the Honda, meaning that efficiency (-L/D) increased by more than 33 per cent.

F1 was not alone in exploiting these benefits – see **Photo 3** showing the Dallara F308's devices, simplified now on the latest F312. The new F3 regulations for 2012 reflected the restrictions imposed in F1 in 2009 to reduce the number and effect of such paraphernalia. But apparently, as ever, the downforce losses brought about by the rule changes in F1 in 2009 were recovered in a matter of months…

Of particular interest, though, is that when these vortices enter the underbody region, their effect is augmented by the general flow acceleration that occurs as the airflow enters the narrow car-to-ground gap. In line with Bernoulli once again, it seems that the velocities within the vortices are also accelerated, and this substantially amplifies their effect.

FRONT WING TIP VORTICES

Open wheeler front wings also generate potent vortices, both from the tips and from any inboard flap terminations, but the route that these take downstream is of course greatly affected by the presence of the front wheels and the width of the wing. With pre-2009 F1 cars and most other categories where the front wings are still significantly narrower than the maximum car width, the tip vortices travel inboard of the front wheels and progress downstream from there. The situation is very different now in F1 where front

The effect of two pairs of bargeboards on the Honda RA107 amounted to an amazing increase of 39% in total downforce


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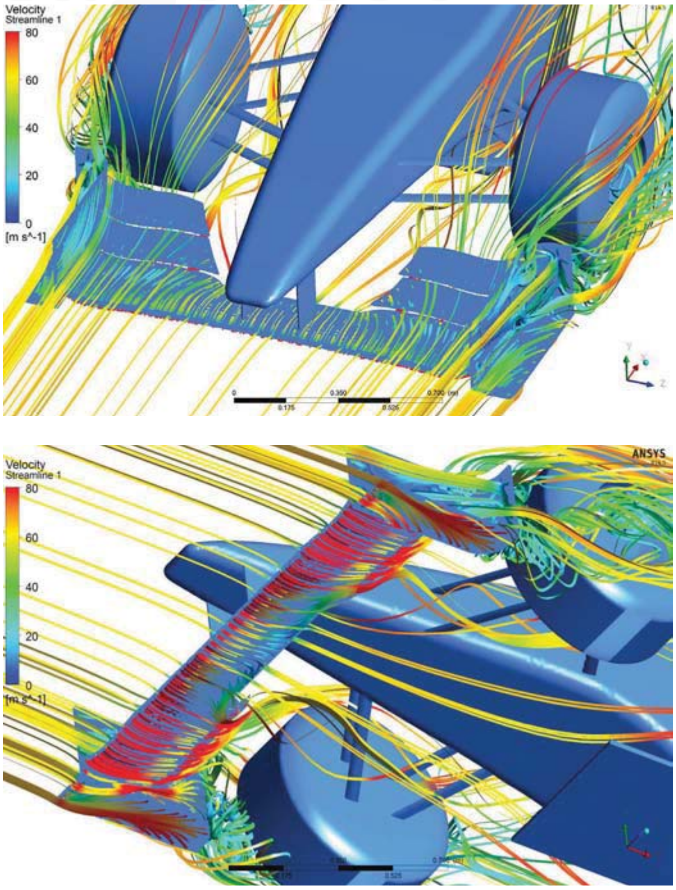
Photo 3: bargeboards and vortex generators proliferated in many single-seater categories; this is the Dallara F308 in 2011 specification



Figures 21 & 22: with new F1 regulations in 2009 mandating full width front wings, the paths followed by front wing tip vortices were different

wing span equals maximum width, and end-plate shaping certainly suggests efforts are being made to steer flows around the outside of the front wheels. Our brief glimpse at F1 front wing behaviour in *V20N10* (October 2010) used a partial model of the front end of an F1-esque nose, wing and wheel assembly in CFD and **Figures 21** and **22** show streamlines superimposed. This does indeed seem to bear out the above notion that the tip vortices are predominantly steered outboard of the wheels. However, the vortices from the inboard terminations of the wing flaps can be seen to proceed downstream, inboard of the wheels. It seems that although these have lost significant energy by the time they reach the underbody, they can assist with the generation of some extra downforce there, and this goes hand-in-hand with the simultaneous desire to steer them away from the cooling inlets.

We looked at the effect of front wing end plate shaping in *V21N5* (May 2011) on the DJ Firestorm hillclimber. Here we swapped a simple end plate made from thin aluminium for a more 3D device incorporating shapes designed to control and steer the tip vortex. The results were much better than anticipated, with 31.1 per cent more front downforce, but also 12.5 per cent more rear downforce, all for just 0.5 per cent more drag.

The gain at the front could in part be explained by the new end plates acting as if they were deeper, allowing the wing to develop more downforce by reducing the amount of air that 'leaked in' from under the end plates. The mechanism must involve the inverted channel that runs the length of the end plate triggering and constraining the tip vortex, which then acts like a seal, reducing 'leakage' to the wing's underside. And the 'cone' towards the bottom rear of the end plate is again thought to steer any vortex that does form under the wing away from the wing itself, allowing better wing performance.

The mechanism that helped to increase rear downforce must remain speculative here, but is thought most likely to have been that the vortices from the new end plate shape interacted with the underbody in a way that helped with downforce generation through the whole underbody. This could either have been by way of vortices entering into the underbody or perhaps running down the side of the underbody, acting like end plates or skirts.

MODIFYING FLOW SEPARATION

This scratch at the surface of a fascinating topic would be incomplete without a look at one vortex generator application that yielded a drag reduction. In a technical review published in 2004, Mitsubishi researchers Koike, Nagayoshi and Hamamoto placed small vortex generators on the rear of the roof of a Lancer Evo and using both computational and practical techniques found small drag reductions. The mechanism was stated to be preventing flow separation over the rear screen of the vehicle. Since then, vortex generators have also been applied to the top and sides of large trucks to achieve drag reductions, and hence improve fuel economy. Interestingly, though perhaps not to truck operators, the Mitsubishi also benefitted from reduced rear lift, this thought to be through enhanced rear wing performance.

A similar application of vortex generators has also been seen in the front diffusers of Le Mans Prototypes, although in this instance the gain would be from avoiding or at least reducing flow separation and gaining (more consistent) downforce as a result.

Finally, this primer cannot end without mentioning 'vortex bursting'. This phenomenon occurs when viscous effects within the vortex overcome the kinetic energy in the rotational flow. And it can manifest itself in a dramatic way – the vortex rapidly dispersing and spreading. This has apparently caused some consternation in F1 circles when it occurs in the rear diffuser. Sometimes vorticity itself is a key element in maintaining flow attachment in an aggressive diffuser, so that should vortex bursting occur it will be apparent that the diffuser may stall when it is not supposed to. There are numerous fine examples of vortex burst images on the internet – mostly aeronautical – but take another look at **Photo 1**, and in particular how the smoke plume rapidly expanded in size at the top right of the image. Could this just be the angle the photo was taken at, or could it be a genuine vortex burst?

Manipulating vortices can have potent benefits then. But efficient 'VGs' require careful design and placement to achieve the kind of gains we have measured in some of the examples here.

Racecar's gratitude goes to Ansys UK for the use of the CFD software

Vortex generators in the front diffusers of Le Mans Prototypes helped to avoid or reduce flow separation, and gain downforce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Dry weight 76kg
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"We had to go full throttle just to get something into the car to turn the wheels"

Baptism of fire

The DeltaWing programme moved into a new phase in 2013, and it didn't start well

BY ANDREW COTTON

The DeltaWing project attracted the second highest amount of media coverage of the Le Mans 24 hours in 2012, just behind the overall winners, Audi, and the momentum continued through the year. By the time the car rolled into Road Atlanta in October, it was a sportscar success story of almost unheard-of popularity.

At Sebring in 2013, however, everything had changed. The 1.6-litre Nissan engine, developed by RML, was replaced by a 1.9-litre Elan Power unit, and Bridgestone had replaced Michelin. In the debut race, the tyres were considered to have too soft sidewalls, and the engine overheated after just 10 laps in the race. It was not part of the script, particularly given the amount of work in just three months that Elan had to develop up an entire engine.

A carbon engine block was planned for the car, but it was quickly realised that this would not be ready for the 12 Hours in March, and instead is expected to debut in the coupe that was also unveiled at Sebring. That meant Elan Power was under pressure from the start to develop a 350bhp engine that fitted into the existing subframe.

'Once we realised that that wasn't going to be ready we had to go full throttle just to get something into the car,' said Chris Smith, engine programme manager at Élan Power. 'That trigger was pulled on 3 December. We figured out what we could do in that amount of time. That wasn't decided on what is best, more what can we get to turn the wheels.

'We quickly identified the crank centre and sump requirement and we realised that our base Mazda MZR block was never going in there.'

'We took a Mazda head that we had a valvetrain developed for, and tried to drive the Mazda fuel pump. Then we built the engine with the Mazda block using all the OE parts that we could. We quickly found that the Mazda parts worked perfectly at 260 horsepower.'

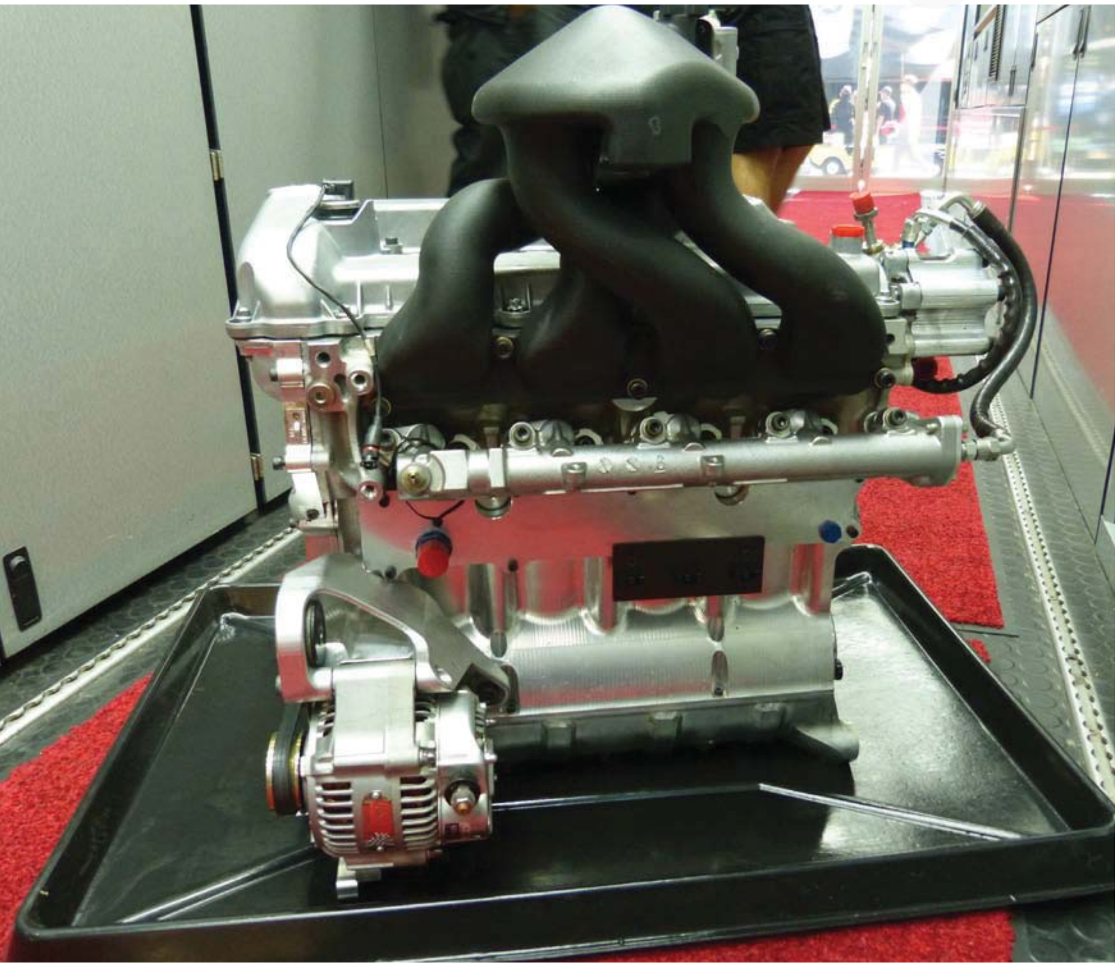
Élan Power had just three months to develop a 1.9-litre engine from scratch in time for Sebring

FLYING BLIND

Engine designer Christian 'Skitter' Yaeger was tasked with designing the car fit aspects of the engine, and he worked on the block and mounting features to meet the crank centre requirements.

'We wanted the fuel pump lobe on the other side, but it turned out to be just where we needed it, so we got lucky,' says Smith. 'The con rods model changed throughout the process. We had an engine that would not rotate due to the con rods hitting the block, and the next day we had it spinning. We machined it, welded it, and got it working.

'Skitter was at full power designing the block and mounting features to meet those crank centre-to-sump criteria. Initially we thought



After a busy early programme, the team now turns to developing active knock control, electronics and water and oil flow

we could raise it up a bit, but the ramifications of that made it impossible. He was the driving force in getting that done. He designed, someone else machined – we did absolutely everything we could.'

ON TARGET

Life Racing supplied the new F90GDI ECU. With a downsized turbocharged engine, fine control is needed for many aspects of the calibration. These include the drive-by-wire throttle system, the knock control system and, of course, the operation of the gasoline direct injection (GDI) high pressure fuel pump and fuel injectors. The engineers used Life Racing's data-logging system (LifeView) to accurately monitor the engine functions. In such a demanding environment, ease of mapping is a must, and the F90 makes this task simple with fast and efficient PC calibration software (LifeCal).

'We used the Life F90 because that is what the car was fitted with before and we wanted to minimise the impact of that,' continued Smith. 'We had a relationship with Life through other programmes. We hit our performance targets on the first day, which was 250ft/lb map and a 270ft/lb map, and how we revved that would give us the power. We produce 270ft/lb at 6900rpm, and that gives us 355bhp.'

The Mazda unit would not support more than 260ft/lb in a steady state, and more advanced electronics were needed. For that, the company turned to Bosch, who redirected them to the Ford Taurus SHO, which runs the Bosch motorsport unit. 'Skitter worked out how to fit the Ford dealer fuel pump and the roller interface from an EcoBoost Focus, so this is Ford dealer and Skitter design,' said Smith. 'Once we put that on there, we bought that Ford roller adapter and figured out how the Ford engineers had made that interface with the camshaft to drive the fuel pump and we copied that, then carefully calculated our preload. Once we had that, we had great fuel pump control. Then we discovered the weakness of Mazda coils, and solved that with a Bosch aftermarket coil. We modified the intake, Skitter drew the airbox and had it 3D printed.'

The intake manifold weighs less than 2lbs and is 30psi capable, but before Sebring, they hadn't managed to test it. The engine itself ran just 30 minutes on the dyno to achieve the target figures before the team needed to fit it to the chassis.

'We were so tight on the tub, which we inherited from the Aston Martin, the Nissan and the rear subframe from RML,' said Yaeger. 'Everywhere just hit hard – a quarter inch or half an inch – and we had to redesign from scratch a new rear subframe to accommodate this and any future motors.

'We couldn't even get the engine close enough to see where it was hitting. That would have sunk a lot of projects that I have been involved in, but we turned it around in a day. I did not find the CAD from the RML engine until probably 10 days before the Sebring race. The design was based on measuring the Mazda parts, making it fit, and then shrink-wrapping the block around it. With oil pump, turbo exhaust and the intake, the weight is 78kg.'

"As far as the engine is concerned there is tons to do – it's perhaps 40% developed right now"

OFF THE PACE

'We are not super proud of the presentation of the back of that car, but from effectively 10 weeks, we are pretty proud of that,' said Smith. 'Our pace may not be impressive, but we can be proud of the fact that we got it out there. We can solve everything – we just need the time.'

Unfortunately, the Sebring race didn't go according to plan, with a wiring problem caused by installation issues, and then the engine let go from massive overheating after just 10 laps. 'As far as the engine is concerned there is tons to do,' said Smith. 'It is perhaps 40 per cent developed right now. The electronics, knock control, cylinder stuff – standard stuff that everybody has. We have EGTs in the new exhaust but not in the car exhaust.

'We called in so many favours to get this ready now. Our vendors got into it and got behind it. Nobody had high vacuum front and rear crank seals for a Mazda-based crankshaft. I told Don at Signal Seals, and he said that he would make them. These engines are raced all over the planet, so he is not just making them for me.'

The team now needs to develop active knock control, and work on electronics, water and oil flow development, and work with Compcast Technologies LLC to prepare the carbon block engine for the coupe, which is scheduled to race at Laguna Seca in May, but is more likely to race post-Le Mans.

The fibres of being

Carbon fibre may currently rule the world of composites, but in this competitive, constantly evolving and innovating industry, there's an ever-growing list of alternatives for teams looking to get ahead...

BY GEMMA HATTON

The importance of composites is immeasurable right now, whether it be in the automotive, motorsport or aerospace sectors. With the composite market predicted to grow at an average annual global rate of 6 per cent to €90bn by 2015 (compared to €80bn in 2012) companies are fighting hard to develop the next new composite.

The future of the carbon fibre industry is nicely set for success. The beauty of carbon fibre is that it is five times as strong as steel, two times as stiff and yet weighs two-thirds less, which is why it plays such a dominant role in the motorsport industry and will continue to do so for the near future.

Put simply, carbon fibre is actually thin strands – 0.005-0.010mm in diameter – of carbon that are twisted together to form a yarn, which are then woven to create a 'cloth'. This is then used to mould parts with the aid of a stiff resin – usually epoxy. Essentially, carbon fibre is manufactured by oxidising the fibre by a furnace, and then graphitising it at high temperatures. Then, by controlling the temperatures you can determine the specific performance characteristics.

Great, then, for motorsport and projects such as the Bloodhound supersonic car. Unfortunately, everything comes at a cost, and for carbon fibre it is a big one. This is the reason why we haven't seen this material utilised in many production cars. However, this may change as Andy Smith, principal engineer of composites research at McLaren Automotive explains. 'There are two fundamental problems with getting composites into road cars and they're both to do with cost: cost of the raw fibre and the cost of the manufacture,' he says. 'With ever-increasing legislation for reduced fuel consumption and CO2 emissions, vehicle weight is a major issue, so carbon fibre is ideal.

'However, there is a worldwide effort to reduce the cost of fibre, mainly by finding a lower cost precursor [the raw material that carbon fibre is made from] because the process of turning it into carbon fibre is just a heat treatment, so it's finding a way

The composite chassis of the Bloodhound SSC, an example of where composites have been pushed to the absolute limits using URT materials

you can make a consistent but cheaper precursor. I'm sure this will happen in the not-too-distant future. It's interesting that the automotive industry has talked about the magical $2 or $5 per lb fibre cost target for years, but seem to have ignored inflation during that time.'

Meanwhile, nanocomposites are materials that incorporate elements that are less than 100 nanometres in size into a matrix of standard material. This addition of nanoparticles can be engineered to enhance the macroscopic properties such as mechanical strength, toughness and thermal conductivity of the composite.

Nanocomposites differ from conventional composites because of the high surface-to-volume ratio of the reinforcing phase and its exceptionally high aspect ratio. The reinforcing material can be made up of particles, sheets or fibres, and are dispersed into the material throughout processing. The high surface area means that a relatively small amount of nanoscale reinforcement can have a significant effect on the properties of the composite.

An example of a type of reinforcement are carbon nanotubes (CNTs), cylindrical carbon molecules that have extraordinary thermal conductivity and electrical properties. Composites are strengthened by adding layers over one another and then bonded by resin. CNTs can be incorporated into the structure by 'nanostitching', which aligns rows of carbon nanotubes perpendicular to the layers, effectively filling the spaces between them and stitching the layers together. The use of CNTs does not add weight, as they are simply taking up the space where the former, heavier resin would have been. Composites that incorporate CNTs into their microstructure are approximately 10 times stronger, and a million times more electrically conductive then composites without.

There have been high levels of activity surrounding the nanocomposite industry. 'Nanocomposites are an interesting development with huge potential, but not a technology we are using at present in automotive,' says Smith. 'For me, the most interesting application is the development of "fuzzy fibres" – nano-fibres grown on carbon fibres to provide improved electrical and thermal conductivity – essentially mimicking a metal, which opens up some interesting possibilities.'

For McLaren Automotive, polymer modification for injection moulded parts is looking to be the most likely near term application of nanotechnology. 'The advantage of using nano fillers is that the effects are realised at much lower loadings than with conventional fillers, and they can have significant benefits to properties such as strength, stiffness, thermal and electrical conductivity,' continued Smith. 'A potential downside is that some nano reinforcements have been reported to have a detrimental effect on impact and toughness – it's a trade-off.'

Fuzzy fibres are on the brink of becoming commercial and overall, Smith predicts that due to the recent developments in the nanocomposite industry, we could see nanocomposites take centre-stage in the immediate future.

"There is a worldwide effort to reduce the cost of fibre, mainly by finding a cheaper precursor"

Another company who is investing in this technology is Bercella Carbon Fiber. 'We're developing a project on nanocomposites with the University of Parma based on the idea to use piezo-material to modify the shape of a component,' says Massimo Bercella. This can be achieved by the piezoelectric effect whereby applying a mechanical force to the material generates an electrical voltage, and when an electrical voltage is applied, the material deforms. Therefore, piezoelectric materials can be used as sensors, actuators, or for power generation. However, original piezoelectric material is very brittle, so to overcome this, piezoelectric composites were developed. Because the fibre is so flexible, it can withstand high deformation without breaking. It is also compatible with other composite processing techniques, making it ideal to be used as an embedded sensor. 'Imagine being able to modify the shape of a wing or an aerodynamic surface at every moment with a simple electrical signal,' added Bercella. 'It could be a revolution for both aerospace and automotive.' This technology is still being born, but could potentially be a futuristic breakthrough.

IMPRACTICAL SOLUTION?

However, not everyone is certain that nanocomposites are the future. 'We have mixed feelings about nanocomposites,' explains Christophe Buchler, global director of sales and marketing from Pyromeral Systems. 'It is a very vague notion that can include a wide range of technologies, materials, chemistries or concepts. Some of these concepts are fairly new, but others have been around for a very long time. Some have resulted in incremental improvements in composite materials, but many are impractical and difficult to

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

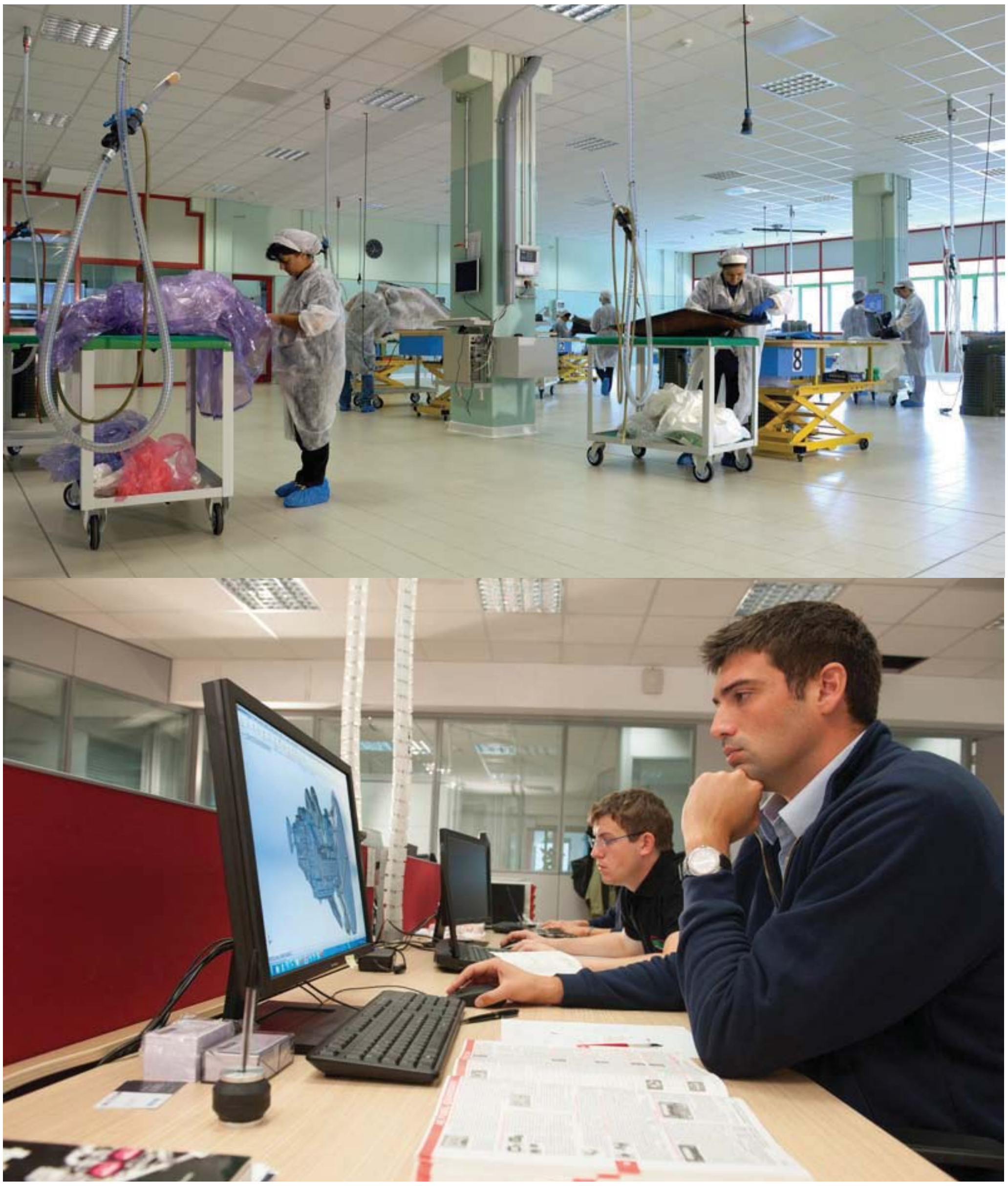
implement outside a laboratory. Some of the work done in the industry on nanocomposites can be interesting, but whether any of that will result in breakthrough advances is yet to see. Regarding Pyromeral Systems, we have been working on nano-structured inorganic polymers and matrix systems for 25 years. However, we do not see this as a defining feature of the material and do not see much technical value in emphasising it.'

Thermoplastics have seen a lot of research over the last few years, and are quickly becoming much more than merely an idea. They are a group of polymers that become homogenised liquid, and therefore mouldable at certain temperatures, and then form a solid once cooled. But this process is also reversible, so the polymer can be constantly re-heated and re-cooled – which is the main difference between a thermoplastic and a thermoset. Thermoplastics are currently widely used as a replacement for injection moulded parts.

'Thermoplastics for use in structural composites are definitely on our radar,' says Smith. 'The benefits include recyclability, improved toughness and energy absorption, good hot/wet properties, environmental resistance and potential simplification in processing.' The latter is particularly interesting for automotive applications, says Smith, 'Thermoplastic-based composites can be press-formed – a familiar process to OEMs – re-formed and welded. Downsides include the high cost of materials and manufacture as most of this class of materials is made for aerospace, as well as the high processing temperatures, which are in the region of 300-400degC. Complex geometries can also be a drawback, since most of the structural thermoplastic composite materials come in the form of pre-preg or pre-consolidated sheets which have no drape at room temperature, unlike thermoset pre-pregs.'

'We are investing in a lot of compression moulding, especially with thermoplastic materials because we believe that this is the future for composites in mass production, especially road cars,' adds Bercella. 'You simply cannot produce thousands of parts per month with autoclave or vacuum moulding. However, it is a different story for motorsport. Since the volumes of production are small, it will be difficult to justify the high cost of tool required to produce thermoplastic parts.'

Out of autoclave composite manufacturing is an alternative to the traditional high pressure and temperature autoclave curing process, which is extremely expensive. The way that this process achieves the desired fibre content and elimination of voids is by placing the layup within a mould and applying pressure and vacuum by resin transfer moulding (RTM) or vacuum-assisted resin transfer moulding (VARTM).



Bercella Carbon Fiber, located in Varano de' Melegari in Parma, is currently working on a project with nanocomposites, based on the idea of using piezo-material to modify the shape of a component

AGAINST AUTOCLAVES

'For automotive series production, autoclaves will never meet the rates required,' says Smith. 'A lot of effort has been expended by the thermoset pre-preg manufacturers in recent years to develop resin systems that cure rapidly – a couple of minutes – and can be press-moulded in isothermal tools, as well as systems that give the low void/high fibre content characteristic of autoclave processing, but at lower pressures and temperatures, to reduce cost.

'The current McLaren composite chassis is manufactured using a resin transfer process whereby dry fabric pre-forms are loaded into a tool which is then placed in a press and resin injected under pressure and cured. The cycle time for us is four hours, which fits in with the maximum number of vehicles we will ever produce, of 4000 per year. BMW will use a similar system to produce the upcoming i3, although their system is a variant on the usual RTM process, known as HP-RTM – high pressure resin transfer moulding. Here, the tool is kept slightly open when the resin is injected at high pressure – this allows the tool to fill in a matter of seconds. The tool is then closed, forcing the resin down through the laminate rather than along the fibres. For structural composite use in the

automotive sector, I think RTM is the manufacturing process of choice for volumes up to – say – 50,000 units per year.

'Motorsport will still use conventional pre-pregs cured in autoclaves for the foreseeable future. Aerospace is also looking at out-of-autoclave processes due to the fact that the size of parts now being considered make autoclaves a very expensive option.'

This is the general feeling from many of the manufacturers that I interviewed, such as Bercella, who concluded: 'I think out-of-autoclave is a smart process for non-structural parts for startup companies at the beginning stages. If you want to produce high-quality structural parts like monocoques or crashboxes where you have very severe rules to withstand, you simply must use an autoclave!'

However, this hasn't stopped the development of out-of-autoclave manufacturing. In Australia, the nine-year FR-1 project – a two-seat roadster sportscar – was the first carbon fibre monocoque cockpit chassis to be built in Australia. And it was designed and moulded out of autoclave. This project involved VCAMM, Autohorizon, Boeing and GMS composites to design and build the cockpit chassis and the glass fibre tooling. An epoxy pre-preg GMS EP270 was used and moulded at only 70degC, but did include eight 16-hour cure phases and a final post cure. However, it weighs in at a light 80kg and still provides the required high torsional rigidity, which was achieved by the design optimisation of the number and orientation of the carbon fibre plies.

It took AUD$1m of investment to complete the handmade project, which makes it unlikely to take off in the motorsport and automotive worlds. However, it does prove that this process is a successful alternative, and interestingly, it is claimed that out of autoclave manufacturing costs are a factor of four times lower, with tooling costs typically reduced by 50 per cent. If this process can become more commercialised then it could prove an intriguing opportunity.

Part of the Bloodhound SSC showing a cross-section of the URT Composites used

With the introduction of the 1.6-litre turbocharged V6 engines in the 2014 F1 season, the issue of high temperatures is fast becoming a major one.

One of the major companies for heat treatments is Zircotec, famed for their thermal coatings, and more recently they're newly developed ThermoHold Gold coatings. These coatings are extremely efficient at heat protection – for instance Zircoflex, used in F1, can reduce surface temperatures by up to 64 per cent.

Some manufacturers produce materials that are adequate to resist heat without coatings, such as Pyromeral Systems, as Buchler explains. 'If coping with higher temperatures is an issue, our materials are ideally suited to provide a user-friendly and practical solution to this problem,' he said. 'We offer solutions for parts exposed to temperatures between 350degC and 1000degC, which far exceeds the capabilities of carbon fibre reinforced composites (CFRP) with organic matrices. Due to the thermal properties of our materials, parts tend to be much more durable than those made of CFRP when exposed to heat. Other advantages include short lead times, use of inexpensive and conventional tooling materials – a rare and valuable feature in the world of high temperature composites – and the use of clean, environment-friendly chemistries and processes.'

'Motorsport applications certainly use coatings which can range from spray-on ceramic coatings to heat reflective films, like gold,' added Smith. 'Our automotive applications rely on heat-shields, since packaging requirements are not as restrictive as they are for the F1 cars. Automotive, even high-end vehicles such as the MP4-12C, is heavily driven by cost, and the application of coatings can prove expensive.

'The main area of interest for motorsport at the moment is high temperature capability. With next year's re-introduction of turbocharging in F1 and the aerodynamic requirements of close fitting bodywork, composite materials will really be pushed to their boundaries in terms of thermal performance.'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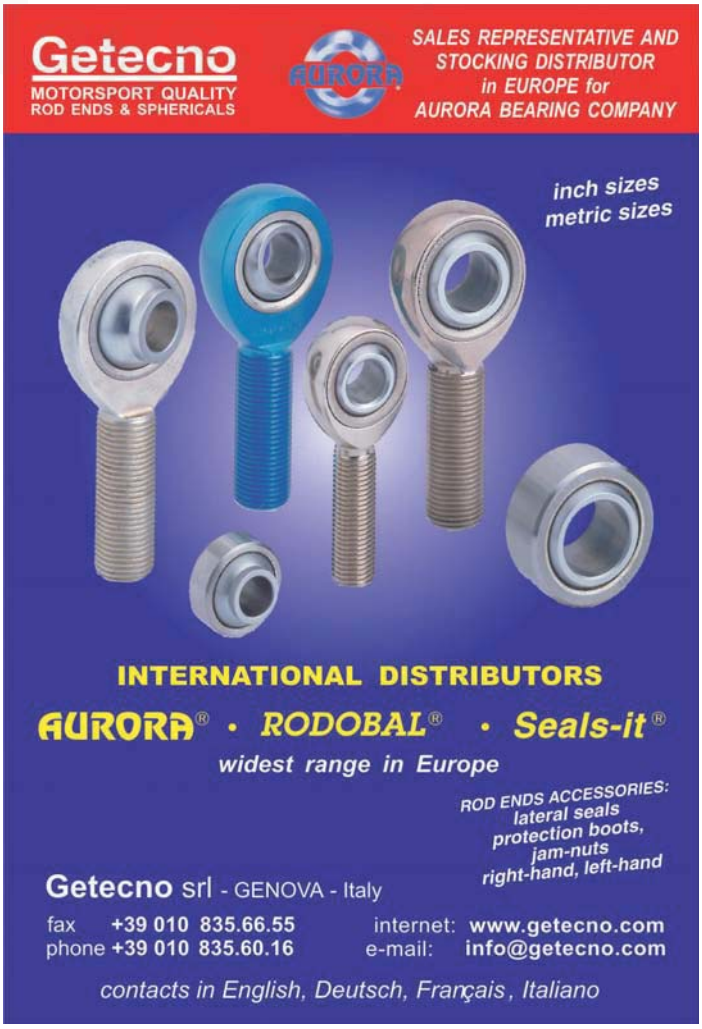
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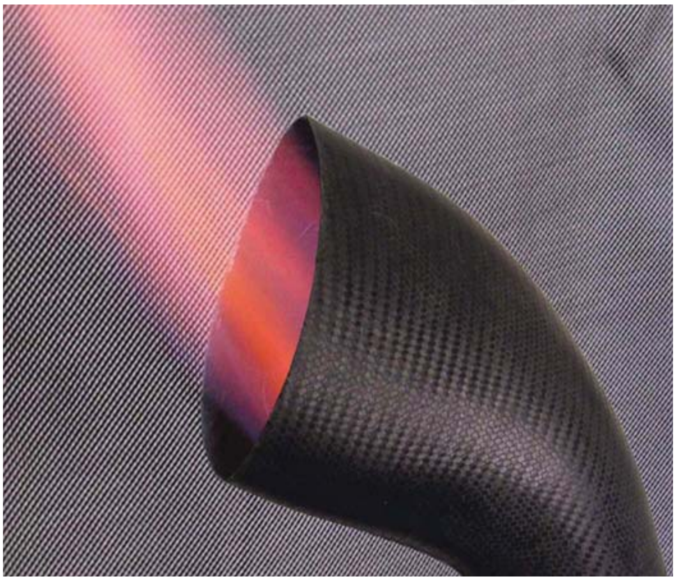
3D PRINTING

A strong current trend in the world of advanced materials is 3D printing, and as this area accumulates ever-more investment and development, the effects on the composite industry could be potentially huge.

An accomplished player in the 3D printing world is CRP Technology, who worked with CRP USA to 3D print parts for the Nissan DeltaWing Le Mans car. For motorsport applications, additive manufacturing could be yet another effective way to process composites.

'Traditional composite materials characterised by long fibres cannot be processed with 3D printing yet,' said a CRP spokesperson. 'This technology requires the use of reinforced materials, but in powder form, such as Windform materials. However, using these types of materials, selective laser sintering (SLS) could be an interesting future possibility.' This method produces prototypes by layering and overlapping polymeric material at constant temperature using a roller that rotates at opposite directions, adding a thin layer of powder on a platform where the laser ray then sinters the material, providing the necessary heat to melt the powder.

The enormous advantage of 3D printing is that there are no limits in designing, so you can design for functionality. Parts with undercuts and complex features can be produced, which would be difficult to achieve with traditional processes. It is also considerably quicker and cheaper.



A PyroSic exhaust duct from Pyromeral Systems. The material is based on glass-ceramic matrix systems reinforced with silicon carbide or carbon, which offers great thermo-mechanical performance for motorsport applications

'We can build individual parts and functional components in very short timescales,' continued the CRP spokesperson. 'Moreover Windform materials can be CNC machined, metallised and painted, adding great value to our processes for sectors that need beautifully-finished and functional parts. At this stage it is not possible to create an entire chassis of a car with 3D printing due to the limited dimensions of current printers. Furthermore, the mechanical properties of the SLS materials need to be improved for that kind of application.' But the possibilities are certainly intriguing.

'Among the many areas of research in the composite industry today, we believe that out-of-autoclave processing, high temperature materials and advances in tooling materials will be the most relevant for the motorsport industry,' concluded Buchlet. 'There are many other topics of interest in the composite industry today, such as fibre placement technologies for automated processing, low-cost carbon fibres, design and modeling, repair technologies and natural fibres. However, most of those efforts primarily target the aerospace and automotive industry.'

"We can build individual parts and functional components in very short timescales"

'For automotive applications, I think automation is the key, particularly for structural applications,' added Smith. 'My personal feelings are that thermoplastic composites will become the material of choice for mainstream automotive manufacture, driven by recyclability and the similarity in processing methods with current metallic technology. Also, I think high-end applications will continue to use continuous fibre, but general applications will use discontinuous short fibre materials, maybe with localised continuous fibre reinforcement. This will allow easier processing into complex geometries since the fibres can move relative to one another without restraint.'

THE NEAR FUTURE

'Motorsport, due to the low volumes and high performance required, is likely to stay with current technologies,' said Smith. 'The main area of interest is the requirement for high temperature capability. With next year's re-introduction of turbocharging in F1 and the aerodynamic requirements of close fitting bodywork – composite materials will really be pushed in terms of their thermal performance.'

There is no doubt that the world of composites today is an exciting one, with such high levels of development, investment and innovation, the materials and manufacturing of the motorsport, automotive and aerospace sectors could be revolutionised in the not-too-distant-future.

THE SAERTEX SOLUTION

Dresden University of Technology's Formula Student team – Elbflorace EV – feel that they are benefitting greatly from the use of Saertex LEO composite technology

Christian Holz, head of frame and body for Elbflorace TU Dresden Formula Student Team, explains the benefits of this composite. 'We choose the Saertex LEO System because of the Formula Student regulations – we have to make our firewall and battery case fire-resistant,' he said. 'With this technology we can ensure very high fire-resistance and good electrical insulation because of the glass fibre layer, which is extremely important for our battery case. Beyond that, the LEO is easy to manage and gives us the best possible combination of fire-resistance, reduced weight and high strength values.

'We think that the LEO technology is a future material for Formula Student, and we will continue using this technology next season and hope to help Saertex to optimise it for the specific application of Formula Student cars.'

After the DeltaWing

It's made jaws drop and heads shake, so is it now time for a new lightweight class?

As I write this article it still blows me away the amount of press interest the DeltaWing car is getting. Love it or hate it, the DeltaWing has certainly sparked a great deal of interest and no small measure of controversy. Despite its on-track success (fifth on the road at Petit Le Mans last year) among my colleagues this is still a deeply polarising car. Yet in some respects I think we have actually missed a great opportunity. Is it time for a specialised lightweight category for sportscar racing that encourages technical innovation?

As many regular readers of this magazine might be aware,

BY DANNY NOWLAN

I am not the greatest fan of the DeltaWing. I wrote an article last year where I explored at length what it did well and what it didn't do so well. The positives are that its reduced frontal area, and small mass opens up significant possibilities in terms of acceleration and fuel consumption. However, from a vehicle dynamics perspective it would be foolhardy to ignore its drawbacks, particularly the load transfer at the rear. Ultimately it has required electronic intervention to aid in this endeavour, which to the great credit of DeltaWing cars has worked well. Also, a number of my colleagues working in the American Le Mans Series have identified some significant safety concerns with the car, because it is very difficult to see in traffic.

All that said, my biggest concern with the DeltaWing is the disconnect between the PR/marketing of the car and its engineering merits. When the DeltaWing did really well at Petit Le Mans last year, I started to seriously think that I'd got it all wrong. I discussed this with a colleague of mine who is an extremely experienced race engineer, who listened to me for the grand total of five minutes. He then stopped me mid-flow and said: 'Yeah, it's amazing what you can achieve when you don't have a rulebook to worry about'. And let's face it, the DeltaWing isn't encumbered by a ban on traction control, the floor is free and they have been given liberties that haven't been accorded to the more conventional prototypes, particularly with regards to the differential.

This got me thinking. The only way we are ever going to resolve what is going on with the DeltaWing would be to have a specialised class for lightweight vehicles for prototype racing. The regulations could be fashioned around the following guidelines:

In simulation, the DeltaWing races away in the straight, while our lightweight prototype model has an advantage in the corners

- **Maximum weight: 600kg**
- **Maximum engine displacement: 2 litres**
- **Turbo limit: 1 bar**
- **Maximum car dimensions: 4.8m x 2.2m x 1.2m**
- **The components on the car (dampers, electronics, gears diff etc) must be homologated/off-the-shelf components or fashioned from off-the-shelf components**
- **The car must be homologated so teams can buy it**

...Apart from all that, complete technical freedom. The electronics are free, the floor is free. Imagine the possibilities!

Table 1: specs for lightweight prototype

Item	Quantity/comment
Weight	600kg
Max power	300 hp
tf/tr	1.6m/1.6m
Wheelbase	2.7m
CLA	3
CDA	0.6
Diff type	Fully active

To further explore this, let's revisit the simulation comparison I did between the DeltaWing car and the LMP1 prototype. To really spice things up, let's introduce into the mix a conventional four wheel car that for all intents and purposes is an F3 car on steroids. The specs of this car are highlighted in **Table 1**.

To aid in the modelling process we are effectively taking an F3 simulation model and enhancing it. To add some sanity to this discussion, I'm applying CLA and CDA numbers that wouldn't be too much of a stretch beyond sports prototypes such as the Pilbeam MP98 VdeV car. If anything the numbers I am presenting are slightly below the specification of this car.

To flesh this out let's compare the DeltaWing from our previous investigation to our lightweight prototype using ChassisSim. The first comparison I want to present is an overall plot of speed and gear ratio and RPM for the two cars. This is shown in **Figure 1**.

The coloured trace is the DeltaWing, the black trace our lightweight prototype. In terms of overall lap times, there was nothing to compare the two. The DeltaWing had a lap time of 3:38.462s and the lightweight prototype achieved a lap time of 3:38.562s. The DeltaWing races away on the straights because it runs at higher speed due to its lower drag.

Where the lightweight prototype has it all over the DeltaWing car is in the corners. The exception is the Porsche Curves, but I think that's a slight anomaly. A typical example of this is illustrated in **Figure 2**.

There are a couple of key takeaways here. Firstly, the mid corner speed is nearly 10km/h faster than the DeltaWing. However the throttle and acceleration plots are very revealing. If we look at the throttle plot and the longitudinal acceleration plot, the lightweight prototype can put its power down in a much more consistent manner. This means that our lightweight prototype is going to get the jump in the corners.

I should also add that our model of the lightweight prototype has had very little refinement. If you look at the RPM trace in **Figure 1**, we can see that the lightweight sports prototype needs a bit of work with regard to the gearing. This is primarily due to time constraints. There is plenty of time to be had in setup refinement of the rough model that has been presented here.

I should also add that the numbers I have applied to our lightweight sports prototype have been conservative to say the least. As we all know, ground effect tunnels have been banned for sports prototypes. The old sports prototypes – aka Group C, Porsche 962 era – running ground effect tunnels produced very high

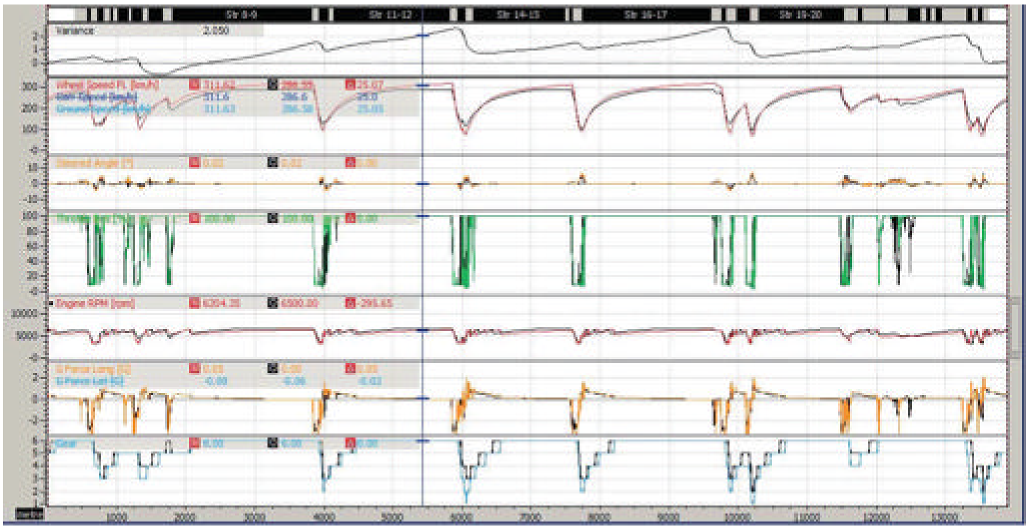


Figure 1: overall comparison of DeltaWing vs lightweight prototype

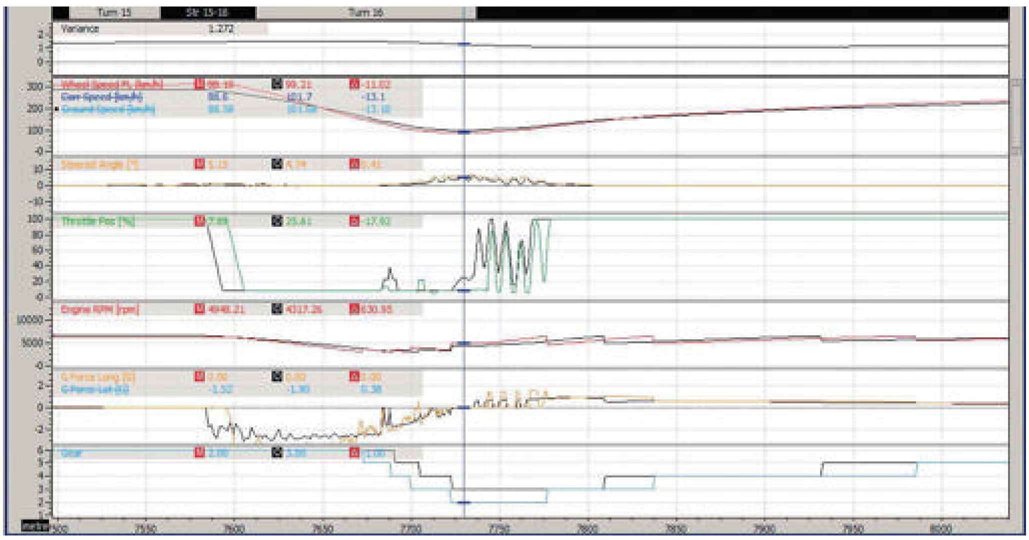


Figure 2: direct comparison of car speed in cornering between the DeltaWing and lightweight prototype

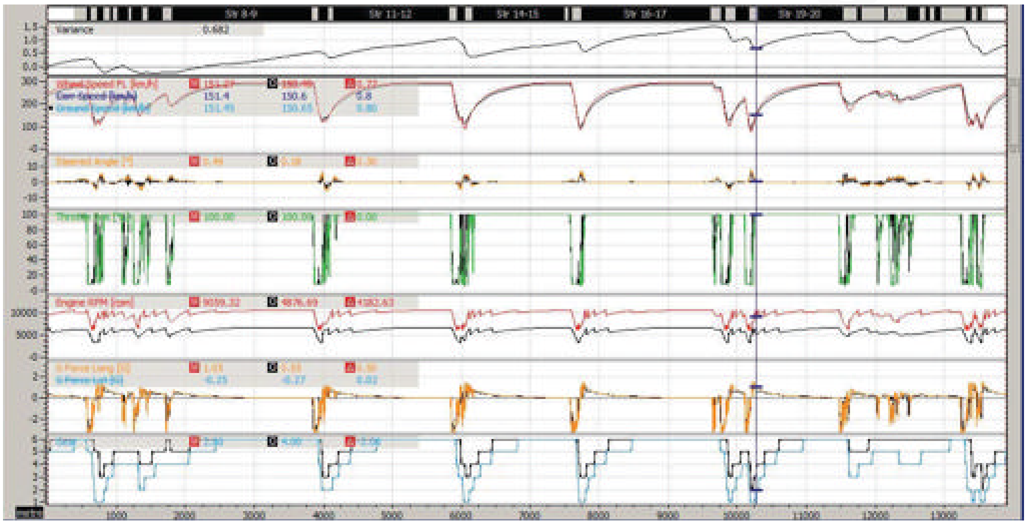


Figure 3: overall comparison of LMP1 vs lightweight sports prototype

Figure 4: individual corner comparison of LMP1 vs lightweight sports prototype

levels of downforce. Just imagine what we could do now with what we know using tools such as CFD and modern wind tunnels. To put this discussion in perspective, a colleague of mine was the chief aerodynamicist of a time attack car that produced as much, if not more, downforce than an F1 car.

What this analysis shows is that a conventional four-wheel vehicle can more than hold its own against the DeltaWing for the equivalent weight. As I alluded to before, one of my principal objections to the DeltaWing is not the fact that it was built, but all the hype that has gone with it. The analysis we have presented here is very preliminary. However **Figures 1** and **2** show unequivocally that for an equivalent weight we can construct a conventional vehicle that will match and – with refinement – will exceed the performance of the DeltaWing. What I would love to see is a framework where we could have a genuine battle of ideas in motorsport and get this sorted out once and for all. This lightweight formula would provide such a framework.

Where this discussion gets really interesting is comparing our lightweight sports prototype to an LMP1 car. If you will recall, the lap time for the LMP1 car was 3:37.782s. The overlay between the two is very interesting – see **Figure 3.**

The coloured trace is the LMP1 and the black is the lightweight sports prototype. As can be seen from the speed trace our lightweight sports prototype has the slight edge in the corners, but the LMP1 car will chase it down in the straights. A more detailed view of this can be seen in **Figure 4** where we see the individual corner speeds.

What this translates to is that our lightweight sports prototype could give the LMP1 car a good run for its money. What we have here is the classic David vs Goliath battle. As we discussed with the DeltaWing car, we have hardly scratched the surface of what our lightweight sports prototype is capable of. However, just imagine what we could do with a bit of development. It's not hard to imagine the lightweight sports prototype being very competitive with a modern LMP1 car.

Also, if cars like this are homologated, it gives small race teams the ability to be competitive against the larger ones. I have a real soft spot for prototype racing. But a very valid criticism of it – particularly at Le Mans – is that unless you have an Audi vs Peugeot battle, the well-funded LMP1 teams romp away, leaving everyone else to squabble over the minor places. This lightweight sports prototype class could go a long way to solving this problem.

Another aspect to consider in this discussion is that the legacy of the DeltaWing is not necessarily the car itself but it the possibility that it could lead to an open lightweight formula. One of the principle challenges with motorsport is that most forms of the sport have technically regulated themselves into irrelevancy. I was having a discussion with a colleague of mine who is an aerodynamicist. He mentioned that the long-term impact of racecar aerodynamics could lead to a significant reduction in braking distances of road cars because of what we have learned about how to generate downforce and drag. The way that most motorsport formulas are going is that they have effectively strangled innovation, so we have all these cars that look the same. An open lightweight formula could provide a great circuit breaker to this.

So, the DeltaWing could provide a significant opportunity. We could engineer a conventional four-wheeled vehicle to be more than a match for it, but then we could also have a car that could challenge the performance of an LMP1 car. This would have several knock-on effects, but the most significant of these could be to provide a fresh look and feel and relevance to motorsport. If this is the only thing the DeltaWing achieves, then the team behind it will definitely have succeeded in their original intentions.

The legacy of the DeltaWing is not necessarily the car itself, but the possibility that it could lead to an open lightweight formula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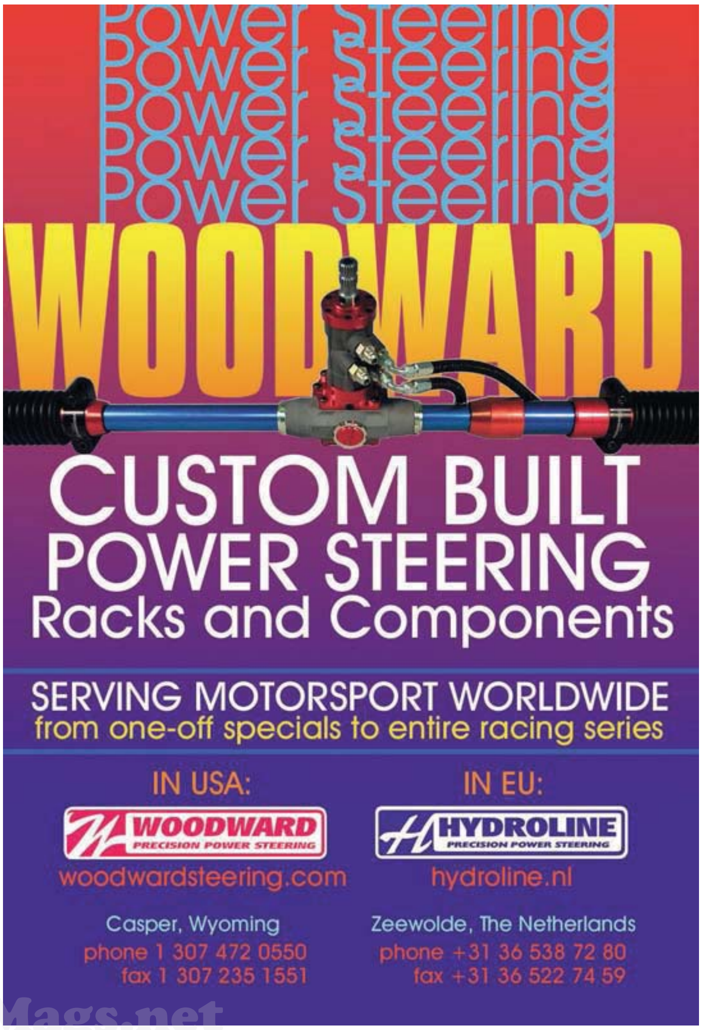
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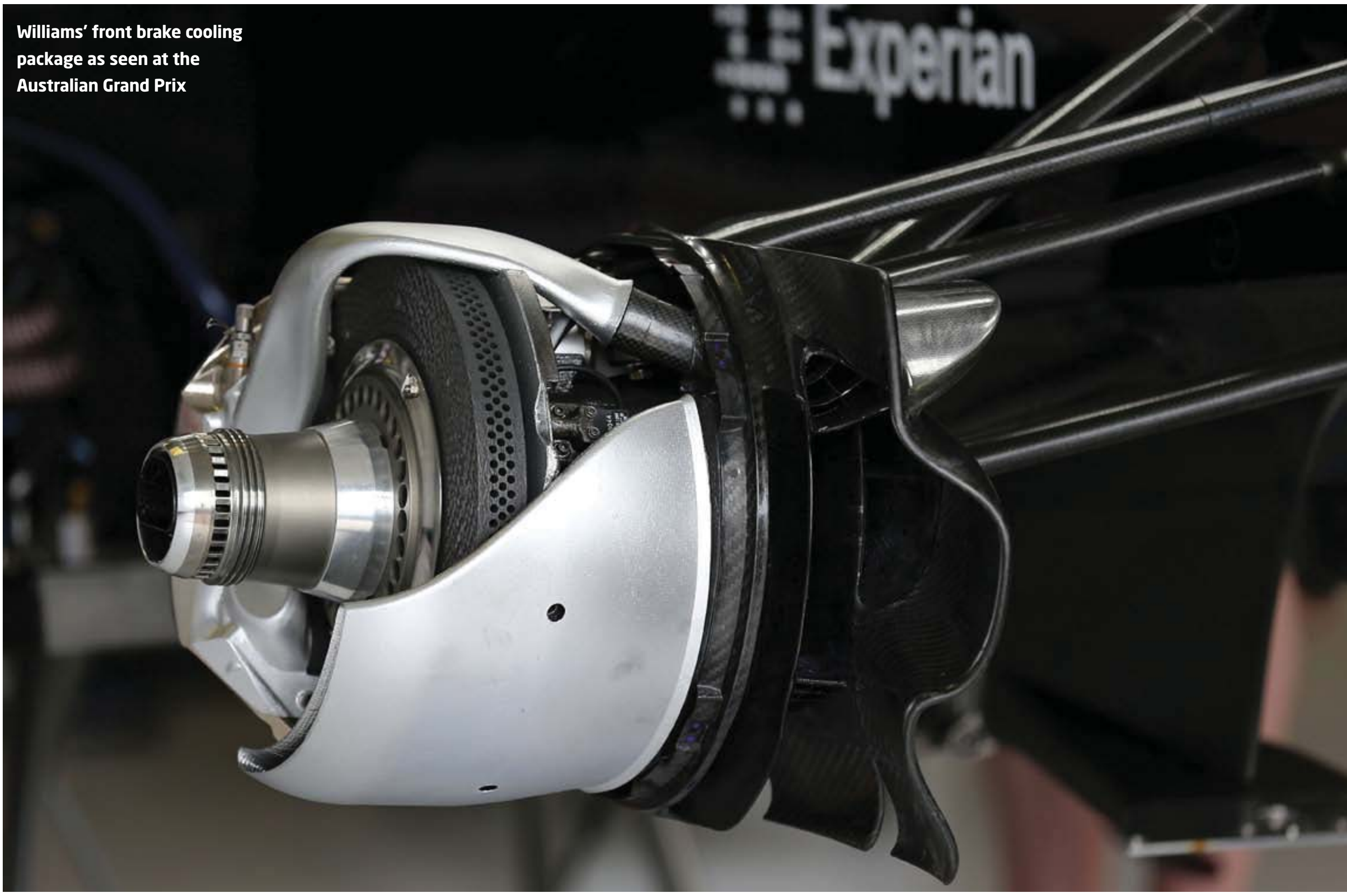
Duct and recover

What has Williams been working on with its front wheel hub and brake assembly? Craig Scarborough presents his view



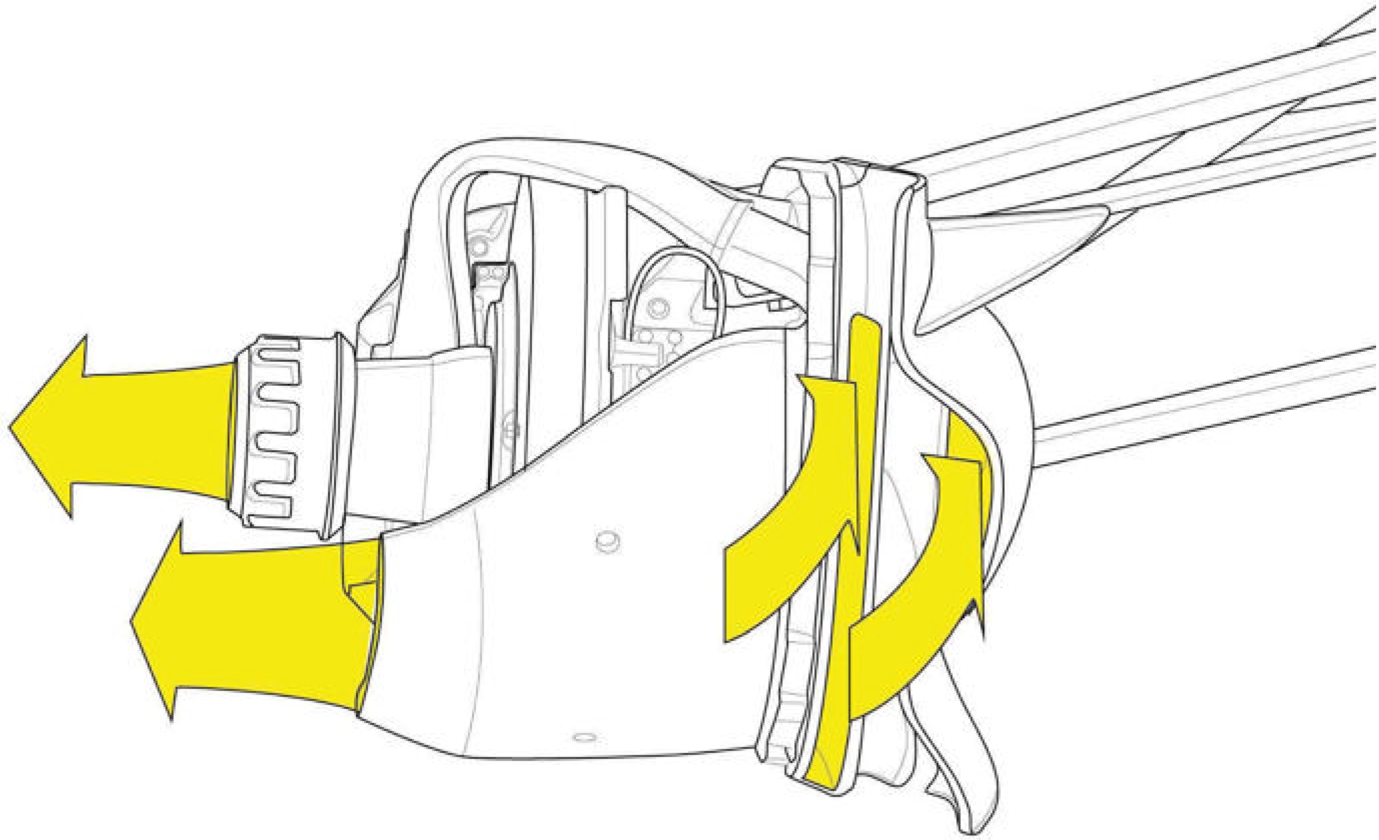
Williams' front brake cooling package as seen at the Australian Grand Prix

Even at its launch, the Williams FW35 displayed an odd opening on its front hubs. Closer examination when the car was running proved that the car was ducting air inside the hollow hubs. At its first race, the car subsequently gained additional ducts inside the front 'cake tin' brake ducts that also fed air out through the wheel, but neither of these airflows has anything to do with the cooling of the brakes or other parts. Instead, these ducts aim to improve airflow around the exposed front tyres.

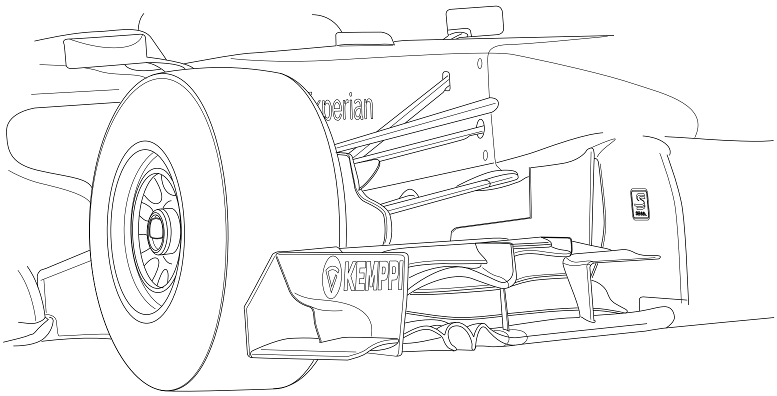
Formula1's high aspect ratio tyre/wheel assemblies are fully exposed to the onset airflow. The combined effect of the rotating wheel and the ground interaction creates a series of strong vortices being shed around the tyre. Both the vortices in near proximity to the ground create particular problems for the F1 aerodynamicists. As the wheels are in relative close proximity to the car's bodywork, the inboard vortex tends to choke the airflow passing under the front wing, while the outboard vortex tends to get pulled back under the floor towards the diffuser. Both of these effects clearly affect downforce, and being unstable flows they will also tend to make the cars handling less predictable.

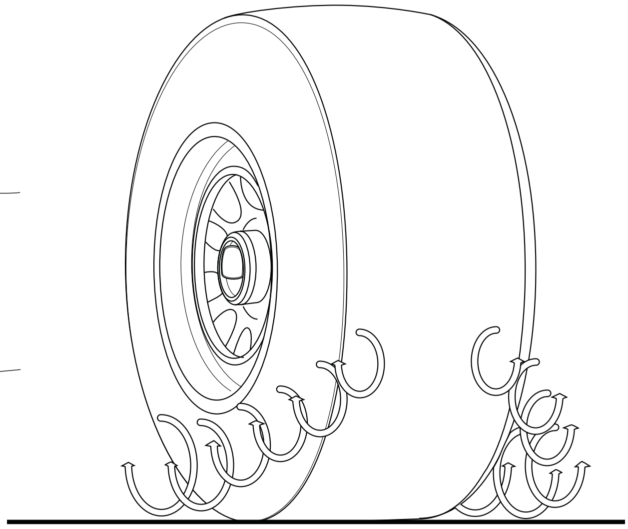
While these vortices have always been a feature of F1 cars, it transpires that the recent preference for 'cake tin' brake duct bodywork filling the wheel tend to exacerbate the problem. Research done by John Axerio-Cilies and Gianluca Iaccarino at Stanford University for Toyota F1 – see bit.ly/fluidmechanics for details – proved that these vortices were stronger when the wheel was fully blanked off. Subsequently opening the wheel to allow more airflow to pass through it reduced and repositioned these vortices. With this knowledge, it's clear that teams need to pass more flow through the wheel. However, the 'cake tin' drums also serve to smooth the airflow passing by the inboard face of the wheel, as well as directing cooling air to the brake discs and calipers. So simply removing the drums is not a solution.

It was Red Bull last year that came up with the ducted hub idea. Their conical shaped hub extended out past the wheel nut and openings in this outboard



Craig Scarborough speculates at the airflow around the front brake cooling layout on the FW35 but full details about the concept are not yet clear





end blew air to have the same effect as passing airflow through the wheel. However, Red Bull's instance of the ducted hub was met with protests, they were regarded as 'air ducts' in the rules (technical regulation 11.4) and therefore may not rotate with the wheel or extend out past the wheel nut. Red Bull deleted the design at Monaco and it did not return in 2012.

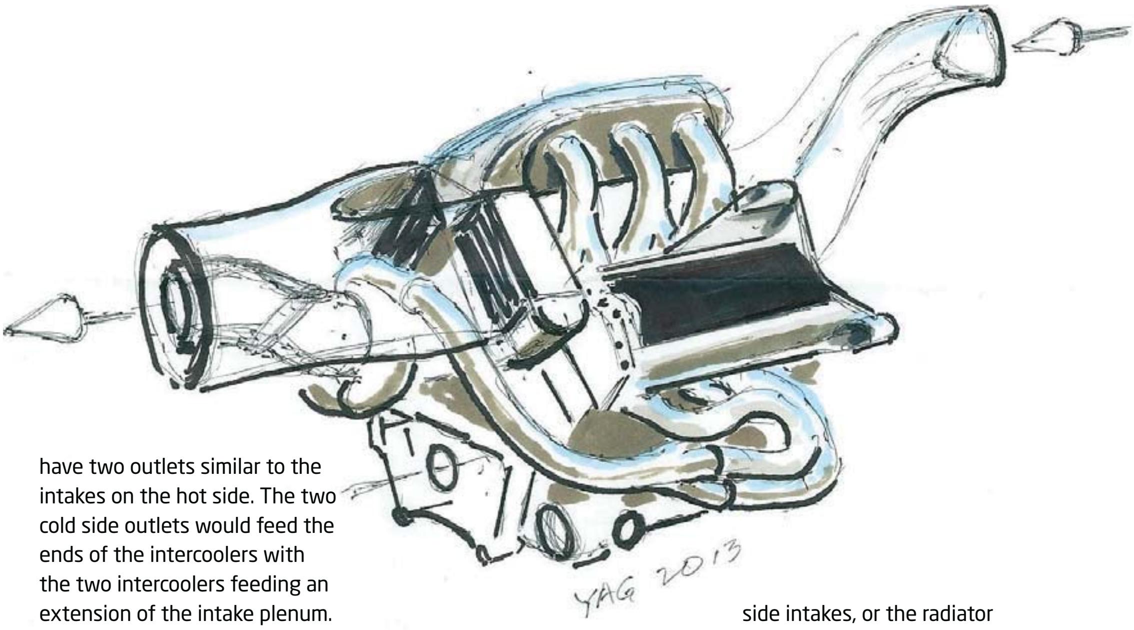
Williams' 2013 solution works around the legality issues by having a separate duct passing inside the hub, and so the part does not rotate with the wheel. Furthermore, this duct ends at the wheel nut – hence the witty name applied to the design by the media, 'blown wheel nuts'. Now aided by the larger duct passing inside the brake drum, but passing around the brake disc, Williams are able to pass a lot more airflow through the wheel. This flow will help reduce the negative impact of the vortices shed from the wheel for better all-round aero performance.

Other teams now have similar pass-through ducts inside their brake ducts. Some of these pass airflow externally to the brake drum, while others route it inside the enclosing brake drum. As yet, no other team has followed Williams in the ducted hub design. Part of the reason for this might be the emphasis on fast pit stops during the races due to the softer compound 2013 Pirelli tyre specification. Williams' hub ends with a flat blunt shape, rather than the domed ends that encourage the wheel to seat on to the hub at the pit stops. And Williams may find their design is not conducive to fast stops. With more pit stops and the speed of those stops being critical to the fastest possible race time, any delay in aligning the wheel back on to the hub during pit stops may end up costing more time than the aero benefit of the blown design. So far Williams do not appear to be around mid-placed in the speed of their pit stops compared to their rivals, so it appears the trade-off is working.

-Craig Scarborough

Power opinion

More on Renault's 2014 engine, with hot air kept to a minimum...

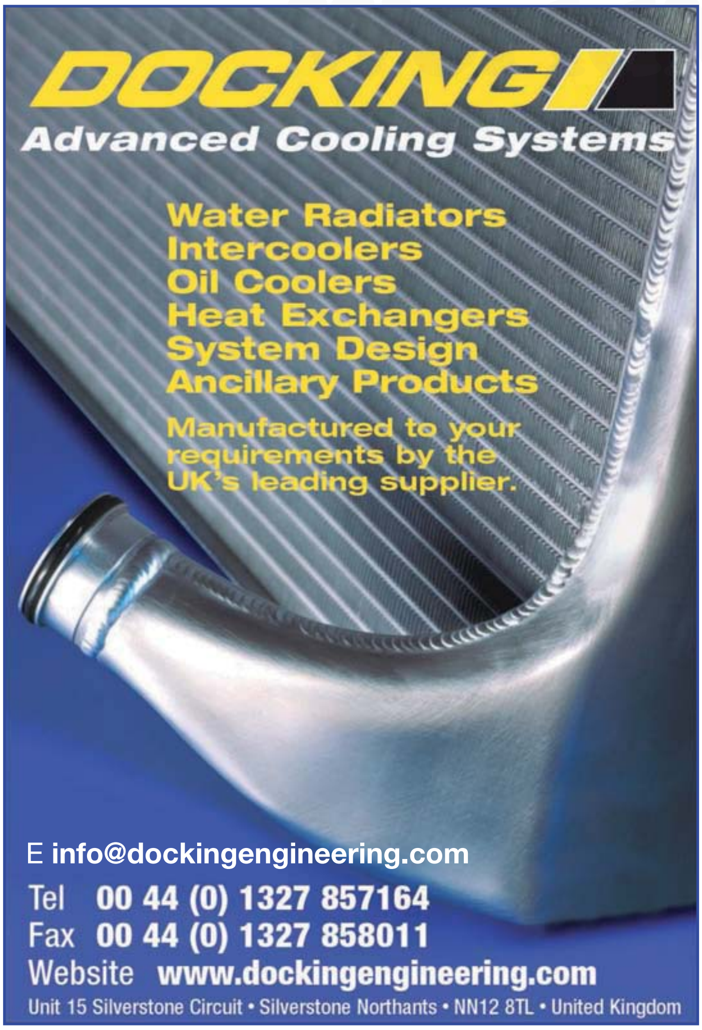


Your December 2012 issue, *V22N12*, showed Renault's 2014 engine possibility. Since all designers try to keep intake tracts as short as possible, I thought I would put in my two cents' worth. I realise, of course, that your illustrations were merely an artist's representation, but here goes...

The rule-makers have done a good job as I see it, since all the designers start from the same point. I think that if the area under the intake plenum and above the valley cover can become a plenum for cold air, feeding the cold side of the turbo, the rest can feed the intercoolers. The intercoolers are in two halves and placed in an upside-down V behind the intake plenum. The cold side of the turbo would have two outlets similar to the intakes on the hot side. The two cold side outlets would feed the ends of the intercoolers with the two intercoolers feeding an extension of the intake plenum. The exhaust duct from the intercoolers would be 'pierced' by the turbo exhaust, which would help pull air through the intercoolers. Both the exhaust and the intercooler air would be aimed at the underside of the rear wing, à la Coanda.

Air for the intercoolers would have to be fed by air from the side intakes, or the radiator intakes would have to be enlarged and air diverted to the intercoolers. The sketch above illustrates this.

– Richard H. Yagami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The new contender

Aston Martin's updated GTE entry already has Porsche drivers worried

The new GTE model features brand new side sills, added to counter the problem of having the exhaust running down the side of the car

The new GTE challenger from Aston Martin launched in London in February, but the car raced for the first time in the opening round of the American Le Mans Series at Sebring in March and was immediately impressive.

Under managing director and team principal at Aston Martin Racing, John Gaw, the team has changed upwards of 30 per cent of the car to make it more driveable, and faster, and already it has been cited by the Porsche drivers as the car they most fear.

One of the main issues with the car last year was the speed at which it reached its V-max on the long straights of Le Mans, Shanghai and Fuji. It was allowed to run at Le Mans without a Gurney flap, had a larger fuel tank and less weight than its rivals, all measures that the new car has been allowed to keep.

Yet it still is a draggy car, despite a new rear wing that has been introduced throughout the GTE field. The Aston runs this year with a minimum weight of 1205kg, five lighter than the Porsche 991 and 55kg lighter than the BMW Z4 that races in the ALMS only. It has a larger air restrictor, at 29.7mm, 1.6mm larger than the Ferrari 458, runs a Gurney 10mm lower than the Ferrari at 15mm, and carries 10 litres more than the Ferrari, five more than the rest of the contenders in the GTE field with a 95-litre tank.

The Prodrive team has modified the suspension, and taken weight out of the car (although the BoP adjustments means that it runs 10kg heavier than last year), making the car more driveable in the corners. 'It is not a good aero car, which is why the air restrictor is bigger, and then we use more fuel,' says Gaw. 'It is a torquey engine so we are good out of the corners.'

The side sills are new, due to the problems of running the exhaust down the side of the car and having a body made from aluminium, a metal that is very good at conducting heat.

'Last year we proved how fast and reliable the car was, and our two GTE Am entries will pick up where the Pro car finished with victory in Shanghai last year,' added Gaw.

'Overall, around 30 per cent of all components on the 2013-spec Pro cars are new, which makes for a significant improvement. We looked at specific areas where we could take weight out of the car and redistribute it to a better location. We have also revised the suspension, which has not only improved the handling but – when combined with the new fly-by-wire throttle allowed under this year's regulations – makes the car easier to drive.

'Our aim is to win at Le Mans and in the WEC, and we are particularly pleased to welcome such a professional driver lineup to Aston Martin Racing for this centenary year.'

F1 team bosses confident that sponsorship market is recovering

Formula 1 team chiefs believe the sponsorship market is beginning to recover from the ravages of the recession, despite the recent announcement that one of the sport's blue chip backers is to quit F1.

In the lead up to the season-opening Australian GP, Vodafone announced it's to leave the sport at the end of this year, after seven years as McLaren's title sponsor, during which time it was believed to have paid out $75m a season to have its name on the Woking team's cars.

There was some talk in the press that the withdrawal had something to do with the Bahrain GP controversy last year, but this seems unlikely, for while Vodafone was sensitive to events connected with the Arab Spring – it was forced to shut down its network in Egypt in 2011 – the pull-out actually follows an established pattern in the company's marketing strategy. In fact, Vodafone has also relatively recently discontinued its sponsorship deals with England cricket, Australian cricket, Manchester United and the UEFA Champions League football, as well as its deal with Triple Eight's Australian V8 Supercar squad.

McLaren's new title sponsor, replacing Vodafone, will be announced in December

The telecom giant also had a less than stellar year – by its standards – in the 12 months to March 2012 (year to 2013 results are due soon), reporting flat profits, which it put down to the economic downturn in Europe. Pre-tax profits for the year to 31 March were £9.549bn, up just 0.5 per cent from £9.498bn the year before. It had seen big profit increases over the previous two years.

Despite the loss of Vodafone, McLaren – which says it already has a replacement title sponsor lined up which is to be announced in December – believes that the sponsorship market in F1 is actually recovering. Its team principal, Martin Whitmarsh, said: 'The world economy certainly hasn't made it any easier, there's no doubt about that. But I think there's some positive signs in the market at the moment. People are seeing that Formula 1 is stabilising, and there have been some great world championships over the last few years.'

This view was backed up by Mercedes GP executive director Toto Wolff, who said: 'The financial crisis and the economic environment has a big impact. If big corporations have to scale down their investment, marketing or sponsorship is probably the first thing that you're looking at, but I guess the sport is in good form and good health.

'It's cyclical. It's going to come back, maybe in a different way, in a different form, maybe different kind of partners... we have seen Coca-Cola [Burn] coming into the sport; Blackberry, obviously, with us [Mercedes], has been a very important milestone for the team, so I don't feel so depressed for the sponsorship market.'

US sportscar scene stands United with new branding

The new for 2014 unified US sportscar championship has revealed its branding while it continues discussions over a title sponsor.

'United SportsCar Racing' is the new branding for the merged Grand-Am and ALMS, though whether it will be actually known as a series, championship or cup has yet to be decided.

The ALMS is backed by Tequila Patrón, while Grand-Am enjoys the support of Rolex. Grand-Am boss Ed Bennett said that both companies are keen to stay involved. 'As a part of the process of developing series sponsors to attach to the United SportsCar brand, we're going to talk to our current partners first,' he said.

The branding – which interestingly does not include the word 'America' – is the result of work completed by top US agency SME Branding, whose client list includes the NFL, NHL, New York Yankees and the Kentucky Derby.

Yet, while it was all change on the branding front, there was some continuity in the news that the new championship is to be run by IMSA, currently the organisation behind the ALMS. 'We made that decision not only because of IMSA's 40-year history but because of the legacy that this brand has, the tremendous equity that it has throughout our industry,' said ALMS COO Scott Atherton.

Racing OEMs perform well in brand stakes

Automotive brands with a presence in motorsport have scored well in recent research by a leading brand valuation and marketing expert.

The research by Brand Finance, which monitors and measures brand values across all industries and market places, showed that Toyota remains the world's most valuable car brand, with a brand value of $26bn.

Meanwhile, German marques have also shown well, with VW (WRC) increasing its brand value by 33 per cent (now $23.7bn) and BMW (DTM), Mercedes (F1, DTM) and Audi (WEC, DTM) all also increasing their brand values.

In contrast, troubled French-owned car manufacturer Peugeot, which quit the WEC last year, dropped 12 per cent in brand value ($6.64bn) – though it should be noted its pull-out was the result of the financial difficulties it was in already.

In the US, the big players have continued to grow, with Ford (NASCAR), America's most valuable car brand growing by 12 per cent to $19.6bn. Chevrolet (NASCAR, IndyCar) is the fastest riser, its brand value having risen 26 per cent to $6bn.

The research also showed that Ferrari (F1) is the world's most powerful brand, not just in the automobile sector, but across all categories and territories worldwide, though its smaller revenues mean that it cannot challenge the OEM giants in absolute brand value terms.

Bathurst eclipses Australian Grand Prix in money race

Higher spending by spectators has led to the success of the Bathurst 1000

The economy of the Australian state of New South Wales is AUS$55m better off thanks to the legendary Bathurst 1000 event, which is now making more money for NSW than the Australian GP does for its host state, Victoria.

A recent study, which was carried out by the Western Research Institute (WRI) and was commissioned by Bathurst Regional Council, showed that the 2012 V8 Supercar flagship event generated 17 per cent of the net inflow of money to NSW, derived from 56 major events and festivals held between July 2011 and April 2012. This compares well to the economic impact of other major events around Australia included in the study, such as the Australian Grand Prix, which brings in around AUS$39m to the Victorian economy.

Part of this is down to the spending of the spectators at Bathurst, with the latest figures from the WRI showing they are spending 27 per cent more than they did at the annual October event five years ago.

The Bathurst Council says a broad cross-section of participants including spectators, teams, the event promoter, contractors, media and suppliers, spent in total AUS$25 million in 2012, an increase of 18.7 per cent on the AUS$21.8 million they injected into the local economy in 2008.

It's not just about fan spending, though, and the event brings the equivalent of 255 full-time jobs in the Bathurst area. Many of these are in the hospitality sector where the race creates 97 positions and generates AUS$6 million in value.

'An event like the Bathurst 1000 requires a significant investment from business and government,' said mayor of Bathurst Monica Morse, 'but what this research shows is that the return on that investment can be very rewarding for all involved.'

The analysis for the WRI study was made on estimates in terms of dollar value added, contribution to household income and impact on employment to the Bathurst, Central West and NSW economies. A total of 828 visitor surveys were completed for the study along with a competitor survey and data gathered from the event promoter, police and Bathurst Visitor Information Centre.

SEEN: SINTER FORMULA FORD

The car that hopes to take the fight to the all-conquering Mygale in this year's new-look UK Formula Ford championship has hit the track for the first time, and its creator – Fluid Motorsport's Lindsay Allen – believes the Sinter will be more than a match for the French pacesetter. 'We have put a lot of effort into several areas of the car where we believe that an advantage can be gained,' said Allen. 'It is early days. This is its first proper run and there are some tiny issues which need to be addressed, but overall everything is looking very promising.'

Allen had hoped to run a Sinter in the first year of EcoBoost Formula Ford last year, but the project was delayed. Since then he has had to redesign the car to the new winged formula. 'We had to go back to the drawing board as far as the front end of the car is concerned,' he said.

The new manufacturer has also had some welcome help in completing the car from Radical Sportscars, which has setup a race team to run Sinters in the championship. 'Having Radical's facilities available to us has made a huge difference to the project,' said Allen. 'We would not be at this point now without their help.'

Radical boss Phil Abbott, whose son James is to drive a Sinter run by Radical, said: 'We were able to step in and machine a new bell housing for Sinter when Lindsay's suppliers let him down, and we turned virtually the whole Radical factory over to the job. But all the hard work is starting to pay off now, and although this is the Sinter's first proper time on track it's all very encouraging.'

DTM racing heading Stateside?

The Grand-Am Road Racing Association and the IMSA organisation have announced a licence and cooperation agreement with the ITR – the body which administers DTM racing – that could see the DTM cars racing in the US in 2015.

The agreement is the first step on the road to Audi, BMW and Mercedes to compete with factory programmes in the American market with their production-based cars. Following the agreement with the GTA for the GT500 cars to share technical regulations with the DTM, Honda, Nissan and Toyota also have the opportunity to race in the US, while American manufacturers Lincoln, Cadillac and Dodge have also been targeted.

'The new partnership between the parties will further increase the value of DTM, Grand-Am, IMSA and the Super GT,' said GTA chairman Masaaki Bandoh. 'This would be the opening of the doors for the globalisation of GT/Touring car races. We have to take this opportunity to cooperate.'

Jens Marquardt, whose BMW brand entered the DTM in 2012 on the understanding that it would compete in multiple racing series with the same platform, welcomed the move. 'We are extremely open-minded regarding these plans,' said Marquardt. 'The North American market represents the biggest market area for BMW in general and the biggest market aread for BMW M vehicles too.'

BRIEFLY

Decent exposure

Austin's inaugural Formula 1 race last year attracted media coverage said to be worth £128m. The figure comes from F1 industry business monitor Formula Money, which said the amount comprised £112m in exposure through TV broadcasts and a further £16.3m through mentions of the Texan city and F1 in online and print media. The analysis also showed that the sponsor that received the best exposure during the race was Pirelli, which took several prime trackside slots and gained exposure worth £16.4m. Other brands to show out well during the US GP weekend were Red Bull (£12.9m), LG (£9.4m), Verizon (£9.4m) and Lotus (£6.4m).

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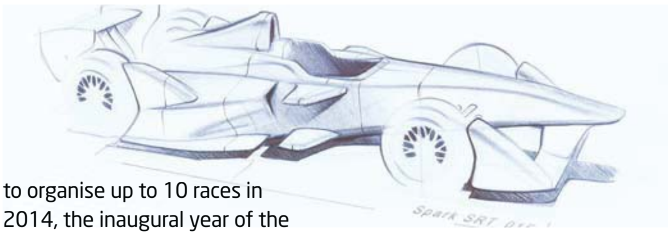
Formula E street races on as battery market grows

The Formula E electric car racing championship seems to be gathering momentum with a preliminary calendar and new stakeholders announced, all against a backdrop of growing sales of lithium-ion batteries.

Formula E Holdings (FEH), the promoter of the FIA Formula E Championship, has unveiled a calendar which includes eight cities which it hopes will host its street race format events. These are: London, Rome, Los Angeles, Miami, Beijing, Putrajaya (Malaysia), Buenos Aires and Rio de Janeiro.

FEH says that since its launch in August 2012 it's received formal demonstrations of interest to host a race from 23 cities across five continents. It intends to organise up to 10 races in 2014, the inaugural year of the championship. A further two slots will be kept free, to include two additional cities from the others that have expressed interest, and the final calendar will be presented to the FIA for its approval at the September 2013 World Motor Sport Council.



Yet while the London race has generated much excitement, and the backing of the city's mayor Boris Johnson, it will first need to negotiate the barrier presented by UK law, which doesn't allow races to be held on the public road.

Meanwhile, Spark Racing Technology has revealed that Dallara is to be responsible for the new chassis (see above), with FE being run as a spec series for its first year.

Frédéric Vasseur, president of Spark Racing Technology, said: 'I have worked with Dallara for over 20 years and I have all the respect in the world for Mr Gian Paolo Dallara, who is one of the greatest figures in world motorsport, as well as for his closest collaborators. It is with great pleasure that Spark Racing Technology will join him and benefit from his expertise and know-how.'

A second team has also been announced, FIA Formula E Team China Racing now joining Drayson Racing as the only confirmed entries. The operation is run by Yu Liu, who was also behind the Chinese national programmes in A1GP, Superleague Formula and the GT1 World Championship, and has promoted various motorsport events in China.

Meanwhile, analysis undertaken by Frost & Sullivan suggests the lithium-ion (Li-ion) battery market is growing quickly, earning revenues of $2.13bn in 2012, and it estimates that this will climb to $12.84bn by 2019.

SEEN: HYUNDAI I20 WRC

Here's the latest version of the Hyundai World Rally Championship challenger**,** which is currently in development and is set to hit the stages next year. 'We are still in the infancy of our exciting WRC programme, so the development curve for the car and team is steep,' said Hyundai Motorsport team principal Michel Nandan.

'This latest version of the i20 WRC has centred on aerodynamics with the objective of improving the car's cooling systems. A new rear wing and front spoiler give the i20 WRC a new external appearance while, under the bodywork, improvements have also been made to the suspension kinematics and chassis stiffness as we gear up for a more structured test programme later in the year.'

BRIEFLY

Alpine return

Renault is to return to Le Mans this year through its Alpine performance brand. The deal essentially involves the rebadging of the Signatech LMP2 team, with the logos of Renault's sister company Nissan being replaced by that of Alpine on the car's V8 engine. The new Alpine LMP2 will compete in the WEC and the 24 Hours.

Ford scoops its second NASCAR business award in Las Vegas

Ford has won the NASCAR Driving Business Award for 2012, becoming the first company to pick up the prestigious accolade on two occasions after it closed a succession of deals made within the NASCAR sponsorship community last year.

The Blue Oval was presented with the award at a ceremony in Las Vegas in March, during the NASCAR Fuel for Business (NFFB) Council. The NFFB is an exclusive group of more than 55 official NASCAR partners which aims to help them get more out of their sponsorships, chiefly by getting partners together four times a year to buy and sell products and services.

NASCAR maintains that the NFFB environment offers a unique opportunity for many Fortune 500 companies to bypass the time and the layers of corporate obstruction that may exist, and to make customised deals to help address their specific needs. NASCAR's Driving Business Award is given to the official NASCAR partner that demonstrates extraordinary leadership and results through its participation in the NFFB Council.

Ford Motor Company has been a member of the NFFB Council since 2007. NASCAR says that the company brings key personnel from across its organisation and matches them up with their counterparts at other NFFB companies during the council's signature Speed Meetings. The Blue Oval's effort to sell vehicles to other NFFB members through its Partner Recognition Programme has been especially noted. As a result of Ford's participation in the council in 2012, it forged a number of business-to-business alliances with official NASCAR partners. According to its data, Ford sold more than 5500 vehicles to partners, with one of its largest vehicle sales deals said to be worth more than $5m. Meanwhile, co-marketing promotions have been run with 12 council members.

'Winning the Driving Business Award for the second time in the past three years is a direct reflection of Tim Duerr, our motorsports marketing manager's dedication to the NASCAR Fuel for Business Council and the value it provides to our brand,' said Jamie Allison, director at Ford Racing. 'As a proud member of the council, we are continuously developing new strategies to drive business and this platform has proven to be a particularly effective tool in generating positive return on investment.'

Ford sold over 5500 cars to partners in 2012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INTERVIEW: PAUL BRANTON

Paul Branton, managing consultant for Jonathan Lee Recruitment, has been in the business since 1988, and for the past 13 years he has worked largely on the motorsport side of it. Branton is also a member of the motorsport employers group within the Motorsport Industry Association. Jonathan Lee Recruitment is based in Stourbridge in the west midlands of England, and it has specialised in the engineering and manufacturing sectors for more than 35 years.

Q. What advantages will a motorsport company gain from using an agency?
It's mostly the networking ability that we have. Our job is to recruit people, and that's what we're doing, day in, day out. We specialise in having conversations, going out there, finding those people and asking: what are you up to? Are you looking? So, when a company does come to us we're ready.

We can go out into the marketplace, which they haven't got the time to do themselves. These are niche skills, which are harder to find. It's our job to increase those applications by talking to more and more people. We are specialists at finding these people.

Q. Is there still crossover between mainstream sectors, such as aerospace, and motorsport, and do teams prefer people with motorsport backgrounds?
There is a lot of crossover. Teams would rather have the experience. But at some point a person needs to be given that experience. This is something we're going through with clients all the time – it's not always about the experience, it's about the attitude. Skills and knowledge can be trained, but it's having that time to invest in those people to enable them to be there. We have clients that come to us and they say: 'We're looking for this skill'. And they will wait three to six months for that skill. Yet if they had somebody in who had, say, 75 per cent of what they were looking for, then they could have trained them up to 100 per cent in that same time period.

Q. How difficult is it to find someone with the requisite skills for high-end motorsport?
Finding them is not too bad. With all the tools that are available to us these days, we can find these people – it's encouraging them out which is always going to be the hardest thing. Because they're already paid very well, and they become loyal to their team – which is only right – you have to show that there is an opportunity for them.

Q. What are the frustrating aspects of the work you do?
One of the biggest factors stopping people moving at the moment is relocation issues. People aren't able to sell their houses because of the property market, and that's stalling the marketplace, making it a little bit harder. Also, the momentum at which companies work when they do have a vacancy, and the speed at which they respond to candidates – one of our biggest bugbears is getting feedback from clients on candidates when they've reviewed their CV or interviewed them. If you've got a good candidate, you have to make them feel that people are interested in them, because you're setting this expectation, this company is really interested in you. It's a flattery thing, but it also keeps the momentum, and you're more likely to capture them at the end of it.

Q. How important is the salary that is offered?
Somebody might be on £50,000, and the company will offer £53,000. Well, typically the candidate is going to go back to their own employer, hand their notice in and the employer's going to say: 'what can I do?', and they then match it or they better it, because they can't afford to lose people. There's a lot of this going on – it's gazumping. We saw this in the estate agent business, now we're seeing its return in the recruitment business. You might have had to wait three months for that person – six months in the case of some of the teams – and then you're back to square one again.

Top rally squad gets British GT programme on track

Crack WRC team M-Sport is to make sure its workforce is completely match fit when it comes to running a race team later this season by fielding an Audi R8 in the early rounds of this year's British GT Championship.

The former works-backed Ford rally team, which still runs the Blue Oval Fiestas in the World Rally Championship, is to build and campaign the new Bentley Continental GT3 car, which will hit the track in the summer. But in the meantime the squad intends to get itself race sharp by running an Audi LMS.

M-Sport's only previous experience on the racetrack was when it fielded a T-Car – a now defunct silhouette series for junior racers which managing director Malcolm Wilson's son, Matthew, won in 2002.

M-Sport will run the Audi R8 in early rounds of the British GT championship

While the R8 venture is independent of Bentley, John Wickham, who is to coordinate the GT3 project for the luxury car manufacturer, will also take on a team management post at M-Sport's Audi races.

'Since the announcement at the end of last year that M-Sport will make a new venture into circuit racing, the team has been working tirelessly to ensure that we are as fully prepared as possible for this new project,' said Wilson. 'Running the Audi R8 LMS in the British GT Championship will allow the team to gain a wealth of knowledge and experience and be as fully equipped as possible for the exciting challenges ahead.'

The Cumbria, England-based organisation has thus far only committed to the first four British GT rounds with the Audi, but may complete the series, Wilson has said. The Bentley GT3 car is due to race for the first time before the end of the season, ahead of an attack on the Blancpain Endurance Series in 2014.

Developed by Audi in 2008 and launched in 2009, the R8 LMS has taken no fewer than 157 victories from 579 races. The vehicle used by M-Sport Racing will be a 2013 evolution, boasting upgrades to the engine, brakes, chassis and aerodynamics.

Clampdown on F1 teams massaging staff numbers

The FIA has moved to restrict the use of physiotherapists to perform duties other than their core work during grand prix weekends.

There has been some controversy over the use of physios in work outside their regular remit, such as holding pitboards or fitting tyre blankets, and this has now been brought sharply into focus with the FIA's clarification of the amount of operational staff – that is the number of employees concerned with the actual operation of the car – a team is allowed on its books.

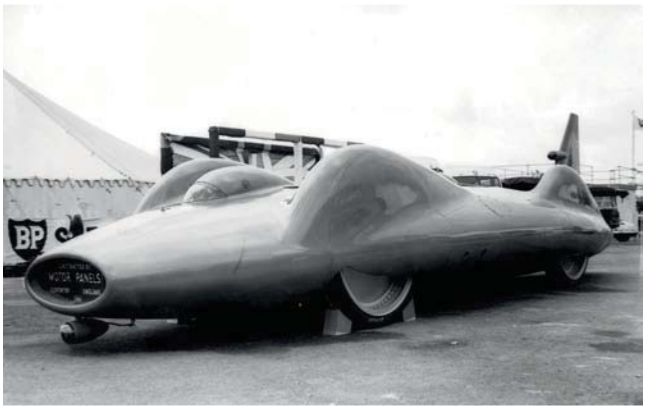
This year the FIA has stipulated that the maximum number of operational staff is 60, with a smaller list of exceptions allowed. Previously, under a FOTA-agreed rule, it was 48, but with a much larger list of exceptions. Exceptions currently include the team president, CEO, reserve driver and medical doctor.

However, there has been some debate over where a driver's physio might stand in all this, as FIA Formula 1 race director and tech head Charlie Whiting explained.' There was some discussion about physios,' he said, 'but opinion was divided and no specific provision was made for it. What became clear is that physios did different things within different teams. Some would literally only look after the driver and so how could you say he is involved in the operation of the car?'

'I felt the best interpretation is that if a physio is just doing what everyone would deem the duties of a physio and not doing any other tasks he should not be counted within the 60. Some teams disagree, but we have made our position clear.'

At least two teams have had to change the way they work because of this clarification.

Technical Excellence – the result



We were staggered by the number of votes cast in response to our Technical Excellence feature than was featured ahead of the Autosport International Show in January, and would like to thank all those who took the time to get involved.

Leading engineers were asked to nominate what they thought was the greatest technical of the last 50 years, and from that shortlist, we asked that you join the debate.

Adrian Newey won the audience vote for his nomination for technology transfer, citing Donald Campbell's Bluebird-Proteus CN7 (pictured). He fended off Ross Brawn's nomination for aerodynamic advances, which itself narrowly beat Norbert Singer's nomination of carbon fibre.

A selection of those who voted for Adrian Newey's design will receive a copy of the Who Works In... guide book.

RACE MOVES

Paddy Lowe has been put on gardening leave by McLaren following his decision to switch to Mercedes in 2014, when his current contract with the team comes to an end. Lowe moved from Williams to McLaren in 1993 and had been the technical director since January 2011. It is not yet known what position Lowe will take at Mercedes, but there is a possibility he might take on the role of team principal should **Ross Brawn** decide to retire.

Tim Goss is the new technical director at McLaren, replacing **Paddy Lowe** in the position (see above). Goss is a McLaren stalwart, having joined the team back in 1990. He has worked as director of engineering at Woking since the beginning of 2011.

Hari Roberts has joined the Caterham F1 team as its head of aerodynamics. Roberts, who has previously worked at Jordan, Renault and most recently Lotus and is said to have a wealth of aerodynamics, simulation and trackside experience, will work closely with Caterham technical director **Mark Smith** and performance director **John Iley.**

Lady Virginia Williams, the wife of Williams F1 team founder Frank, has died at the age of 66. A statement from the team said: 'Lady Virginia, or Ginny as she was better known, died peacefully at the family home last night surrounded by Frank and the rest of the Williams family. Ginny had been bravely battling cancer for the past two-and-a-half years.' The team planned to announce the appointment of Claire Williams as deputy team principal at the start of the season, but delayed it following Lady Virginia's passing.

Rob Dijkstra (pictured) has joined well-known Netherlands-based simulator specialist Cruden, where he takes on the position of sales manager. Dijkstra will be responsible for the company's sales in the automotive, motorsport, attractions and research sectors.

Stefanie Olbertz (above) is now responsible for Falken Tyres' Motorsport activities across Europe, including its German VLN campaign with a Porsche 997 GT3 R.

Malcolm Swetnam has been recruited to run the new Murphy Prototypes squad – a team set up by Irish businessman Greg Murphy, who has previously had his LMP2 ORECA-Nissan car tended by RLR. Former RML engineer **Michael Jakeman** will oversee technical matters at the new team.

High performance coating specialist Zircotec has now started to run a nightshift, and has recruited **Mark French** and **Monty Green** to work in the production area. Meanwhile, **Liz Turley** has come onboard to work in sales administration.

Gerard Lopez, boss of the Lotus F1 team, staked the winning bid for a pair of driving gloves used by **Ayrton Senna** when he was on his way to winning his third world championship back in 1991. Lopez paid £22,000 for the gloves at an auction held for **Jackie Stewart's** Grand Prix Mechanics Charitable Trust. In total, the auction raised more than £92,000 for the cause.

James Strong, the chairman of Australian V8 Supercars, has died at the age of 68. Strong, who had only taken on the job of running the series at the end of 2012, had previously worked as head of the Qantas airline, while in the past he had also taken on roles with the Australian Grand Prix as well as with MotoGP promoter Dorna Sports.

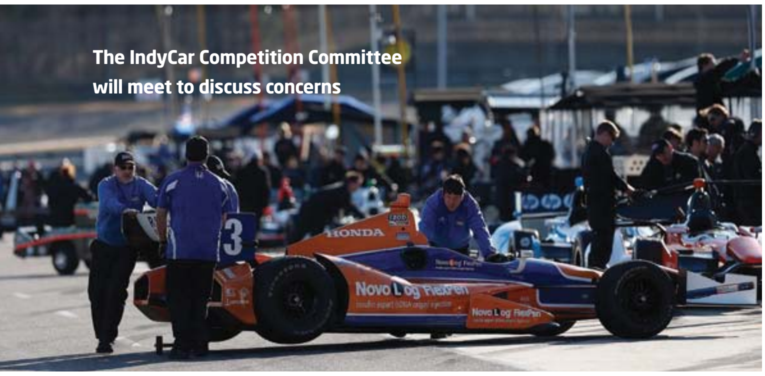
Benjamin Franassovici, SRO's British GT Championship coordinator, was presented with the British Racing and Sports Car Club's (BRSCC) John Nicol Memorial Trophy at the club's awards event for the 2012 season. In announcing the award, BRSCC chairman **Bernard Cottrell** said: 'Benjamin has solely been responsible for turning around the British GT Championship.'

IndyCar by committee

IndyCar is to form a Competition Committee to give teams and other stakeholders in the series a way of discussing their technical and sporting concerns.

The committee will meet regularly to discuss regulations, technical specifications and safety, although will not have rule-making power. It will make recommendations to the sanctioning body.

The committee will include two team representatives, four manufacturer representatives from the series' engine, tyre and chassis manufacturers, two drivers appointed by the driver group, and one at-large member appointed by the IndyCar CEO. Other stakeholders in the series, such as track owners, promoters and broadcasters, can also be invited to attend meetings.



The IndyCar Competition Committee will meet to discuss concerns

UK government boost for motorsport valley

The UK government has announced a £1.2m cash injection into motorsport and other high performance technology sectors in the Silverstone area.

Vince Cable, secretary of state for business, innovation and skills, says the aim of the new funding is to bolster an already successful industry in the county of Northamptonshire, the home to Silverstone and many other motorsport companies. The funding is to help companies in the motorsport, aerospace and defence industries which are looking at investing in new equipment, machinery or premises, or are trying to develop new research. It is hoped the fund will enable the creation of 300 new jobs in the area. Cable told local press outlets that the new funds would strengthen engineering in the county. 'There is a lot of job growth in Northamptonshire despite problems in the economy generally,' he added.

Tim Bagshaw, from the Northamptonshire Enterprise Partnership (NEP), which is overseeing the fund, said: 'High performance technology is an incredibly important industry to the Northamptonshire economy, and with such a large proportion of the industry being smaller businesses, it has powerful potential to grow. Access to finance is a major restraint to growth so we're delighted to launch such a considerable fund to help address this issue.'

For details of how to apply for the funding visit www.northamptonshirelep.co.uk

BRIEFLY

iSport out of GP2

New squad Russian Time is to replace series stalwart iSport on the GP2 grid this year, after the British team decided to sell its entry because it was unable to find drivers with the required €1.8m budget for the season. The 2007 championship-winning outfit, which has been in the series for eight years, has sold its entries and cars to the German-based Russian team, which although new to the formula is said to be staffed with a core of experienced GP2 hands. The new team is headed by Igor Mazepa.

Circuit of Wales latest

Plans for the proposed Circuit of Wales development have now been submitted and the planning authority of Blaenau Gwent Council is expected to come to a decision over whether it will go ahead in May. The development, which would include a technical park for motorsport businesses, a motorsport race academy, retail floor space, a hotel and other leisure activities, is centred on a 3.5-mile circuit which would be built to FIA international standards.

British Rally Championship – officially good for business

The UK rallying community will be heartened by the results of a brace of economic impact surveys that show British Rally Championship (BRC) rounds really are good for business in the areas in which they take place.

Independent studies carried out last year by the relevant town councils for the Ulster and the Yorkshire rallies came to the conclusion that both events provided a 'significant' economic boost to local business, travel and leisure industries.

Taking into account both surveys, which covered spectators and teams, an average attendance of over 20,000 people boosted the local economies by £1.75m over a rally weekend. Based on this evidence, seven rounds of the BRC project a benefit to the UK economy of over £12m, the BRC claims.

The latest report, issued by Rally Yorkshire which was the final round of last year's championship, determined that out of the attendees 63 per cent were aged between 25 and 59, a third were female, while 61 per cent of the visitors were from outside of the local region, staying for an average of three nights. For 20 per cent of spectators it was their very first rally.

All of this contributed to a direct economic impact of actual money spent of £1,021,735 for the UK economy as a whole and £976,735 for the local economy. Induced economic impact – the continuing effect of the actual money spent through the economy – averaged at £1,524,237 for the UK economy as a whole and £1,450,339 for the local economy.

British Rally Championship manager Mark Taylor said: 'Information like this is invaluable to the events and the sport as a whole, which is why we have made it a requirement for the each of the BRC events to work in partnership with the local authorities to carry out independent surveys in 2013.

'It is just fantastic to know that the events that make up the BRC raise in the region of £12m for the UK economy, providing much needed income to local communities and businesses in this difficult economic period.'

Rallying attracts an audience of 61 per cent from outside the region

McLaren awarded for environmental excellence

McLaren has become the first motorsport organisation to pick up the FIA Institute's Environmental Award for Achievement of Excellence.

The award is part of a joint FIA and FIA Institute initiative which is aimed at evaluating and reducing the environmental impact of motorsport. It's also said to be the highest level attainable within the FIA Institute Sustainability Programme, which helps motorsport companies to measure, improve and be recognised for their environmental performance.

McLaren team principal, Martin Whitmarsh, said: 'We're delighted to receive this Award for Excellence from the FIA Institute. It's great that the sport is encouraging those within it to improve their environmental performance, and we are thrilled to be the first to achieve the highest level.'

FIA president, Jean Todt, said: 'McLaren's award is an important step in the recognition by motorsport of the social responsibility our community must acknowledge if our championships are to remain in tune with the key environmental debates we are all a part of. The FIA and the FIA Institute are researching the environmental impact of motorsports across all our world championships.'

BRIEFLY

HRTs sold for scrap

It has emerged that the cars used by the HRT team in 2011 and 2012 have been sold for scrap. A Madrid-based auto-recycling company owned by Teo Martin has bought the majority of the material assets of the bankrupt Spanish team, including three of the 2012 cars, two 2011 chassis, a scale model of the 2012 car and the garage equipment. One of the 2012 cars has gone to Pirelli to use for promotional purposes, while all engines have been returned to Cosworth and the gearboxes have gone back to Williams.

SPONSORSHIP

Global information services company **Experian** has signed up to partner the **Williams Formula 1 team**. Experian's logo will be visible on the chassis side and front wing of the Williams-Renault FW35, and will also appear on each driver's overalls, their helmets, and team personnel kit. Experian helps businesses to manage credit risk, prevent fraud, target marketing offers and automate decision making. It also helps individuals to check their credit report and credit score, and protect against identity theft. Experian's total revenue for the year ended 31 March 2012 was $4.5bn.

PaucoPlast, a company specialising in the manufacture of carbon composite parts, has signed a deal to become a partner of the **Sauber F1 team.** The company, which has been a supplier to the Swiss team from its earliest days – the relationship goes back as far as 1973 – will now see its logo on the rear of the sidepods on the car as well as on the team's equipment.

Prevost has signed a new multi-year partnership with **NASCAR** which will see the motorhome manufacturer become the official luxury motorcoach of the premier US stock car series. The company, which is owned by the **Volvo Group,** already builds motorhomes for a number of NASCAR team owners and drivers.

On top of its commitment to support the **LADA team** in the World Touring Car Championship, Russian oil giant **Lukoil** has now also signed to back the RML-run Chevrolet Cruze of Yvan Muller.

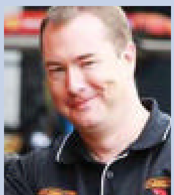
RACE MOVES

Howard Strawford, the owner of the popular Castle Combe circuit in the west of England, has died at the age of 77 after suffering a major stroke. Strawford and his wife Pat bought the circuit in 1976 and went on to make it possibly the most successful club racing venue – certainly in terms of spectator numbers – in the UK.

R David Jones, 75, has retired from the position of Area 7 representative on the Sports Car Club of America (SCCA) board of directors. Jones is a former chairman of the US road racing club, a member of its Hall of Fame and a winner of its Woolf Barnato Award, the highest individual honour presented by the SCCA. He is also still an active competitor with the club, racing a Formula Vee and a Formula Mazda. **Dan Helman** has replaced Jones on the board.

Chris Berg is to fill the newly created post of public relations coordinator for the Sports Car Club Of America, Inc and SCCA Pro Racing. He will now be the main point of contact for on-site media on behalf of SCCA Pro Racing at each Mazda MX-5 Cup and Pirelli World Challenge Championship race. He will also handle other assignments for SCCA's Club Racing, Solo and Rally divisions.

NASCAR has reinstated former Sprint Cup Series crew member **Jerome Frey** after he successfully completed its Road to Recovery Programme. Frey was indefinitely suspended from NASCAR back in August 2011, when it was discovered that he had violated the governing body's strict substance abuse policy.



David Addison

LAT

Carlos Garcia, the FIA's vice president and the head of Spain's motoring association, has had his driving licence taken from him after he was caught drink driving. The incident took place in Zaragoza, Spain, in October of last year and Garcia has now been banned from driving until June of this year.

Wilson Fittipaldi Sr, father of Emerson and Wilson Jr, a prominent motorsport broadcaster and one of the men responsible for bringing Formula 1 to his native Brazil, has died at the age of 92.

British prime minister **David Cameron** (above) has paid a visit to Caterham Group's Leafield Technical Centre, the home of its F1 team since August last year, which lies within the PM's constituency. Cameron said: 'It is businesses like this which are helping to lift our economy out of a very difficult time and making sure that Britain thrives in the global race. I am so excited to welcome this great business to Leafield and I wish them every success.'

Bosch, the global supplier of technology and services, used the UK's National Apprenticeship Week to highlight the range of engineering apprenticeships it has available. Among its 6500 apprentices worldwide is one who, through his work for the Bosch Engineering Group, has helped support the Audi team at Le Mans.

Ralf Schumacher has quit the driving seat to take on a managerial role. The former F1 driver, who for the past few years has plied his trade in the DTM, will now work with Mücke Motorsport, while also taking on driver coaching duties for Mercedes.

Alain Prost is to take on a wider role within Renault as a consultant within its engine supplier division Renault Sport F1 this year. The four-time world champion, who has been a brand ambassador for Renault since 2012, will also assume an advisory role within the Renault Sport F1 executive committee.

David Addison (pictured above) is the new lead commentator for ITV's coverage of the British Touring Car Championship, replacing **Toby Moody**.

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

GEARBOXES

Hewland transmissions

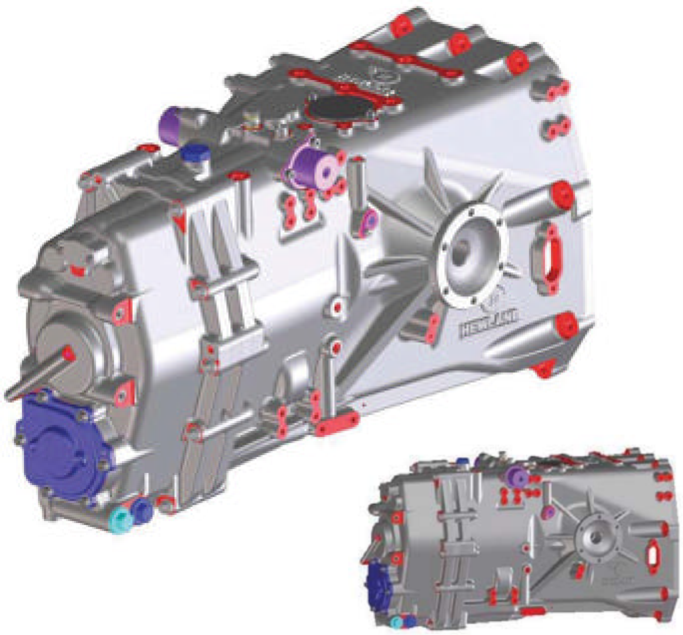
Hewland Engineering has further enlarged its transmission range with two new gearboxes, the LLS-200 and LWS-200, and the ED-200 differential.

The LLS-200 gearbox is a 6-speed and reverse 'off-the-shelf' unit designed for mid- or front-engined rear wheel drive sports cars in GT racing. The bigger brother of the LLS-200 is the LWS-200 gearbox, which has been designed for low-revving, high torque engines.

The LLS-200 and LWS-200 will replace the NLT gearbox; a unit that has been part of Hewland's standard product range since the 1990s. As Hewland has continued to innovate and adopt new technologies in its later transmissions, the NLT required an update with the latest design features. The new design can also integrate any features related to a pneumatic paddle-shift system.

The ED-200 differential unit has been designed to mate with in-line gearboxes such as the Hewland IGTC gearbox, and for the first time is available to purchase directly from Hewland. Hewland state that this high-end diff unit is the answer for most serious rear-drive axle cars.

For more information go to www.hewland.com



LUBRICATION

New vegetable-based fluid

Blaser Swisslube's expertise in creating vegetable-based metalworking fluids has led to a breakthrough in the machining of titanium, particularly in aerospace applications where stable, and safe working environments are paramount.

The new vegetable ester oil-based, micro emulsion from Blaser Swisslube – Vasco 7000 – is a high performance metal cutting fluid specifically targeting what are seen as difficult-to-machine materials, including titanium and nickel-based alloys. Its composition excludes the use of chlorine, boron, formaldehyde and zinc, making it safe for operators, components and machine tools.

During customer trials, Vasco 7000 has been benchmarked against competing metalworking fluids and Blaser claims its product has consistently outperformed them in terms of increased tool life, and longer sump life.

For more information visit www.blaser.com

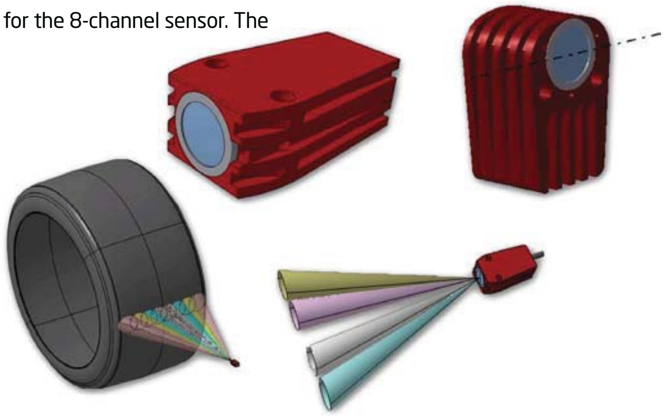
SENSORS

New Variohm range

Sensor manufacturer Variohm has launched a new range of 4- and 8-channel IR tyre temperature sensors aimed at motorsport and automotive testing. The CANbus interfaced IRN4C and IRN8C models from Texense provide temperature readings across the width of a tyre or shaft at four or eight points with response times to 260msec and accuracy within +/-0.1 per cent FS up to 200degC.

The multi-channel sensors can be supplied with front-facing or right-angled lens exit configurations to suit your installation requirements, and can be setup to measure across total widths up to 304mm for the 4-channel version or 532mm for the 8-channel sensor. The field of view for each individual lens determines the actual measurement area, and by setting the sensor further from the tyre, the target diameter increases. As a practical indication, the maximum distance for the 8-channel version is 700mm for a target diameter of 105mm. The minimum distance for the 4-channel version is 50mm and its target diameter is 15mm. Both versions can be supplied in a choice of two temperature ranges: -20degC to +140degC, or -20degC to +200degC, with a supply voltage between 6 and 16V.

For more information on these sensors log on to www.variohm.com



HAND TOOLS

Ratchet wrenches

We do not often feature tools in *Racecar Engineering*, however these ratcheting ring spanners are an exception. Firstly they are designed to save time – always useful in a racing environment – and secondly, they can reduce tool inventory, also helpful when every space in the transporter counts. The neat feature of these ratchets is that each double-ended unit will in fact fit two different sized bolt heads, meaning that the standard range from 10-19mm can be covered with just three spanners. The head thickness is not compromised, so access to confined fasteners is possible. All in all these look like a worthy addition to any pit box.

For more information visit www.britool-expert.com


elf
3


NISSAN

THROTTLES

New Jenvey Duratec throttle bodies

Fuel injection specialists Jenvey have recently launched a new throttle body conversion kit for the 2.5-litre Duratec engine. The kit contains everything required to convert the engine to twin DCOE-style throttle bodies and includes a pair of lightweight twin choke throttle bodies mounted on a manifold. A fuel rail and four 90mm-long Jenvey aluminium air horns and mounting bolts are also included in the kit.

Log on to www.jenvey.co.uk to find out more

CONNECTORS

Altair's latest connector

The extensive use of vehicle simulation and CFD tools has seen cluster computing become commonplace within motorsport, an approach that provides effective computing power without having to invest in high cost, multi-core machines. And now Altair, a global provider of simulation technology and engineering services, has recently announced a new connector to aid in the implementation of cluster computing solutions.

The new connector allows the integration of Altair's workload management product, PBS Professional, with the HP Insight Cluster Management Utility (CMU) for cluster lifecycle management. Altair has accomplished this integration using a 'connector' that furnishes seamless integration and provides the administrator an interface to automate 80 per cent or more of the administrator's tasks. The CMU PBS Professional Connector simplifies cluster deployment and automates the most common tasks for managing a PBS Professional cluster via CMU.

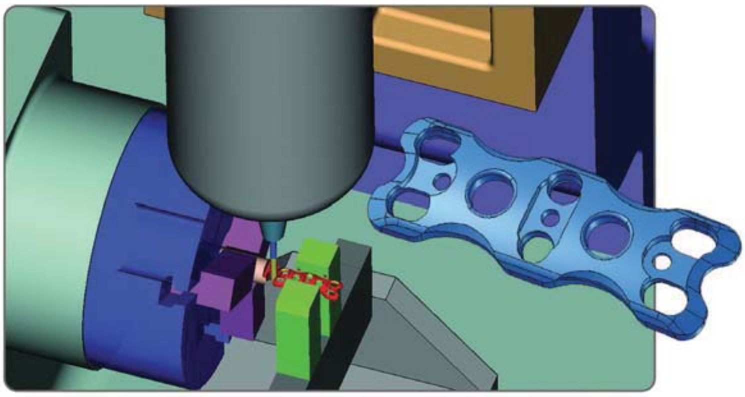
The HP Insight CMU is an efficient and robust hyperscale framework for cluster lifecycle management, and offers a suite of tools for large Linux clusters such as those found in high performance computing (HPC) environment.

Better integration of the Insight CMU makes the management of a cluster more user friendly, efficient, and error free than if it were being managed by scripts, or on a node-by-node basis.

For more information, check out www.altair.com

SOFTWARE

Delcam PartMaker Viewer



CAD/CAM specialists Delcam has launched a free downloadable utility called PartMaker Viewer.

This enables 2D prints, 3D models and even complete 3D assemblies to be viewed and allows PartMaker users to collaborate with others within or outside of their own organisation. With PartMaker Viewer anyone can see the work being done in PartMaker by simply exporting a file from PartMaker's Simulation as an STL and bringing it into PartMaker Viewer.

Visit www.delcam.co.uk to find out more

CARBURETTORS

Mighty Demon carb

US-based Demon Carburetion has introduced a new 850cfm carburettor with annular boosters for high performing, big-block engines and large displacement or high-revving small blocks.

Prepared with 1.560in venturii and intended to operate with 425 to 540cu in engines with camshaft duration of 240-plus at 0.050in valve opening, the new carburettor is aimed squarely at high-performance racing applications. With mechanically operated secondary throttles and equipped with removable air bleeds and idle-feed restrictors, it possesses all the features of the company's former Race Demon with the exception of removable emulsion bleeds and boosters.

The removable idle-feed restrictors are particularly helpful for perfecting the idle mixture on individual engine combinations.

For more details visit www.demoncarbs.com

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Land of opportunity

The 1999 Le Mans 24 hours featured no fewer than six manufacturers, including BMW, Audi, Mercedes, Nissan and Toyota, plus Panoz. The following year, only Audi and Panoz remaining from the previous year, alongside newcomers Cadillac, and by the end of the 24 hours, with victory in the bag, the expectation was that Audi would exit, stage left.

Instead, Dr Wolfgang Ullrich, head of the motorsport department, stated that he wanted to come back, win three Le Mans, and claim the trophy. This Audi did, winning in 2001 with the first Direct Injection engine, and again in 2002, becoming the first manufacturer to have the same three drivers win three in a row, and in essentially the same car.

So, when in March Dr Ullrich announced that he wanted to find a way to return to America in 2014, it immediately became a topic of serious discussion. During these discussions, it became clear that there was a dearth of opportunities for European manufacturers with a full works programme Stateside, and that firms would have to take their DTM cars to the US and setup their own series which would be managed by IMSA. This, unsurprisingly, occurred.

The problem is that the American racing scene has taken such a pounding that there are few options for a manufacturer. IndyCar is a spec Dallara chassis, and to produce an engine was of no interest to European manufacturers such as Porsche. Wolfgang Duerheimer confirmed in 2010 that, if Porsche was to do top level motorsport programme, it would need to be able to influence the entire team, including chassis, engine, and strategy. Grand Am has homologated only three chassis manufacturers in 2013, so engine supply is the only route there, too.

What else is there? The only way to stay in the USCR programme is to build an LMP2, but you are compromised on quality of drivers by regulation. There were rumours at Sebring of a breakaway championship with LMP1 cars. This does not strike me as a good idea. Grand-Am and the ALMS banged heads for years, and what would a new series achieve?

Jens Marquardt was equally unequivocal in his statement of the importance of the American market to BMW with a factory programme, hence the GTE Z4 programme. BMW's year-end report detailed a 13.8 per cent increase in sales in the USA, and an 11.8 per cent increase in the Americas. This pales to insignificance compared to the Asian market, however. In China, the number of BMW Group cars sold rocketed by 40.1 per cent in 2012.

This does explain the urgency that the European manufacturers have placed on developing racing series in the Asian market, and why the Automobile Club de l'Ouest is trying to establish an Asian Le Mans Series. However, that market does not need European manufacturers, or European-style racing.

The GT500 cars are considerably more interesting and powerful, and will go hybrid. They bought into the DTM philosophy for chassis construction, and they will use the front splitter, floor, rear diffuser and rear wing, and may also use the transmission, driveshafts, uprights and perhaps also the dampers and brakes. Tyres too will be the same size, although the Japanese will remain multi-brand.

BMW committed to DTM as it can race the same chassis in multiple markets

BMW committed to DTM on the basis that it could race the same chassis in multiple markets. The Japanese deal was critical, as is that struck in America. This is clearly a good move for the Americans – they asked for a reputed $15m/manufacturer to host this new series, and it appears that the German manufacturers were happy to pay to hit this market.

'The next steps in this process will involve further discussions with various automotive manufacturers, whose commitment to this concept is essential if a North American DTM-style series is to become a reality,' said the press release. The new series is aimed at attracting Cadillac, Lincoln or Dodge within the framework. Technical innovation will be limited, and the DTM announced a crude version of DRS for this season. But while this globalisation grates for us at *Racecar Engineering*, for manufacturers it is the holy grail – affordable racing, multiple markets, and with an extreme product-based look that will help to sell cars.

EDITOR
Andrew Cotton


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