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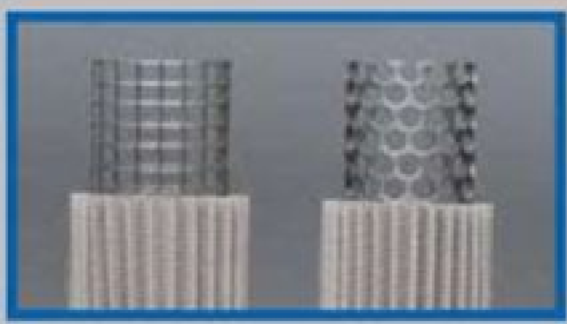

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The generation game

Data data everywhere, and not a thought to think…

The number of people and cars in the world is increasing, without an infrastructure to cope. With this in mind, let's start this month with some random facts…

1. The automobile is part of life. More than 1 billion cars circulate, and trends suggest that number will double by 2020. The European manufacturing and servicing industry employs more than 12m people, 6% of the working population.

In the US, it consists of 4.5%, or 8m jobs. Sixty million cars were added to the world fleet in 2011, in the middle of a worldwide recession. The majority of growth is in Asia, Latin America and Africa.

2. The average mileage of an automobile worldwide has been decreasing in most first world countries, despite the fact that 70% of all trips are made in cars. A recession and increasing fuel prices have their role to play, but the trend is there, and shows a car saturation in the G20.

3. More people now live in towns than in the countryside. In fact, since 2009 urban population accounted for more than half of total global population, up from 33% in 1960.

In the growing world, more cars come into circulation than roads are built for them. I expect the world will end not with a sigh or a whimper, but with a traffic jam.

4. Urban planning has, since the 1930s, catered for cars, but the trend today is towards infrastructure and mass transport, bus and cycle lanes. The pool of cars in America already outnumbers the licensed drivers, and these drivers are from an increasingly old age group.

5. I was born in a world of 2.4bn people. Today we have 7.2bn. In 2030 we are predicted to have over 8bn. By the middle of the 21st century, it is estimated that the urban population will more than double, increasing from 2.5bn in 2009 to almost 5.2bn.

The future of motor racing is to become unrecognisable due to social change

6. This year, Nevada's Department of Motor Vehicles issued the first licence for a self-driven car – a Toyota Prius using Google's experimental driverless technology, and this week California allowed self-drive cars to circulate, with the addendum saying it requires the department to adopt regulations covering driverless vehicles at least by January 2015.

7. Due to points 2, 3, 4 and 5, we have a generation of individuals that prizes flexibility, information, gadgets, a generation that prefers to have a social life, and stay connected, that wants green transport and convenience, that doesn't need cars as status symbols, that lives another life style, and to whom a car is just another means of transport. They, like me, look at a one and a half ton lump of metal carrying 80kg of flesh as waste.

And point 6 means that, long term, eventually driving will be a skill set that involves no fast driving on the limit.

Motor racing caters to, and interests, a demographic which is ageing, and seems to be a peculiarly western cultural habit. The growth of it outside the OECD does not match the population and income growth it should have.

Formula 1 still has the rarity value, and has the near monopoly of TV exposure, whereas in entertainment you need a dramatic device: a narrative arc creating conflict and resolving it, personalities (when not diluted by the handlers that make most young drivers cookie clones – only the world champions end up able to act out their characters.), traditions, minutiae of tactics and innovation (some artificial, the current era of 'great racing' is down to artificial factors – DRS and aero restrictions, the frangible tyre policy and engine restrictions, but only a churl would carp.)

"Racing outside F1 is withering on the vine, apart from niches for the gentleman driver"

But even this is dependent on a growing, or at least stable, viewing public. It works for other sports like football, but motor racing, apart from F1, does not have the visceral pull of national or regional totemism and athlete character to keep the attention of the public.

The other inconvenient truth is that any form of motor racing is expensive, partly due to the specialisation of the equipment, and the ancillary costs. Gone are the days of driving your racing car to the track and having at it.

So all other racing is withering on the vine apart for niches for the gentleman driver in championships that have full paddocks and empty grandstands. The proliferation of single-make championships in the name of cost reduction or ROI for the sponsor (usually a manufacturer) is equitable for the competitors, but rather boring for the spectators, who have, not unsurprisingly, voted with their remote controls.

There will still be a demand for what is a growing segment. X-Games, drifting, monster-trucks. WWF brought to the track, a rather Circus Maximus approach to motorsport. Extreme personalities, celebrities and the white and black hat guys so the crowd can cheer and groan. Showbusiness, catering to the ratings.

Fear not for the future, weep not for the past. The old generation will still tell tales of how it was in the golden age, and the new one will get on with their lives and interests, and there will still be, on some track somewhere, a group of people earnestly fiddling with batteries, trying to go faster than the opposition. (If the sole purpose of life was to be rational, we would have banned golf years ago). It will be motor racing, but not as we knew it.


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Hunting inspiration

Is complexity leading to a shortage of complete car designers?

With the demise of my old firm Lola, with Patrick Head departing Formula 1, and a few more recent occurrences, it set me wondering from where the future standout Formula 1 chief designers with an intimate understanding of the complete racing car are to come?

When I first joined Lola Cars, as it was back in 1976, the design staff consisted of Eric Broadley (also MD of the company), Bob Marston, John Preston (who also prepared the bills of material and parts-book exploded views), and a couple of draughtsmen. Eric and Bob also doubled as track engineers for testing and race support. This covered F5000 / Can-Am, sportscars of various descriptions, F2 / Atlantic and Formula Ford, plus other projects such as the forthcoming Indycar for Carl Haas. A similar situation applied at Chevron and March. These two, together with Lola, were then the world's leading players in customer racing car design and manufacturer.

It is inconceivable, nowadays, that any serious racecar company with a diversity of products even remotely approaching those mentioned above would be able to operate with such a meagre headcount. Cars and their systems have become so much more complex in virtually every discipline. The same applies to F1, due to the level of continuous development and change required under current regulations. This tends to result in engineers becoming specialists in certain aspects and systems of the design process, and running the risk of being typecast as such.

The great beauty of Lola's then minimalist operation – apart from making the cars affordable – was that it provided tremendous scope and experience for the young engineers who were employed on a fairly regular basis. With such a workload, they were exposed to virtually every area of the car and quickly had to understand how the various aspects had to come together to form a complete design. In addition, because the cars were quite simple, an engineer could draw something on Monday, oversee it being manufactured ready for testing on Thursday and quite probably have it racing the following weekend. Such immediate feedback could be a great source of quick learning and motivation.

The young engineer would often have to fight their corner with Production in order to get his parts made among many other priorities, and it encouraged an attitude of respect for – and close liaison with – the generally sorely-tried shopfloor workforce. In so doing, these trainees also picked up the practical side of how parts could be made more quickly and efficiently, whether fabricating and welding, machining or creating bodywork – still key aspects of F1 design and manufacture.

"Lola provided tremendous scope for young engineers"

Ben Bowlby (above) learned to understand overall car concept at Lola

Via ambition, poaching and natural desire for advancement, most of these engineers moved on to greater things within Indycar and especially F1. Not for nothing was Lola in particular described many times as 'the university of motor racing'.

Even a good many years after this period, the same flexibility and range of thinking was common in Lola. Back when Ben Bowlby first started as a junior designer, he was pointed towards an F3000 car and told by chief designer Mark Williams that the sidepods needed to be shortened and ready for testing by a very imminent date. To a new recruit, even of Ben's character and ability, this must have been quite daunting as he had to find his way around the parts book system, access the CAD files and drawings he needed, work out the revisions to the radiators etc involved, source and plead for some hands-on assistance, book time in the composites department, detail draw where necessary what was needed and assist in getting it all sorted and fitted. He got it done and exceeded our expectations, but the point is that the responsibility he was given and the way he responded led to him having more and more influence on the development of the car in all areas: mechanical, structural, composites, aero, power / drivetrain, electronics and, through track testing, tyre performance. This practical as well as conceptual experience is invaluable.

Further aggravating the lack of overall car design knowledge is the proliferation of one-make series that has grown over the past couple of decades. It's one thing to design a one-make car where there's no competition to judge one's abilities and product against, and quite another when your product's performance is on the line almost every weekend. The accent becomes more on attaining a certain performance target with good durability of the machinery than continuously seeking better lap times. The quality of design and manufacture is highly impressive, but there is a subtle distinction in the conceptual process here. Apart from Oreca in France, which is growing its racing car base but still around exclusively sports prototypes, there doesn't appear to be any natural replacements for the Lolas, Marches, Chevrons and Reynards of the past.

Of course it may be that the sheer complexity of the current F1 car means that understanding the whole vehicle in sufficient detail is no longer practicable. The chief designer needs to be more of an orchestra conductor, giving a lead and tempo and pulling all the different elements of the musicians together to create the resulting music.

However, I believe that the best F1 chief designers have acquired a fundamental understanding of the complete car made up of all its disparate parts. Only in this way can they make judgments on the various routes of development open to them. A recent case is surely Adrian Newey and hotblowing of the rear diffuser. Such was his view of the benefit to be gained, that the 2011 RB7 F1 car was virtually designed around this concept and accordingly gained such an advantage. Whenever one considers the great designers of what one might call the 'modern' F1 cars from Colin Chapman through Patrick Head, Gordon Murray, John Barnard, Rory Byrne and Newey, they had all been exposed to the design and operation of the complete car. This I suggest gives them an intuitive 'feel', backed-up nowadays by much simulation, of what route to develop. One might call it inspiration.

Whatever description is applied, there is a strong argument that this is what makes great F1 cars, rather than merely competent ones.

Enstone's dark horse

Always in the hunt, but never quite there, the Lotus E20's consistency has made it the stealth challenger of the 2012 F1 season

BY SAM COLLINS

Despite its iconic black and gold John Player tobacco-inspired paint job and famous name, many have overlooked the Lotus E20. With three-quarters of the 2012 season completed, the car had not won a race and the only headlines it had grabbed were for driver-induced mishaps.

But that is not the whole story. The Lotus E20 has consistently run towards the front of the pack, and going into the final races of the year, finished on the podium and, at time of writing, had Kimi Raikkonen third in the drivers' World Championship standings.

'The car has not been that consistent in the last few races,' James Allison, technical director at the Enstone, England-based Lotus F1 Team complains, 'but in the first 10 or 11 races we were very strong.' Strong seems to be something of an understatement. While every other team on the grid has seen variable performances, there always seems to be a Lotus in the points. Of 30 possible finishes in the

"The traditional way of going racing is you make a car, and that car is either good or bad, and it tends to remain that way all year"

first 15 races, 21 have been in the points. Of the nine that were not, four were due to driver errors forcing the car into retirement, and another one due to a failed alternator, making the E20 the most consistent points finisher of 2012.

'This is just quite a good car all round,' Allison continues. 'The traditional way of going racing is that you make a car, and that car is either good or bad, and it tends to remain that way all year. What is strange this year is that the other teams have not been like that. We have not been there every race, though there have been a couple of races where we haven't been able to get the tyres warm enough to do well either in qualifying in the race.'

Despite wearing a different name on its nose, the Lotus

The E20 is a fairly conventional 2012 F1 design, with pullrod rear suspension and pushrod front suspension. Note the side impact structures sitting just forward of the sidepod duct

E20 followed on from the radical Renault R31, which was designed to fully take advantage of the off-throttle exhaust blown diffuser concept by having its exhaust exits at the front of the sidepods. Allison feels that lessons were learnt with that car and that the E20 is a major improvement.

'When I think of this car, I think of it just as a neat car. There is no bit of it that I think is embarrassing - it is a well-conceived neat workable good car. That is what I'm proud of. Last year's car was a bold old thing but it was ugly in many ways; this one is a step forward on almost every single item. It is proper tribute to Martin Tolliday, our chief designer, whose first car this is. He took all of the strength and goodness that Tim Densham had engineered into previous generations of our car, and took us on to another level.

'Depending on where you look, some parts are a ground-up redesign, and in other areas we have further optimised the best bits of the design philosophy we've adopted for several seasons. The front and rear suspension layouts are substantially revised to try and give us better aerodynamic opportunities. The front wing is a continuation of the concepts we have worked on since the 2009 rules were published. With the rear wing system we've continued to try to work on having a satisfactory level of rear downforce stability, while having a maximum DRS switching potential.'

While the team's 2011 car was radical in its application of the exhaust gases, the E20 could not be more different - its exhaust ports are found in a conventional location on the rear of the engine cover. 'As far as the exhausts are concerned, our forward exhausts would now be illegal under the new rules, and didn't live up to our expectations in any case,' Allison explains. 'So that part of the car we say goodbye to and welcome in a complete redesign. We had a very plain jane exhaust system for most of the season; indeed it was the same one that we ran at the start of the year virtually right up until Korea. It served us OK and it is a very easy system to make work. You just make the exhausts the length and shape that gives the engine the best chance of producing as much power as it can, and then put the exits in a place where you get a mild advantage, but nothing special.

'In that respect we were ploughing something of a lonely furrow on the circuit with our exhaust, but since well before the launch of the E20 we were carrying out parallel developments in our wind tunnel programme based around a Coanda-effect exhaust. Once we saw the potential gain of the Coanda system surpass that of

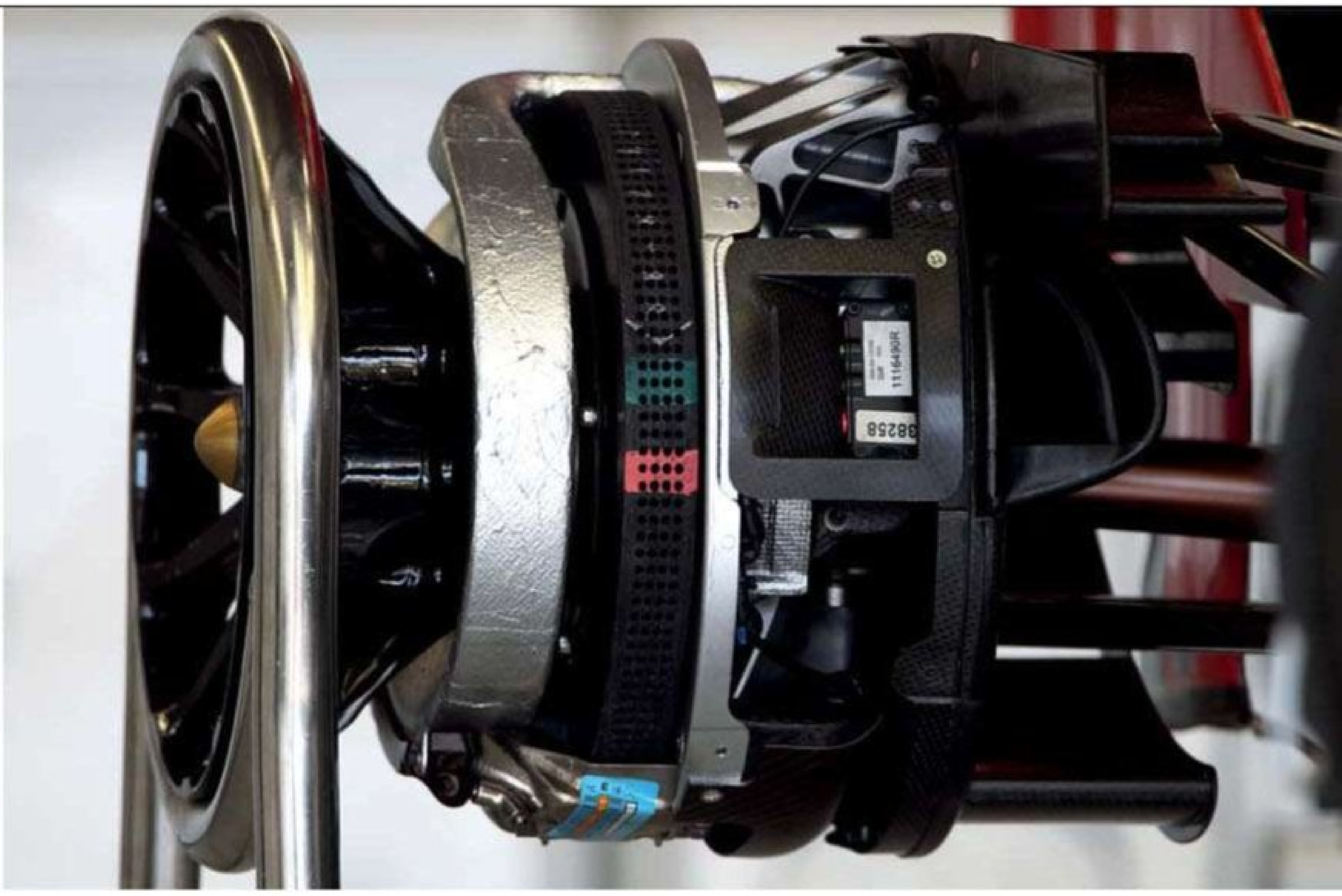
"Our forward exhausts would now be illegal under the new rules and didn't live up to our expectations in any case - so we welcome in a complete redesign"

'THE DEVICE', by Craig Scarborough

'The device' as it is known, came about from the Lotus request for clarification on the Mercedes DDRS, which is linked to the rear wing's DRS to stall the front wing. This system was controversial as switchable drag reduction systems were effectively banned after the F-Ducts of 2010. However the rules to counter this were largely worded to reduce the stalling slots in the rear wing and the driver interaction in turning the system on or off. The Mercedes system sidestepped these rules by having the stalling slot in the front wing and the system switch by the DRS opening (an allowable moveable aero device). When in Bahrain, the FIA gave clearance for other drag reduction systems, whether linked to DRS or not, Lotus announced they would take advantage of the clarification and develop their own device.

Unlike Mercedes, whose system stalls the front wing to balance the aero when the DRS rear wing is used, the Lotus system is passive and not linked to an external switch. Instead the system uses increasing airspeed to send more flow to slots under the wing to stall the airflow and reduce drag (and downforce). Having the passive system means that the Lotus device can be used to stall the wing above a certain speed on every lap, meaning the small 5-8km/h speed advantage is available on every straight and fast corners. With the system being tuned to airspeed, the wing can be designed to stall at speeds high enough to allow fast corners to be taken with the rear wing stalled. At these speeds the diffuser provides enough downforce for cornering and the rear wing is not required for aero load. Typically teams will want this stalling to occur at speeds of over 250km/h.

The system is formed of two roll hoop inlets feeding a central duct, and then an L-shaped duct tees off the central duct to blow the rear wing. The inlets are clearly visible either side of, and slightly behind, the roll hoop inlet, reminiscent of the 2010 Renault F-Duct, although they are permanently bonded to the roll hoop structure, so even when the car is running without the device, they are still in place. These inlets form ducts that pass up and over the airbox snorkel to merge into a single duct that then passes down our current design it was clear that we needed to implement it, both for the benefit we could get in the last quarter of this season and also for the learning experience it presents us for next year. Installing this style of exhaust is not as big a deal as the 2011 style blown exhausts. Last year – for all teams, but especially for our forward exhausts – it was quite challenging to ensure that the exhausts did not set fire to the car. The Coanda system is a little more indirect, and the jet has cooled a little before it impinges on the floor, which makes things a little easier to manage. There's still a fair amount of rearrangement, including new Coke panels, new exhausts, new exhaust exit panels, some fireproofing of the floor and so on.'



As has been the case for several teams this year, the area surrounding the brake ducts has been approached as a key development region for the engineers at Lotus F1 Team

the back of the airbox. Part of this duct is bonded to the airbox before a tail section of duct is bolted to it. This is where the complexity of the central duct is hidden; the duct splits again into two above the airbox, with one exit above the other. The outlets are formed by machined metal flanges, to ensure that the connection to the subsequent ductwork is air tight. One further curiosity ahead of these two outlets is a stepped feature in the ducts profile. This may be crucial to the airflow towards these two flanged outlets at different airspeeds. How the two outlets are then linked to the final duct that exits over the beam wing and the duct leading up to the rear wing are yet to be seen, so we can only speculate how the diversion of flow works.

The tail of the central duct exits over the centre of the beam wing. Here a small winglet is formed around the exit to rescue pressure at its trailing edge. Visible inside the exit of this duct is a smaller duct exiting within, so the apparently large cross-section central duct may be a double walled structure housing two exit ducts.

With the central ducts outlet blowing over a revised beam wing, it's possible that the effect of the device when not stalling the rear wing is to aid the upwashed airflow coming up under the centre of the car, to create downforce. Although this would be an inefficient way to create downforce, it is probably a way for the system to contribute to lap time when the upper rear wing is not stalled.

Teed off from the central duct is the upper duct. This is far smaller in cross-section than the central duct, and would offer a lot of resistance to airflow, most likely to encourage airflow at lower speeds to pass into the central ducts exit, rather than up to the rear wing. This duct has a 90-degree bend, not for aero reasons, but as a workaround to the zone ahead of the rear wing not being allowed to have bodywork. This was part of the 2010 F-Duct ban on bodywork (shark fins and F-Ducts) reaching the rear wing.

Other than the join of the duct to the underside of rear wing's main plane, the top rear wing and endplates appear to be the same as the non-device set up. The duct meets the wing, but does not blow into it. Unlike the 2010 F-Ducts, the stalling slot is not a lateral slot across the wings span, but instead four small vertical slots in the duct. These blow sideways where the duct meets the wing's underside. Being part of the duct and in the middle 15cm of wing, they are exempt from the minimum radius rule that was introduced to ban F-Ducts.

It's clear the system has had to be compromised to fit into the post F-Duct rules, but in every sense it meets the regulations and would be hard to declare illegal without a new clarification of the rules being issued by the FIA.

One issue facing the FIA is that the Mercedes DDRS solution will be banned in 2013, via wording to prevent secondary use of the DRS opening. But as it stands, being passive, the Lotus system does not employ this solution, and will be legal.

"The passive system means the Lotus speed advantage is available on every straight"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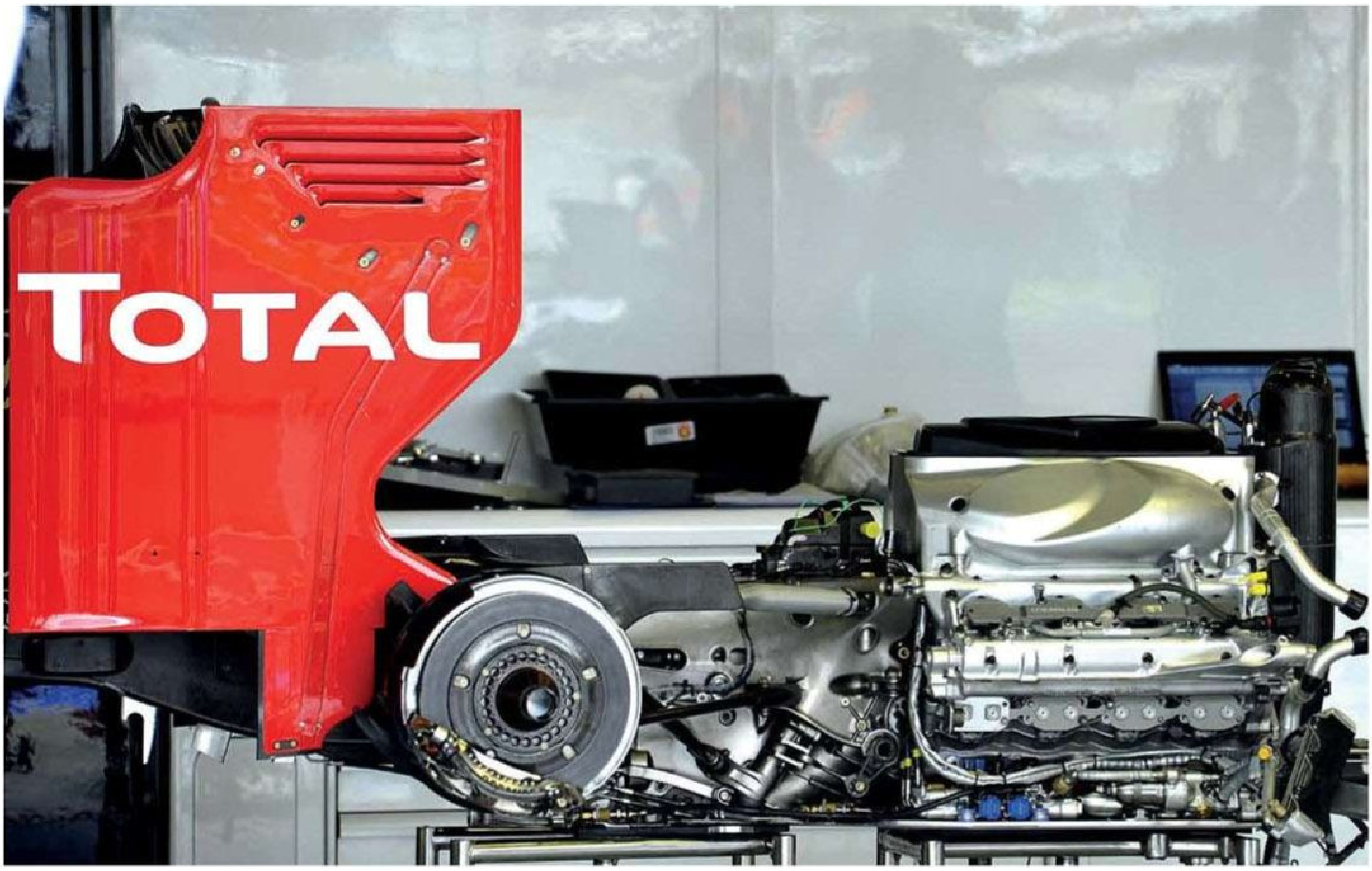


The E20 is powered by the Renault RS27 2.4-litre V8 engine seen here mated to the in-house titanium transmission. Note the rear suspension arrangement mounted on the side of the transmission

Another key to the new exhaust working adequately is the flexibility offered by the transmission, but unlike some other top cars the Lotus does not use a carbon fibre maincase. 'The transmission has a titanium case. Like everyone, the main development path of the transmission has not been the internals for some time,' Allison reveals. 'Everyone has had seamless shifting for a good while now. The development that has been done is all about making the case as teeny weeny as you can, so you can waist the car in as tightly as possible. That is to do with getting as much high energy air to the back of the car as possible, and have the transmission provide the minimum blockage. All of our efforts have been on that.

'The only advantage to a composite casing is weight. You can make a casing in either material small. You can expect the carbon casing to be slightly less stiff but a kilo or two lighter, and that's a lot. I think that carbon boxes are a better ultimate solution, but there is a lot of time, money and effort in making that, and the amount of benefit it gives you is relatively slender. The way that the rules are at the moment, especially the tyres, in order to get the car into the permitted weight distribution and still have a high performance car, you tend to be struggling hugely to get weight off the front of the car and really not in any real stress at the back. That's the reason that the Red Bull has its KERS batteries at the back of the car. We don't need to use the Red Bull solution because we can get the weight distribution where we want it without putting the batteries back there, and it is an awful lot easier to have all of the parts in one place than have a distributed system around the car.'

Despite its strong run of results, it could be argued that the E20 lacks slightly in pace over a single lap, something Allison hopes the new exhausts will go some way to improving – but not at the expense of changing the car's tyre usage characteristics. 'We've often been devastatingly fast on the harder of the tyres in qualifying but then come up a bit short on the softer option,' Allison admits. 'You can point to cars on the grid that are very quick in qualifying but not so competitive in the race and vice-versa. We seem to have a car that is not among the very quickest in qualifying at the moment, but has very good race pace. It's not a bad combination, and we'd rather have it this way round than the other, but if we want to win races we are going to have to improve our qualifying performances. It's not going to take much, we just need that little bit extra if we want to challenge for higher honours.'

TRICKY TYRES

The way the E20 uses the famously tricky Pirelli rubber seems to be one of the keys to understanding just why it has been so consistent during the season, and the giveaway is how the car tends to perform in hot temperatures. 'Tyres have a certain window in which they work – get them too cold and they don't grip, get them too hot and they don't grip. There's a reasonably wide band in the middle where they work well. It seems like the E20 generates a little less heat in the tyres than some of our opponents' cars, meaning we can live with a hotter track when some of our competitors are starting to move out of the tyre window. The downside of this comes when we have a cold track – or after a safety car. Fortunately, most of the races are contested in summer conditions where you are trying to keep temperatures down rather than having to worry about generating heat, so we've probably got it the better way around – even if it can be a bit frustrating at times.

'Our knowledge of the tyres is no deeper this year than in other years. We just try to use that to keep them in the window where they behave well. It's not very sophisticated. I'd be surprised if it was very sophisticated in any team. After each session Pirelli give you wear information showing whether you are wearing the inner shoulder or the outer shoulder, they tell you if you are wearing your front axle rather than your rear axle, and you work with the set-up

Lotus ran 'plain jane' exhausts on the E20 for most of the year, but finally fitted the more effective Coanda exhausts at the Korean Grand Prix in October

of the car to compensate. If you are wearing the inner shoulders you take a bit of camber out, if you are wearing the front more than the back you try to move the weight back a bit, but that's just standard car set-up. The only thing about the tyres that is unusual is that they punish you heavily for being too hot or too cold and the plateau where they are good is narrower than at other times.'

WIND TUNNEL BLISS

Allison had a significant new tool to use in the development of the E20 with a significantly upgraded wind tunnel at its base in Enstone. 'The 60% wind tunnel has allowed us to expand dramatically the realism of the tests that we perform, so we get the car to more realistic steer and yaw values,' he enthuses. 'Those are pretty fundamental things. That means that the car can be more tolerant of a wider range of cornering conditions. The simulation methods in the factory are good, allowing around 70%-80% of the upgrades that we put on the car to work straight away with no problem.

'Of those that suffer birth pangs, a fair proportion are eventually found to perform as expected when given a second hearing. When you're not running dedicated track testing, there's a whole raft of variables you're not in control of. The drivers might not get clear laps, and with the track constantly evolving plus tyres not always being a new set for each run – you do not have a stable baseline to compare against. These factors can cloud the assessment of a new part, so if you are struggling then you very often remove them from the car out of an abundance of caution and look for a suitable opportunity in the future to have a second go with them.'

STALLED AIR

One update to the car that has suffered from significant birthing pains is the team's version of the rear wing stalling device (see boxout, p10), similar in concept to the one debuted by Mercedes. While Lotus has tested their version on a number of occasions, it has yet to function as the team would like. 'I rather like calling it "the device"; it has a kind of Dr Strangelove appeal,' Allison jokes. 'It has been really tricky to get working, though. We have not had anything from it as yet, because with no real testing opportunities we have not managed to make it deliver the anticipated benefit. We know it is all there for us, but we have not got it to work: it is a difficult birth and it is not out of the birth canal yet. We will work on it until the end of the year, but we need to be careful not to get too distracted. It punishes you by taking one session out of the weekend each time you play with it.'

Overall Allison simply puts the E20's consistency down to its neat design. 'The car has a reasonable amount of downforce,' Allison assesses. 'It's quite driveable – the drivers are not fighting oversteer one minute, understeer the next. It is consistent and predictable; it does not suffer from front locking at one corner and rear locking at another, so the drivers can wring a fair amount out of it. On the large majority of circuits it has had better tyre degradation and lower tyre wear than the competition, which has meant we have tended to race strongly. I hope we can stay in the driver title hunt. If our plans unfold as I hope they will, then we have some performance upgrades coming that will serve us well. Hopefully we will grace the top step of the podium at some point!'

TECH SPEC

Lotus F1 Team E20

Chassis: Moulded carbon fibre and aluminium honeycomb composite monocoque, manufactured by Lotus F1 Team and designed for maximum strength with minimum weight. RS27-2012 V8 engine installed as a fully-stressed member.

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

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

Transmission: Seven-speed semi-automatic titanium gearbox with reverse gear. Quickshift system in operation to maximise speed of gearshifts.

Fuel system: Kevlar-reinforced rubber fuel cell by ATL.

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

Electrical: MES - Microsoft Standard Electronic Control Unit.

Braking system: Carbon discs and pads. Calipers by AP Racing. Master cylinders by AP racing and Brembo.

Cockpit: Removable driver's seat made of anatomically formed carbon composite, with six-point or eight-point harness seat belt by OMP Racing. Steering wheel integrates gear change, clutch paddles, and rear wing adjuster.

KERS: Motor generator unit driving into front of engine with batteries as an energy store. Motor Generatorsupplied by Renault Sport F1. Electronic control unit by Magneti-Marelli.

DIMENSIONS AND WEIGHT
Front track: 1450mm
Rear track: 1400mm
Overall length: 5038mm
Overall height: 950mm
Overall width: 1800mm
Overall weight: 640kg, with driver, cameras and ballast

The battle for middle ground

Battles are raging from the front of the grid to the back, and Caterham is looking over its shoulder at new challengers after taking a bold new path with the CT01 Renault

BY ANDREW COTTON

It is easy to look at Caterham and think 'that's an underperforming team' as Marussia closes in from behind and starts to challenge their position as a mid-field runner, but the team has taken some brave steps this year and from Abu Dhabi onwards expects to reap the rewards.

As if contesting the full World Championship schedule wasn't challenging enough, Caterham decided to move, mid-season, from the Hingham facility in Norfolk to the former TWR factory in Leafield, Oxfordshire. It also ran KERS for the first time, and switched from the Aerolab wind tunnel in Italy to the Williams tunnel in the UK, which led to their first major headache of the season.

'Fundamentally the intention was to have one set of bodywork for the first four races,' said Caterham technical director, Mark Smith. 'As you would expect, moving the model from one tunnel to another produced big differences. One of them was a cooling offset. We were faced with the dilemma: either to trust the numbers from Aerolab, or when we switched, we completely switched, and we just go with the new numbers from the Williams tunnel.

'We felt it was too big a risk to go with the previous numbers from the Aerolab, and we found that we had to revise our cooling which prompted the bodywork change with the big hole in the engine cover. It was fairly apparent fairly quickly that we didn't need to worry as much as we did. We didn't have the cooling issues that we thought we had at Williams. Had that [issue arisen] mid-season, it wouldn't have been an issue because we would have had track data, but this was a brand new car – there was no track data and so caused a little bit of a dilemma.'

The CT01 featured shorter sidepods as part of the overall aerodynamic package and improved underfloor airflow, but a lack of resources meant that the development of the most fundamental part of the aero package, the exhaust plume, had to wait until the British Grand in July before it was introduced, and represented a significant risk to the performance of the team.

With Marussia closing the gap and Toro Rosso and Williams pulling away, Caterham has undeniably lost ground.

'Essentially the first challenge is to accurately model what you do, whatever that is,' says Smith. 'That requires all sorts of things to replicate the car, and one of them is to create as close an approximation of exhaust gas flow as you can get.

'We don't have reciprocating engines or hot gas on the model, but we can govern the mass flow rate of the cold air that we are feeding. When we introduced the system, we weren't able to accurately model the exhaust gas flow rate, so there was some limitation in the ability to model the system. That means that we had very little choice other than to model it as best we could. We were trying to understand what the exhaust plume is doing on the full scale car, which people have been doing with thermal cameras. We are now using them too, so are better able to represent the car in the wind tunnel.

'Once you have got a reasonable match between model and car, you can start to model the areas that the plume is feeding, but essentially it has been about trying to identify what we have on the real car compared to what we have on the model, and have the two as close as possible. This means working on the model to get what we have on the car, bizarrely, because you want it the other way around!'

With a model that's not as accurate as the team hoped for, everything has to be validated on the track. That means that much of Friday's running on race weekends involves a lot more validation work than the team would have liked. 'If you have as near total confidence in the model environment, then you go from model to track. We have to validate quite a few components that are directly related to the exhaust plume aerodynamically,' says Smith. The new package in these circumstances was risky, but the team felt that it was worthwhile as the regulations will remain the same for next year. With the validation work completed mid-season, the results are starting to come through on the track, with a further upgrade introduced at the Abu Dhabi Grand Prix.

RED BULL LINK

While Marussia is undoubtedly benefitting from its tie-up with McLaren, Caterham opted to go with the Red Bull mechanical package at the rear, including engine, gearbox and alternator. Significantly, it also runs the Red Bull developed KERS for the first time and has found that to be the least troublesome part of the car.

With batteries sitting in front of the gearbox, and one either side, weight distribution and reliability have not been an issue. 'We were aware from the outset that there were concerns about the alternator,' says Smith. 'We revised the way in which we loaded the electrical system at low rpm, managed the system ourselves reasonably well, and by and large we have been fairly trouble-free. There will be developments [for next year] led by Renault that we will integrate as required.'

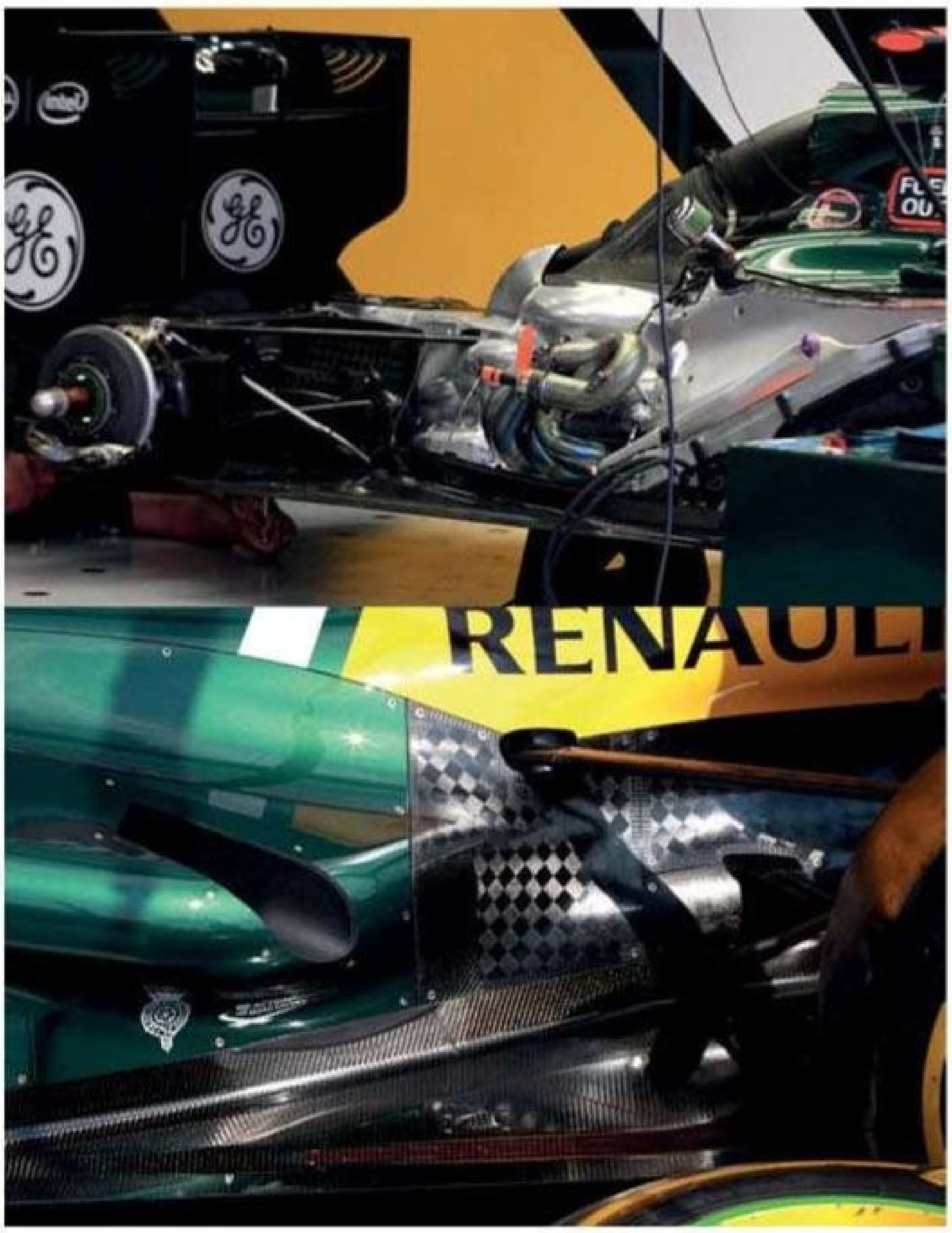
"We're developing at the same rate as other mid-field teams – but that doesn't close the gap"

DEVELOPMENT CURVE

With the team having introduced the new aero package without simulated data, it has now lost its ability to be able to open out track space to the Marussia during the races to enable it to make a pit stop and not lose position. This, says Smith, is a more realistic situation than at the start of the year when the luxury was there, but means that the team has to adapt its race strategies accordingly. However, the gap to the front of the grid is static as all teams follow their development curve in the first 15 races of the year.

'To the front of the grid it is close, but the problem is that we all have our performance development gradient, which is predominantly an aero development gradient,' says Smith. 'As every team we do competitor analysis, and we have been developing at the same rate as the other mid-field teams, but that doesn't close the gap, and that is the problem. On the one hand, given our resources and the relative immaturity of the team, why would we expect to close the gap at a faster rate than the guys who are more established? On the other hand, the further back you are, the steeper the development gains, so you should be able to close the gap. We have struggled

A potential cooling problem was highlighted following a switch from Aerolab to Williams' wind tunnel and led to new bodywork introduced earlier than planned, diverting the team's resources



The team's understanding of the exhaust plume has relied on track testing rather than the wind tunnel model, and has led to the team losing ground to its rivals. At least the introduction of KERS has been relatively painless

"We have seen the benefits, but we haven't yet felt them"

to close that gap simply because to get a steeper gradient to the others is tricky. One of the ways to do that is to bring in people from other teams who are at the front of the grid and benefit from what they are doing. The other is to give ourselves more resources, like ramping up the number of hours in the wind tunnel.

'You do that from one week to the next and you don't see the benefit overnight, and so we are only now starting to see the benefit, but to be honest we haven't felt it yet this season. That should come with the introduction of the 2013 car.'

Tyre management has been a significance in 2012, and Caterham has found a particular issue with generating the necessary heat in the front tyres. It has been a general pattern that the CT01 performs better at the hotter races than the cold. A lack of outright downforce means that the car is more prone to sliding, and so degredation has been an issue, too, as has the fact that the car has had to run flat out to maintain its position on the grid. As front-running teams may be able to back off on overall pace slightly in order to maintain their tyre performance, Caterham has had no such luxury.

PEOPLE MOVES

The move from Hingham to the motorsport valley, close to Brackley, has opened the door to the team being able to recruit more experienced staff as the team grows, and the increased experience should, in theory, translate into speed on the track.

The team opened up the design office to be an open plan room, with all the engineers and designers in the same place, including the race engineers, aerodynamicists and CFD operatives, leading to better communication within the team. The workshops were operational almost immediately following the compulsory two-week summer shutdown, when Caterham completed its move, and while there were reservations, and logistical problems due in part to some of the production remaining in Hingham, it looks to have been a positive step for the team.

'There is no secret that we did it for the recruitment perspective,' says Smith. 'Obviously for the first 12 months there are some retention problems, but by and large most people have moved here. Now we are here, we have more interest from guys who are living here, which is what we wanted. That will be advantageous for us.'

TECH SPEC

Chassis material: Carbon fibre

Bodywork material: Carbon fibre

Front Suspension: Push-rod actuated, arms made of carbon fibre

Rear Suspension: Pull-rod actuated, arms made of carbon fibre

Dampers: Penske & Multimatic

Steering: Caterham F1 Team

Gearbox: Red Bull Technology

KERS: Red Bull Technology

Clutch: AP

Discs: Carbone Industrie or Hitco

Calipers: AP

Pads: Carbone Industrie or Hitco

Cooling system (radiators, heat exchangers): Caterham F1 Team

Cockpit instrumentation: MES

Seat belts: Schroth

Steering wheel: Caterham F1 Team

Extinguisher system: FEV

Wheels: BBS to Caterham F1 Team specification

Engine: Renault V8 RS27-2012

Capacity: 2400 cc

Architecture: 90° V8

Weight: 95 kg

Max rpm: 18,000 rpm

ECU: MES SECU

Fuel: TOTAL

Fuel cell: ATL

Lubricants provider: Various

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New horizons

The Caterham SP/300.R was originally designed as a track day car, and is a hybrid of Formula 3, Ford and Lola. Its future now appears to be in North America

Until the start of 2012 when it entered Formula 1, Caterham cars was only really known for one thing; a seemingly endless range of Lotus 7 derived road and racing cars. Indeed since the company was founded in a 1973 just outside Croydon, England, that was all it had done. But at the Autosport International Show in 2011 it suprised everyone with a new model. A partnership had been struck with Lola cars to create an all new Caterham, that owed nothing to the famous 7 designed by Colin Chapman. At the car's launch it was stated that the chassis and aero package was designed by Lola to a brief provided by Caterham, but in reality the car was to be a heavily reworked variant of the

BY SAM COLLINS

Lola B08/90 track day car, itself a reworking of the same firms B07/90 Sports 2000 project.

Twenty-five cars a year were to be produced by Lola at its factory in Huntingdon, England and a one make racing series for the car was to have started in 2012. But as the months passed by there was no news, eventually it was claimed that the car was felt to be too fast for amatuer racers and would again have to be reworked. Later Caterham insiders stated privately that the delay was down to production issues at Lola.

Finally in the spring of 2012 the first SP/300.R chassis started testing and was shown off to the press. The result was a very neat small sports prototype utilising the transmission and rear suspension found on the Lola B05/30 Formula 3 chassis. These were mated to a supercharged two litre Ford Duratec engine capable of producing up to 330bhp. The basic chassis is the aluminium tub carried over from the track day car albeit with some modifications.

The SP/300.R bodywork, developed using Lola's CFD capabilities, also features an F1-style raised nose section and sectioned panels, which will help reduce repair costs, ease maintenance and, importantly, allow single-handed removal of body panels track-side. Caterham's research suggests that most sports prototypes in today's market require more than one person to assist in the removal of body panels, e.g. oil check, set-up, etc; the SP/300.R is currently the only sports prototype that offers this convenient feature. Overall the design is very conventional with almost every element of the car developed with gentleman drivers in mind.

"Overall, the design is very conventional, with almost every element of the car developed with gentleman drivers in mind"

The first new Caterham was supposed to take part in a full championship in 2012, but Dyson Racing has enquiries to use the car for schooling emerging talent

'Motorsport has been ingrained in the Caterham DNA from day one,' explains Caterham Motorsport Manager, Simon Lambert. 'Our philosophy for racing has always been that it should be run efficiently and it should be cost-effective to take part. Above all, it has become a community, almost family-like, which is why it continues to grow from strength to strength year-on-year.'

But the new Caterham has proved more popular than expected with track day enthusiasts. 'We have taken the decision, based on the orders made for SP/300.Rs thus far, to postpone the race series that had been planned,' explained a spokesman for the company. 'The vast majority of the orders for the cars have come from trackday enthusiasts and, in the US in particular, the distributor Dyson Racing has a lot of requests; there is even talk that the SP/300.R could form the basis of a race school type set-up somewhere but that is still in the very early stages of discussion at this point. With that in mind, the spec of the SP/300.Rs being built now has been somewhat ramped up, to reflect the nature of the new owners who like a little more comfort in their trackday machines than the average racer requires. There's nothing vastly different, just additional trim for instance. Naturally, there is still scope for an SP/300.R race series in the future and that is something that Caterham will look at in due course once this first phase of orders are taken care of and the product itself can be fully verified for racing.'

With the collapse of Lola cars in mid 2012, the production of the SP/300.R could have been brought into doubt but Caterham is keen to stress that this is not the case. 'It has no impact whatever on the build of the SP/300.R. Lola was a consultant in the design process but none of the parts that make up any components of the SPR are from Lola, so the manufacture of the cars is entirely unaffected.'

The SPR, as Caterham staff call the car, has clearly found a market in North America and it is possible that this, the last Lola will never race.

BEHIND THE WHEEL - SAM COLLINS

Climbing behind the wheel of the SP/300.R it feels like a generic sports prototype. The cockpit is slightly larger than an IMSA Lite but not all that different to a CN specification Ligier.

Curiously, it does not feel similar to the Lola B08/90, which was the basis for this car. Indeed there is nothing to remind you of its heritage.

Pulling out of the pits at an unusually dry Rockingham circuit, you realise that a lot of effort has gone into reminding the driver that Caterham is no longer just a manufacturer of tubular steel kit cars, but in fact is now racing in Formula 1. The steering wheel mounted paddle shift is just the first thing you discover. Once you are out on track the CT-01-inspired steering wheel springs to life with a fairy light rev counter and all manner of other electronic bits and bobs. But I think this was a step too far for a car aimed at gentleman drivers, unused to F1 style driver information systems. The gear indicator, shift lights and crucial 'your engine is about to burst' oil pressure warning light were all out of my line of sight. Frustratingly there is a flat panel at the front of the cockpit right where you would like these readouts to be. If I was buying one of these cars, I would demand that the dash and all of the important warning lights were mounted there, rather than on the steering wheel. The team behind the car at times may have lost sight over who would be driving it. They are neither built like F1 drivers, and nor do they have their ability. For them to take thier eyes off the track to check the steering wheel readouts could result result in a hefty repair bill, so maybe the Caterham engineers (or accountants) did think of that!

The SP/300.R was originally squarely aimed at a wealthier version of me, someone wanting a car somewhat more potent than the usual track day pilot. So, would I buy one of these? Out on the circuit, the car is fairly easy to drive, perhaps with a slight tendancy to understeer, but that can easily be tuned out. The car is highly adjustable, as you would expect with its Formula 3 rear end, that may mean that a gentleman racer would need to employ someone to get the setup right. Ultimately most of the cars will only ever be used on track days where the base setup is more than adequate for that, and if the proposed one make series ever gets off the ground then its likely that Caterham support engineers will be on hand to do all of that for you. As a school car, the adjustability will be ideal for aspiring young drivers.

The only thing that bugs me - the engine in the car is not stretched. There are plenty of other units which would slot right in, and would the car be quite so tame in SP/450.R form? Someone should find out.

TECH SPEC

Caterham SP/300.R

Class: N/A

Chassis: Lola-developed aluminium honeycomb monocoque chassis, Left or right hand drive, onboard jacks.

Body: Seven-piece lightweight polyurethane body, adjustable carbon rear wing, composite front splitter, composite rear diffuser, three stage downforce configuration. Downforce 450kg @ 250kph

Safety: MSA specification twin roll over protection hoops, MSA specification front crash structure, Schroth six point harnesses

Transmission: Hewland FTR six speed sequential gearbox, Shiftec paddle shift system, Dual plate sintered clutch, Limited slip differential

Suspension: Adjustable pushrod activiated coil-over spring-dampers, adjustable anti-roll bars front and rear

Brakes: AP Racing with adjustable pedal box

Wheels: ATS centre-lock Formula 3 wheels 9x13 and 10.5x13

Tyres: Cooper Formula 3 size bespoke slick tyres

Lighting: Front low/high beam lights with permanent LED running lights, Rear LED running lights with integrated brake lights, High-intensity rain light

Electronics: Cosworth Electronics engine and gearbox management system with integrated data logging, Momo steering wheel with integral driver display system

Engine: Supercharged Ford Duratec 2.0L, Rotrex supercharger with charge air cooling, Uprated conrods, pistons and bearings, Dry sump oil system

Max Power: 335PS @ 7800rpm

Max Torque: 290Nm @ 7500rpm

0-60mph (claimed): 2.8s

Top Speed: 290kph

Dimensions
Wheelbase: 2600mm
Overall Length: 4200mm
Overall Width: 1700mm
Height: 1015mm
Weight: 545kg

On the ropes

Engine Developments Ltd has been supplying engines to major international series for 40 years. In 2012 however, things haven't gone according to plan...

BY ANDREW COTTON

The question that has resounded across the endurance racing and Indycar paddocks in 2012 is: 'what happened to Judd?' The British manufacturer, Engine Developments Ltd, founded in 1971 by John Judd and Jack Brabham to produce their own competition engines under the Judd name, has developed a stunning reputation for reliability and efficiency for an affordable price.

For a decade the company headlined in Formula 1, working with Williams, Lotus, Tyrrell and Arrows, grew to employ 25 people, and now finds the majority of its work in sports car racing, supplying LMP1 and LMP2 teams. It also partnered with Lotus once again, supplying the marque's Indycar engines to five cars at the start of the year.

As featured in *RCE22N5*, the 2.2-litre V6 Indycar engine was produced in such a short time frame that by the time the cars hit the track, the engine was short on development and on pace alone, that showed. The low point of the year came at the Indianapolis 500, where the two Lotus cars, driven by Jean Alesi and Simona de Silvestro, were black flagged after just nine laps as they were about to be lapped, and were running 13mph off the speed of the front runners and were outside the 105 per cent range of the top times required to stay on the track.

Everyone pointed the finger at the Lotus engine, but John Judd questions whether or not the engine was the only factor at fault. 'We are down on horsepower, but I am not in a position to say that we are down by that amount,' says Judd. 'If you put down a figure of how many mph we are down, is that all horsepower? I can't tell you, but I doubt it. From what I know about engines, if someone says you are down by 'x', OK, but if you are down '2x', probably not.'

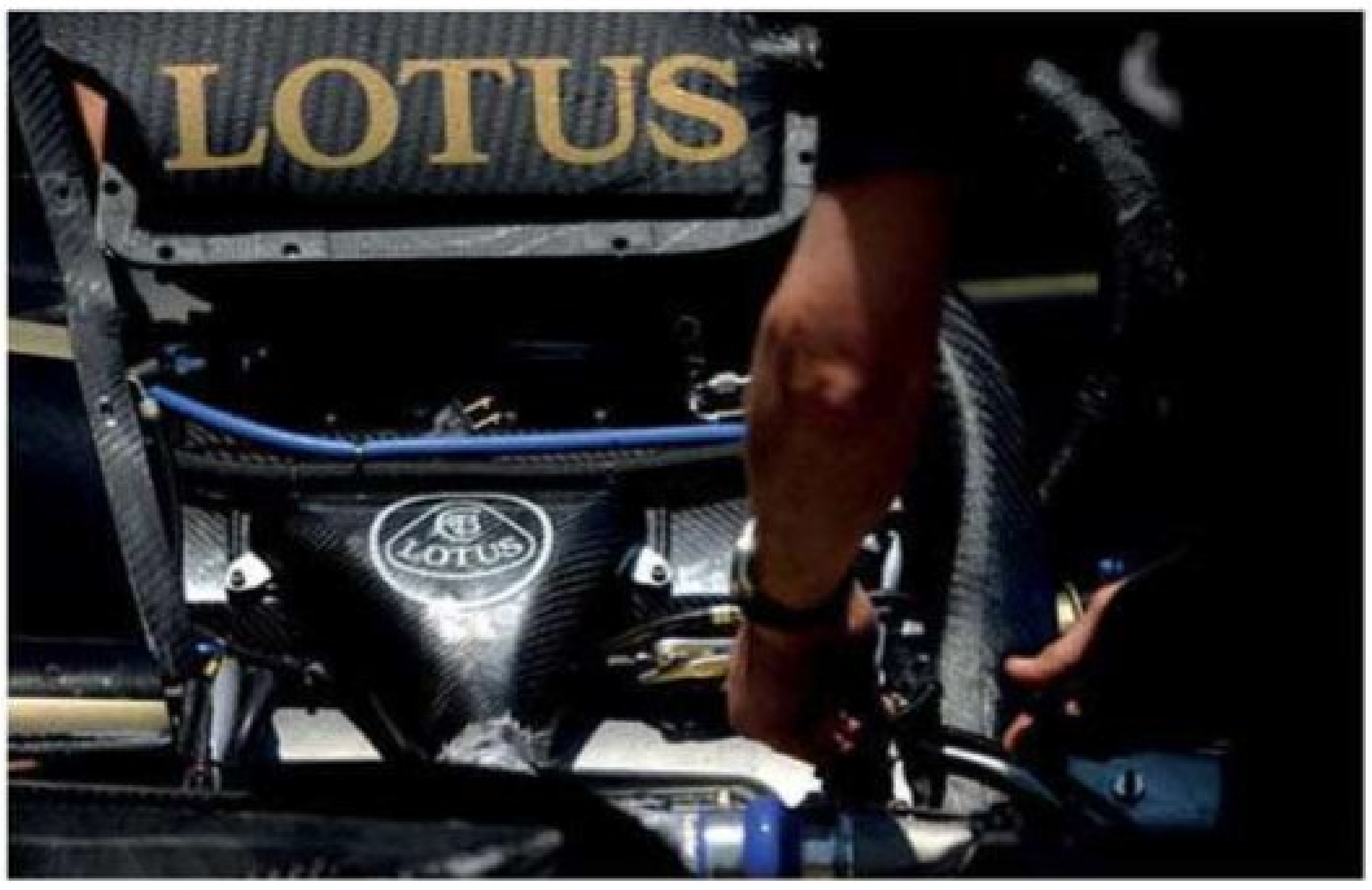
EDL has been allowed to change and develop the engine, outside the strict regulations imposed by IZOD, although Judd is reluctant to explain exactly what they have been allowed to work on, with the approval of its rival engine manufacturers. 'We certainly have made progress with the engine,' he says. 'The list of homologated parts cranks, conrods, bearing sizes, cam profiles, valves, valve size, ports, cylinder layouts, fuel injection...we have changed some of those. I don't want to go into detail.

'We do have more power than we had, but as we now only have one car, post Indy, let's say we have done only one test since, and so what we do gets run for the first time at a race meeting, and that does limit what we can do by way of improvement. Obviously it is common knowledge that we are a low budget operation. That, combined with one car, and a lack of testing, is a factor as to where we are right now. We are disappointed with the relative performance of the car – it doesn't seem to have improved.'

With the Indycar season now finished and a long winter of reflection ahead, Judd is confident that the engine can improve for next year, but whether anyone will take it on is another matter. Lotus's plans are unclear following the departure of Danny Bahar mid-season, and EDL's contract was with them, and them alone. Without doubt, the lack of development time hurt the outright performance, and supplying five cars severely restricted the already stretched staff. 'We did supply five cars at the start of the year, and all those five cars were able to start races with Lotus engines,' says Judd. 'There was no team that could not start a race because of

The Nick Perrin designed Pescarolo 03 featured the Aston Martin AMR-One chassis, and the Judd DB V8 engine

a lack of engines, but that was certainly not a good thing to be doing. There is no point in taking on any team until the engine is ready. If you want to work with customer teams, the engine has to be competitive, or close to competitive, and if it is not, the manufacturer needs to be giving the team reasons to stay with the manufacturer, and that comes down to assistance, like money, road cars, wind tunnel programme, whatever. If the engines are tickety-boo, you can just take the money, and that is fine. What you need is to have a team that you can work with through good and bad. If the engine is going to be thrown out of the car on the back of a bad performance, you won't go anywhere. We are paying the price for starting late and missing a lot of pre-season testing. It is six months since the start of the season, and we started the project six months after the other manufacturers. If we had spent those six months on the dyno and circuit testing, we would be closer to the front than we are now. You never know what you can achieve against other people until you get to the racetrack. We would be better than we are. The other manufacturers have tied up the better teams, and done the right thing doing that.'



Indycar performance was lacking, but Judd doubts it was all about power

Yet there were more problems on the horizon. In the sportscar world, reliability was also left wanting. Judd supplied engines to Dome, Pescarolo and Oak Racing, which ran in LMP1, and the BMW-derived four-litre V8 developed from the M3 engine in LMP2 following a change in regulations that stipulated production-based engines. Dome suffered failures in testing, and at Le Mans, Judd's reputation took another battering.

Much was expected of the Judd-powered Dome S102.5, but it failed to deliver in the race. The team had switched from a V10 to a flat crank V8, and the inevitable vibration took its toll on the sensitive electrical system that were featured on the car. That system, for example, included so many ride height sensors that the team ditched most of them.

During testing, a cylinder broke with Nicolas Minassian behind the wheel and, although he heard a problem and switched off the engine, it was finished. 'In the race, they had an internal water leak from a crack in the cylinder block, and the car retired with that,' said Judd, although Henri Pescarolo, who ran the car, insisted that it finish on Sunday afternoon as a thank you to the mechanics who worked so hard on it. 'It was just a local casting detail. You can't avoid high stresses in some areas, and the block was well within the safe limits that had been established, but it cracked. I guess if you look at fatigue test results, you get a big scatter when things fail, and with the mileage at the end of the race, it was not an issue.

'They had a torrid time in qualifying, put the engine in, and it then stuck in first gear going out of the pit lane, so Emmanuel [Collard] tried to do a lap of Le Mans in first gear. It is an unusual thing to do. At some point the engine quit. From the data clearly he did a sensible job and he was not in a hurry to get back, so he spent some time on the rev limiter and some time not, but we saw the engine temperatures rise and it all came to a grinding halt.'

Judd fitted a spare engine that was set up for another of its teams. Oak needed a modification to the oil system, Dome had a Zytek electric

Much was expected of the Dome S102.5, but a series of problems, some of them engine related, led to a disappointing race result

Judd spent a decade in Formula 1, supplying Williams with a 3.5 litre V8 in the FW12

throttle kick for the downshifts and the air boxes were different for all three. 'We took off the inlet manifold, scavange pump and switched to Pescarolo specifications. When they went out, it was on seven cylinders because one of the injectors that came with the airbox assembly from another engine, and which was working perfectly well, decided not to work any more. We started the race on seven cylinders. The thing was slow. It came in, we found the problem and fixed it and the engine was fine. Henri had a big bitch about the engine, but it was a normal DB V8 and we got it back after the race, put it on the dyno and have used it as our dyno development piece. When it retired, it had a power steering issue or something. It was not slow on the straight, it was four clicks slower on the straight than it was in qualifying. The power was slightly better than when it left us, so I won't take any shit on that one.'

Judd admits, however, that Oak Racing were let down, and the company paid the price as the team switched to HPD for the final two races of the World Endurance Championship. 'We certainly didn't do a good enough job for Oak in P1 or P2,' says Judd. 'In LMP1 we had an internal component failure that shouldn't have happened, and P2 they were leading the class and suffered an engine problem. We run the standard BMW road car valve springs and in the race the end of one of the springs fell off. If you look at a valve spring, you have to ground off the end so that it's flat, and it tapers off. This batch of springs had been ground down thinner than usual. The thin end broke off, which hadn't happened last year, or this year, but it got into the scavenge pump and sheared the scavenge pump drive. It is fair to say we should have put something on there to stop it happening. These aren't high-stressed racing springs. We were a bit unlucky that this bunch of springs were like that and it failed in Oak's engine, but that is life.'

Far from being despondent, Judd is examining the engine regulations for the 2014 season, and believes that he can produce a competitive non-hybrid gasoline engine for an affordable price, if there are any privateer teams that are looking to compete in the LMP1 category.

'The technical part of the regulations is defined,' says Judd. 'We have energy usage and the engine is free. I totally support that. The difficult bit is that it is easy for Audi and Toyota; they can just go and do their hybrid, but for us, will our customer teams do the 830kg non-hybrid petrol engine? Perhaps we'll do a V10 for that. The name of the game is getting the best fuel consumption. We can do a good job with the V8 or the V10. The V8 is 4.4-litres, the V10 5.5, so the horsepower will be between 400-600, the mid-point. You can do that with either engine with not a lot of revs.'

PRODUCTION BASED WASTE

The ACO switched from pure racing engines to a production-based, cost cap engine formula (engines limited to €75,000) in 2011 and in 2013 have plans to improve the reliability even further, suggesting that engines complete more than 10,000km between rebuilds.

'There are concerns among the manufacturers, particularly Nissan and ourselves, regarding the life of the standard parts,' says John Judd. 'We have got standard parts that don't do enough miles. It is absolutely stupid to make a regulation that says that you cannot use a racing engine. You have to use an engine that is made for something else. It is like saying that you have to use a washing machine as a fridge.

'We could do a cheaper and a better job with a racing engine. All the major components with that will do 20,000km, but we have parts now in the production engine that won't do 8,000km! In 2010 we were supplying DBs to race performance at a bit below the cost cap for the following year, but it was interesting to see that after 35 years, Formula 3 engines are not production based. You have a million production-based four cylinder engines, but the FIA have allowed race engines instead. It is heavily cost capped, but you can do a racing engine.'

WINNING FORMULA?

'A normally aspirated petrol engine,' Judd says, 'wants to be light, run low rpm, direct injection, and it is unlikely that we will do a turbo engine. The development cost of doing that would put it out of the reach of the privateers. I don't know if the teams will go 830kg non-hybrid, or mild hybrid solution. Any hybrid will be more complex and expensive for the teams to manage, and we need opinions from teams to do that and see what it is going to be.

'It is intended that we will have privateers, but they won't be able to win. You might do OK in the first year because some of the hybrids will trip up, but the ACO's intention for the hybrids is that they will win. Back in the early 2000s, Audi was wiping the floor at Le Mans with a petrol engine, no hybrid, no diesel, just that they had more monkeys and typewriters and did a better job. The manufacturer domination is nothing new, and not attributable to the diesel or hybrid.

'It is down to fuel consumption, and you need the best you can get. I am confident that we can produce a good petrol engine. The average power over a lap will be achieved by the engine that has the best fuel consumption, grams per kilowatt hour. We have ideas how to do that and they include producing a light engine, low revving, reduce friction losses and we can do that OK. The question is whether or not anyone will be there, and we rely on that. We are like a corner shop. We need to make more money than we spend.'

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(Im)proving ground

Far too late for 2012, and quite late for 2013, will the appointment of James Key to the role of technical director help Scuderia Toro Rosso become more than the Red Bull nursery?

BY SAM COLLINS

"I would say we have been consistently slow, apart from the qualifying in Bahrain, which was really a flower"

Red Bull has two teams in Formula 1. One is tasked with winning championships, the other is primarily used to prepare the next generation of drivers to win championships for Red Bull. Scuderia Toro Rosso may have been around for seven years, but the team has only built three Grand Prix cars in that time. Prior to 2010, STR used identical cars to its sister team, albeit with Ferrari engines and an in-house transmission. It took a major step forward at the start of the 2012 season with a significantly upgraded facility in Faenza, Italy, and numerous new hires. The first fruits of this expansion were seen in the STR7, as it was rolled out in the pitlane of Spain's Jerez Circuit.

The design was immediately notable for its raised sidepods and roll hoop-mounted cooling duct. 'Looking at the design of STR7 in general terms, we could start from the fact that 2011's STR6 was a good concept,' explains former technical director Giorgio Ascanelli, who headed up the car's development. 'But it didn't lend itself well to running a low exhaust and was better with a high one. Therefore it was logical that as the rules have changed in this direction, we should stick with a similar concept for 2012, expanding on the idea and its characteristics. Cooling – as always – plays a major part in the design of the car, and we've done something which should allow even more of an undercut on the sidepods, aimed at getting a better

streamlining of the rear of the car. In simple terms, we've made a shorter chassis, with a larger distance between the engine and the gearbox, so that the car can be thinner and more streamlined. We've also tried to improve the behaviour of our DRS and have a new generation of wings aimed at this, hopefully in time for the debut of the car. We've also worked on the braking system, because we wanted to improve its efficiency, both front and rear.'

It looked good on paper, but the results were not what the team had hoped for. The first half of the season saw only two low-level points finishes, and it was clear that the car was underperforming. Following the open test in Mugello before the European leg of the season, Ascanelli was clearly not happy with the progress of development. 'With the new people and capabilities do we get more bits? Yes, we do. Are they good bits? Sometimes. Half the things we brought to Mugello worked, half didn't. We have to keep looking at it. I would say we have been consistently slow, apart from in Bahrain [where Daniel Ricciardo qualified 6th on the grid], which was really a flower.'

Things did not improve, and by mid-summer Ascanelli had resigned from his post and left the team. Former Sauber and Force India technical director James Key was eventually named as his replacement. 'You could not pick a worse time for a TD to start at a team than September,' smiles the Englishman. 'You're just in time to catch the new car if you're quick, but too late to catch the overall architecture of it. You're just on the edge of being able to do something, so it would have been nice to start earlier, but it's certainly not too late to have an influence.

'My chance to look over the car has been quite brief as that time has been split between races, the factory in Italy, and the tunnel in the UK,' Key explains. 'Divide that by four weeks and it doesn't leave you with too much time. My feelings looking over the 2012 car are

Top: The STR7 started the season with very basic exhaust exits as the team had struggled to simulate the plume in the wind trunnel. New facilities lead to a better understanding and the installation of a Coanda style exhaust. Above: The heavily undercut sidepods on the Toro Rosso are one of its defining features, this raises the centre of gravity of the cooling system but has a number of aerodynamic gains

mixed, to be honest. I think that there are some very nice bits on it. It's really a nicely put together car. The quality of the parts is generally very high, the gearbox – for example – is very, very tidy and very compact, a long step from where cars were 10 years ago. Those sort of details are very nice on it.

'I think where it's suffering, though, is on the aero side. The car is efficient, but the total downforce is not enough, and if you look at qualifying performances it has been a bit variable. It's a little bit too aerodynamically sensitive, so there's work to do there. I think mechanically there are a few areas that are a little bit strange, in ways that don't allow you to balance the car in lots of different ways that you would perhaps want to. There are a few restraints mechanically, but a lot of those things have been tackled for 2013 anyway. The team had recognised those problems, so next year the track engineers will have a far bigger toolset to play with.'

While it's pretty clear that not everything on the car is ideal, Key has still to make up his mind about some of the concepts featured on the STR7, including its most striking features. 'From what I've seen of the sidepod concept so far it clearly has its advantages, but potentially there are some disadvantages there as well, so it is difficult to

know how to proceed,' he admits. 'The team has developed around the concept for a couple of years, so it's quite well established and the moment you step away from something like that you step backwards.

'You have to be sure that the step backwards leads to a higher rate of development. It's one of a number of areas of the car we're looking at right now. The problem is that it's all of the areas aerodynamically are interlinked – you change one thing and it means two other things need changing. That carries on and it gets quite complicated, so you need a history to the car before you make too many big decisions. While the radiators sit higher, your cooling layout is not particularly ideal because you've squashed the box it has to sit in. It is one of those factors we need to assess for next year to see if it's worth taking those hits for the aero gain.'

When the STR7 was first rolled out, it featured a very conventional exhaust exit blowing onto the underside of the upper wishbones. The design caused early headaches for Ascanelli, with the suspension getting too hot. The Italian was also open about his ignorance of how to control the exhaust flow, but as the season progressed, his ignorance appeared to fade and the original exhaust layout was replaced with a more effective solution, not dissimilar to the one found on the McLaren.

'There is obviously a strong interaction there between the sidepod shape and the exhaust,' details Key. 'If you look at a more traditional sidepod design where you have the Coke bottle shape, there is a lot of inwash, and that is acting at an angle that isn't ideal for your exhaust trajectory. With ours you have less of that inwash due to the shape of the back of the car. So I'm not sure the sidepod concept of the STR7 is that detrimental to the exhaust; while there is more we can get out of the current system it doesn't dictate things one way or the other.'

TRANSMISSION

One area of the car Key highlights as a strong suit is its transmission. Toro Rosso has continued the Minardi tradition of designing and building its own transmissions, whereas most of the team's immediate rivals buy their gearboxes in. 'The current gearbox as a packaging exercise is really tidy,' enthuses Key. 'It is an aluminium casting with a carbon front end / bellhousing which contains the suspension components; it is a fairly conventional layout in terms of a pull rod suspension, but it is all our design. We have the rigs at the factory to build and test it. It is very much an in-house part, but there are pros and cons to that, because there are teams considered to be our rivals that source their gearbox elsewhere, and that's fine.

'To produce a gearbox takes a lot of resources: there are a lot of people involved and it is a reliability critical thing – you don't have that hassle if you do not do your own gearbox. However, what you do have is complete flexibility over the design of the rear end of the car; your wheelbase, diffuser design, rear suspension, bodywork, [and] cooling philosophy are all areas that are affected by the gearbox and they are completely open. That's good, because rather than finding out what you will have, which is what happens when you buy in your gearbox, you get to define what it is going to be. It is a trade off, but it is nice to have the freedom.'

Despite the mid-season misgivings and the departure of Ascanelli, Key is impressed by the Toro Rosso facilities in Italy.

'When I arrived I was pleasantly surprised,' he admitted. 'It's a lot bigger than I thought, though it is quite spread out. The resource and manpower is slightly bigger, if anything, than Sauber and Force India. In terms of facilities it is OK. There are a lot of performance-related rigs, for example, but it suffers slightly as it has grown from little more than a race team to what it is now in three years, so in many respects it is a new team. It has kind of exploded in F1 terms, going from 80 people to more than 340 in such a short space of time, but you have to make sure that what you end up with is the shape you want, and there is work to do to make all of that stuff fit together. The different departments are all fairly separate and dispersed – the buildings are all near each other but they are not next door to each other. But for its size it is really quite good. The new facilities that are being built will solve a lot of the issues and people will all be in the same place.'

"STR have done a good job in the last three years in getting something from nothing"

One of the departments that Key has set out to change is the simulation group. 'To date, STR have done a good job in the last three years in getting something from nothing. Having said that, and having come from teams with more time and budget, there are some clear steps we need to make to improve. We're reforming the department that does all of the simulation work. We are calling it vehicle performance and it covers vehicle dynamics and the bits attached to that. We are looking at stepping up our simulation capability quite a bit.'

Where the car, and the results, are concerned, Toro Rosso's 2012 season was not one to remember. Key hopes that he has turned the team's fortunes around in time for the 2013 season.

TECH SPEC

Official car name: STR7

Engine: Ferrari V8 Type 056

Chassis material: Composite monocoque structure

Bodywork material: Carbon fibre composite

Front suspension: Upper and lower carbon wishbones, torsion bar springs and anti roll bars, Sachs dampers

Rear suspension: Upper and lower carbon wishbones, torsion bar springs and anti roll bars, Sachs dampers

Steering: Scuderia Toro Rosso

Gearbox: Seven-speed hydraulic

Clutch: Sachs Triple-plate pull-type

Calipers: Brembo

Pads and discs: Brembo

Cooling system (radiators, heat exchangers): Scuderia Toro Rosso

Cockpit instrumentation: Scuderia Toro Rosso

Seat belts: OMP

Steering wheel: Scuderia Toro Rosso

Driver's seat: Carbon fibre construction, moulded to driver's shape

Extinguisher system: Scuderia Toro Rosso/FEV

Wheels: Advanti

Racing fuel cell: ATL

Overall weight : 640kg (including driver and camera)

Rallying revived: Peugeot 208 R5

Peugeot steal the march on the competition by revealing their FIA R5 rally concept car

BY SAM COLLINS

One of the best-selling rally cars of all time is the Super 2000 specification Peugeot 207, of which over 100 examples have been sold. That car has now been replaced, with Peugeot Sport unveiling a concept version of its new FIA R5 specification rally car based on the 208 production car. The 208 R5 was developed by a team headed up by Alexis Avril, technical manager of Peugeot Sport, and Bertrand Vallat, formerly responsible for the 207 S2000. The R5 category consists of group A vehicles derived from a production model of which at least 25,000 must have been produced. Launched for 2013 by the FIA, among the category's objectives is a noticeable reduction in costs, including operating expenditure. As a result, the technical regulations carry over much of the philosophy of the S2000 category; four-wheel drive, five-speed sequential gearbox, no central differential, and long travel suspension. The similarities don't stop there: externally wider tracks, a spoiler, and bigger wheel arches are all permitted. The FIA has also set the maximum price for the R5s at €180,000 (excluding taxes).

'Based on an optimisation of costs,' explains Vallat, 'the regulations impose, among other things, a maximum price for certain parts and technical limitations such as a minimum weight of components of the chassis and engine. In addition, a certain number of components of the vehicle must be similar. The hub carrier is a perfect example. All four must be identical. This makes operation considerably easier and limits costs and stocking.'

One major difference is the engine. The 2.0-litre naturally aspirated S2000 unit has been replaced by a 1.6 litre turbo Global Race Engine. With a GRE engine already developed, it would not be a great step for Peugeot to join the World Rally Championship, but senior figures within PSA – the company which owns both Peugeot and Citroen – explained to *Racecar* that the brands would be represented in different categories. Peugeot will prepare cars for R2 and R5, while Citroen will run in WRC and R3, albeit with Peugeot Sport developing the R3 on Citroen's behalf. 'We are aiming for performance which is slightly higher than that of the S2000,' Vallat asserts. 'We are starting with the 1.6l THP that is already a prize winner. We know that it is reliable and powerful and we can achieve 280 horsepower. We have serious foundations with this engine as it is the same as that of the RCZ Racing Cup, which currently develops 260 horsepower in its endurance version. We are also aiming for a very high level of durability and reliability: with between 3000 and 5000 kilometres between rebuilds (according to the components and conditions), which will also reduce the operating costs.'

The 208 Type R5 benefits from the developments of the 208 production car, particularly with regard to weight. The shell of the 208 is approximately 40kg lighter than that of the 207.

Peugeot Sport has big ambitions for the R5 208, and will begin an extensive test programme from the end of 2012, both on asphalt and on loose-surfaces. This testing will continue throughout the car's life as part of an in-house development programme.

The R5 208 will be on sale by mid-2013, and Peugeot is hoping that it will sell at least as many R5 208s as it did S2000 207s. Peugeot will not have it all its own way, however: Toyota is thought to have an R5 car in development and Ford works team M-Sport has announced that it too will build a car to the regulations.

It seems Group-R has revived rallying, and many more cars are likely to join the fray.

Peugeot Sport will sell the 208 R5 mid-2013 and will also prepare an R2

> **"With a GRE engine already developed it would not be a great step for Peugeot to join the World Rally Championship"**

TECH SPEC

Engine

Type: EP6 CDT 1.6 litre 4 cylinder
Location Transverse: Front
Power: 280bhp at 6,000rpm
Torque (Nm): 400 Nm at 2,500rpm
Max engine speed: 7,500rpm
Injection: Magneti Marelli High Pressure Direct
Intake: Single throttle
Number of valves: 16

Transmission

Mode: Four-wheel drive
Clutch: Dual disc
Gearbox: Five-speed with sequential control
Differential: Two self-locking differentials

Chassis

Structure and materials: Shell + Tubular roll-over bar
Front and rear suspension: Pseudo MacPherson

Brakes / Steering

Front brakes: Alcon 4 pistons
Diameter: 300 (gravel) 355 (asphalt)
Rear brakes: Alcon 4 pistons
Diameter 300 (gravel) 355 (asphalt)
Steering: Direct with hydraulic assistance
Wheels: Aluminium monoblock 8"x18" (asphalt) / 7"x15" (gravel)
Asphalt wheels: 225x40x18
Loose surface/gravel wheels 215x65x15

Dimensions

Length: 3,962mm
Width: 1,820mm
Wheelbase: 2,560mm
Minimum weight: 1,200kg (asphalt & gravel)


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Valve Locks:
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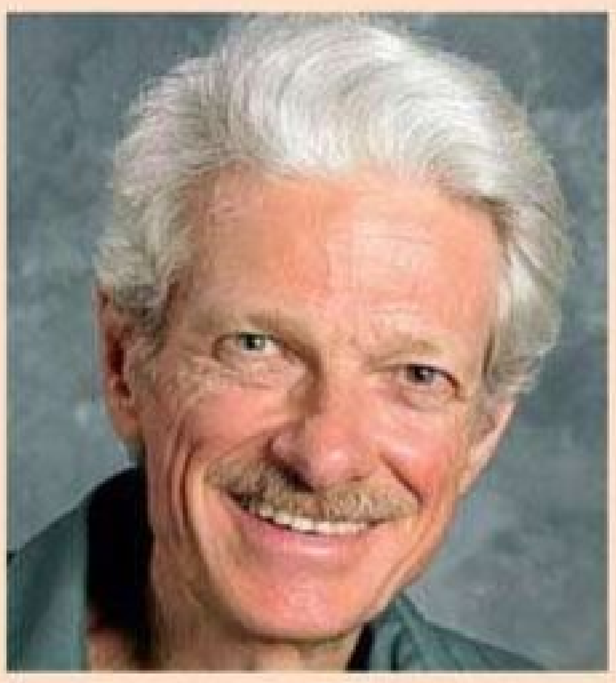

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Static deflection...

...and what that means as used in ride frequency calculations

Q In ride frequency calculations, what's your definition of 'static deflection' when used in the form f = 188/sqrt(x) in cpm? Could this mean static deflection of the chassis (or spring with a motion ratio of 1) as the car sits on the scales at setup, for example, taking just the spring: spring free height – spring height at static load = x.

Or does this refer to static deflection at some estimated 'g' loading?

I've found many opinions on this, but as yet no clear-cut answer.

The equation shown is for English units (inches and pounds), and gives the undamped natural frequency for the sprung mass in cycles per minute.

Static deflection, as used here, means the amount that the corner of the car being analysed deflects under static load (the car sitting still in the shop), from a real or theoretical condition where the suspension is extended to the point where the spring completely unloads. In some cases, we can measure this directly, and be fairly accurate. However, in many cars, the suspension cannot actually extend that far; something stops the motion before the spring completely unloads. Also, in many cases, the wheel rate in ride is not a constant.

Therefore, it's often best to use a calculated value for static deflection; weight of the sprung mass at the corner of the car being analysed, in pounds, divided by the wheel rate in ride for that wheel in pounds per inch, at the ride height we're examining.

We should note that it's really the mass of the sprung structure that we're concerned with, rather than weight or load. The equation takes the mass as weight in Earth's gravity because that's easy to measure. However, it shouldn't be supposed that the frequency changes when we adjust wedge, or when the car sees cornering loads. It might, a bit, if the wheel rate is not constant, but if the system is linear it doesn't. It also doesn't change due to aerodynamic loadings, if the system is linear. The frequency does change with fuel burn-off, or if we move ballast.

If we have an existing car, and we want to know its undamped frequencies, we can get a good approximation of the sprung weights by taking the springs out and measuring the weight of the unsprung components with our wheel scales, and then putting the springs back in and noting readings, then subtracting to find the sprung weight. When we read the scales with the springs in, we need to have the car in an unwedged condition, meaning equal left percentage front and rear, and equal rear percentage left and right.

When there is a lot of unsprung mass, as with a 300lb rear axle, and the unsprung mass is roughly centred left to right, but the sprung mass is very left-heavy, there may be a noticeable difference between equal total left percentage front and rear, and equal sprung left percentages. In such a case, we should try for equal sprung left percentage front and rear; get the left percentages equal, after deduction of the unsprung weights.

Fortunately, especially in racecars, we don't need a high degree of precision in these measurements or calculations. Even if we do get really good precision, the result is only an approximation of actual car behaviour, because we have damping, tyre compliance, and various other things that cause the running natural frequencies to vary from calculated undamped frequencies.

Nevertheless, it's a good idea to try to take a look at the calculated natural frequency relationships, particularly for a lightly damped dirt car.

"We should note that it's the mass we're concerned with, rather than weight or load"

Traction on dirt

Mark Ortiz considers the theory

Q I'd be very interested to know your thoughts regarding a tyre's behaviour on dirt. You've stated in many previous newsletters that chassis dynamics on dirt behave in much the same way as they do on pavement for a given level of grip, and here I agree. However, there is still much confusion among racers, a language problem really, about terms such as side bite vs lateral acceleration capability and the like.

In the case of side bite on dirt, when is elastic load transfer more beneficial than geometric load transfer? Is there really a difference, and if so, why?

So my request / question is this: Would you run through the different phases of traction available as a dirt track goes from a soft tacky surface to a dry hard surface? Also, could you detail which of the chassis dynamic parameters are most pronounced during the phases of that progression for both lateral and longitudinal grip.

I was reading your old newsletter dealing with the subject of traction in the snow, and I got to thinking how, early on in the night on a wet dirt surface, the compaction / shearing mechanism must be the dominant player in traction, very quickly followed by sticky adhesion between tacky dirt and a cold tyre and then finishing up with a dirt surface harder than the tyre itself, in which the interaction is much more like pavement.

Dirt is a lot like pavement, in that it's basically just grit and some gravel, with a binder. The big difference is that the binder is clay, and its behaviour is highly sensitive to water – it gets soft when wet. If it's really wet, it gets greasy. If it's somewhat wet or just damp, it gets tacky or sticky. As it dries further, it gets hard and brittle, and not sticky at all, with the result that the grit it's binding can be torn loose fairly easily, and some of the clay itself can be loosened to create a fine dust.

We occasionally end up racing on greasy-wet or sloppy dirt, but we try to avoid that. To get traction in outright mud requires a very toothy tread – very low rubber-to-void ratio – that's also self-cleaning. Off-road tyres are often this way. Dirt racing tyres are not really optimised for this condition, because we don't spend much time on such surfaces.

It's a bit hard to determine whether lateral load transfer has the usual effect in serious mud, partly because when there's so little grip there's very little lateral load transfer, and the vehicle is going every which way, making it hard to discern whether it's loose, tight, or what. However, we can say that mud does not reward a narrow tyre the way snow does. It generally rewards a tyre that floats rather than penetrates, but has a tread that penetrates.

Moving to less wet conditions, dirt becomes firmer, yet still soft enough for a tread to indent. A dirt track may be like this for a time, particularly for the heats. The tyres can grab dirt and throw it. One might think that concentrated loading of the tyres might benefit grip on this sort of surface, but experience suggests that there's no reversal of the effects of wedge.

Dirt is like pavement, but the binder is clay which is sensitive to water

As the dirt dries further, it reaches a state where it's still sticky, but too hard for a tread to leave an impression. This is generally the condition in which the track is fastest, and also the condition in which it most resembles pavement. The surface rewards contact area. Edges and grooves cease to have much effect. Slicks will be very fast.

With further drying, we'll see the track either go to a blue-groove condition, or an outright dry-slick state. In the blue-groove condition, the surface absorbs enough rubber to visibly blacken. The rubber serves as a binder, and also may chemically bond with the tyres. The surface will often be shiny. Slicks will work on this sort of surface too.

Alternatively, the surface may be loose and sandy enough so that it gets hard, but with a lot of sand and dust on top. The surface then has properties a bit like asphalt or concrete that is either very dusty or wet: there's a hard, gritty surface with a lubricating layer on top, and sipes in the tread blocks become useful for creating edges to penetrate the lubricating layer. Some believe that, in this situation, tyre load sensitivity reverses, due to the importance of penetration. My own observations contradict this; wedge still seems to tighten the car. The surface seems to reward slightly lower tyre pressures than a firm but tacky surface, and wide tyres still seem to beat narrow ones.

On dry pavement, tyres work by a combination of chemical bonding and mechanical interlock. On wet pavement, chemical bonding is largely prevented and the tyre relies on mechanical interlock. The only time chemical bonding can occur on dirt is when the surface is either tacky or blue-grooved. But whether chemical bonding is involved or not, more contact area helps, and lateral load transfer hurts.

Is there a difference between geometric and elastic load transfer? No. The tyres can't tell where their loadings come from. However, it is quite possible for people to be confused.

For example, suppose we reduce the geometric roll resistance at the rear. The car will then roll more, and there'll be more elastic load transfer at the rear, although the overall load transfer at the rear will be less. The rear will stick better. The outside rear corner of the car will ride lower, creating the appearance of increased lateral load transfer at the rear. A layman can then easily conclude that load transfer is helping side bite (by which I mean lateral acceleration capability), or that elastic load transfer is helping it.

I still have yet to encounter a case where lateral load transfer helped side bite on dirt, although I've encountered plenty who've concluded that it does, due to a misunderstanding of when lateral load transfer is being increased or decreased.


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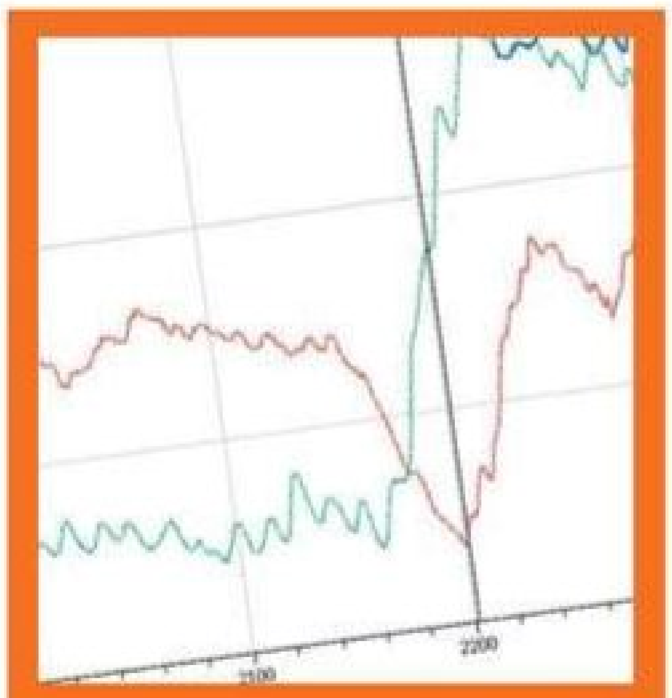

Databytes gives insights to help you improve your data analysis skills each month as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems. Plus we test your skills with a teaser each month

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

Pressure sensors

An invaluable source of data when analysing performance

Pressure sensors can provide vital information regarding the performance of a racecar. Previously the topic of aerodynamic pressures has been covered, but there are other equally interesting and often critical pressure measurements that need to be conducted. These pressures usually relate to gases or fluids that exist in the engine, such as oil pressure water pressure and manifold pressure. All these can affect the maximum performance of an engine in various ways.

There are several different ways of measuring pressure, with the major differences being what is the datum or reference pressure used? There are generally three different types of references used. Absolute pressure measures pressure relative to perfect vacuum – for example ambient air pressure and sometimes turbo boost pressure.

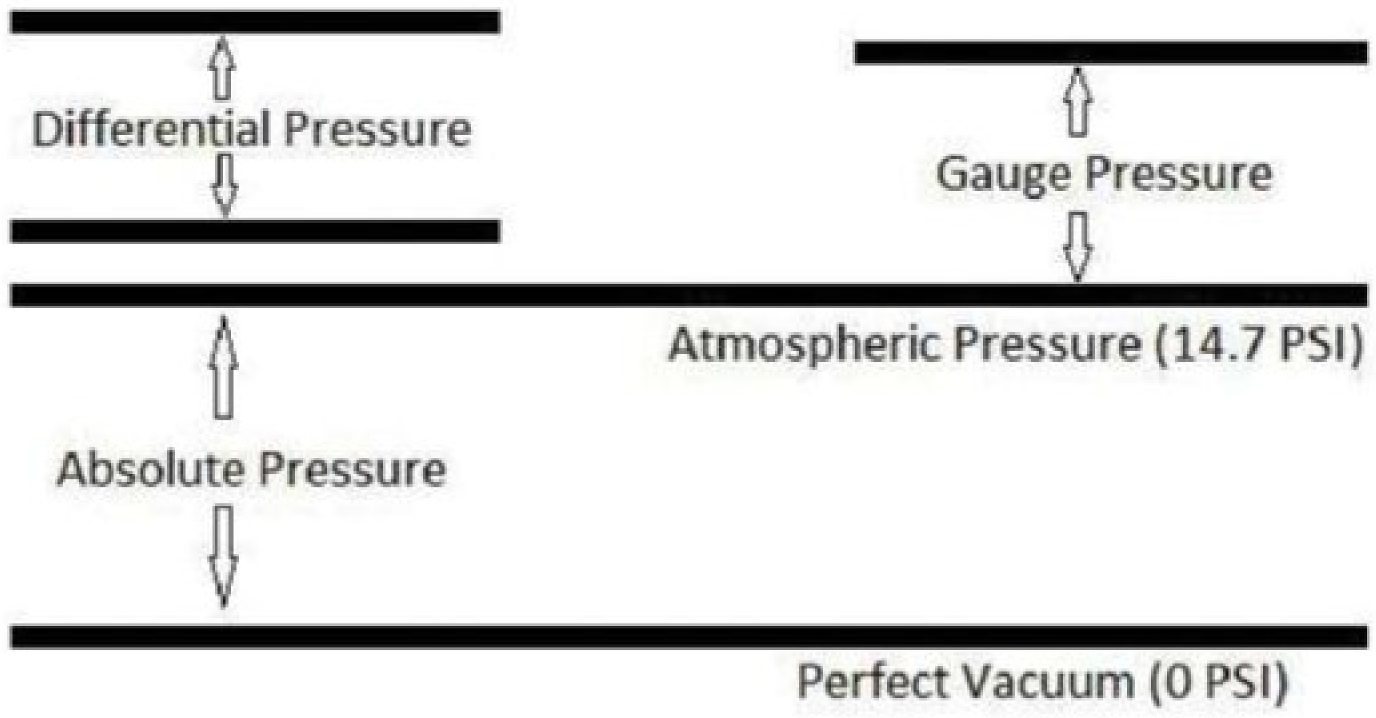

Figure 1: gauge pressure is measured relative to ambient air temperature and is commonly used for engine coolant and engine oil pressures

Differential pressure is the measurement between two pressure points, normally used for aerodynamic measurements.

Gauge pressure is measured relative to ambient air temperature and is commonly used for engine coolant and engine oil pressures **(Figure 1)**.

There are several different types of pressure sensors, all of which are best suited for different applications. The principle is always the same, converting the mechanical pressure into an electrical signal and this can be done in a number of different ways, including potentiometric, inductive capacitive, piezoelectric and strain gauge sensors.

Two common types for motorsport applications are the potentiometric pressure sensor and the strain gauge pressure sensor. The potentiometric pressure sensor uses a mechanical link such as a bourdon tube, capsule or bellows to drive a wiper arm on a resistive element. Much like a standard linear sensor, this means there is potential for repeatability and hysteresis errors. These sensors are, however, very low cost and perfectly acceptable for installations that don't require maximum accuracy. The strain gauge pressure sensor is perhaps the one most widely used for motorsport applications. Traditionally these sensors were based on a metallic strip with a strain gauge bonded on, and the deformation of the metallic strip then causes minute electrical changes in the gauge that can be amplified and measured. Another type of strain gauge pressure sensor is the semiconductor type. This has the strain gauge embedded in, or bonded on, to a silicon diaphragm. The crystal lattice structure of the silicon is then deformed when stress is

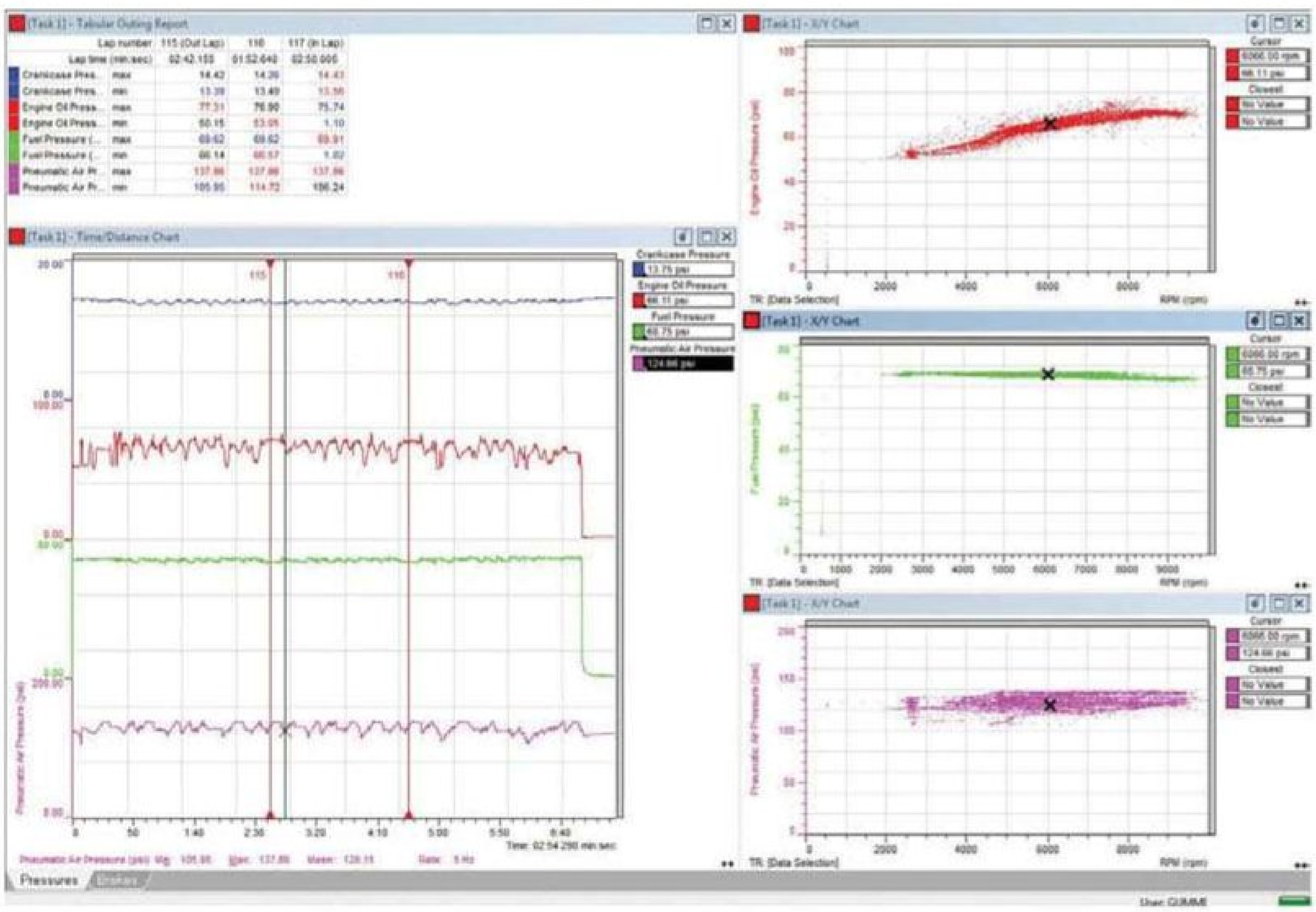

Figure 2: a simple but effective worksheet for engine pressures. Top right has the overview per lap, on the right-hand side are x-y plots with pressures versus rpm and the middle shows the detail graphs

Figure 3: a simple maths channel

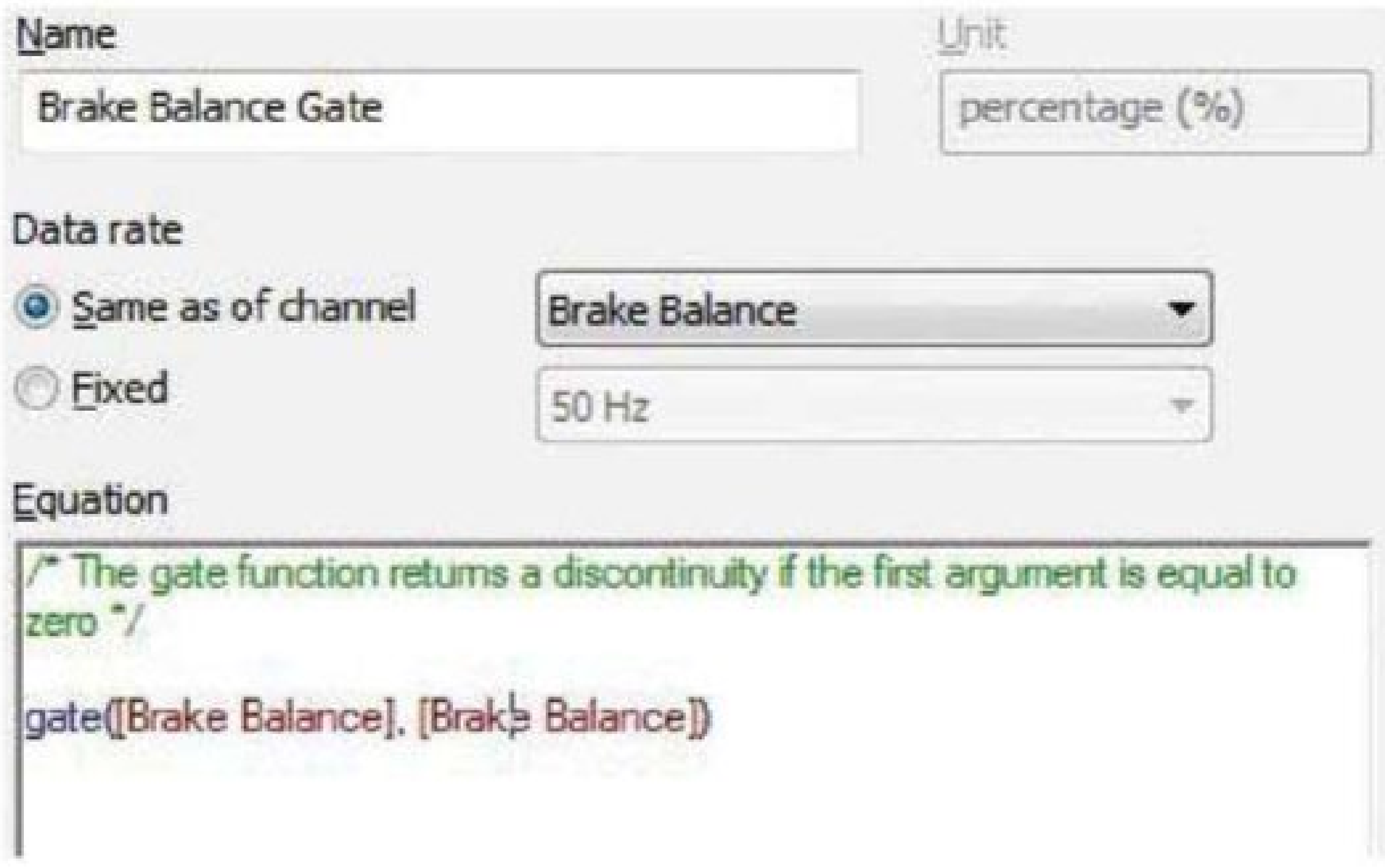

Figure 4: good data analysis software should have a gating function that can be applied to the maths channel

applied and the resistance in the strain gauge changes, generally termed a piezoresistive effect.

VIEWING PRESSURE DATA

In most instances, when pressure data is concerned the points of interest are maximum and / or minimum values. These are often best gauged using a lap-by-lap outing report. This simple format can give a good overview of all pressures involved and which ones require further attention. Once a pressure channel has been identified as being out of the acceptable range, there are a number of ways to view the data to determine whether there's a cause for concern or not.

Oil pressure is a good example of a very important pressure for the health of an engine. The oil pressure pump is generally driven by the rotation of the engine hence the oil pressure should be directly related to engine rpm. Using this information it's possible to generate an x-y plot that shows engine rpm versus oil pressure. It now becomes very easy to see whether a low oil pressure reading is normal for a set of circumstances. If the oil pressure minimum value is where rpm is low, the chances are the spike will be minimal and won't hurt engine performance. Equally, if the engine isn't equipped with a dry sump lubrication system, it would be possible to qualify the engine oil pressure with lateral

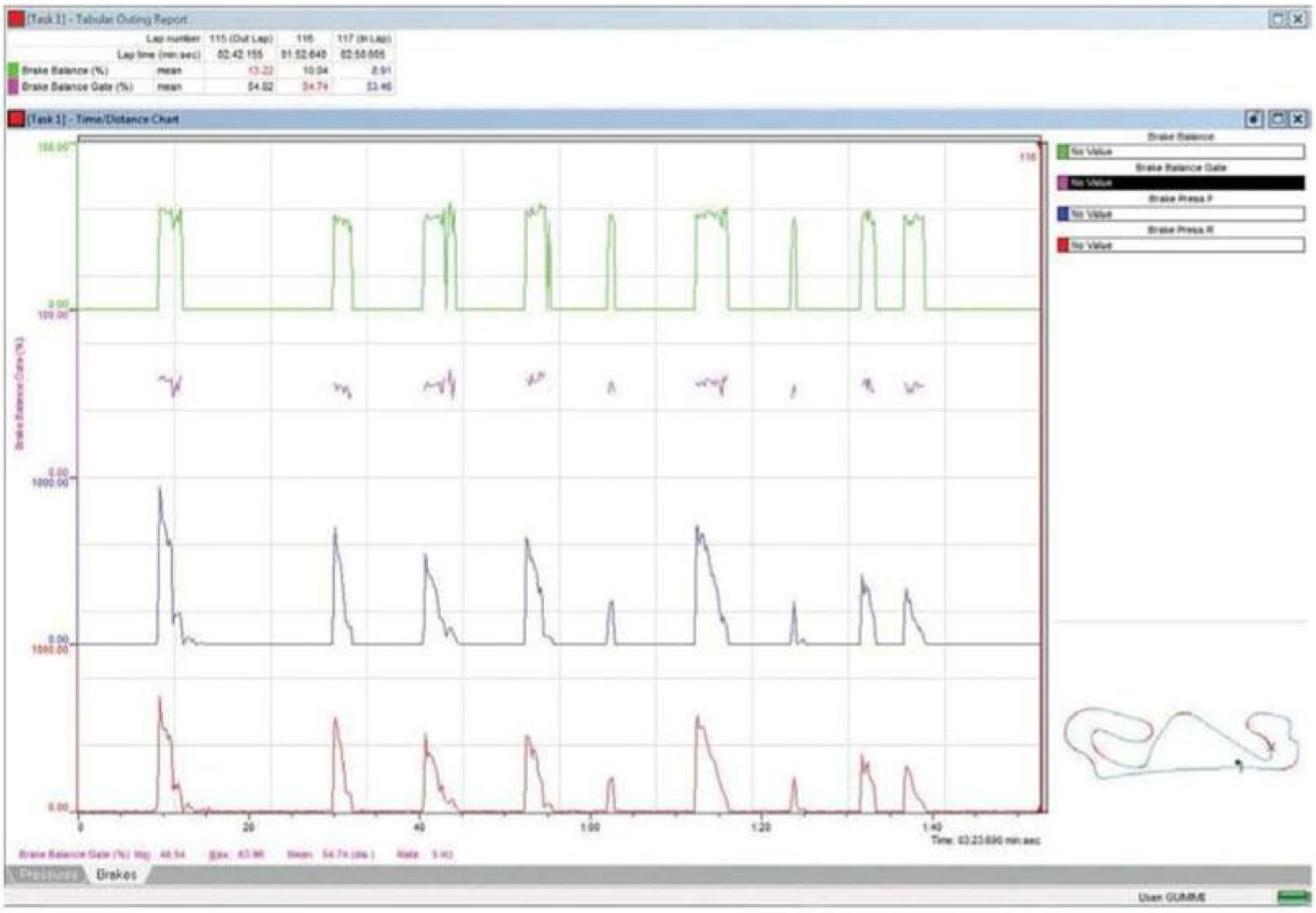

Figure 5: here the difference between the standard brake balance channel and the gated one can be seen. The outing report above show clearly the effect on the average per lap value

acceleration. This information could then also be used to optimise the design of the oil pan.

Brake pressures can provide some very useful information about how the driver is using the brakes, and how well they're performing. Looking closely at the shape of the brake pressure trace, it shows clearly whether the driver is confident on the brakes or whether there's work needed. From an engineering point of view, the brake balance is perhaps more of interest. Using the brake pressure channels it's possible to calculate the brake balance fairly easily. A simple maths channel is shown in **Figure 3**.

This channel returns a trace of the brake balance and can be viewed on a graph. Sometimes it is more useful to have just a single figure for the brake balance for every lap. If the above brake balance channel was used unmodified, the number returned would be incorrect as the channel exists for all values hence will be zero at all points when the driver isn't on the brakes. It's therefore necessary to create a channel that returns "nothing" or discontinuity when the brakes are not being applied. This is simple enough in most cases, as good data analysis software should have a gating function that can be applied to the maths channel. See **Figure 4**.

The result can be displayed as shown in **Figure 5**.

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"The principle is always the same, converting the mechanical pressure into an electrical signal"

Speed matters

Continuing our studies of the Honda RA107 Formula 1 racecar

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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Even though the Honda RA107 was not the fastest car on the 2007 Formula 1 grid, the opportunity to carry out some trials on one in the MIRA full-scale wind tunnel was just too good to pass up. So thanks once again to Bjorn Arnils and Nadine Geary as we work our way through some of the configuration changes made in an all-too brief half day session.

SPEED CHECKS

It is routine at the start of Racecar's wind tunnel sessions to check the aerodynamic coefficients at 60mph and 80mph, the latter being the maximum speed available in the MIRA wind tunnel. Sometimes the coefficients vary little between the two speeds, in which case we run at 60mph to save both energy and time. However, more often than not the coefficients are lower at 60mph. Why should this be? Clearly we'd expect the measured aerodynamic forces to be lower because they rise with the square of speed, but the calculation that the wind tunnel's data acquisition software does to generate coefficients from the measured loads takes the test speed into account. The only reason that the coefficients can be lower at the lower speed is because the forces are smaller than square law scaling of the higher speed forces would suggest, and the usual conclusion is that the flows over (and under) downforce inducing devices are not fully developed at the lower speed. Another way of putting it is that the velocity is below the stall speed of the devices concerned.

So let's take a look at the coefficients on the Honda at the two speeds to see how they varied. The changes (Δ) in counts, where 1 count is equivalent to a coefficient change of 0.001 are also given.

Clearly, at 80mph compared to 60mph, -CL increased, CD decreased and accordingly efficiency (-L/D) increased. Interestingly, however, balance did not alter, suggesting that the flows that were not fully developed at 60mph had developed equally along the car by the time it reached 80mph.

The benefit of downforce can be thought of in terms of its magnitude relative to the car's weight, conveniently ignoring the phenomenon of tyre load sensitivity for a moment. So let's for once tabulate the actual measured forces so we can compare them to the weight of the car with driver (minimum 605kg or 5935N at the time, excluding any allowance for fuel weight).

So, at 60mph downforce is already 18.9% of the car's dry weight including driver, which very simplistically means that if the tyres' coefficient of friction were – say – 1.5, that the car could actually corner at

Table 1 – the effects of speed on the aerodynamic coefficients of the Honda RA107

	CD	-CL	-CLfront	-CLrear	%front	-L/D
60mph	1.060	2.154	0.813	1.341	37.74	2.032
80mph	1.046	2.201	0.831	1.370	37.76	2.104
Δ, counts	-14	+47	+18	+29	-0.02%	+72

Table 2 – the effect of speed on the total forces measured at two test speeds

Test speed	Drag, N	Downforce, N
60mph	553.2	1119.4
80mph	991.3	2075.0

'Trip strips' can be seen here, which cause the airflow to separate on the tyres approximately where it would if the wheels were rotating

Table 3 – the effects of a 15mm Gurney on the rear wing

	CD	-CL	-CLfront	-CLrear	%front	-L/D
With	1.054	2.207	0.818	1.389	37.06%	2.094
Without	0.943	1.977	0.853	1.123	43.15%	2.097
Δ, counts	+111	+230	-35	+266	-6.09%	-3

Table 4 – the effects of a 12mm Gurney on the Benetton B199's rear wing

	CD	-CL	-CLf	-CLr	% front	-L/D
With	1.041	2.248	0.884	1.364	39.31	2.159
Without	1.002	2.203	0.889	1.314	40.35	2.200
Δ, counts	+39	+45	-5	+50	-1.04	-41


'Trip strip' on the rear wheel


Fitting a Gurney to the Honda's rear wing


Gurney tested on the Benetton B199 rear wing

nearly 1.8G at just 60mph. But increase speed by just 20mph and downforce had actually increased by some 85%, whereas had it simply scaled according to the square law it would have increased by just under 78%. And downforce was now equal to approximately 35% of the car's weight, which if the same simplistic assumption on additional grip were made, would suggest that with the same hypothetical tyres the car would be capable of cornering at just over 2.0G at 80mph, compared to just 1.5G if there were no downforce assistance.

At this point we should remind ourselves that although 'trip strips' were attached to the wheels to simulate the effect of wheel rotation, the MIRA wind tunnel has a fixed floor so our downforce data will have been underestimated. However, once actual forces have been looked at, it's impossible to resist the temptation to work out the 'stick to the ceiling' velocity, and we can quickly work out that if the car developed 2075N of downforce at 80mph it would develop the equivalent of its own weight at about 135mph – and in reality slightly less than this, given that we were dealing with somewhat underestimated downforce values.

"The rather large Gurney had a potent effect on total downforce and drag"

BIG 'GURNEY'

While watching the many wool tufts that the car's owners had diligently applied all over the visible 'wetted' surfaces of the car, MIRA's aerodynamicist Joe Masterson, an ex-F1 man himself, observed that the flow may still not have been fully attached to the rear wing's underside near the trailing edge of the flap. He suggested simultaneously removing the wool tufts themselves, in case they were affecting the flow, and affixing a 15mm Gurney to the flap's trailing edge upper surface to see what the effect would be. Note that a lower downforce wing had been fitted by this stage, as described in last month's issue. Table 3 shows the results.

This rather large Gurney had a potent effect on total downforce and drag, increasing both by between 11.5% and 12.0%, and it obviously shifted the aerodynamic balance markedly to the rear. Overall efficiency was scarcely affected, though, because downforce and drag had increased in proportionally similar amounts. What we cannot tell from this is whether the Gurney increased the rear wing's downforce contribution by simply adding camber and angle, or by increasing the area of flow attachment. What we can do though is compare a similar test carried out on the Benetton B199 we studied back in 2009. Table 4 shows the results of that test, which featured a slightly smaller 12mm Gurney.

In this instance the Gurney produced a much more modest effect, certainly when considering that it was almost as big as the one tried on the Honda, and the efficiency of the downforce gain was considerably worse. This suggested that perhaps the Benetton wing, which was at its steepest available setting, was already at its peak angle and working hard. But perhaps the Honda wing wasn't working as well at this test speed and the Gurney did indeed help the flow to better attach to the flap's 'suction surface'. Given that the Honda's wing was the lower downforce device of two available to the owners at the time, perhaps it was not intended to generate fully developed flows until a higher speed than 80mph was reached.

Racecar's gratitude goes to Bjorn Arnils and Nadine Geary.

The Parisian powerhouse

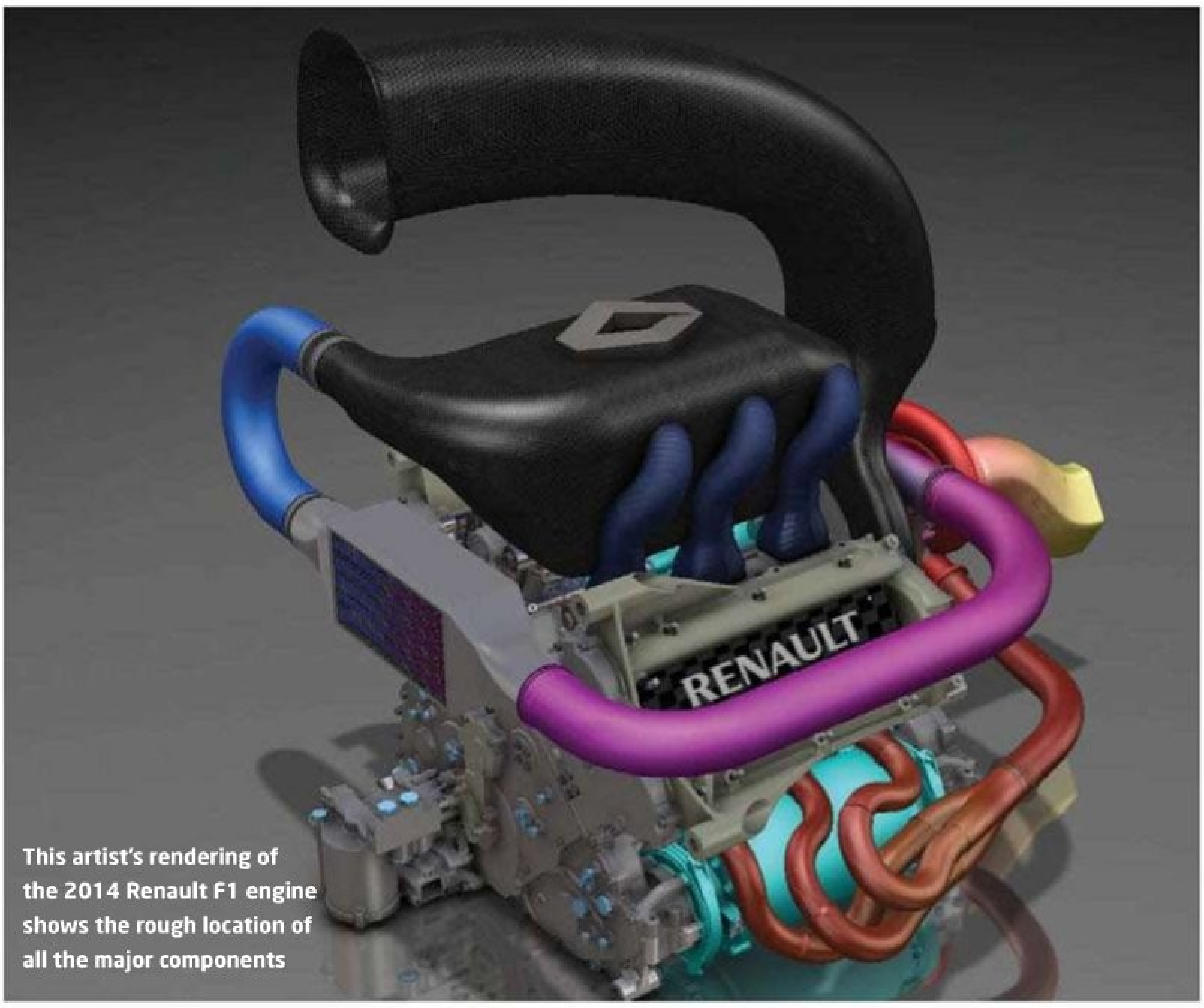
Racecar Engineering gets an exclusive look at Renaultsport F1's 2014 engine

BY SAM COLLINS

The 2014 season will see significant upheaval in Formula 1, with the arrival of a new engine formula. Following the production car trend for downsizing, the current 2.4-litre normally aspirated V8 engines will be replaced by much smaller 1.6-litre turbocharged V6 units. So far, three engine manufacturers have committed to building the new engines, and Renaultsport F1 is the first of them to reveal its as yet unnamed design.

The French firm has been working on its new engine for some time, and has already had a number of iterations on the test bench. While the final design has yet to be settled, the overall architecture and general engine concept is. The images you see on these pages are what deputy managing director Rob White describes as 'very provisional', and indeed the renderings here are more artist's impression than output from the CAD system. However, *Racecar* was shown the actual CAD data and photographs of an early iteration of the power unit, and the images here are generally indicative of the engine's layout. Formula 1's technical regulations are famously restrictive when it comes to engine design, defining a number of key elements, and the situation has not changed for 2014: the V-angle, number of valves and bore among those aspects fixed by the rule book. Renault has a four-year contract with CD Adapco for its CAE and CFD work, and this continues to the new engine.

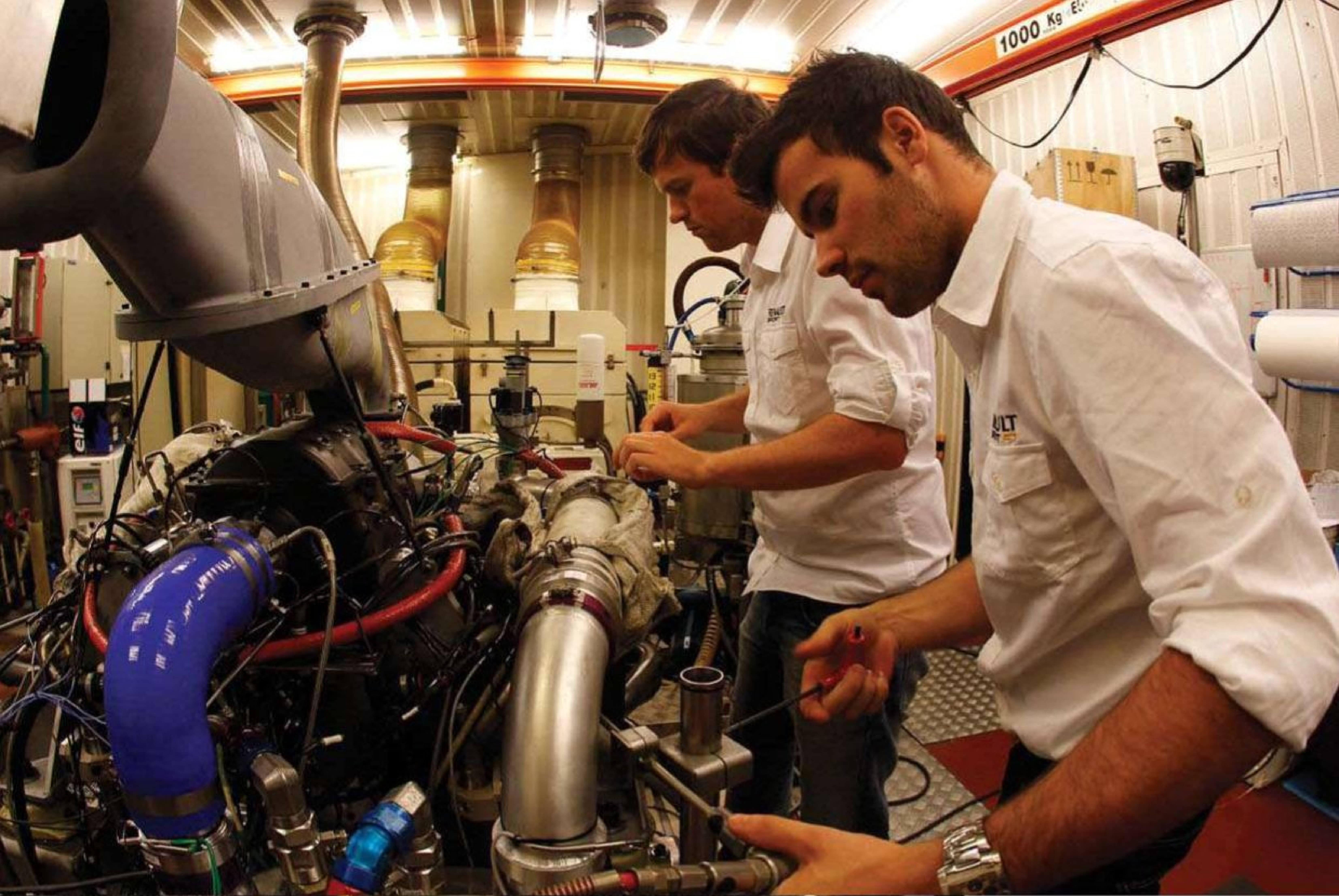
'In some ways the limitations can be a bit frustrating,' explains White, 'but it's the same for everybody. There are a small number of design decisions that are made for you by the rules, things such as the crank minimum height and the bore size, but there are tens of thousands of other freedoms we still have.'



This artist's rendering of the 2014 Renault F1 engine shows the rough location of all the major components

Of note is a slight relaxation on the materials allowed to be used in the engine's construction. Previously a number of materials were outlawed, but notably one – magnesium – has returned in limited applications. 'The materials regulations are still fairly restrictive,' White points out, 'but there are a few more freedoms in order to help us get to the required weight for the power unit which is quite challenging. The heads and block still have to be made of aluminium- or iron-based alloys and cannot have composites in them. But we are allowed to use magnesium again for some of the stationary components on the engine. In the real world, I suspect everyone will use aluminium for the heads and for the block.' As is the case with the current V8 engines, the regulations dictate the unit's maximum speed of the new V6s. While the V8s initially ran at 20,000rpm, later limited to 18,000rpm, the V6s will not rev as highly. 'The engine is still going to be a very high speed unit, even though the regulations limit us to 15,000rpm. We will probably not run quite as fast as the regulations allow in reality, because the efficiency game is about making the power at the lowest possible RPM for friction reasons. The way that the fuel flow curve is developed, the engine will still run at around 12,000rpm,' White clarifies.

"Direct injection was not specifically outlawed on the previous engines, but there was a fuel pressure limit that made it impossible to do"



Above: the 2014 V6 being prepared for a run on the dyno in Paris. Note this is not a 'show' engine

The fuel flow limit is a crucial new factor in the regulations: each car will have a maximum flow rate of 100kg/h which will be monitored by an FIA-specified fuel flow meter. While the supplier of that has yet to be decided upon, British firm Gill Sensors is thought to be a leading candidate with its award winning ultrasonic flow meter. How that fuel is delivered to the cylinder is also a major difference, with the introduction of direct injection.

'Direct injection was not specifically outlawed on the previous engines, but there was a fuel pressure limit that made it impossible to do,' White explains. 'It is a huge step change for us and one where we benefit to some extent from some of the experience gained in road cars. However, the key difference is that our engine spends 70% of its time at full throttle and a road car does not. Also, our fuel consumption and performance are crucial at full throttle, which is not the case with direct injection road car engines – road cars are about keeping the engine alive, but we can't afford to use fuel at full throttle to keep things cool, which is a classic approach in road car engines. So some things like that will be very different.' Another major change for the engine designers is the reintroduction of turbocharging, last seen in Formula 1 in 1988. The 2014 regulations stipulate that cars can feature only a single turbocharger, and define where on the car it can be located.

'The rules stipulate that the axis of the turbo is parallel to the crankshaft and within 25mm of it. So the only things to be decided with its packaging are its altitude and its fore and aft positioning. In the real world, that means that the turbo can only go behind or in front of the engine, and as the exhaust has to exit at the back of the car I'd be surprised if anyone put the turbo at the front of the engine, but never in this game should you rule anything out,' says White.

That the engine is turbocharged means that the overall architecture is totally different to that of the V8s, as White explains. 'You will see very high cylinder pressures compared to the current engines. That

The development work on the V6 engine led to a major upgrade of Renaultsport's facility

Renault continues to use CD Adapco for CFE and CFD work on the new engine

means that the pieces internally need be proportioned differently. You can see that straight away when you compare a piston from the RS27 V8 with one from the 2014 V6. It's immediately obvious that the V6 piston is smaller, as the bore is fixed at 80mm, but you also detect straightaway that it's a very different animal from a design point of view. The balance between pressure and inertia forces is much more in favour of pressure forces with the V6 pistons, while on the V8 pistons inertia forces were dominant.'

According to White, all of the cars on the F1 grid will run intercoolers, creating a number of challenges for the aerodynamicists and designers. 'It's the thermal efficiency we are seeking to get,' he says. 'In order to make use of the fuel flow limit, the boost pressure is likely to be in the range of 2-3bar. The compressor outlet temperatures will be in the range of 140-150degC, and you would not want the air in the plenum to be at that temperature for reasons of volumetric efficiency and detonation resistance. Cooling the air down will bring a direct engine efficiency which - with the fuel flow limited - is a direct power improvement. Therefore there is an immediate benefit to trade off against the weight and aero downside. It is also pretty clear that the optimum solution will involve some degree of charge air cooling.'

The installation of another air duct on the car will create quite a headache for the aerodynamicists developing the new cars, many of which are already on the drawing board. 'I think where the intercoolers will be mounted is still to be determined. It's another cooling package on the car, and that is a trade-off with the overall car performance optimum. Clearly the aero guy would not want to cool the inlet air to the engine, while the engine guy would like it to be cooled a lot. The performance trade-off is to determine the aero, weight and packaging advantages vs the engine performance advantages,' White continues.

PARKING ISSUES

The development of the turbo engine has had some unexpected side effects for the staff at Renaultsport F1, with White among a number of employees who lost their car parking places at the firm's factory on the outskirts of Paris. 'Fundamentally the big thing we are looking for is thermal efficiency, and the way that will come is from combustion development. The big meat of that is understanding the combustion system, and the interactions between the combustion system and the supercharging system.

'You can do a lot of this on single cylinder research engines, but the tricky thing with that is that you can't have a representative turbocharger driven from the engine, so you have to provide the charge air and compress it separately from the engine, which created one of the spin-off projects for us in this engine's development. The first big spend on this programme for us was an upgrade to our mono cylinder test facility, which involved digging a swimming pool-sized hole in our car park in order to install a compressor and air conditioning system underground in order to supply the single cylinder engine with combustion air in the right range of temperature and pressure. We had to do it in the car park as we had no more space in the building or on the roof. For a few weeks I had to park further away than normal, but now my car is parked directly above the compressor for the single cylinder engine!'

FUEL FLOW

The fuel flow limit and tank size on the new cars will result in much lower downforce levels, with the cars running Monza levels of downforce at Monaco. In addition, the turbocharger means that the current trend towards blown diffusers will come to an end as the engines simply will not produce enough mass flow from the exhausts to create the effect. The existing mass flow will not be wasted, however. While the V6 engine in isolation will not produce as much power as the current V8s, the overall power unit will, thanks to the introduction of far more potent hybrid systems than previously seen in grand prix racing: one of the biggest challenges of the 2014 regulations.

'The subject of engine and power unit becomes interesting to the layout when you add the electric motors,' White says. 'There are two motor generators (MGUs): MGU-K for the kinetic energy recovery, essentially the same as KERS today, and MGU-H for the heat energy recovery. It's not perhaps obvious how this layout works. In a conventional turbocharged engine the exhaust gas passes through a turbine and that turbine converts the temperature and pressure found before the turbine into a lower temperature and pressure after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the turbine; the difference comes out as mechanical power on the shaft which is used to drive the compressor.

'In a conventional turbo, the power needed to drive the compressor is the dimensioning feature for the turbine, but what we're doing here is that in addition to driving the compressor we are driving an MGU – a turbo compound. If you take the electrical transmission between the two MGUs then effectively that's a type of compounding. The regulations say that the exhaust turbine (MGU-H) may be directly coupled with a fixed speed ratio so that it can be mounted co-axially with the compressor and running at the same speed, or it can be offset because of a gear ratio between the two. The most likely outcome is that that the MGU-H will be driven at turbo shaft speed, something over 100,000rpm.' But this is not a pure electronic turbo compound in the traditional sense, as detailed in *RCE V21N8*. Although lag is an issue with all turbo engines, you will not hear the WRC-style gunshots of anti-lag systems coming from the new breed of grand prix cars. 'It is worth noting that there are energy management strategies at many levels: when the driver requests an output torque from the car, he puts his foot down, then instantaneously the engine should respond to that,' White explains. 'But the torque can come from a number of places. The engine itself will make the torque it makes, the turbo will be at that point accelerating, and once it reaches a steady state then the torque will be higher than it was initially. This is the classic turbo lag scenario. With this system, if there is a shortfall between the torque that the engine can deliver and the amount that the driver requires, we can fill that shortfall, or lag, with electrical power via the MGU-K, so we can use energy stored in the battery to make up that shortfall.

'But we can also use the energy stored in the battery to accelerate the turbo, increasing the boost pressure via the MGU-H and making up the shortfall that way,' White continues. 'This all happens in a very short timeframe; there is this sort of arbitration to do about how to use the chemical energy in the fuel, the electrical energy in the battery and the three torque actuators (the IC engine, the MGU-H and MGU-K). Each time you recover energy with either MGU you get to choose whether you use that generated power to drive the other MGU or whether you store that energy in the battery.

'Clearly, from an efficiency point of view it is better to use it directly to drive the other MGU, rather than the energy going into the battery and out again, which causes some losses. If you can use the energy from the MGU-H to drive the MGU-K directly, then that's the most efficient path. That's turbo compounding, a direct efficiency improvement. The only reason not to do that all the time is that it can be better overall to store the energy and save it for later use, either because it's quicker in terms of lap time – even with the efficiency loss – to deploy the energy later in the lap, or if you want to use it later on, not for accelerating the car directly but instead accelerating the turbo.'

"As the exhaust has to exit at the back of the car I'd be surprised if anyone put the turbo at the front of the engine"

The management of so many variables, in addition to real world situations like overtaking or defending a position, and other complexities like DRS creates a substantial headache for the trackside engineers, White says. 'You then have to consider the performance optimisation of the longer timeframe, the course of a lap, for example, in the same way we have with the KERS of today, there are different strategies for overtaking or for lap time. In 2014 there will be different strategies for overtaking or laptime and for racing and qualifying in terms of how the fuel is used around the lap. There is performance that is driven by the fuel flow rate and the maximum amount of energy you are allowed to take out of the battery per lap.

'That's perhaps analogous to a qualifying situation, but that is not sustainable if that results in fuel consumption that will exceed the amount of fuel available for the race, and because the maximum amount of energy you can take out of the battery per lap is greater than the amount of energy you can put in per lap, that is clearly not sustainable. The battery is not allowed to discharge by more than a certain amount, so there is another sustainable performance limit there. Then there will be different modes within those modes mentioned to deal with tactical situations like pit stops, etc. Then there is the overall energy management problem, which is to get to the end of the race in the shortest possible time and with the best track position with that fixed amount of fuel. It's definitely a bit tricky.'

It is not yet clear when the new engines will make their track debut, but it seems likely that they will be fitted to some kind of test mule in 2013. Indeed, four-time Formula 1 World Champion Alain Prost is rumoured to be a possible candidate for the role of Renaultsport F1's test driver. With a testing ban in place, the teams themselves seem unlikely to be able to run the engines on track until pre-season testing begins in early 2014. It will be fascinating to see how they deal with the challenge.

All under control – the TAG320 ECU

Any army may march on its stomach, but an F1 team races on its ECU

BY SAM COLLINS

While Formula 1 teams will have to wait until 2014 before they can run the new 1.6 litre V6 engines, one element of the powertrain will make its race debut 12 months earlier. McLaren Electronic Systems has replaced the TAG310B FIA-mandated single ECU with a new, more powerful unit, called the TAG320.

'The main difference between the two is processing power,' explains Peter Van Manen, managing director of McLaren Electronic Systems. 'The TAG320 has probably about a factor of five more in the unit. There is a different balance of inputs and outputs which is really just catering for the fact that in 2014, when we go over to the V6 turbocharged [engine] with the energy recovery systems, there is a different balance of sensors and actuators that you need.'

When McLaren embarked on the project to supply a spec ECU to Formula 1, it teamed up with two other firms to deliver the TAG310, Freescale Semiconductor on the hardware side and Microsoft for the software. But the TAG320 is more of a McLaren project. 'Microsoft is not involved in the standard ECU from 2013, although all of the garage-based systems run on the Microsoft platform, and we clearly still have a very strong link with them. Freescale is still the supplier of most of the microprocessors we use in our racing equipment,' Van Manen reveals.

The TAG320 has been in development for a long time, and development was made rather more tricky by uncertainty surrounding the specifications of the new power units and when they would be implemented. Initially the plans were for an inline four, but political wranglings saw the final 1.6 litre V6 concept adopted.

'The development of a control unit is not something that happens overnight, particularly one like this that is quite complex – it is an 18-month to two-year development,' Van Manen explains. 'We started it quite early because there was a lot of uncertainty about the new engines and when they would be coming in, so I guess the biggest challenge in the early days was to keep abreast of where the engine regulations were going. Once it was settled we just got into the hard graft of things that just need doing, all of the application software reads across from the existing unit. But what sits underneath that, the basic input, output, the low level software, has to be quite different to cater for the different hardware platform and the different processors. There are a lot more moving parts in a control unit than you think when you just pick up a black box.'

Indeed, the software that would be a key element of the new ECU would have to be versatile enough to handle the demands of the 2013 V8s as well as the 2014 V6s. 'Software is never finished, but it's there and it is running,' Van Manen reveals. 'We are tidying up some

"The development of a control unit is not something that happens overnight"

loose ends on that, and the ECUs started to be shipped to the teams early in the year. The first software releases were in spring and early summer, but there is work right through the year, so it will be ready in time for when the cars are ready to test. It will run on the V8s for a whole season and it will also run on the 2014 engines and cars.

'The application software which is controlling the engine and gearbox this year will move directly onto the new ECU. Then there will be new software to accommodate the new engines in 2014,' Van Manen continues. 'The number of inputs the ECU can handle is very large but it is not limitless – the number of sensors that you can have is ultimately determined by the number of pins you have in the connector. In that respect, the number of sensors on the cars will be pretty similar to what we have at the moment in race trim: 120 to 130 sensors. There are additional sensors which teams run on a Friday at a Grand Prix in Free Practice 1; some go in via the main unit and some via serial bus / CAN links.'

The TAG320 ECU has to be versatile enough to cope with V8 engines in 2013, and V6s direct injection turbos, and hybrid systems, in 2014

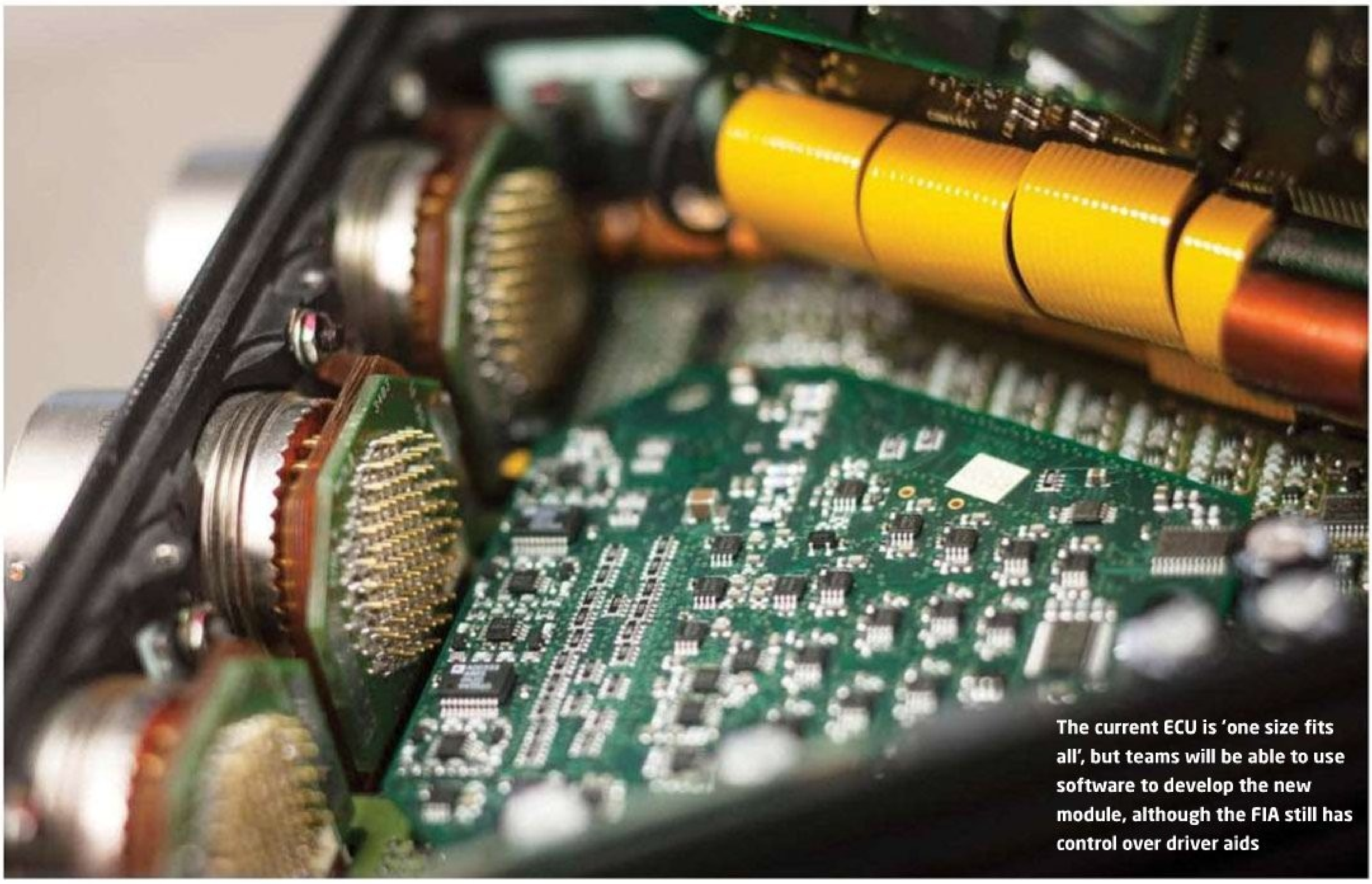
While the level of inputs and outputs is similar, one reason that the ECU has so much more processing power is the introduction of direct injection into Formula 1. 'There is nothing simple about direct injection! What I can say about it is that it is more of an issue and a challenge for the engine maker as he has to design the combustion chamber to get the right level of fuel mixing,' admits Van Manen. 'In terms of the ECU, the main thing is that your injection times are much shorter so you need a higher level of precision for injection timing and that in itself puts a demand on processing power.

'The other thing with direct injection is that engines are far more prone to detonation, so knock control – which historically has not been in Formula 1 – will come in. With direct injection, if you get detonation you can damage the engine very quickly. There are real challenges with doing direct injection, but it is the right way to go as it is more efficient and it is the way that engines are going in the automotive sector. On top of that, the powertrain is a lot more complex than a V8 in a lot of ways; that means that means that the control of the powertrain is a lot more complex in many ways but there are a lot of things that do not need to change like the gearbox controls.'

Both hardware and software have to be versatile enough to cope with the fact that the FIA has opened up a number of areas of the technical regulations to allow teams and engine builders to develop bespoke solutions.

'Currently the standard electronic system comprises of a number of units: the master unit (the TAG310); a power box which distributes power to the various sensors and has the ignition and the injection drivers; the dash display; hub units to deal with all of the sensors around the wheels; a lap trigger receiver; and finally a piece of electronics which deals with the steering wheel controls,' Van Manen makes clear.

'In 2013 all of those companion units will stay on the car, with the master unit swapped for the TAG320. But in 2014 only the master unit, steering wheel electronics, and dashboard display will be



The current ECU is 'one size fits all', but teams will be able to use software to develop the new module, although the FIA still has control over driver aids

mandatory components – all of the companion units will be free. The teams and engine makers can decide what interface units they want for their injectors, ignition coils, electric motors, and things like that.'

One reason for this freeing up of the spec components is to allow the teams to develop the new power units and the strategies themselves. 'It is the biggest difference for us between 2013 and 2014,' Van Manen confesses. 'With the current standard ECU, it's a single version of software for everyone, and although the teams can change the setup of data and maps within the unit, they cannot have any special software which is individual to them. What we move into is that the core of the system is still a standard ECU which allows the FIA to maintain control over things like driver aids, but it is a bit more open in that teams can use an element of software in the development.'

These control strategies will be crucial for the teams as they balance the twin motor generator units and the single turbo charger in real world situations like battling for positions with DRS and qualifying laps. But these torque management tools could conceivably open up the door to traction control and other banned aids. The TAG320, however, has been designed in such a way that the use of such aids can be prevented.

'The new powertrain is about managing both torque and energy, so to be able to do that there is an element of torque management which will come down to the engine makers and teams,' explains Van Manen. 'There is a control over what inputs and actuators are seen by the those applications that the engine makers and teams create. This is the basis of how the FIA will maintain control. The little bit of magic in the new master unit is the way in which the different memory areas in the processor are protected so that we can ring-fence different areas of the processor from each other, which means that you can have all of these different applications running on the same silicone but still maintain the control by the FIA. The essence of the standard ECU remains the same, but we have released a bit of freedom to the teams and engine manufacturers.'

While the new ECU has been specifically developed for use in Formula 1, Van Manen is certain that it will be used in other areas. 'It is a little bit specialised in as much as in terms of other racing categories – with the exception of LMP1 sportscars – it has more processing than most series need. It supports most of the powertrain and the telemetry feed. It is quite a powerful beast for other racing categories, but I see where it will probably start to be used is as a development platform for other automotive applications. In the automotive world there is a push towards hybrids and energy recovery, this whole issue of managing torque, managing energy. A lot of the things we are able to do in the TAG320 are as relevant to pre-production and prototyping in road cars as they are to F1.'

First deliveries of the new units have already taken place. 'The focus at the moment, I suspect, is to get the TAG 320 running on the V8s, then move across to the V6 – but that's down to them,' Van Manen admits. Despite the unit being new and more complex than the old ECU, Van Manen is not overly concerned that there will be any reliability problems.

'I'm confident but not complacent,' he allows. 'Every time I look at a grid full of cars with all of our systems on them you know you can't be complacent. But so far this year in NASCAR, Indycar and Formula 1, our electronics have not stopped a car. By three-quarters of the season in 2012 we had accumulated over half a million race miles.'

So, despite the uncertainty surrounding the timing of the introduction of the 1.6 litre engines, one thing the teams can rely on to be ready in time is the ECU. The TAG320 will make its debut at the 2013 Australian Grand Prix.

"A lot of the things we are able to do in the TAG320 are as relevant to pre-production and prototyping in road cars as they are to F1"

Flexible working

Composite optimisation techniques are being bolstered by new tools that enable more targets to be met ever more efficiently

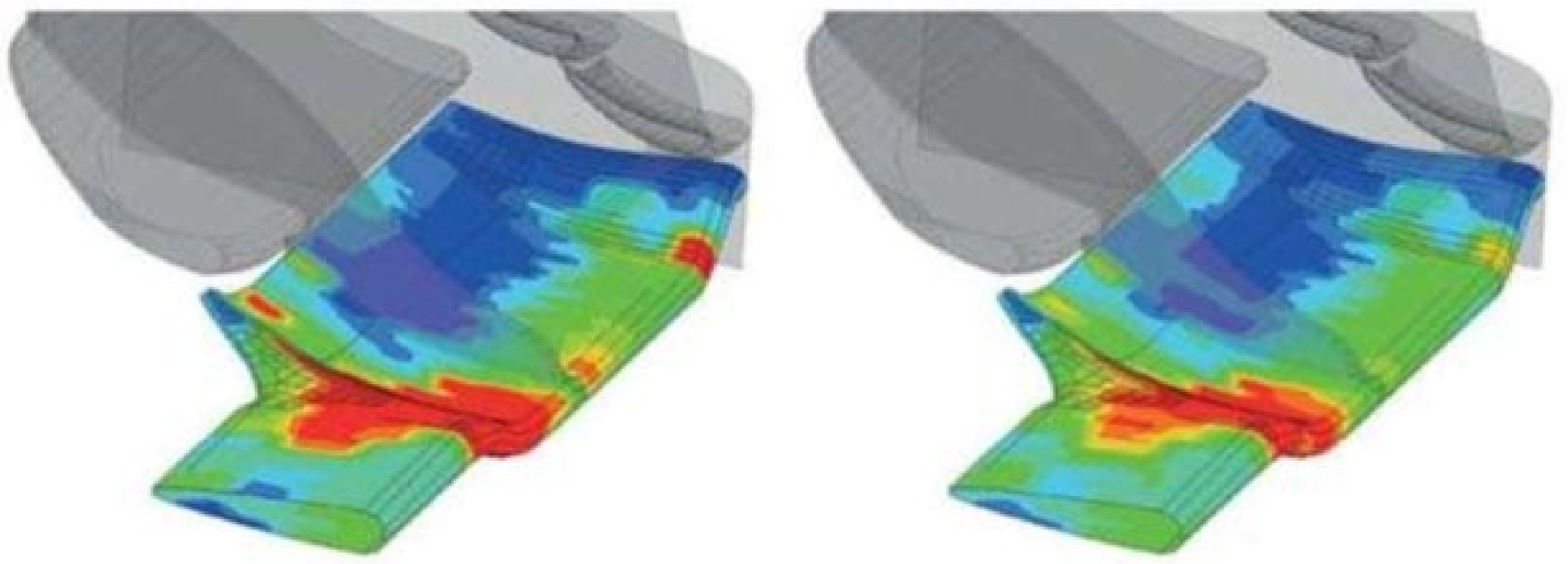
BY SIMON McBEATH

One of the hot aerodynamic topics in Formula 1 during the 2010 season was flexible front wings, when the teams at the sharp end of the grid could be seen to be utilising wings that, somehow or other, were capable of flexing closer to the ground. More recently the subject has became very topical once again. Prior to that, we'd seen rear wings that were quite clearly capable of flexing backwards under load in order to reduce their angle of attack. Allied to this, wing flaps that 'feather off' at speed - or deflect to close up slot gaps - have abounded for years. Double diffusers and blown exhausts may have supplanted flexi-wings in the public gaze until recently, but nevertheless the performance of structural composite components under load - aerodynamic or otherwise - remains very much at the top of the designers' priority list. *Racecar Engineering* visited GRM Consulting, in the midlands of England, to gain some insight into the computational tools now in use.

The shape of the external surfaces of most modern top level racecars is fundamentally defined by three things: the technical regulations, packaging requirements (driver, powertrain, peripheral components and systems); and aerodynamics. In the context of Formula 1, the chassis, suspension members, bodywork and all other aerodynamic devices are manufactured in composite materials, and optimising each of these components to meet structural and aerodynamic requirements occupies substantial design time and resources.

Until relatively recently this has involved engineering experience and progressive evolution. For a long time this produced satisfactory solutions for frequently manufactured components (and still does in some teams). Periodic challenges, such as revised crash test requirements, would cause some increase in the grey hair content of the composite design department, but experiment and experience produced solutions.

Inevitably though, the quest for ever smaller performance gains pushes engineers to come up with improved techniques. Furthermore, when the objectives alter, for example to include not simply maximum stiffness but instead to deal with multiple load cases differently, the problems become more complex. Thus, if a Formula 1 car's front wing had adequate beam stiffness such that it could meet the FIA's static vertical load test applied to the top edge of the end plates, could it also retain aerodynamically beneficial flexibility in different directions or modes?



FLEXI-WINGS

This was clearly one of the questions that were being asked in relation to flexible front wings. GRM Consulting produced a case study to illustrate how their optimisation tools can be used to provide solutions to this type of problem (see boxout, p58). The aerodynamic scenario presented may or may not represent what the F1 teams have actually been doing, but it does showcase the capability of the analysis tools for this type of problem.

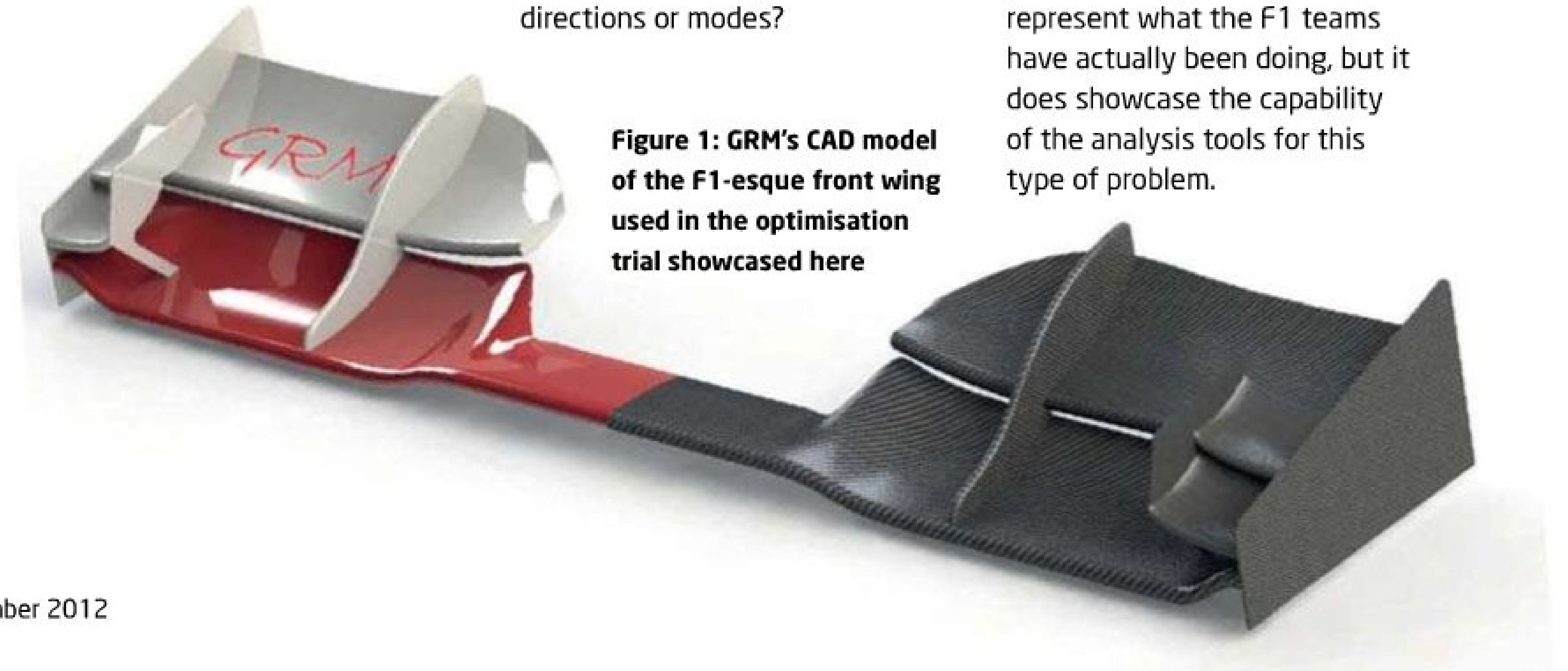


Figure 1: GRM's CAD model of the F1-esque front wing used in the optimisation trial showcased here

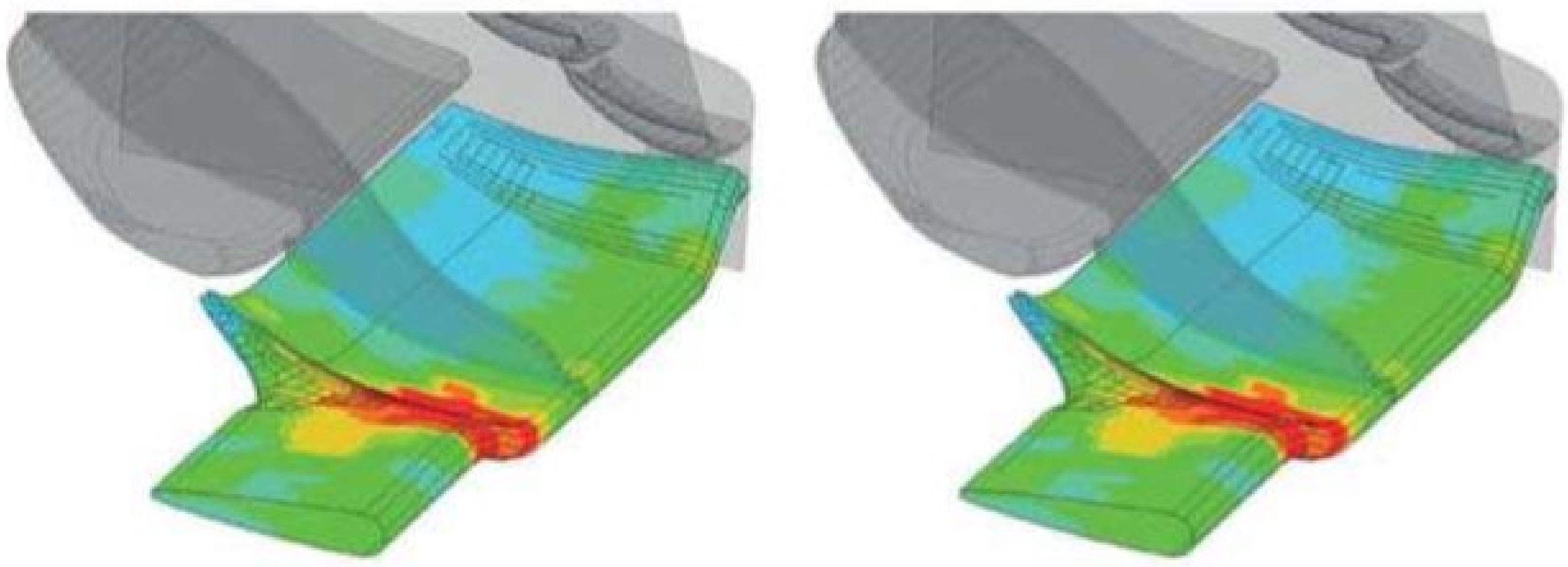


Figure 2: the lay-up variation constraint produced fewer plies and less variation in plies across the part

TECHNICAL IMAGES COURTESY OF GRM CONSULTING

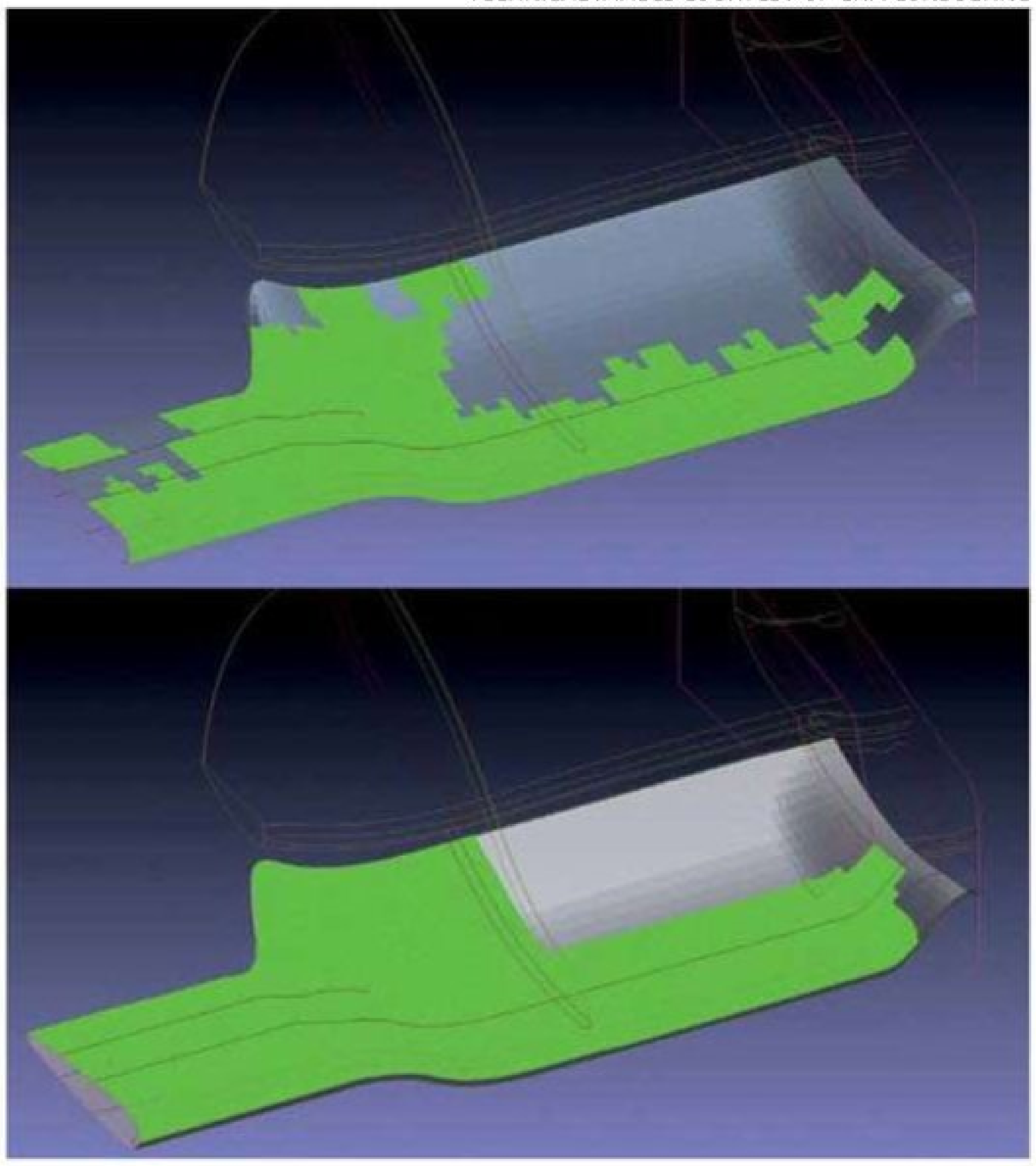


Figure 3: manual ply editing was carried out (lower image) to make manufacture more practical, avoiding unnecessary ply tailoring

Table 1 – aerodynamic and 'FIA' displacement optimisation results

	Displacement, mm	
	Aero	**FIA**
Target	n/a	16
Initial	79.1	19
Verification	85.5	14.6

The software tool that GRM has developed is called OptiAssist, which GRM says provides the user with a 'Genesis-based composite optimisation solution that fits into a design department's existing composite analysis process'. It is said to be usable at the initial concept phase or after detailed, virtual layup construction. Genesis is the underlying finite element analysis (FEA) and optimisation package, and OptiAssist is described as a 'pre and post-processing environment developed specifically for the optimisation of composite structures'. OptiAssist extends the capabilities of Genesis for composite laminate optimisation using methods such as ply placement optimisation and detailed sizing optimisation, wherein optimisation is done either via the orientation of plies, or the number of plies (see sidebar, p62).

The first step with the front wing exercise then was to generate a CAD model (see **Figure 1**) of an F1-esque device. Next, the initial candidate ply lay-up was stipulated, and typically this would involve outer and inner plies of woven carbon fabric orientated at 0 degrees, encapsulating a variable number of uni-directional fabric plies orientated at 0 degrees and at +/-45 degrees. However, before any analysis and optimisation could be done it was necessary to define the analytical constraints. In this instance, the FIA's static load test requirement, which at the time required less than 20mm deflection with a 1000N load applied vertically to one or both sides of the wing, 800mm ahead of the front axle line and 795mm from the car's centreline (this was revised in September 2012 to 945mm from the centreline to try and stamp out wing flexibility!) had to be passed. But at the same time the wing was to be allowed to twist back at the outer ends under aerodynamic load to reduce the angle of attack of the wing at speed. Indeed, the objective of this exercise was to maximise the displacement of the wing's twist under aerodynamic load.

Next, an optimisation run was done, automatically performing multiple iterations in which variations in the lay-up and the orientation of the plies were considered from the point of view of absolute performance versus manufacturing complexity. The finite element technique used here is an element-by-element approach where the thickness of each individual ply of each element is optimised. The downside of this in a composite application such as this is that there is one design variable for each ply per element. This would yield impractical solutions in terms of

"There is no more complicated or crucial a component to get right than the composite monocoque of a Formula 1 car"

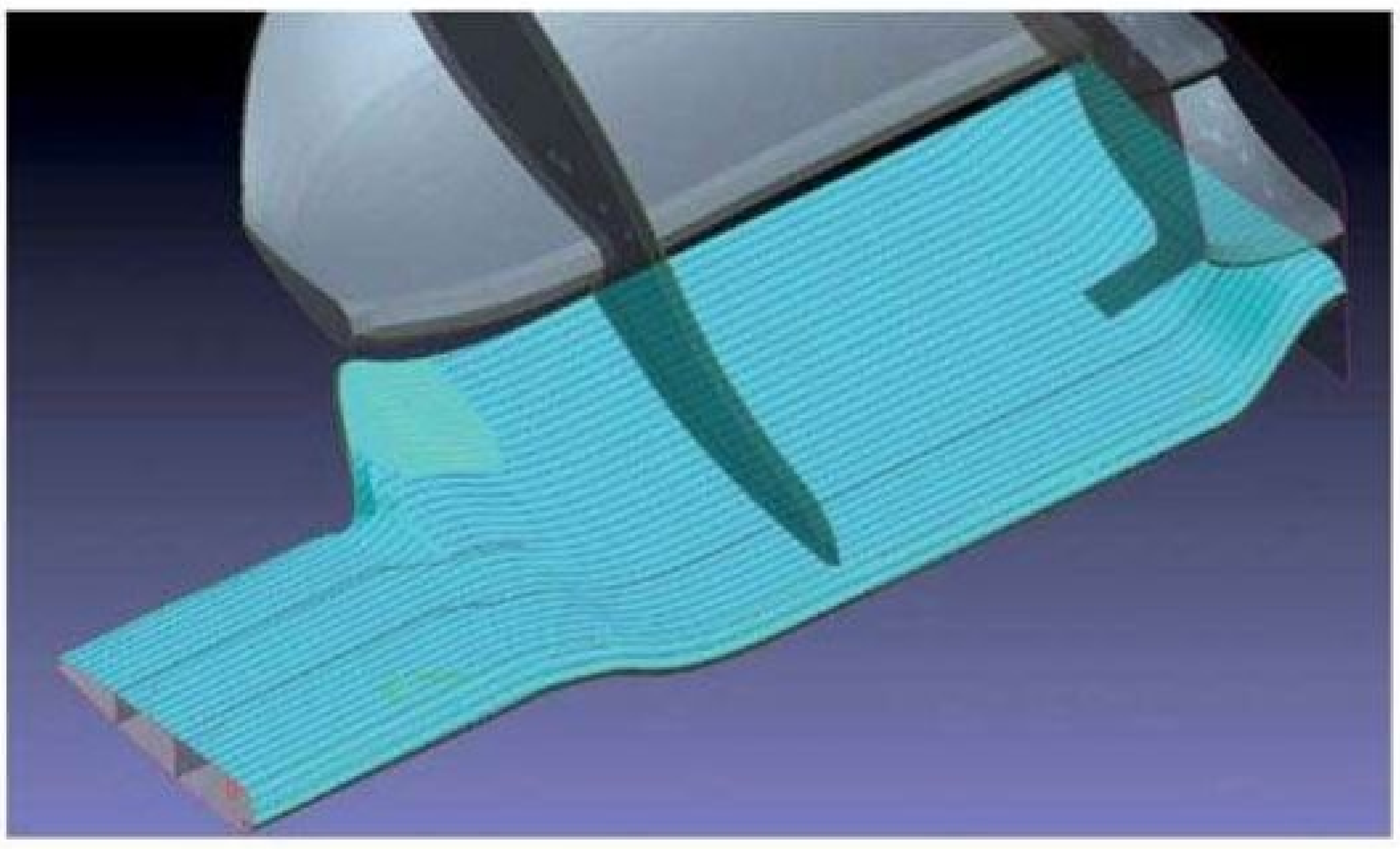


Figure 4: Laminate Modeler shows how uni-directional fibres conform fairly well to the complex curvature of this component

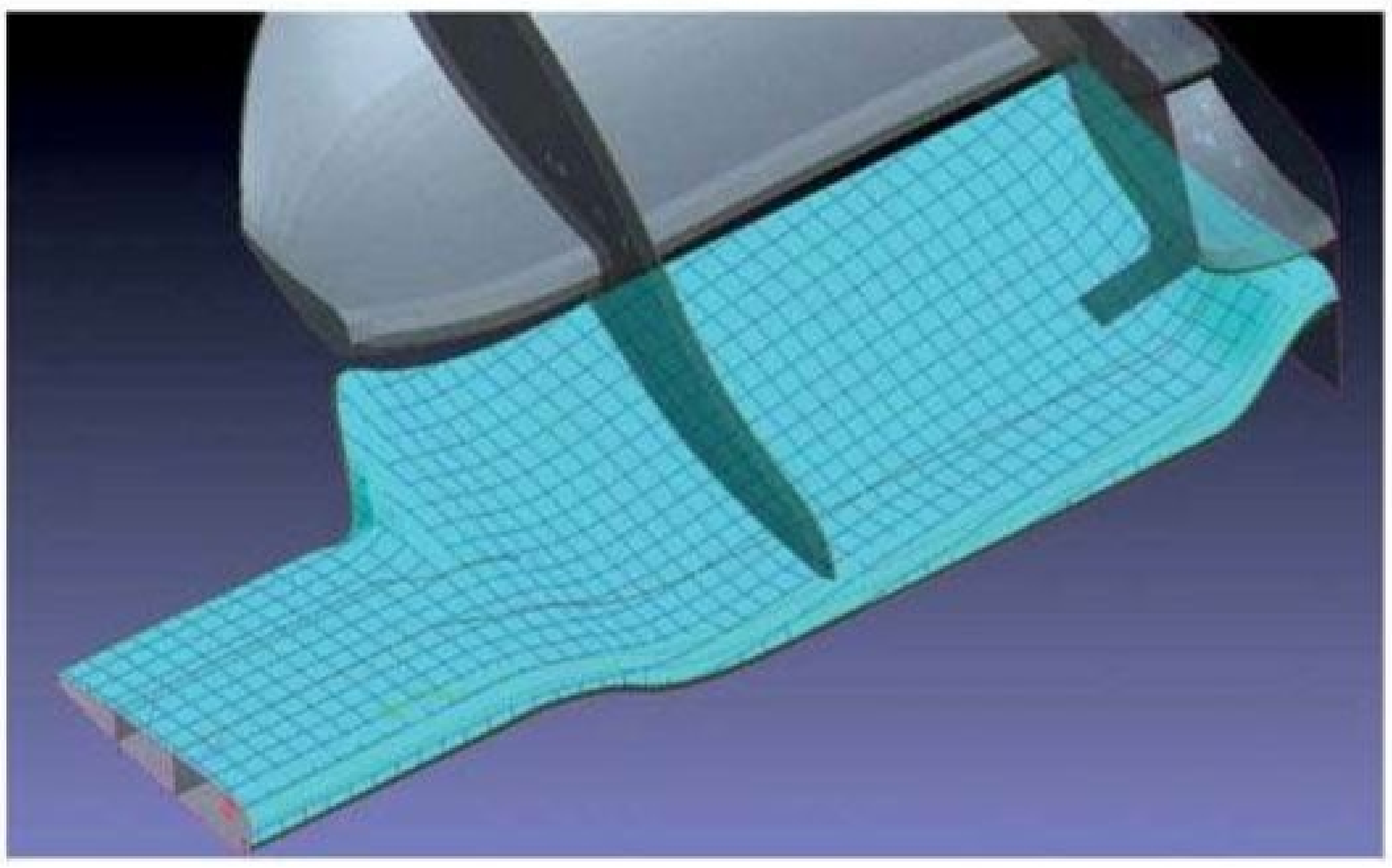
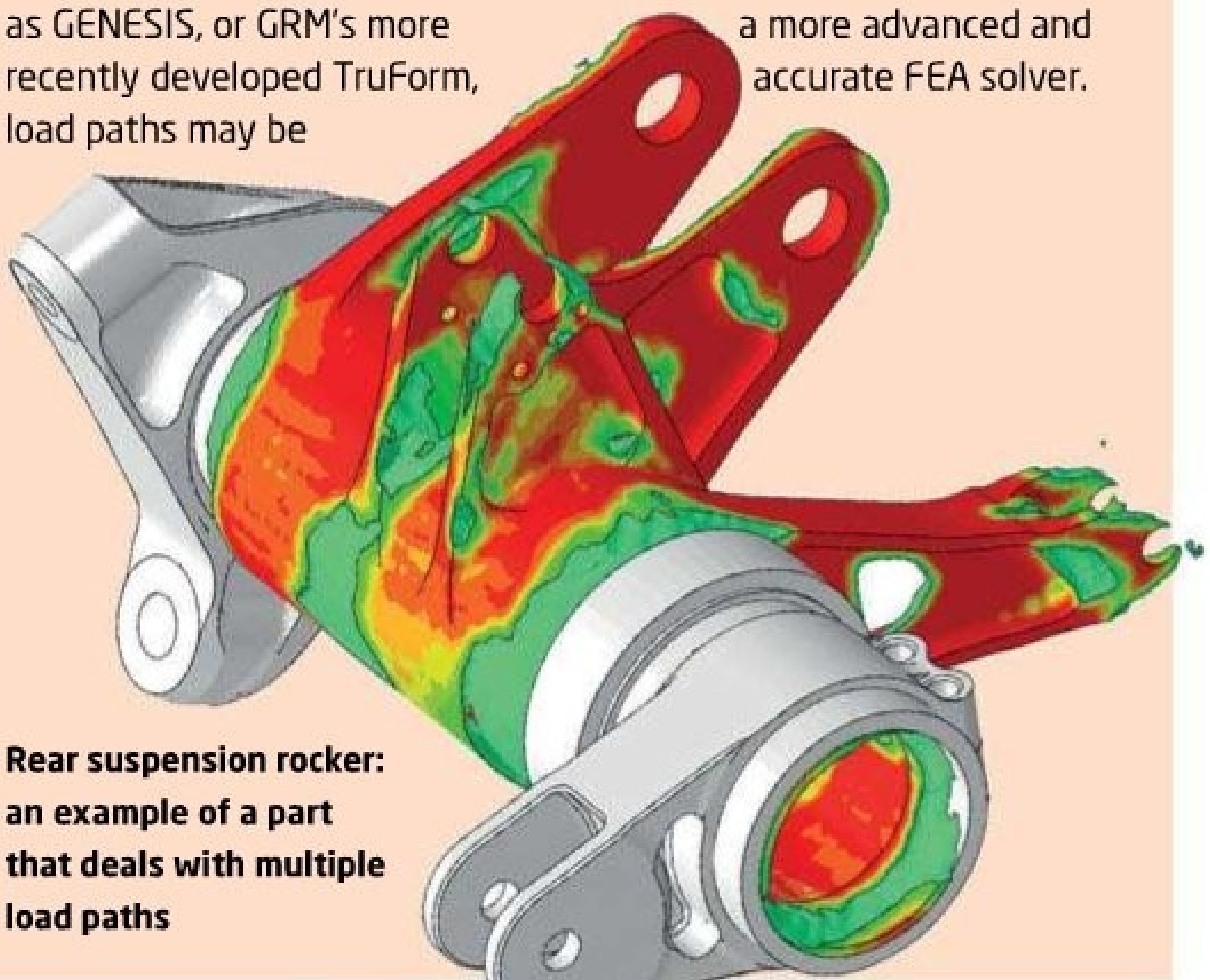


Figure 5: woven fabric does not conform so well to complex curvature, and fibre orientations can deviate from the desired directions

METALLIC COMPONENTS

GRM also works with, and provides, optimisation software tools to a number of F1 teams optimising non-composite components. Among them are Marussia, who have been taking advantage of Genesis and OptiAssist this year for such things as the uprights, gearbox and roll hoop as well as the composite chassis. Using software tools such as GENESIS, or GRM's more recently developed TruForm, load paths may be optimised and mass can be reduced, depending on the client's aims. The example shown here is a rear suspension rocker, in which nine individual loads were considered in order to optimise the object's design and minimise its mass. TruForm was applied, which enables the optimisation methods to be applied to Dassault Systemes' Abaqus, described by GRM as a more advanced and accurate FEA solver.



Rear suspension rocker: an example of a part that deals with multiple load paths

manufacturability – composite laminators would not appreciate being asked to cut, and lay up, vast numbers of small squares of carbon, or highly complex-shaped plies! And in any event, composite components benefit from long uninterrupted lengths of fibres. So, a 'lay-up variation constraint' was applied, which produced successively fewer plies to assist the manufacturing process (see **Figure 2**). The resulting properties in terms of the 'aerodynamic deflection' were calculated for each lay-up variation, and an informed selection of the optimal solution could be made that met the deflection criteria and which was also practicable to manufacture.

It should be noted that the optimisation also enabled an aerodynamic 'load failure index' to be applied, essentially a strength constraint to ensure that although a certain amount of rotational 'flex' was being permitted, the wing would not come anywhere near failing under load.

OptiAssist then automatically generated ply patterns as sets of data that could be imported into the lay-up definition packages popular in the industry such as Anaglyph's Laminate Tools, MSC's Patran Laminate Modeler or Beta CAE Systems' Ansa. At this stage in the development of this type of software though, it is apparently still necessary to carry out manual editing of ply boundaries to generate a fully manufacturable lay-up. GRM admits that this can be a time-consuming step, but also states that generating ply patterns from scratch can take a similarly long time. Clearly this is a part of the optimisation process that is under continual development (see **Figure 3**).

The next step was to use

GRM CONSULTING AND OPTIASSIST

GRM is a young company started in 2003 by Martin Gambling, now managing director, to offer finite element analysis and optimisation products and services. The first step in the company's development was to offer a product known as OptiAssist, which to quote Gambling 'was a front end to enable [access to] the key bits of Genesis.' This is a reference to the finite element analysis and optimisation package from Vanderplaats Research and Development Inc. that is well-known in the field. 'Genesis dates back to 1995 and enables the optimisation of composite laminate thickness and ply orientation, but not many [in motorsport] were doing that. It involved a two-stage process that defined patterns first and then thicknesses, but what was needed was a single stage process that went straight to the manufacturing stage. I decided I could bridge the gap in the then current tools, so I went to McLaren and said "I can do this." They gave me three months to deliver OptiAssist, and they tried out my ideas. From then on, the take up from F1 teams accelerated and we've won all the Formula 1 World Championships since 2006, except Kimi Raikkonen's title with Ferrari in 2007!'

Some teams use OptiAssist for composite structures but others use it for metallic components. The first 'published' chassis to have its design assisted by the product was the 2006 Red Bull. 'We're now looking at the next level,' continues Gambling. 'The software is much more refined now, so we're trying to automate more, integrate with other FEA solvers such as Abaqus, and make it easier to get to the manufacturing stage. OptiAssist provides a Genesis composite optimisation solution that fits into the user's existing composite analysis process, usable at the initial concept phase or after detailed layup construction. Interpretation of the optimised solutions is now key.'

The company's composite activities continue primarily to focus on F1 projects, but it is talking increasingly with automotive manufacturers that are using composites, and also wind turbine manufacturers.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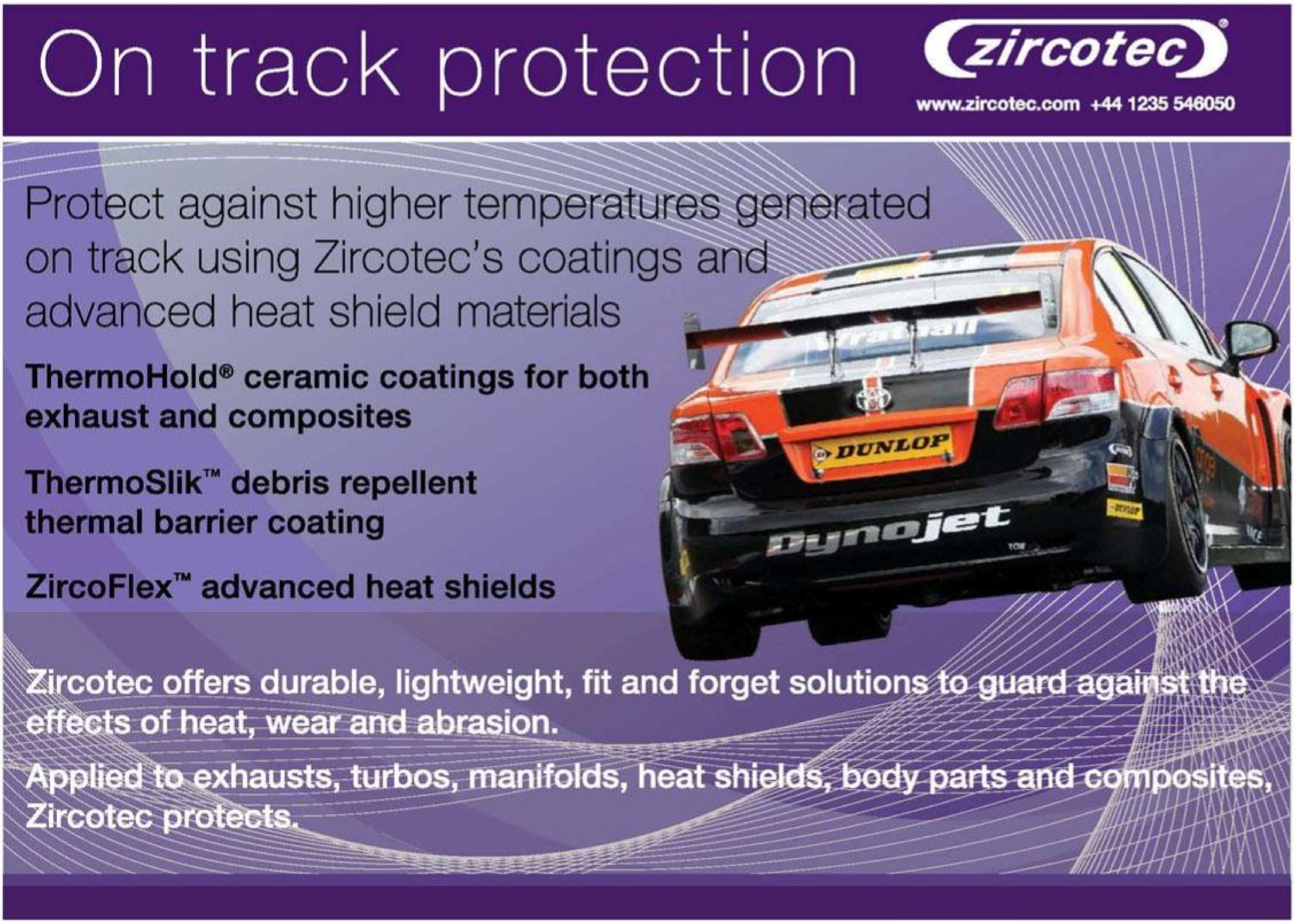
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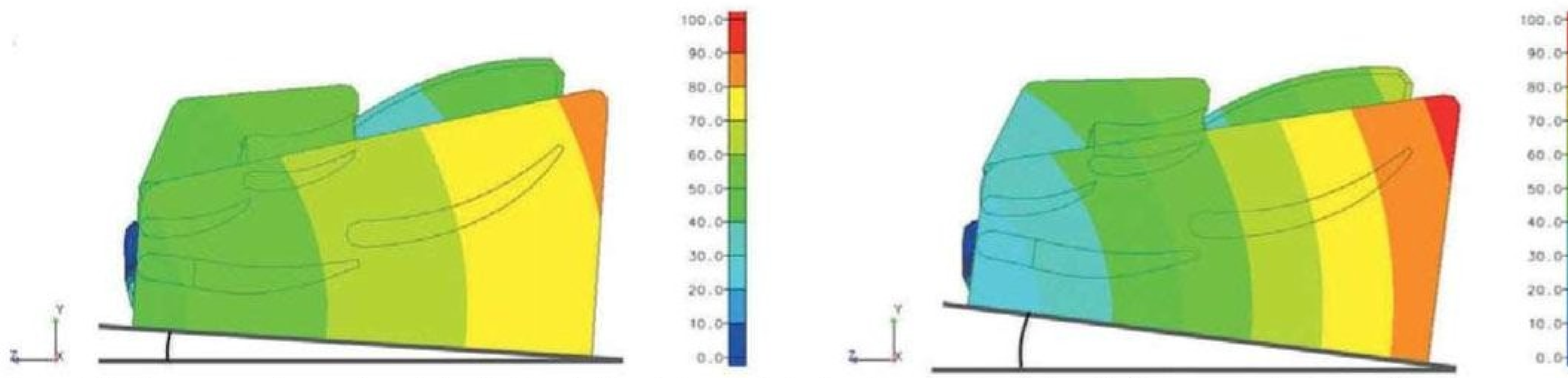

Figure 6: displacement under aerodynamic load before (left) and after optimisation. Note that there's less displacement at the front of the wing, but much more at the rear of the top in this view after optimisation

Figure 7: the red wing is the original, the green wing is the optimised one; note again how the green wing bends less but twists back more under aerodynamic load. Yet it met the prevailing FIA test load

a package such as Laminate Tools to 'drape' (in the virtual environment) the plies on to the mould. This takes into account how the complex curvature of an object such as today's F1 front wings affects how the fibres will actually lie in the mould and hence in the finished product. While the skilled laminator can take account of this during the physical lay-up process and minimise distortions, there can nevertheless be deviations from the supposed fibre orientations, which in turn could affect the performance of the end product. For example, we can see in **Figures 4** & **5** how uni-directional fabric is more conformable, that is, less prone to distortion than woven fabric.

The results of the optimisation in **Table 1** make interesting reading. What we can see from here is that the aerodynamic displacement, measured at the rear of the wing and representing the outer sections twisting back under aerodynamic load could be made quite substantial. Meanwhile, at the same time the 'beam stiffness' required to pass the FIA static load test was actually increased, that is, the deflection under that load decreased to within the required limit. See **Figures 6** & **7**.

Clearly this is just one approach to the problem of meeting multiple load cases on a front wing, and as mentioned in the introductory section, the approach shown here may or may not be what the F1 teams have actually been doing. But it's very evident that having a computational optimisation tool like this would save time, cost and guesswork in carrying out physical trials. Undoubtedly physical lay-up and verification testing would be carried out too, but far fewer trials would be required to achieve the desired end result.

CHASSIS OPTIMISATION

There is no more complicated or crucial a component to get right than the composite monocoque of a Formula 1 car. The monocoque does not simply serve to accommodate the driver and carry all the hardware to propel, steer and stop the vehicle, and support all the loads generated; it must also pass stringent static and dynamic load tests to help maximise the driver's safety. And as it comprises of many hundreds of individual plies of composite fabrics, achieving multiple structural requirements with minimum mass is no small task. With consulting support from GRM, aided by OptiAssist within the actual optimisation process, Force India were able to take advantage of the capabilities of GENESIS in the design optimisation of their monocoque. Up to 10 strength-based loading conditions and three stiffness targets were considered, and studies were able to deal with the design of the complete laminate for all of the major structural requirements. According to Force India the project yielded a 'notable mass saving over traditional design approaches, while increasing structural efficiency, all within a production timeline.' See **Figure 8**.

With more recently

WHY MAKE FLEXIBLE FRONT WINGS?

The recent return of the flexible front wing saga came amid suggestions that some teams were allegedly trying to do exactly what our showcase example was doing – allowing the front wing outer sections to rotate back at speed, so reducing their angle of attack. Eliminating this twisting moment is of course impossible, and the current rules that define the front wings have actually increased the moments involved by placing the heavily aero-loaded sections so far outboard of the mandatory single element centre section. But as we've seen, it would've been possible to pass the earlier FIA load test yet still enable considerable twisting to occur. Again then, why would teams want to do this?

Certainly not primarily to decrease drag, as has been suggested in some quarters, for as we saw in last month's Aerobytes on the 2007 Honda F1 and as we've seen previously with other single-seaters, reducing front wing flap angle doesn't decrease drag. But clearly what it does do is decrease front downforce. This would have two effects; first it would help to maintain an aerodynamic balance when the rear wing's DRS system was 'open'; and second, by so doing, it would help to maintain a more consistent chassis rake. With the rear wing DRS open, the rear ride height would be higher than 'normal', leading to an increase in chassis rake and a forward shift in the aerodynamic balance of the floor, exacerbating the forward shift in balance that the loss of rear wing downforce has already caused. This is why the Mercedes 'double DRS' system was so clever; it 'switched off' some front downforce when – and only when – the rear DRS system opened, so helping to maintain a more consistent aero platform. A twisting front wing would have a similar effect that was linked to speed, though obviously not directly coupled to the rear wing like the double DRS system.


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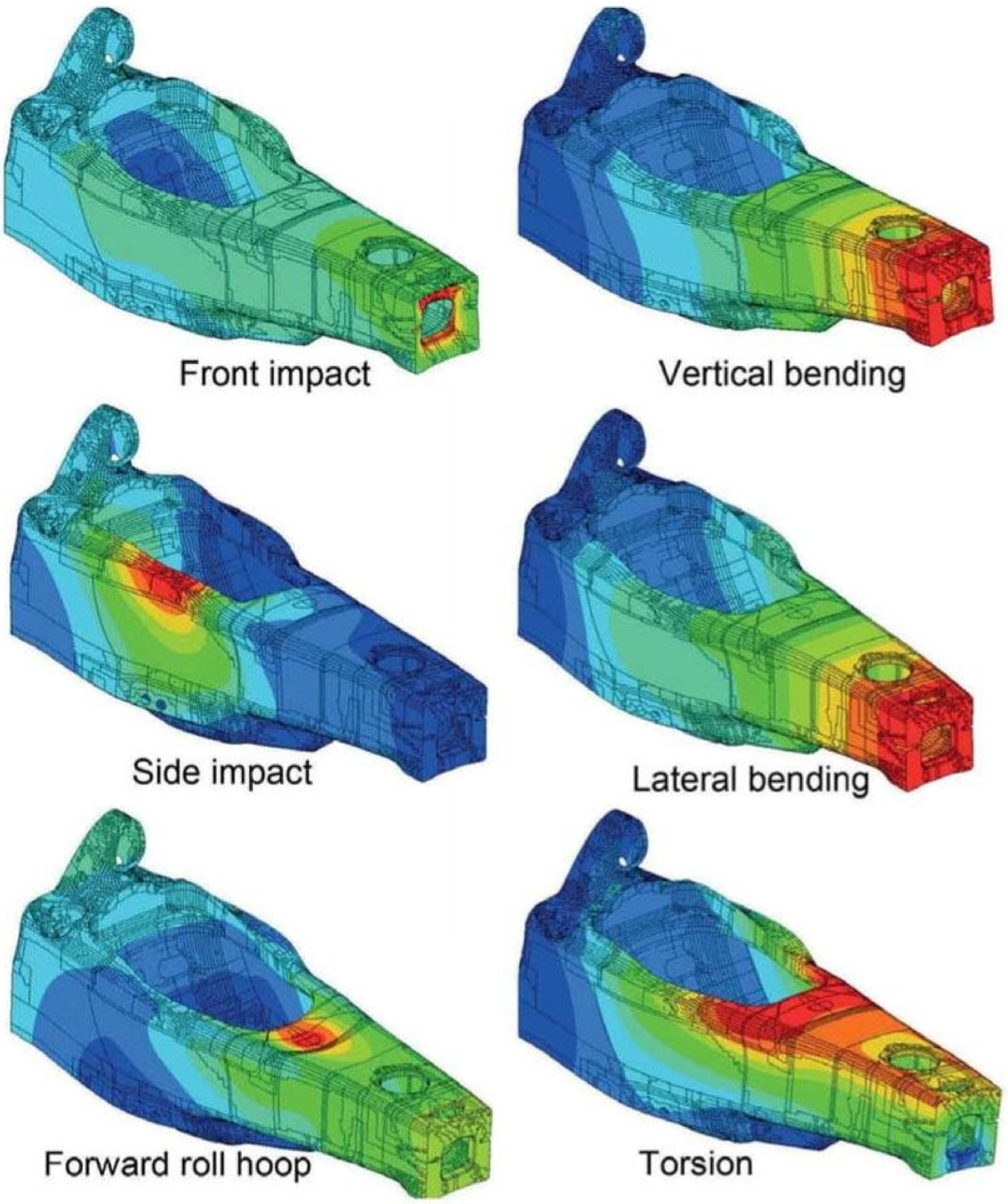


Figure 8: Multiple chassis load cases were examined by Force India

introduced FIA regulations on side penetration that dictate the laminates along the chassis sides, there is perhaps less scope nowadays for this level of benefit to be achieved in F1. But that does not rule out other areas of the chassis, and indeed other components, where there are still design freedoms and where benefits could be found using this kind of optimisation. And maybe that raises a key point too – that as areas where benefits may accrue become harder to find, a computational tool that enables improved understanding in a given time, and perhaps points to a better design direction becomes even more useful.

BACK TO THE FUTURE

It should be added that there is a level of scepticism among some experienced F1 engineers regarding computational optimisation of composite structures. This is probably analogous to the 'CFD or wind tunnel' situation that prevailed in aerodynamics, but objectively there is not only room for both, they are in reality complimentary tools. As has been shown in the case of aerodynamics though, physical validation of computational simulation and optimisation is still the order of the day, and it's probably fair to suggest that the same holds true with composites.

TAILORING COMPOSITE PROPERTIES

Reference has been made in this article to 'woven' and 'uni-directional' reinforcement fabrics used in the manufacture of composite components. Woven reinforcement fabrics are created in much the same way as conventional textiles, by combining threads of the fibre in question in two directions, generally at right angles to each other, to create a long run of fabric that can be rolled onto a tube. The fibres running the length of the roll are known as the 'warp' fibres, and those running across the width are known as the 'weft' fibres. Similarly, the woven fabrics are sometimes referred to as 0/90° fabrics, where the 0 direction is the warp direction. Different weave styles are available, and these not only have different appearances but they also offer slightly different handling and structural properties.

Uni-directional fabrics, or UDs, are comprised of fibres running wholly or almost wholly in a single direction, usually the 0 of warp direction. Sometimes prior to resin impregnation the fibres of UDs are loosely held with widely spaced weft threads to prevent the fabric from falling apart, and sometimes this role is done with a lightweight chemical binder. In practical terms though, UDs comprise of reinforcing fibres running in one direction only.

When any reinforcing fabric is encapsulated in a cured resin system, the major structural properties (strength and stiffness) are of course aligned with the fibres. So a ply of woven fabric can provide strength and stiffness in two directions, while a ply of UD fabric provides them in a single direction. By arranging successive plies in different orientations, a more or less isotropic end product can be obtained. That is, one with equal properties in all directions. However, it's equally possible to tailor specific structural properties by aligning woven and especially UD fabrics in specific orientations. Often a lay-up will comprise fabrics at +/-45°, and these could be woven or UD. A relevant example might be a component like a front wing that requires high beam stiffness across its span but also high torsional stiffness to resist twisting on either side of its central supports due to aerodynamic loads at speed. Or it might require less torsional stiffness to enable deflection due to aero loads at speed. There is also no reason why fibres cannot be laminated at any desired angle to obtain the desired properties.

The rise of the back street boys

The increase in computing power is allowing smaller consultancy companies to flourish once again

BY CHARLES CLARKE

CAE/CFD simulation, in its classic sense, has always been the preserve of the specialists, and many racecar companies have darkened rooms where the stressheads ply their trade and get up to their particular brand of black magic. Lesser mortals are left wondering why their favourite components need defeaturing before they can be analysed, and why the mid-surface is such a big deal anyway.

As the technology advances, and as high-performance computing becomes an affordable reality, many more of these specialists have gone freelance as their back bedroom, homemade PCs begin to resemble the late-'80s supercomputer in processing power. With all this freelancing going on we've seen a significant resurgence in the automotive consulting company. The new companies tend to be analysis houses rather than the classical Ricardo / Prodrive type of engineering consultancy with workshops and labs. These classical firms tend to have large infrastructures developed during the boom years, but they have faltered a little in recent years as the world-wide recession took hold and large OEM motorsport contracts became fairly scarce.

The complexity spectrum of the work is from relatively simple linear static FE analysis at one end through non linear FEA, multi-physics analysis, complex CFD to non destructive and destructive testing and regulatory approval of crash structures at the other end. And such is the comprehensive nature of the motorsport support services that most of these facilities are supplied by homegrown companies within the motorsport triangle in the UK.

Companies like Ricardo have come the traditional route of refining components for the general automotive industry. Companies like Engenuity and Composites Analysis (their analysis arm) have grown out of developments in the software.

'We've all seen Formula 1 and Le Mans cars involved in spectacular crashes as recently as Spa this year,' says Graham Barnes, founder of Engenuity, 'and most times, happily, the

Discovering the vehicle's DNA on the MIRA Kinematics and Compliance (K&C) rig where suspension characteristics can be gathered and verified

drivers have been able to walk away. That's because composites, as well as being lighter than metals, have a significantly higher Specific Energy Absorption (SEA).'

Composite crash structures are stronger, absorb energy much more effectively, and save huge amounts of overall body weight. The main problem is that conventional crash analysis systems designed for metals simply don't predict how composites behave. But C-Zone, developed in the UK by Engenuity, does.

As an 'add-on' to Abaqus – an iconic non-linear FE code recently acquired by CATIA makers Dassault Systèmes – C-Zone gives results against predictions that can't be achieved using any other technique. In addition, C-Zone analyses whole body structures, not just individual components, giving real-world performance data that will enable design teams to meet regulatory test requirements, and give management the confidence to invest in manufacturing capability.

With this software a composite nose cone doesn't need to just be designed for strength, but its design can be tuned to give a consistent level of energy absorption, while using its whole design length. With 'ordinary' FE software it's possible to design composite structures for strength. If you don't have access to sophisticated crushing simulation software you have no control over the propagation of the crushing. You can have situations where the energy absorption is too rapid or too slow even though the component, overall, does the job. Clearly this lack of control over the energy absorption can have significant consequences for the rest of the car and the driver.

In contrast, Cranfield Impact Centre (CIC) is a major tester for the F1 front, rear and side impact structures, but they also get involved other structural testing. There are only three places in the world were Formula 1 teams can do their FIA certificated destructive chassis testing: TRL, CIC and CSI in Milan.

CIC takes components from all over the world, not just the motorsport triangle in the UK. They do static tests on the roll hoops, squeeze testing, chassis testing as well as all the dynamic testing of front, rear and side impact and also steering column tests.

Most of the F1 companies have kept the front bulkhead of the tub the same and use the stepped nose in order to comply with the new T-bone regulations. Things change again next year with new nose regulations, so CIC is looking forward to the challenges that will bring.

The new regulations allow the introduction of a fairing to make the nose blending a little bit better.

For the roll hoops in certain classes it's permissible to validate the roll hoop by calculation only. The physical compound angle needs to be checked, but the front impact test can be done by calculation.

MIRA has been offering advanced simulation services to the motorsport industry for decades. MIRA is one of the few places in the UK where they can offer a 'simulation only' FIA roll cage certification service.

"There are only three places to do destructive chassis testing"

This is because they have been able to demonstrate to the MSA excellent correlation between their crushing rig data and their simulation techniques, so much so that in the majority of cases physical testing is unnecessary.

MIRA is also in a unique position in vehicle dynamics modelling. They work in partnership with VI-Grade, the developer of the leading multi-body simulation software which bridges the gap between real-world testing and technical simulation in complex engineering applications. MIRA has configured their software and hardware systems so that data can be exchanged between their Kinematics and Compliance (K&C) rig and the VI-Grade software environment.

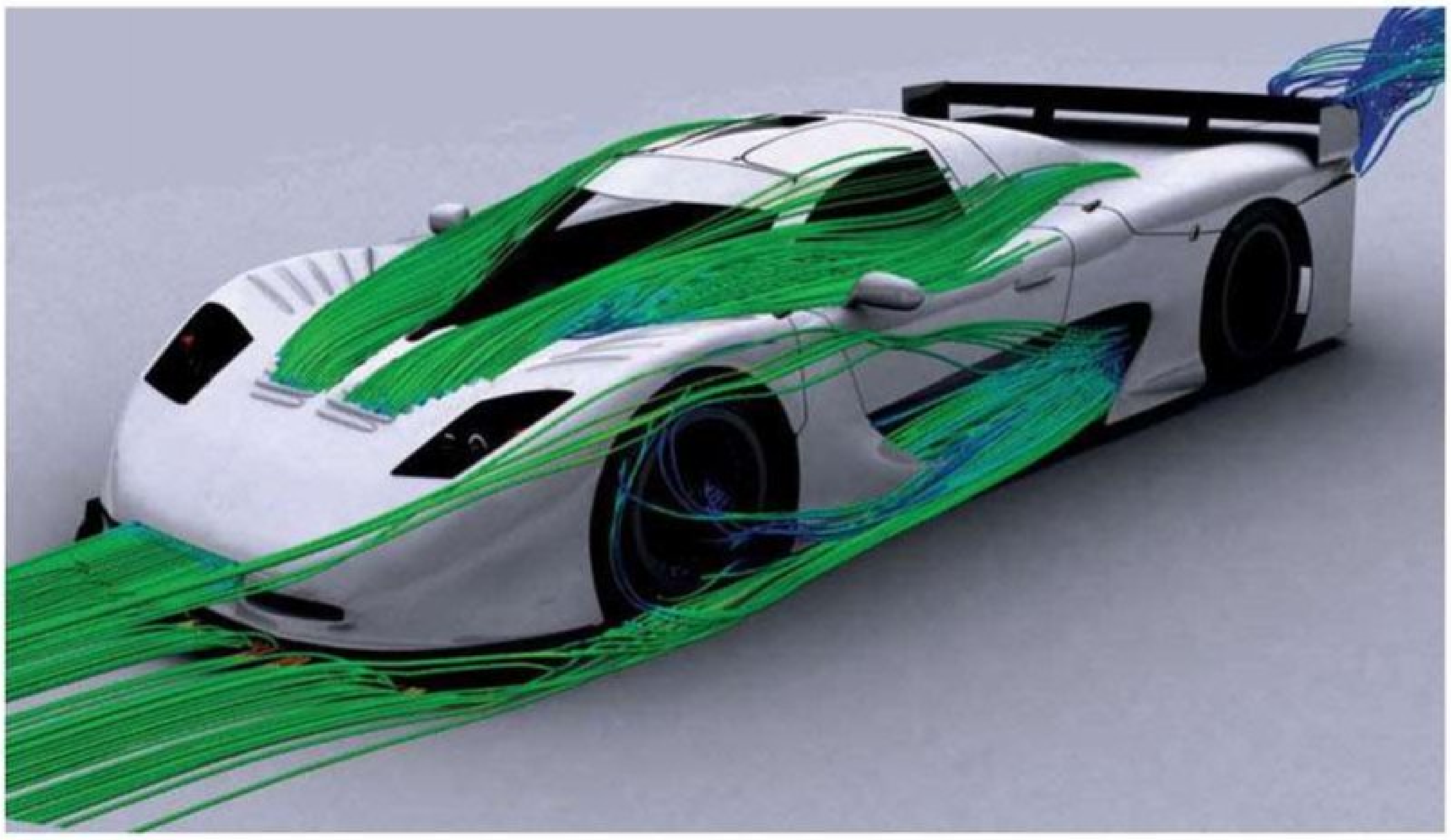
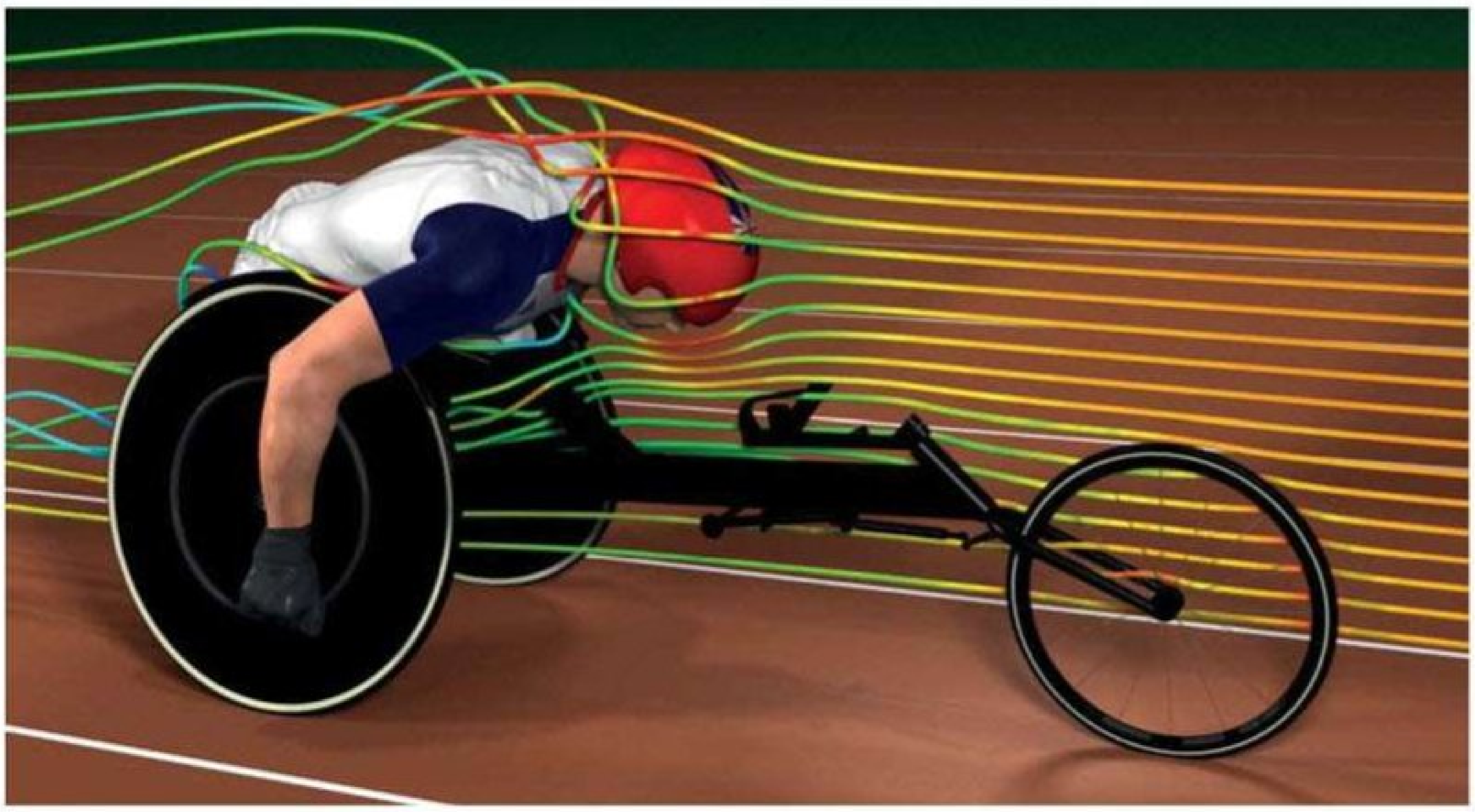


Image courtesy of Rollcentre Racing/Mosler Europe



CFD streaming using OpenFOAM at TotalSim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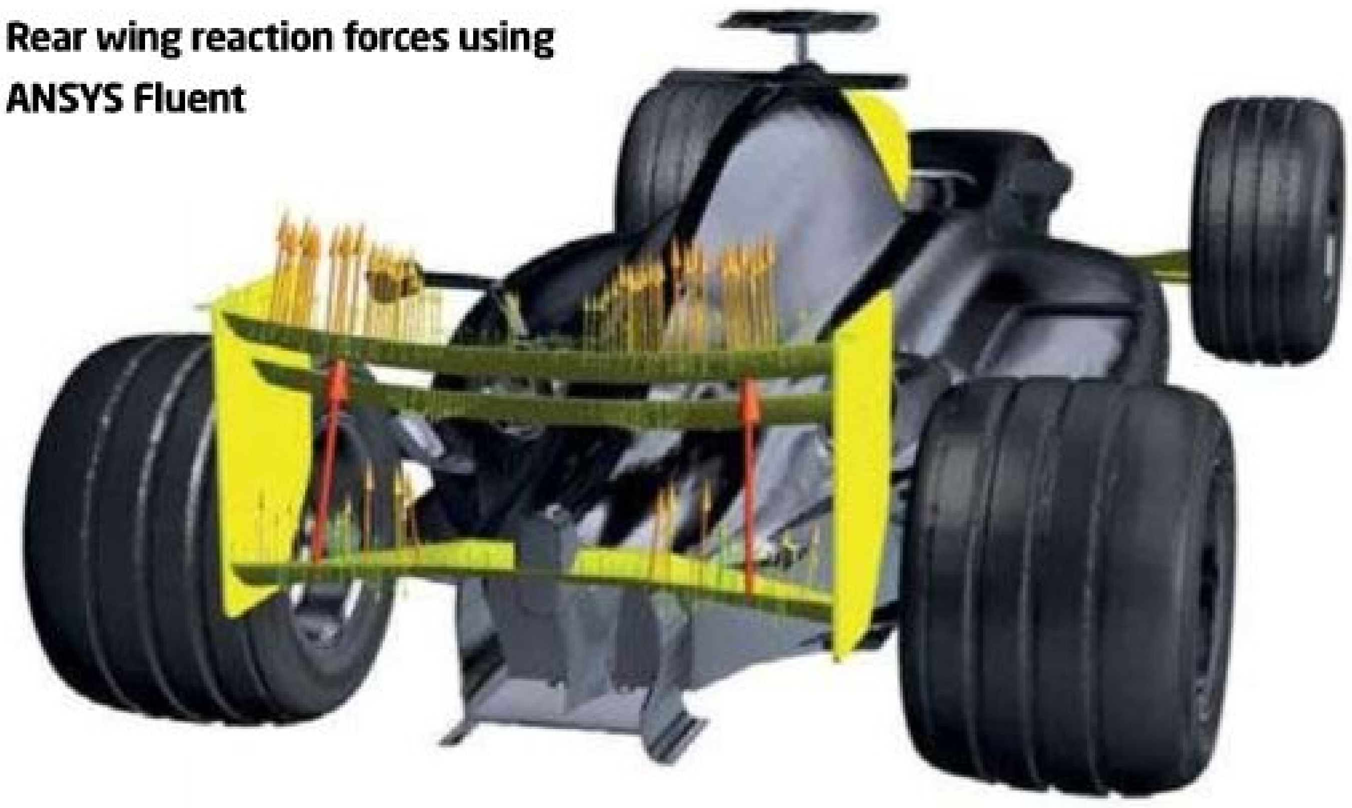
'This means we can quickly populate a vehicle dynamics model with high precision data directly from our K&C rig,' says Richard Adams, business development manager at MIRA. 'This is useful in a range of scenarios. One being that a "winning car" has a desirable set of characteristics that we can measure and recover from the K&C rig. We then feed this data into the virtual environment to create a new car model (possibly a new style or new generation model) that retains these winning characteristics.'

The K&C Facility at MIRA was supplied by Anthony Best Dynamics. It is now well established as the only twin axle SPMM (Suspension Parameter Measuring Machine) in the UK and is still the benchmark design for such rigs. More than 1200 vehicles have been tested in over 15 years since its installation, ranging from F1, WRC, WTCC / BTCC cars to minibuses.



Rear wing reaction forces using ANSYS Fluent

Swift Engineering in the USA decided to alter the aerodynamic design of the racecars to make it easier for the trailing car to pass and so revolutionise the spectator experience. A Swift engineer came up with a device called a 'mushroom buster' designed to 'wake shape' or modify the wake signature of the vehicles and make it easier to execute lead changes. However, while the effects of a lead car's wake are understood in principle, the details of the dynamic interaction of the two car wakes was not. In order to evaluate their solution, Swift needed to understand the aerodynamic effects throughout a complete simulated pass of one racecar by another.

Simulated passing manoeuvres had been done before, but in order to reduce the computational overhead the lead car was usually static. Similarly many teams have tried to put two cars (in whole or in part) in wind tunnels and masks have been used in tunnels that corresponded to the lead car's wake profile. But until Swift took up the challenge, no one had published a full CFD simulation of an overtaking manoeuvre with two cars at racing speed.

From a computational perspective, simulating a typical passing manoeuvre is extremely difficult because the aerodynamics change dramatically as the cars change position relative to each other. In the CFD field it's an unsteady state problem – a computationally intensive one that involves simulating a complex time-dependent aerodynamic flowfield.

Swift needed significant processing power, so they turned to Cray. Using the Cray XE6 system and CFD, Swift was able to break a 13-second passing manoeuvre down into a series of steps. When you are running an unsteady state solution in CFD, you are solving the equations at each time step. You are making

OPEN SOURCE CFD

The OpenFOAM (Open Field Operation and Manipulation) CFD Toolbox is a free, open source CFD software package produced by OpenCFD Ltd. It has a large user base across most areas of engineering and science, from both commercial and academic organisations. OpenFOAM has an extensive range of features to solve anything from complex fluid flows involving chemical reactions, turbulence and heat transfer, to solid dynamics and electromagnetics. It includes tools for meshing, notably snappyHexMesh, a parallelised mesher for complex CAD geometries, and for pre- and post-processing. Almost everything (including meshing, and pre- and post-processing) runs in parallel as standard, enabling users to take full advantage of computer hardware at their disposal. By being open source, OpenFOAM offers users complete freedom to customise and extend its existing functionality, either by themselves or through support from OpenCFD. It follows a highly modular code design in which collections of functionality (eg numerical methods, meshing and physical models) are each compiled into their own shared library. Executable applications are then created that are simply linked to the library functionality. OpenFOAM includes over 80 solver applications that simulate specific problems in engineering mechanics and over 170 utility applications that perform pre- and post-processing tasks.

'We've been here over five years as TotalSim and before that as Advantage CFD,' says Rob Lewis, owner and founder of TotalSim. 'We started to look at open source CFD codes and OpenFOAM in particular in about 2005. We worked with it and helped develop various routines specific to our business and made it useful for racecars. We validated it on external projects – we were doing external projects as well as the Honda F1 project. We managed to get the code to a state where it was useful and then when we left Advantage CFD and started this place. We based almost all our work on the open source code OpenFOAM.'

The code is free to use and free to download, but you generally need support and training to be able to use it, so the idea is that the services around this code is what keeps it going and TotalSim in their turn sell support and training to their customers.

OpenFOAM users are living and breathing the code on a daily basis for critical projects. So when an OpenFOAM user sells a support contract, what you get is its support derived from real-world experience, not ivory tower software development experience.

One of the things that the F1 companies are realising is that because they're using the same brand of commercial code there aren't very many areas in the standard code where you can gain particular advantage. Also because it's a commercial code, they can't take the lid off and tweak it or adjust it to suit their own requirements. With the open source you can download the code and create your own modules for all sorts of things and add your own layer of speciality on to the basic CFD solvers.

'With a support contract our users have access to everything we know,' says Lewis. 'The old days of us retaining specialist IP have gone. In the past we used to do wing projects and give the client the output, but we wouldn't tell him how we did it. In the new open source environment the client gets everything including our IP and we are quite happy to do this because of all the advantages that the open source environment brings to us.'

The other benefit of the open source environment is that you can couple at a much deeper level the CFD code to any other analytical code quite easily as long as you understand both, so linking to FEA and membrane analysis is not as difficult as it is with commercial codes.

a solution every 10 milliseconds. For a 13 second manoeuvre, that's 1300 time steps. What that looks like in CFD is essentially 1300 different grids as the grid changes with every positional change of the cars. That's not as easy as it sounds. Setting up that kind of CFD run means essentially creating grids upon grids composed of millions of cells. Ultimately, Swift created a grid composed of 118 million cells. Because you have a different grid for each time step, it makes it difficult to solve and limits the scalability on a supercomputer as it's a numerically intense solution.

PRODUCT SIMULATION

Strategic Simulation and Analysis (SSA) provides software and services in Computer Aided Engineering and carries out product simulation using Finite Element Analysis and multi-physics.

SSA is a reseller for the Simulia product line, which includes the Abaqus simulation products with associated training and implementation services. Abaqus is recognised by engineers as the leading solution for non-linear, implicit and explicit structural analysis and more general multi-physics problems such as fluid structural interaction (FSI). In addition Abaqus covers buckling, thermal, computational fluid dynamics (CFD) and electromagnetics and has some specific technologies for some analysis problems, for example Coupled Eulerian-Lagrangian Analysis (CEL), Smoothed Particle Hydrodynamics (SPH), XFEM (eXtended Finite Element Method), composite analysis and topology shape optimisation.

SSA is one of a new breed of simulation software providers and consulting companies. They have a dedicated team of simulation experts doing simulations for individual projects, and methods development to help their customers create and implement simulation strategies to gain real financial and technical benefits for their businesses.

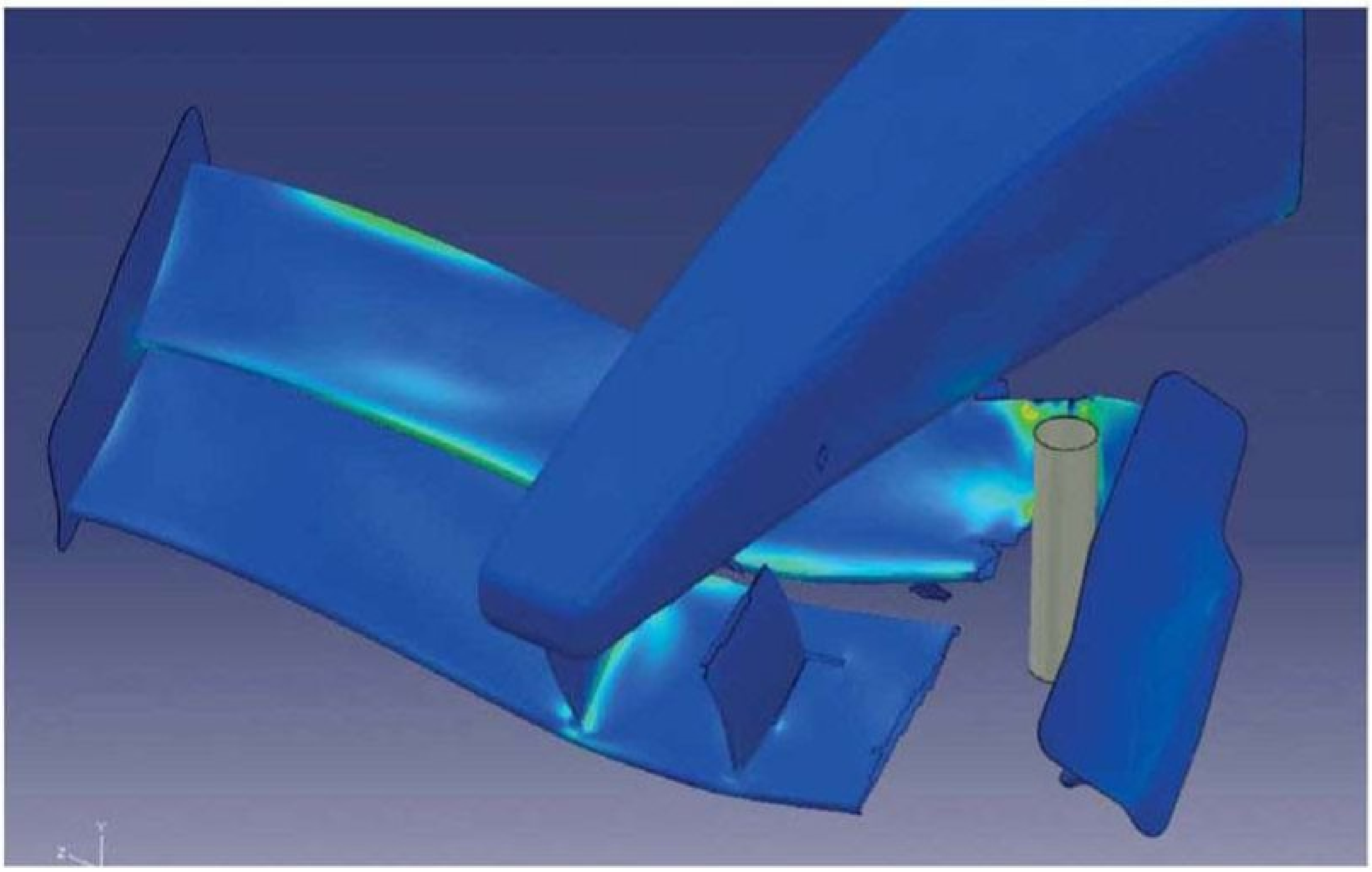
Atom – the Abaqus Topology Optimisation Module – allows non-linear topology optimisation analysis. Non-linear is tricky and topology optimisation is tricky – combining the two is close to impossible.

'The interesting thing today is that we can do analyses that used to take weeks about 10 years ago, sometimes in a matter of minutes on modern hardware,' say Laurence Marks, co-founder of SSA. 'We have an eight processor machine with 64GB of RAM which cost less than £2000, on which we are now running cases that used to require a multi-million pound supercomputer 10 years ago. We can run fluid structure interaction, rotational mesh CFD, topology optimisation – all things we knew about 10 years ago, but because we were machine limited we couldn't even think of running half of them.'

SSA is looking forward to another step change in compute power as GPU solutions come on stream so that fluid structure interaction with nonlinear topology optimisation is a realistically achievable in the near future.

'From our point of view we would like to see GPUs takeoff because you only grow the business by allowing people to solve large problems,' continues Marks. 'Having access to multiprocessor GPUs in affordable hardware will allow many, many more companies to perform very large analyses.

'Raw processor speed of itself is not particularly helpful, what you need is fast processor speed and the ability to link different



Carbon Fibre front wing pole impact failure using Abaqus C-Zone from Engenuity

CFD of a sprint cyclist using OpenFOAM from TotalSIM

processes together. Things like fluids and structures and thermal and optimisation engines all working together that capitalise on the fact that you can now solve all these problems. The capabilities of the software needs to get in line with the massive increase in compute power."

With the help of Altair Product Design, Altair's in house CAE consultancy, a linear topology optimisation was undertaken using the aerodynamic shape as the design volume, with constraints such as mass, compliance and stress being among the most important design considerations.

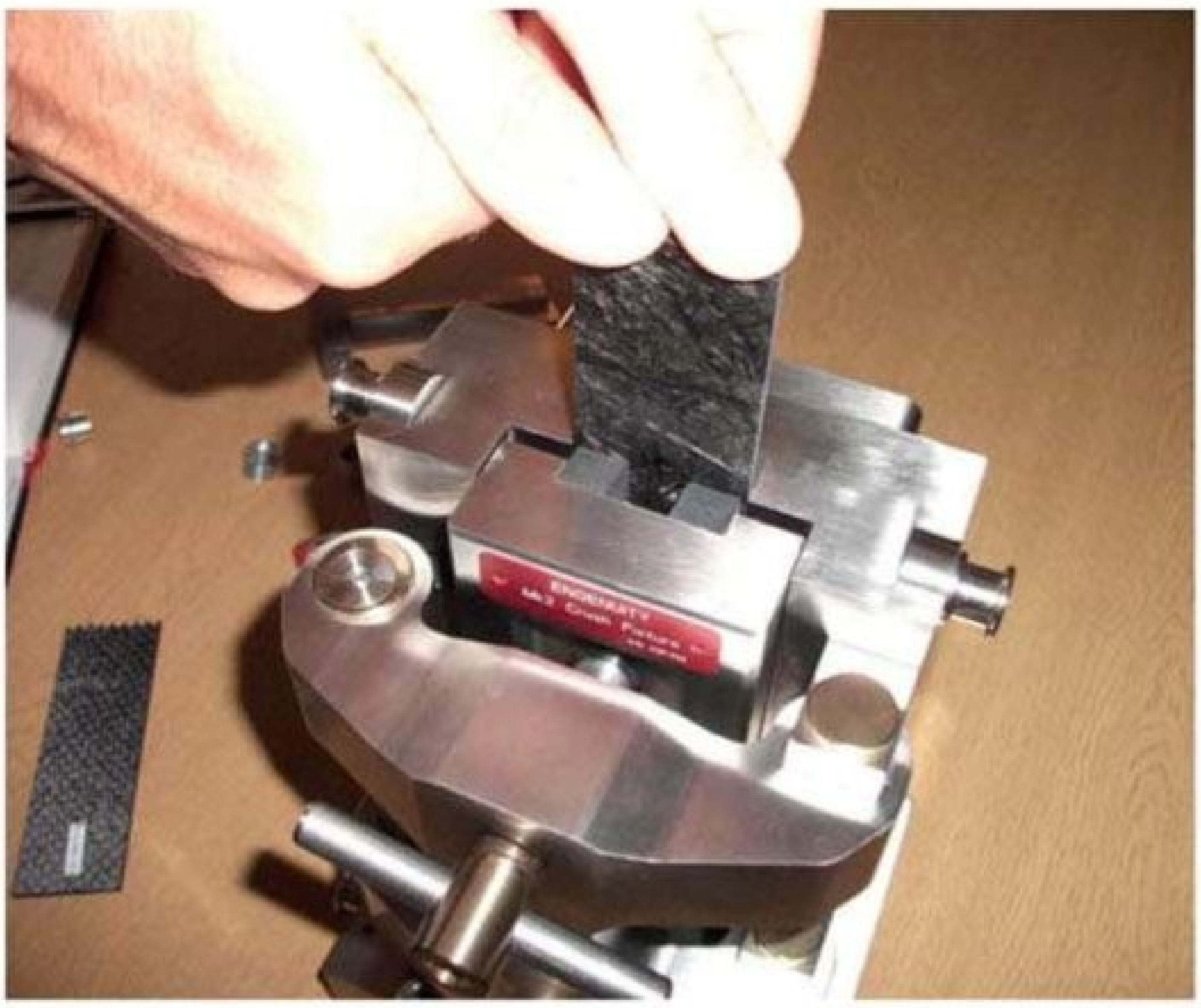
New to Altair's HyperWorks 11.0 is the ability to perform a non-linear optimisation from within the OptiStruct module. The method allows optimisation of models containing material and geometric non-linearity as well as contact using either an implicit or explicit solution sequences.

This offers a very efficient technique for optimisation of non-linear events as it only requires a small number of non-linear simulations. The design is optimised for loads, which are recalculated after every major iteration.

Free-shape optimisation moves the nodes on the outer surface of the structure, and the mesh is altered to meet specific pre-defined objectives and constraints. The main advantage of this type of optimisation is that the user is relieved of having to define many shape perturbations, and the movement of the outer boundary is automatically determined by the solver during the optimisation.

The new geometric non-linear and free-shape optimisation capability within HyperWorks 11.0 has enabled the Force India F1 team to improve the design of the primary roll structure significantly. The final design was able to reduce mass, pass all FIA regulation criteria, and significantly reduce the time taken to design the primary roll structure for the car.

Altair's focus in the motorsport industry is lightweight optimisation.



Carbon Fibre crush testing fixture at Engenuity gathering real-world performance data

'Basically it's static and dynamic FEA, but we can couple that with multi-body dynamics and we also have CFD capability,' says Jamie Buchanan, director of Altair Product Design. 'We tend to focus on the structural side of things. This is mostly from a historical perspective and most F1 teams like to keep the CFD side in-house.

'We started using generic algorithms, but as the software developed more functionality we developed a technique called free element size optimisation, which for a composite structure, allows you to define the ply boundaries. You basically specify the number of plies you need based on the new ply boundaries.'

The Altair optimisation is based on the actual physics; you know the kind of space available for the part, you have an understanding of the loads and boundary conditions. From that you can quickly established load paths and once you've found those you populate them with material to build up the shape. The software decides where in the design space the material can be used most effectively.

'There's a lot more interest at the moment in using GPUs to do some of the aerodynamic calculations and looking at the ways to speed up the whole process,' says Mark Keating, senior CFD engineer at Ansys. Ironically, in a bid to reduce costs and get teams to reduce the amount of time they spend in the wind tunnel and using CFD software, the FIA has inadvertently shifted the emphasis in CFD departments to using faster and more automated codes.

Also because of the FIA Resource Restriction Agreement (RRA), the CFD users in F1 companies are pressing their software vendors to make their solutions more efficient and reduce the overall runtimes – getting the software to run on GPUs is one way of doing this.

"The FIA inadvertantly shifted the emphasis of CFD departments"

In this context the problem that also arises is the definition of what CFD actually is. The major part of a CFD run is spent on formulating the problem – getting the geometry from the CAD department, conditioning it for the analysis and actually setting up the runs. Only 10% of the process is actually involved in CFD computation. Lots of companies are tending towards automating the model preparation and taking it out of CFD, then running the CFD when all the analysis cases are set up, thereby attempting to stick to the letter of the restriction imposed by the FIA.

The more efficient they can make the process, the more runs they can get in under the FIA limit on processing time.

Another key time saver is the transfer of information between all of the different processes. If you can keep the transfer time down as much as possible, you can reduce the overall runtimes which forces you down the integrated systems route.

There is also quite significant differences in the interpretation of the rules and the RRA by the different companies. Everybody is trying to concentrate on the solve process as being the only measure of CFD processing time.

This also puts pressure on the software vendors to not only improve their processes at a fundamental level, but to supply the customers with constant tips and tricks in order to reduce the runtimes of existing solutions.

This presents a problem for the software vendors, as they have to increase the level of support they provide, because of cost-saving restrictions imposed by the FIA.

'From our point of view we're currently working to reconcile all the different solvers that we have for CFD and bring them into a single solver,' says Keating. 'This uses some new technology which will help move things forward when it comes on stream.'

In all areas of simulation consulting there is a lot going on. Regulation changes mean that more calculation needs to be done along with more physical testing or certified calculation verification.

Composites are still scarce and expensive commodities, especially when compared to metals. But with software improvements, manufacturers can be developing and analysing these structures now while the supply chain catches up – as must. Future domestic vehicles will contain more composites – all thanks to initiatives that have started in motorsport.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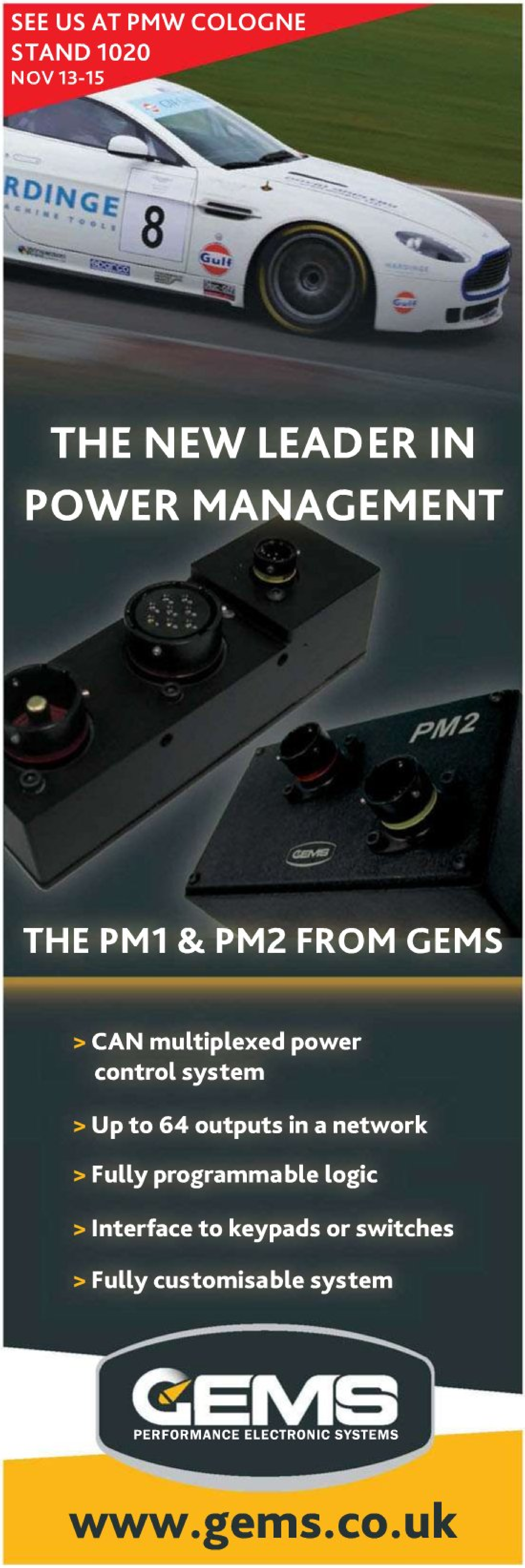
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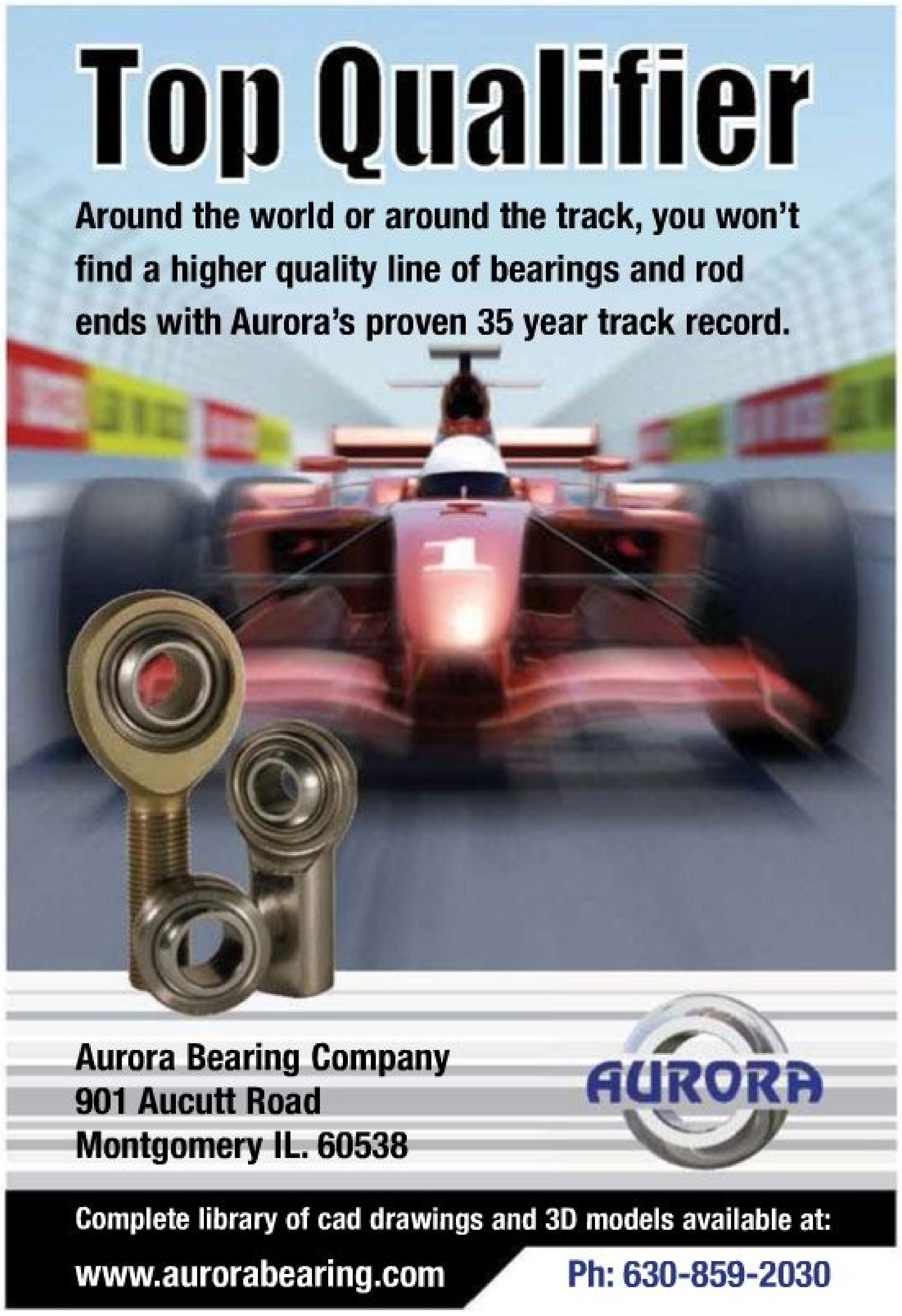
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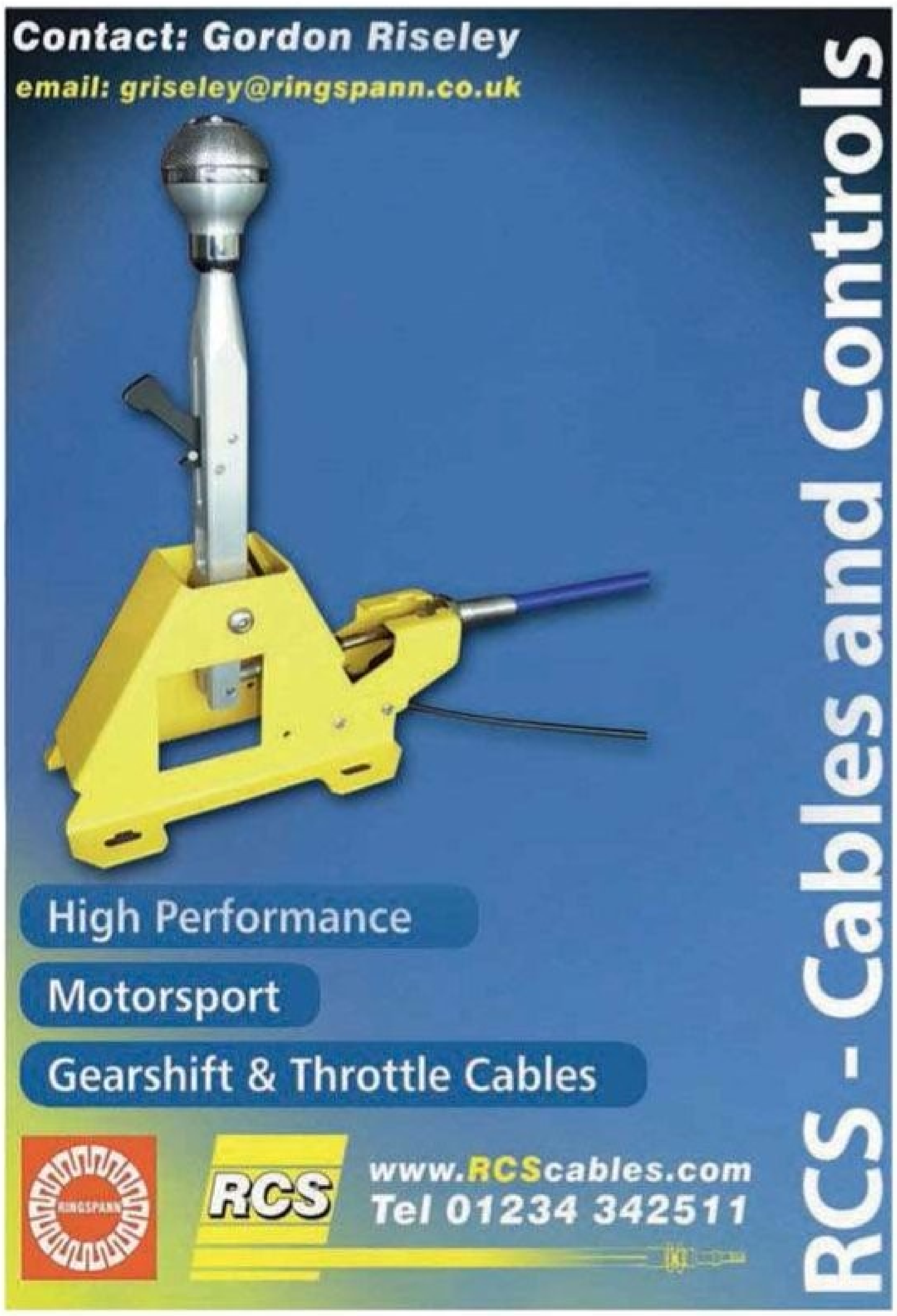
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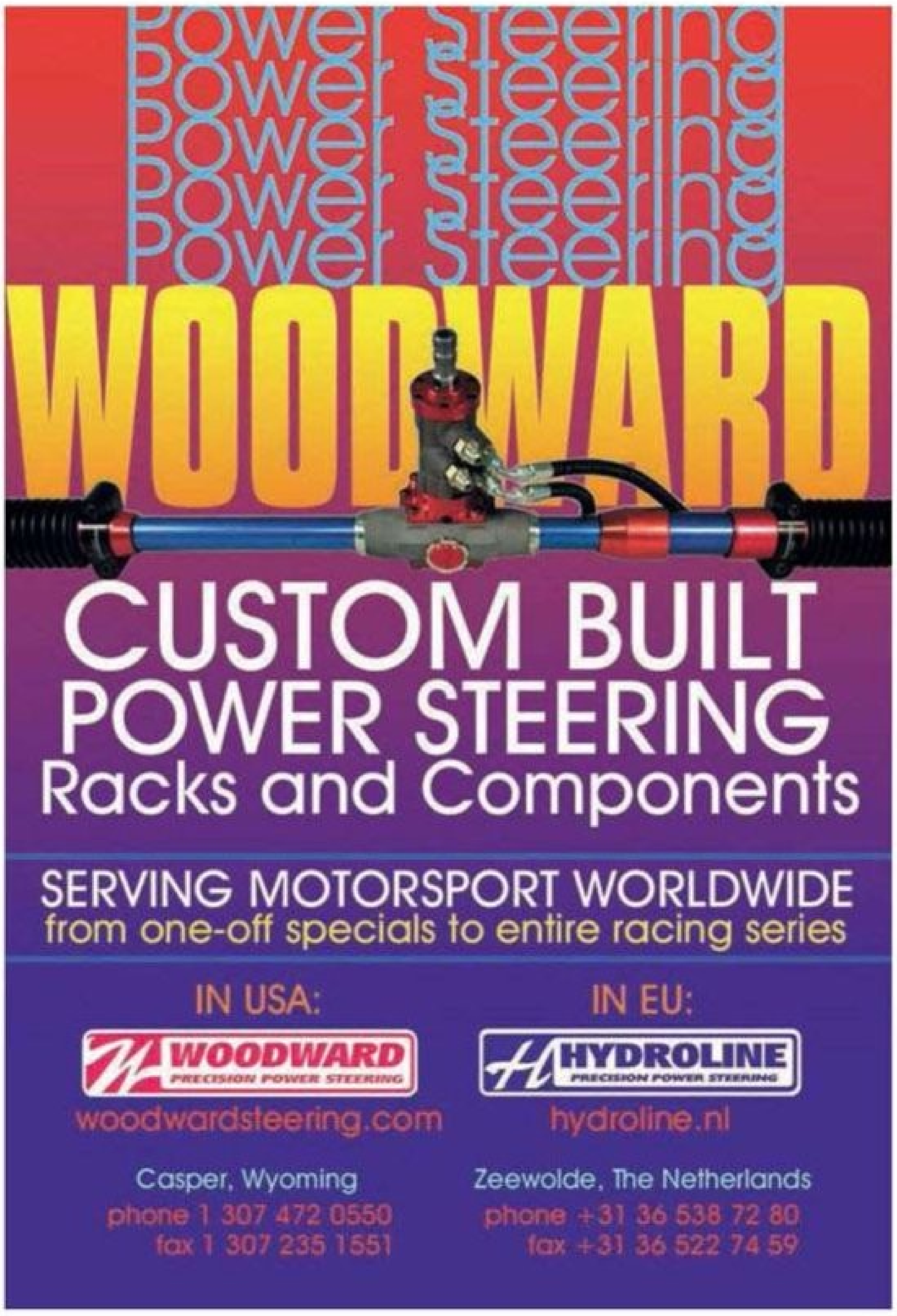
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Suspension geometry and the origin of force application points

Dispelling popular misconceptions, and how best to make it work for you

Over the last couple of months I've been seeing a lot of internet traffic about suspension geometry and jacking forces. While it's great to see these matters discussed in the open, I'm still amazed at the misconceptions about suspension geometry that are still out there, in particular the way in which it transfers forces from the tyre to the sprung and unsprung masses.

In some respects it gives me a great feeling of sadness that I feel the need to write this piece at all. I say this because there's a wealth of knowledge out there proving the validity of force application points. Respected

BY DANNY NOWLAN

figures in the industry, such as Bill Mitchell, have discussed this, and if you dig hard enough you'll also see the same things crop up within the roadcar community. A notable example of this was the book *The Multibody Systems Approach to Vehicle Dynamics* by Mike Blundell and Damian Harty. Yet despite this wealth of knowledge, I still see the same myths cropping up regarding suspension geometry. To put this matter to rest I'm going to discuss some of the misconceptions out there and where force application points come from.

The first misconception that I see is the incorrect use of the D'Alembert approximation. This quantifies the acceleration of a body as a force equal to its mass x acceleration at the centre of gravity. It's a very powerful way of using static analysis techniques to approximate dynamic problems. It's also extensively used in structural analysis to quantify / estimate what forces the structure is being subjected to. Used that way, the D'Alembert approximation is a very powerful tool.

However the biggest danger in using it is that the approximation can sometimes blind you to the true nature of the way the forces are generated. To illustrate this, let's consider a car in 2D view turning a corner.

In **Figure 1**, the car is coming towards us, which is why the left and right are swapped around. From Figure 1 we can solve readily for the vertical forces Fz_right and Fz_left. The drivers in this case are the weight of the car coupled with our approximation of the lateral force. In this respect the D'Alembert approximations serves us very well. Where it runs out of steam, however, is for the lateral forces for two key reasons:

- **The above visualisation is statically indeterminate.**
- **It also blinds us to the way these lateral forces where actually generated in the first place.**

The first point we can sort of get around using structurally compatibility or some fancy footwork using vectors. The structural compatibility has some pretty solid foundations but it's terribly complicated. However, given the fact that Figure 1 is statically indeterminate, laterally the vector approach will run out of steam.

There are some who claim the distribution of the lateral forces doesn't matter in order to work out suspension geometry forces. But the question has to be asked: does this add up? To keep things simple, let's take our 2D approximation and put in some actual numbers. These numbers are illustrated in Table 1.

If we go through and sum up the vertical forces and take moments at the ground, we can readily solve for our vertical forces. I'll let the interested reader prove this in their own time, but let me summarise the results:

$$F_Z = \frac{mg}{2} \pm \frac{m \cdot a_y \cdot h}{t} \qquad (1)$$

Where Fz is the individual vertical forces on the tyres, g is acceleration due to gravity and the parameters are what we've described in **Table 1**. Punching through the numbers we have Fz¬_right at 691.4kgf and Fz_left at 58.6 kgf. This is where things get really interesting. Let's consider when we have the lateral forces split 50 / 50, and when the lateral forces are distributed with the load. The angle of the vectors is shown in Table 2 for both cases.

Table 2 shows very clearly how it's highly optimistic to claim that the distribution of the lateral forces doesn't matter. Given the difference between the angles of the vectors in **Table 2**, they actually matter a great deal.

However, even assuming we can get around this, the D'Alembert approach misses how these forces were generated. We'll return to this point very shortly.

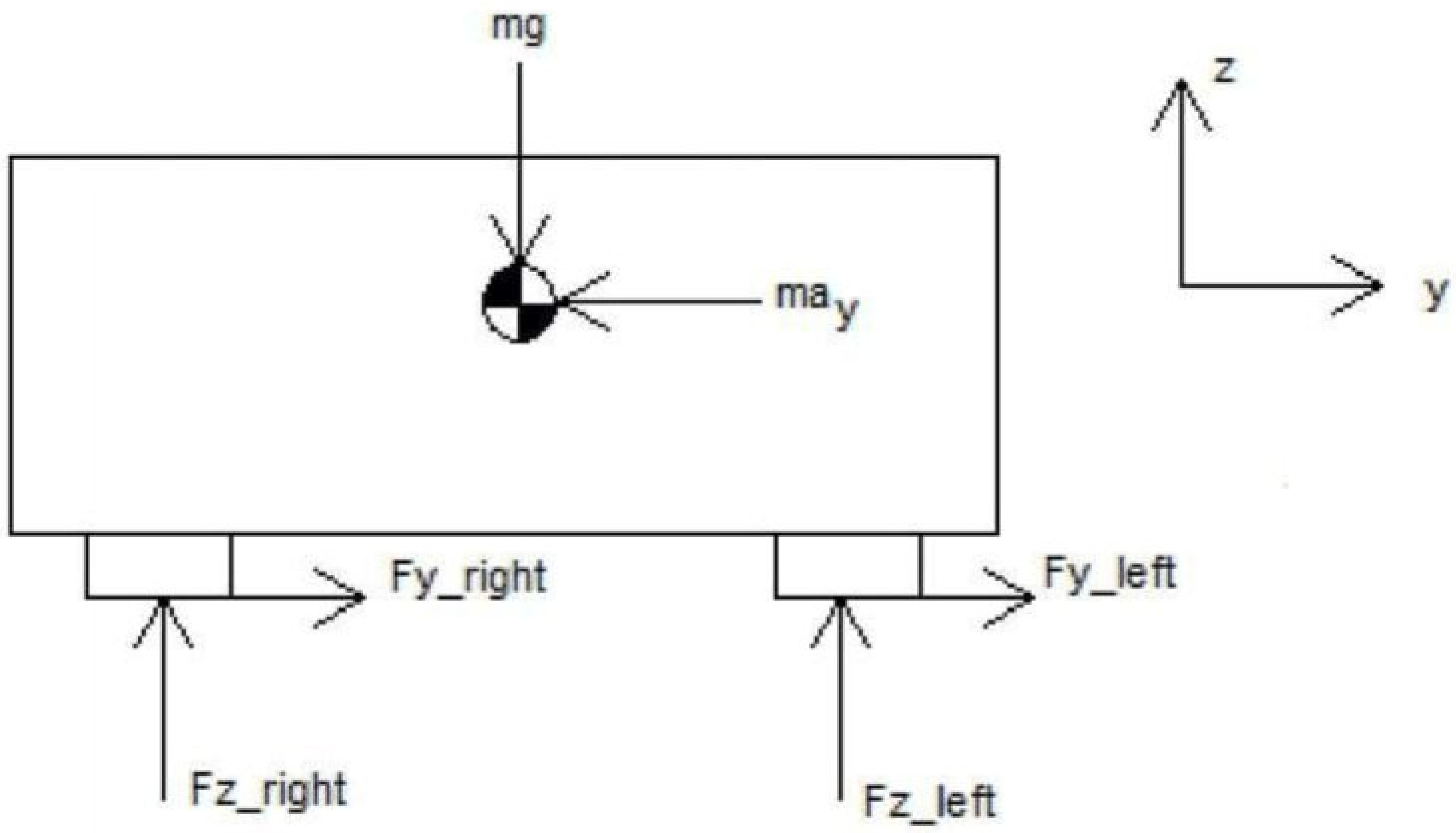


Figure 1: 2D view of forces acting on a car using the D'Alembert approximation

"It can sometimes blind you to the true nature of the way the forces are generated"

The other huge misconception is that the Kinematic roll centre is the place at which the lateral forces are applied. This only applies for a few cases the most notable being:

- **When the car is symmetric or near symmetric.**
- **The lateral forces are equal or near equal to each other side to side.**

Of all the old wives tales that are out there, this is the big one and it sucked in a lot of people, including me. Where it breaks down is where the car starts to roll and you start getting significant weight transfer, which means the lateral forces are now totally different. Bill Mitchell and I have discussed this matter in some depth.

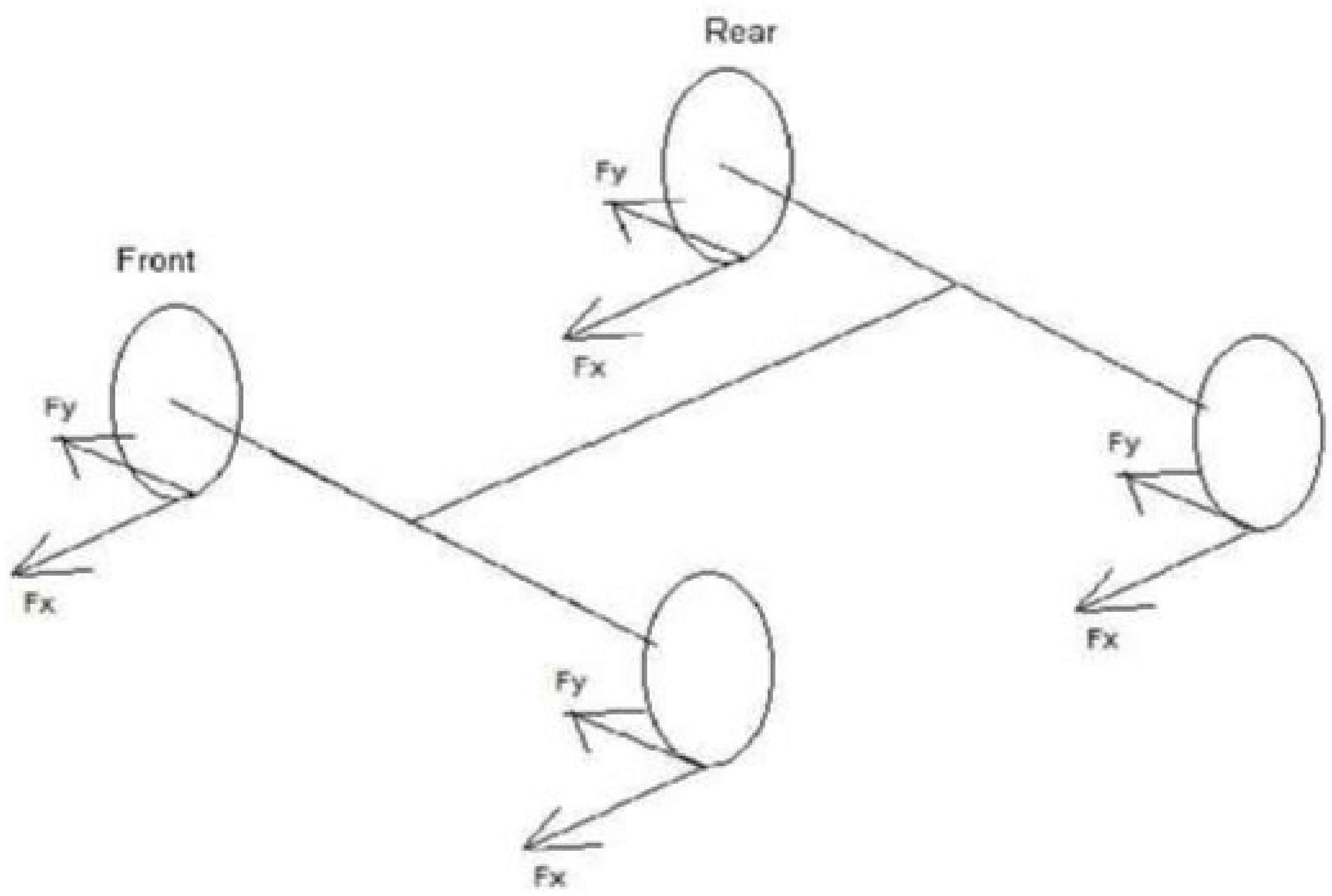


Figure 2: illustration of forces applied at the contact patch

Table 1: typical Stockcar/V8 Supercar parameters

Parameter	Value
mt	750kg
t	1.6m
ay	1.5g
Centre of gravity height – h	0.45m

Table 2: angle of the vectors for different lateral force cases

Case	**Right side angle**	**Left side angle**
Evenly distributed	50.90	60
Distributed with load	33.70	33.70

Let me give you a war story on how this caught me out, and how I went about fixing it. One of the first things I did when I started on ChassisSim was to do a force analysis on a double wishbone suspension system. Being young and silly, I just considered the symmetric case and showed that for the symmetric case, the kinematic roll centre was the place where the forces were applied to the sprung mass. So after reading other documentation, I naturally assumed this was the point the forces where applied. This was a mistake. As ChassisSim went on, the roll correlation was OK, but from time to time it would come up with results stuff that were just plain weird. I then read Bill Mitchell's article on force-based application

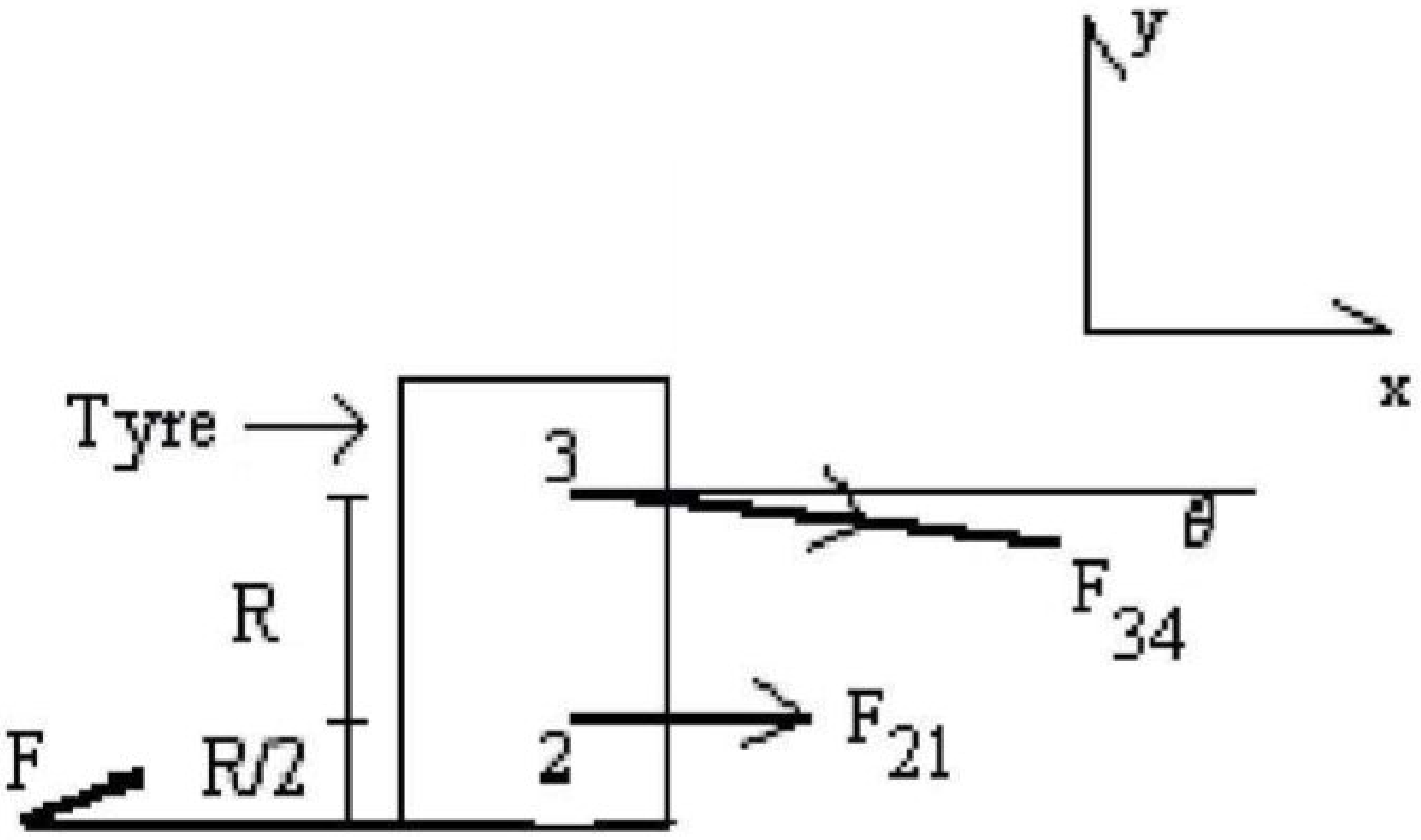


Figure 3: FBD of a double wishbone suspension in 2D view

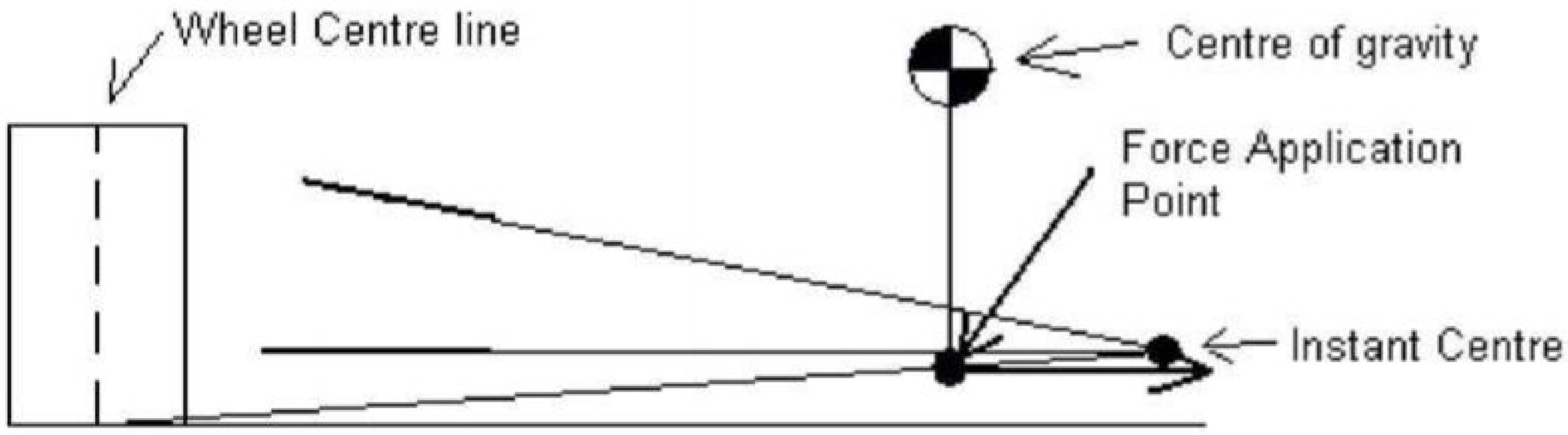


Figure 4: how to find the force application point

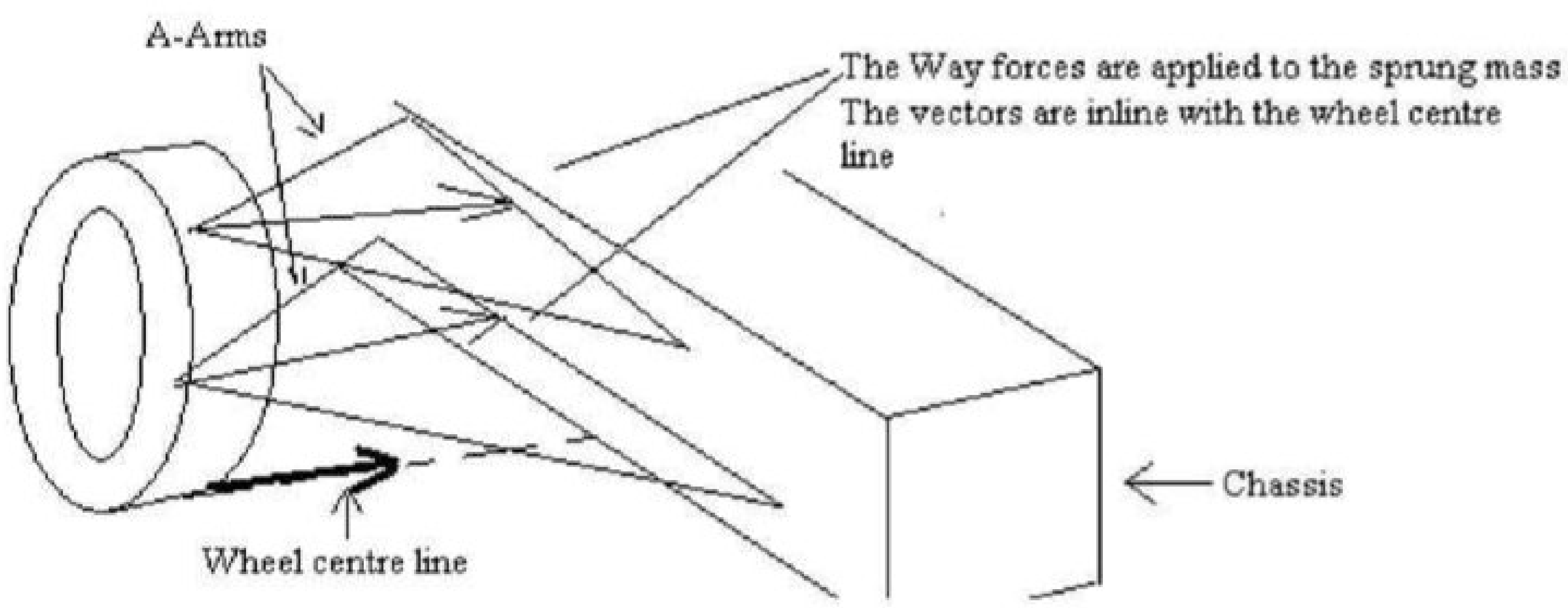


Figure 5: dealing with non parallel A-arms

points, and subsequently felt like a complete idiot. Anyway I redid my proofs and incorporated it into ChassisSim and two things happened: the correlation went from being good to spot on, and the odd tendencies in roll evaporated.

So all this being said, what really is going on with suspension geometry?

Our first port of call is to recognise that all the forces that turn and accelerate the racecar (with the exception of aero and mechanical drag) are generated from the contact patch of the tyres. There are exceptions, but for 99.99% of cars, the forces that will turn and accelerate the car come from generating forces at the contact patch of the tyre. This comes through the generation of slip angles for lateral forces and slip ratios for the longitudinal forces and combinations thereof. To help visualise this, consider this illustration of forces acting at the contact patch.

The suspension geometry comes into play where the mechanism transfers the forces into the sprung mass and directly into the tyres. The forces that are reacted into the tyres are often referred to as the jacking force; personally I think the term is a bit of a misnomer. The tyre loads are controlled through two methods, the reaction of the springs / bars / dampers to forces applied through the sprung mass, and directly through the suspension geometry. The mechanics of what drives this process is illustrated in **Figure 3**.

The beauty about this free body diagram is that we can see in an instant what is driving our suspension geometry interactions. The forces through the two arms will generate rolling moments around the sprung mass and the vertical component of the top arm is what is driven directly into the tyre.

There will be some who claim this visualisation in Figure 3 has no validity, but this isn't the case. The primary method of solving the forces in Figure 3 is to sum the forces laterally and take moments in roll at the ground. This is a reflection of two fundamental physical interactions.

The first is the lateral forces which have to be transmitted to the sprung mass via the suspension linkages. In most cases the sprung mass is much greater than the unsprung mass, which covers about 90% of most racecars you deal with. Even with the unsprung mass being very large we can still get a fair way down the road.

The second interaction is that the roll angle acceleration of the unsprung mass is negligible. This means we can approximate the rolling moments about the hub and ground at zero. The combination of these two interactions greatly simplifies things.

The power of force application points is that they offer a very powerful but simple way of quantifying all this. I do not intend to repeat the proof here, however the following visualisations might be of some assistance.

The following equations should help you quantify this:

$$M_x = F_y \cdot (h - rc_f)$$

$$F_t = \frac{F_y \cdot rc_f}{t} \qquad (2)$$

where:

M_x = rolling moment applied to the sprung mass (Nm)
F_t = force being applied straight to the tyre (N)
F_y = the applied lateral force (N)
$Ø_{ic}$ = the angle of the line from the contact patch to the instant centre
t = the horizontal distance from the tyre to the centre of gravity (m)
rc_f = force-based roll centre/ force application point height from the ground (m).

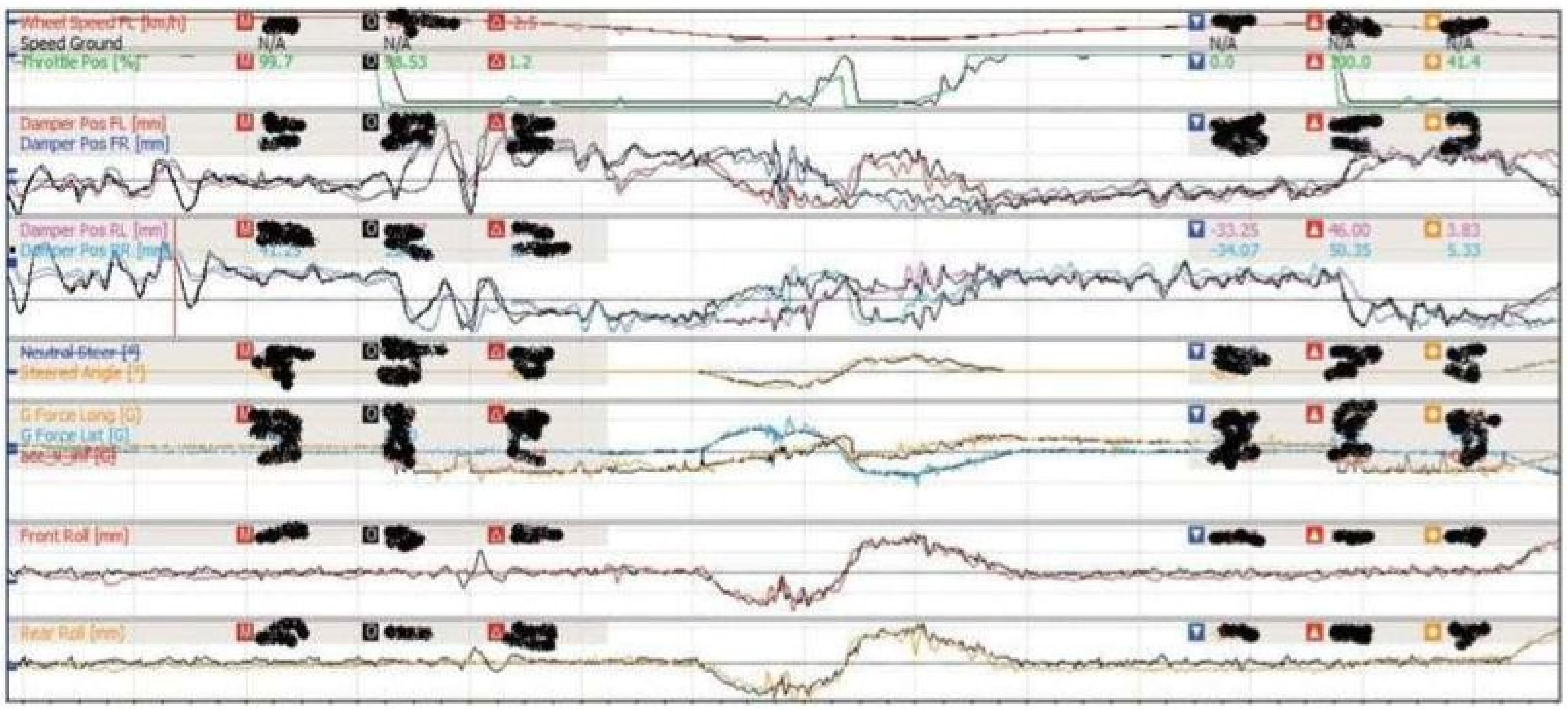


Figure 6: comparison of actual data vs simulated using force application points

So all we need to do is find the instant centre, draw the line from the contact patch to the instant centre and the force application point is under the centre of gravity. It is something which equation (2) will quantify for us.

This is all well and good for the 2D case, but what happens when you have 3D suspension geometry? The answer is actually more straightforward than you might think. Consider the case illustrated in Figure 5.

If you take a free body diagram of the hub, it can be shown conclusively that the forces are transmitted along the wheel centre line in the same planes as the respective planes of the A-arms. The inboard points as we discussed in our proofs can be derived as illustrated in Figure 5. That is the point where the wheel centreline crosses each respective A-arm plane on the chassis. This is what you find to derive the force application points for the 3D case. It's that simple.

The great news is that it applies for the longitudinal case as well. I go into further depth about the why of this in my book, *The Dynamics of the Race Car*. However, the interested reader can prove it to themselves. Try looking at Figure 3 horizontally.

To conclude this discussion, it would be wise to look at some correlation based on these techniques. Force application points are a key component of the ChassisSim vehicle model that is used in a variety of different formulae. I have presented an overlay of actual vs simulated data. Actual is coloured, and the black is the simulation. For privacy reasons the scales have had to be blacked out.

As we can see, there is very little difference between actual and simulated data, particular in the damper displacements. There may be some bumps slightly out of scale, but that is to be expected from race data. However, the thing to pay particular attention to is the last two traces which is front and rear roll. This speaks volumes for the validity of force application points that we've discussed here. The results speak for themselves, and I hope this lays to rest some misconceptions out there in the racing community.

Middle East money saves Citroen WRC, WTCC possible

The Citroen World Rally Championship effort has been saved thanks to an injection of capital from Abu Dhabi, while it has emerged that the beleaguered French firm is now also considering a World Touring Car Championship programme.

There had been doubts over Citroen continuing in the WRC after a 13 per cent drop in car sales was reported for the first half of 2012.

Following the dismal sales figures, which led to 8000 job losses in France and the closure of a factory, Citroen was instructed to find some 60 per cent of its rallying budget from sources outside the PSA Group (which includes Citroen and Peugeot).

Abu Dhabi has now come up with a rallying budget, stepping in as a primary sponsor, and while there is no news on how long the deal will be for, it has been confirmed that the programme is now safe for next year. Yves Matton, Citroen's team principal, said: 'We are particularly proud to welcome Abu Dhabi on board. This partnership will provide us with the means of continuing our programme and entering three DS3 WRCs in 2013.'

Sebastien Loeb: coming soon to the World Touring Car Championship?

Citroen has also revealed that it is evaluating entering the World Touring Car Championship with Sebastien Loeb from 2014. The nine-time WRC-winning driver has said he intends to compete in rallying on a part-time basis next year, but Matton has said that a WTCC programme with Loeb was a serious possibility for the following season in 2014.

'The role of brand ambassador for Citroen cannot be a passive one for someone as driven as Sebastien,' said Matton. 'This project [the WTCC] would give him the opportunity to pursue his career in track racing with the support of the manufacturer with which he has worked since his competitive debut.'

However, Matton made it clear that this would not just be about providing Loeb with a place to race, pointing out that the WTCC calendar would also suit Citroen's global business plans. 'For Citroen, the WTCC would enable us to showcase "Creative Technologie" in major markets, such as China and Brazil,' he said.

Matton added that any WTCC programme would ultimately depend on the regulations and on sponsorship: 'The final decision regarding this programme is linked to the FIA regulations and, obviously, the determination of our current and future partners to support us in this project,' he said.

Olivier Fisch, managing director at WTCC promoter Eurosport, said: 'We would be extremely pleased to welcome in WTCC a top car manufacturer like Citroen and a superstar like Loeb that boast impressive winning records in motorsports. While waiting for their decision, I can say now that we are flattered by their interest in the WTCC that is the recognition of the joint efforts put in by the FIA and Eurosport Events to grow and promote the championship.'

Thai Grand Prix could be good for Formula 1's OEMs

News that Thailand is looking increasingly likely to host a Grand Prix should go down well with car manufacturers involved in the sport, as research suggests vehicle sales in the Asean region are set to double by 2018.

Following speculation earlier this year, a Thai government official has now confirmed that an F1 race is a real possibility after he met with Bernie Ecclestone at the Singapore GP, and the inaugural Thai Grand Prix could take place as soon as 2014.

Kanokphand Chulakasem, governor of the Sports Authority of Thailand, said the provisional plan agreed with Ecclestone was for a night race to be held in Bangkok. 'It will be a city race ... a night race like the Singapore Grand Prix,' he said.

However, there still seems to be some way to go before the event makes it on to the calendar as Chulakasem also said the fee for holding the race had yet to be agreed. It is believed that most of the funding for the race will come from the Thai government, with some input from Red Bull, which has been taking a prominent role in the discussions. Beer producer Singha is also likely to contribute.

News of a race in Thailand will be welcomed by those motor manufacturers involved, or looking at getting involved, in F1, as recent research from industry analysts Frost & Sullivan has suggested that the Asean region - The Association of Southeast Asian Nations, of which Thailand is a part - will see a doubling in vehicle sales by 2018, from 2.4m in 2011 to 4.7m.

This will be driven by growth in Thailand and Indonesia, says the research. 'Individually, none of the Asean countries has featured in the top 10 markets globally, but as a region, it has assumed greater importance in the last few years due to the implementation of the Asean Free Trade Agreement in 2010 and healthy rivalry among Asean member countries to attract foreign investments,' says Frost & Sullivan research manager for Asia Pacific Automotive Practice, Vijayendra Rao.

Rao added: 'Thailand and Indonesia vehicle sales are likely to hit one million units by 2013 driven by local demand, increased buying power and significant investments from Japanese OEMs.'

Worries that there might not be an appetite for Formula 1 in Thailand would have been put to rest when Mark Webber attracted over 100,000 people to a Bangkok Red Bull street demonstration in 2010.

Customer demand puts Bentley back on track

Bentley's Continental GT3 concept racecar, unveiled at the Paris Motor Show

Bentley says the launch of its all-new Continental GT3 racecar is a result of customer pressure for it to return to the racetrack and that the project could well lead on to bigger things in motorsport.

The Continental GT3 marks a sportscar racing comeback for the luxury car maker, which last raced with its LMP Speed 8, winning Le Mans for a sixth time, in 2003. The car will be developed throughout the remainder of this year and will begin a testing programme in 2013. Development of the car will be headed by Bentley's motorsport director Brian Gush, who led the marque's 2003 Le Mans programme.

While the car shown at the Paris Motor Show – very much a show car and not the definitive item, Bentley says – was built in conjunction with Ray Mallock Ltd, there is no word on which company will build the racecar, but both M-Sport and RML are thought to be in the frame to land the contract.

Dr Wolfgang Schreiber, Bentley chairman and chief executive, said the project was partly the result of pressure from customers. 'The clear message from our customers is that Bentley belongs on the racetrack, and the Continental GT3 is the realisation of a dream we've had ever since the launch of the Continental GT. The new GT Speed is the perfect car for us to develop into a racer, and our work so far has shown huge potential.'

Schreiber also hinted that the GT could lead on to bigger and better things, saying he sees it very much as a 'foundation' for further projects in the sport: 'The Continental GT3 is set to show the world what the Continental GT is capable of in its most extreme form, and establishes a solid foundation for Bentley's long-term motorsport plans.'

Bentley is currently riding high in the global luxury car market with sales for the first half of 2012 increasing by 32 per cent (on the same period last year) with 3929 cars delivered to customers. Its biggest market is the Americas (1140 cars delivered) closely followed by China (1059).

PEELING BACK THE STICKERS. NUMBER 8: PETRONAS

Ask yourself this question: had you heard of Petronas before you saw its name on an F1 car? Chances are, unless you're from Malaysia, the answer to that question is a no. It could certainly be argued, then, that Petronas is one of those rare companies that actually prove the value of Formula 1 sponsorship.

Petronas deals largely in oil and gas and was founded in 1974. It is wholly owned by the Government of Malaysia and controls the entire oil and gas resources in that country. It is also hugely important to Malaysia, with some 45 per cent of the government's budget dependent on its dividend.

These days the Petronas turquoise adorns the Silver Arrows cars of Mercedes, but before the company tied the knot with Merc, it had a long relationship with Sauber that started in 1995. At the end of 2009, and with the withdrawal of BMW (the team which Sauber has morphed into) from F1, Petronas was left without a car on which to promote its product. New team Mercedes, which had raced as Brawn in '09 (and before that Honda and BAR), won the hotly contested fight to secure the sponsorship, and the company signed on for five years.

Petronas is now three years into that deal, said to cost the company around US$42m a year – which while it is a healthy amount, is not as much as Mercedes itself sinks into its team, around US$70m a year. It's also not an amount Petronas is likely to miss, either, because it's ranked among Fortune Global 500's largest corporations in the world and its most up to date results show it to have annual revenues of US$76.8bn, of which US$19.7bn is down as an operating profit.

But even if US$42m might seem like small change when held against these sorts of figures, it still appears to be money very well spent, and Petronas will be happy at the way Formula 1 has put it on the world stage. Speaking a year after the Mercedes deal was signed the company's senior general manager of corporate services, Medan Abdullah, explained the reason why Petronas became involved in F1 in the first place. 'As Petronas began globalising its business, it became necessary to secure a good branding position. And it was on this basis that we decided to get involved in F1 in 1995. It was the ideal platform to brand ourselves and get our name out there on the international stage.'

Beyond the international exposure there is also the chance to develop its products. Petronas now supplies Mercedes with what it calls its 'Fluids Technology Solutions' package, which includes fuel, engine oils, hydraulic and gear oils and transmission fluids, all of which are tested in one of the toughest laboratories on Earth: Formula 1. 'Undoubtedly, the knowledge we have gained from our involvement in F1 is cornerstone in our research and development to produce high quality lubricants and products integral to our brand competitiveness particularly for our downstream business,' says Medan.

Petronas has sunk US$42m into the Mercedes team, still less than the car giant itself

New promoters for World and European rallying

The landscape of international rallying has been radically altered with the news that the WRC and ERC have both found new promoters, while the IRC will cease to be at the end of this season.

As widely expected, Red Bull Media House is to be the new promoter of the World Rally Championship (WRC) while Eurosport Events has been taken on to promote the European Rally Championship (ERC) at the expense of its own Intercontinental Rally Challenge (IRC), which will come to an end at the close of the season.

Eurosport has a good track record as a motorsport promoter, the broadcaster having successfully looked after the WTCC since its inception in 2005. The FIA said of the move to bring Eurosport onboard as its ERC promoter: 'As part of the FIA's commitment to strengthen the regional rally championships and implement a global strategy for the sport, the WMSC [World Motorsport Council] approved the principle of the appointment of Eurosport Events Limited as the promoter of the FIA European Rally Championship from 2013 for a period of ten years. Eurosport Events' commitment will ensure the series is televised and promoted in all mediums.'

On the demise of the IRC. Eurosport said: 'The agreement will mean the Intercontinental Rally Challenge, which Eurosport Events created and has promoted since its inception in 2007, will not run next year in its current format across Europe.'

It added: 'Eurosport Events is delighted to have secured this exciting opportunity and will announce full details, including the provisional calendar for 2013, at a later stage.'

Meanwhile, Red Bull has now been confirmed as promoter of the WRC (see *RCEV22N10*), which will be run as a joint venture with German company Sportsman Media. The contract will be in place from 2013, but there has been no word yet on how long it will run for.

The FIA said of the deal: 'The promoter will be responsible for investing and developing the WRC with a view to increasing its profile, reputation and commercial value. In particular, the promoter, working in close collaboration with the FIA, will be focused on introducing live television and an innovative digital media strategy in the next years.'

This announcement brings to an end months of uncertainty for those involved in the WRC, after its erstwhile promoter, North One Sport, was put into administration at the end of 2011.

SEEN: HYUNDAI I20 WRC

Hyundai has revealed its new i20 WRC car, which is expected to compete in a number of rounds next year before a full campaign in the World Rally Championship commences in 2014. On the car's launch at the Paris Motor Show, the Korean manufacturer said that a return to the WRC, and the setting up of a team in Europe, has been its long term goal since it withdrew from the championship nine years ago.

The company's past involvement in the sport began in 1998, when it competed in the F2 class of the WRC for two seasons. In 1999 the team announced it would step up to the top class in 2000, rallying a fully-developed WRC car based on the three-door Accent, which competed until 2003.

Mark Hall, marketing director at Hyundai Motor Europe, explained the reason for the company's return: 'The World Rally Championship is recognised as one of the most dramatic sporting series on Earth. It's a spectacle filled with excitement and dynamism – the perfect embodiment of the Hyundai brand. The WRC also offers the most technologically-diverse challenge for an automotive manufacturer. Our participation will demonstrate Hyundai's engineering excellence and durability, and will also help to enhance our passenger vehicles in future.'

Mobil 1 and Porsche extend partnership deal

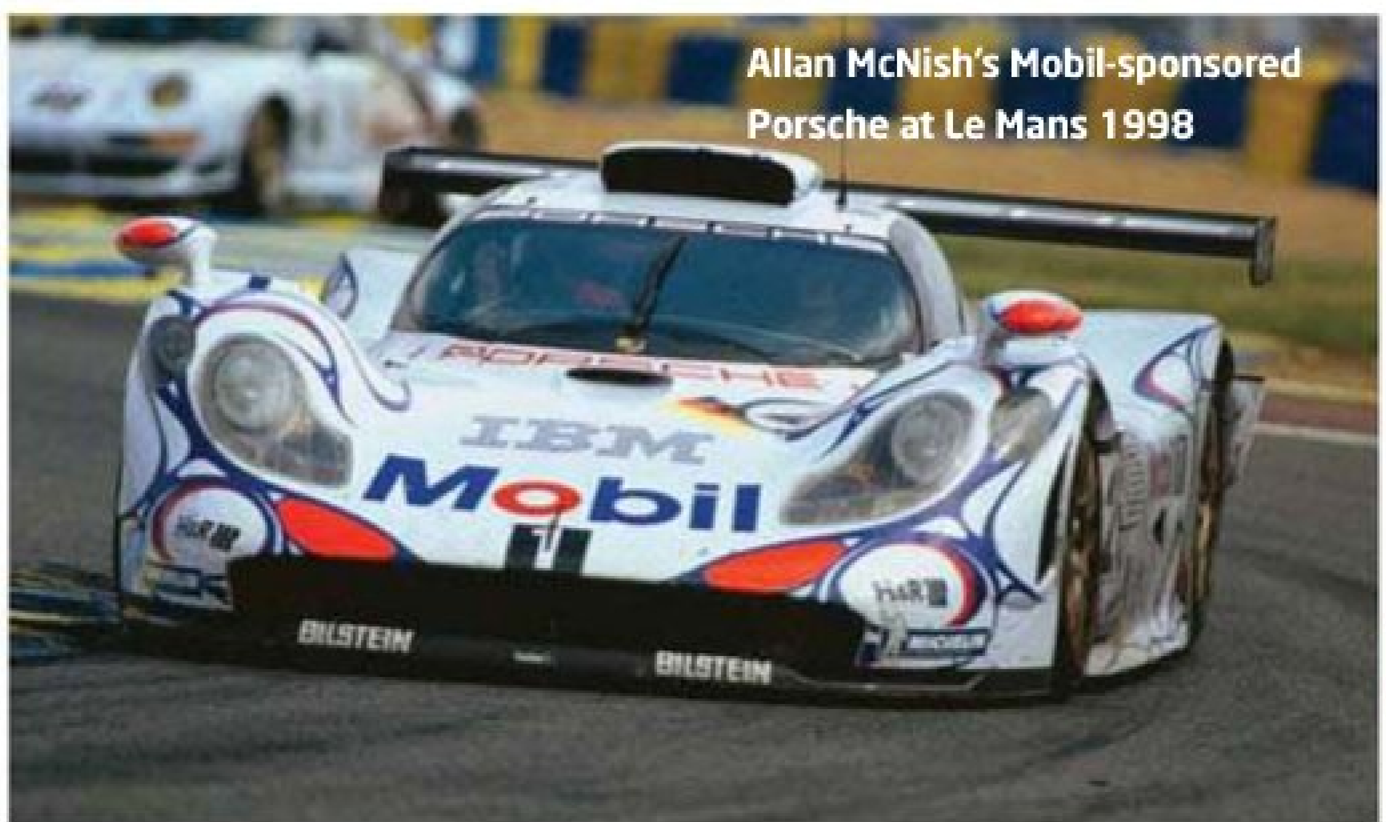
US oil giant ExxonMobil has announced a multi-year extension to its partnership with Porsche, which will include technical support of the manufacturer's return to LMP1 in the World Endurance Championship in 2014.

The Porsche deal with ExxonMobil has been in place since 1996, since when the German car maker has used Mobil 1 as its 'factory-fill' and recommended motor oil.

During this time the two companies have also collaborated on a number of motorsport programmes, most visibly with the Porsche GT1 Le Mans victory in 1998, and this will now continue with Porsche's planned return to the pinnacle of endurance racing in the LMP1 class in 2014 - which will include a return to Le Mans.

Alan Kelly, president of ExxonMobil Fuels, Lubricants and Specialties Marketing, said of the contract extension: 'For nearly two decades, Mobil 1 and Porsche have partnered on some of the most exciting advances in high-performance automotive engines and lubricants. Working alongside the passionate and innovative engineers at Porsche has allowed us to develop advanced lubrication technologies specifically to protect and optimise the performance of every Porsche engine.'

Wolfgang Hatz, member of the executive board - research and development, Porsche AG, said: 'A critical fundamental in engine performance is lubrication. Teaming with the Mobil 1 technology experts has helped Porsche to achieve its outstanding racing performance and meet the expectations consumers hold for our brand. We are delighted to extend our technical partnership.'



Allan McNish's Mobil-sponsored Porsche at Le Mans 1998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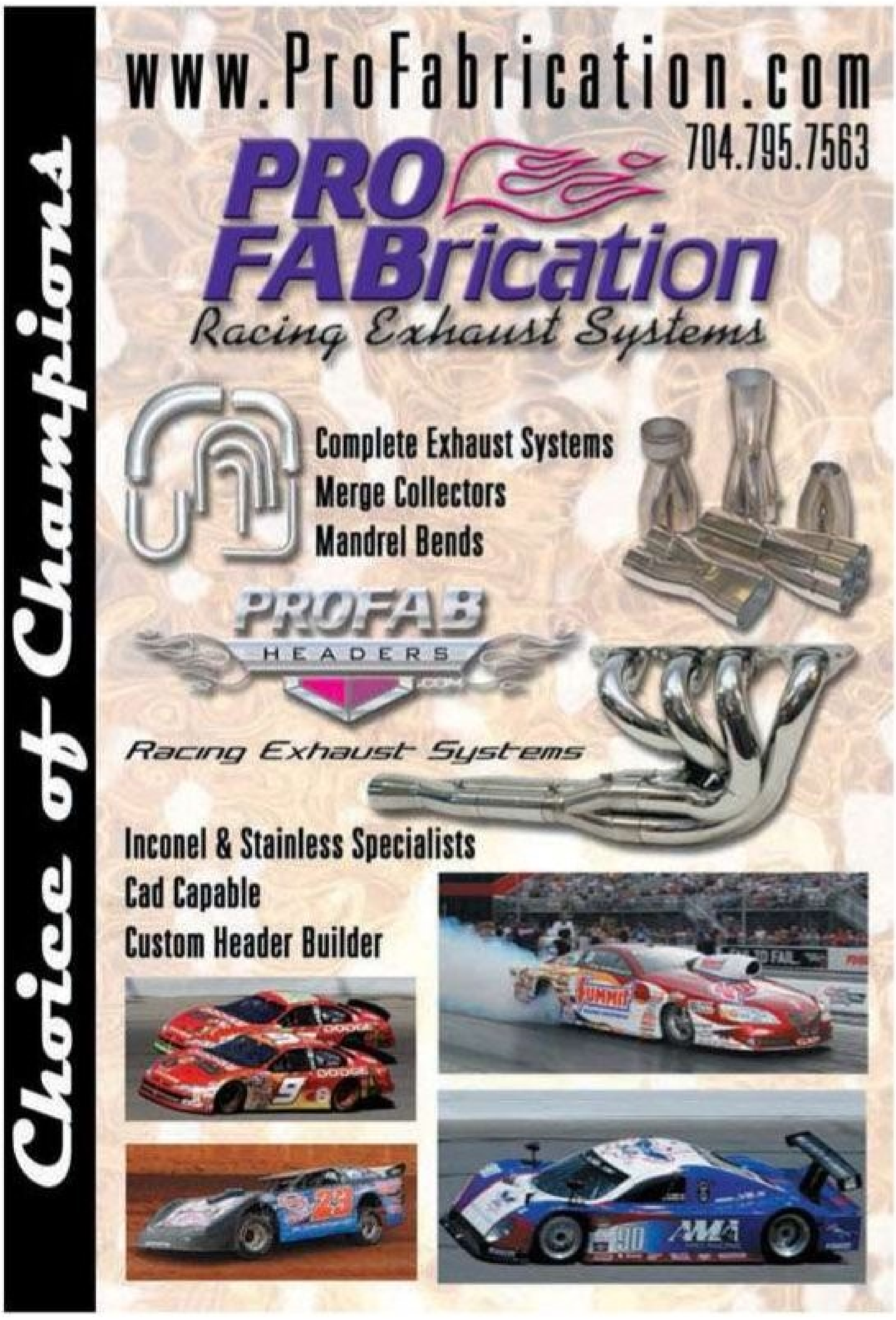
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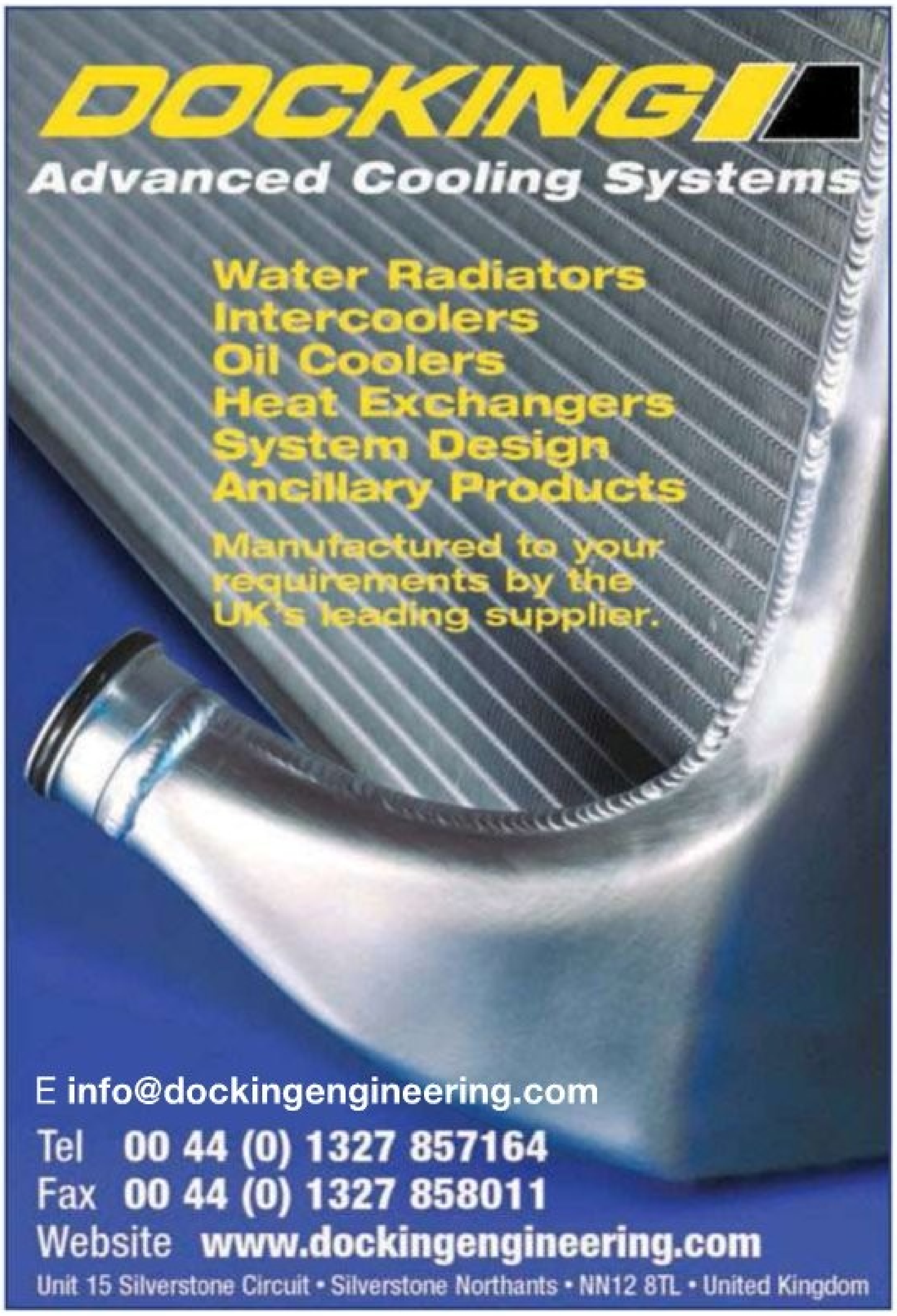
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Sauber power comes from the car park

Panel power: Sauber's innovative new car port at its Hinwil base

Formula 1 team Sauber has moved to slash its energy bills while augmenting its green credentials with the installation of a solar car park at its Hinwil HQ.

The solar park, which has been constructed for Sauber by partner Oerlikon, is said to be one of the largest solar car ports in Switzerland. The construction, consisting of 1573 thin-film silicon photovoltaic modules, stretches over an area measuring 2249sqm. A roof on one of the factory buildings has also been fitted with solar modules.

Sauber tells us it took just six weeks to construct the solar park, thanks to the innovative and cost-efficient way the modules are fitted. The installation delivers 155,600kWh of power per year – equivalent to the electricity needs of 44 households – and generates peak power of 173kWp, while the energy pay-back time for the thin-film silicon solar modules is said to be less than a year. Its efficiency can be monitored on a display panel which shows information on the system's current output and the energy produced both on that particular day and in total.

Cash available for UK exporters

The UK government has offered a further £13m of funding to help British companies who are hoping to export, and small and medium motorsport businesses are in line to reap the benefits.

Funds are to be allocated to the UK Trade & Investment (UKTI), to help more companies make foreign contacts and to sell to overseas markets. The majority of the investment – up to £9m – will go directly towards boosting trade opportunities for small and medium sized businesses (SMEs).

Chris Aylett, CEO of the Motorsport Industry Association (MIA) welcomed the news, saying: 'This is just the kind of direct help from Government and UKTI needed by motorsport and high performance engineering companies in the UK. It comes at just the right time to boost and grow international sales, which already exceed 65 per cent of this sector's business.'

The new funding means there's more money available for SMEs to attend trade shows abroad through expanding the Tradeshow Access Programme (TAP). There will be substantial discounts for the Overseas Market Introduction Service (OMIS), for targeted market research to help businesses find crucial first contacts overseas and help deliver relationships in new, fast-growing markets. There will also be increased support available for travel on overseas trade missions.

UK business secretary Vince Cable said of the initiative: 'One of our major ambitions for growth is to boost UK exports: we have to excel in trade. Small and medium-sized enterprises are crucial to this challenge – over half of the monetary value of the UK's exports comes from SMEs.'

Aylett said that motorsport companies interested in benefitting from this should contact the MIA: 'As the only motorsport related Accredited Trade Organisation for UKTI, we ask all UK motorsport businesses to grasp the chance to work with us, secure a good share of this funding and build new export business by contacting us now.'

Simpson gets hands on HANS

Well-known motorsport safety gear producer Simpson Performance Products has snapped up the company responsible for the Hans device.

Hans Performance Products, formed in 1991 by five-time IMSA driving champion Jim Downing and Dr Robert Hubbard, will now operate in Atlanta as a separate division of Simpson. Downing and Hubbard – who is the inventor of the HANS Device – will continue to provide engineering experience and support to Simpson and its new Hans division.

Chuck Davies, CEO at Simpson, said: 'We are glad to have the Hans device under the Simpson umbrella of racing safety products. This acquisition positions Simpson as the clear market leader in innovative racing safety products. Our total restraint-system capabilities now include a comprehensive range of car restraints for all types of racing, including seatbelts, in-car nets, parachutes and the top models of head and neck restraints in the world today. We are excited about the new team we are forming and the growth possibilities for the future.'

Speaking for Hans, Downing said: 'We are thrilled that Hans has joined the Simpson family. Together, we look forward to bringing new and innovative products to the market.'

BRIEFLY

Russian racing

The hugely popular DTM track racing series, for advanced-specification 'silhouette' touring cars, is expected to include an event in Russia in 2013. ITR, the longstanding series promoter, takes the championship this year to Austria, Britain, the Netherlands and Spain, alongside seven race meetings in Germany.

The series is contested by factory teams from Audi, BMW and Mercedes-Benz, all of which have expressed wishes to race inside the Russian market. The anticipated venue is Moscow Raceway, which opened in July.

Super Dallara

Dallara has won the contract to design and supply the cars for the all-new premier Japanese single seater championship, Super Formula (SF), which is set to replace Formula Nippon in 2014. The new Dallara SF14 is scheduled to have its first shakedown test in mid-2013.

CAUGHT

Grand-Am team Starworks Motorsport was fined and placed on probation until the end of the year after its Riley Daytona Prototype was found to be in violation of the width regulations following the Laguna Seca round of the championship.

FINE: US$3000

INTERVIEW: MARTIN WHITMARSH

Martin Whitmarsh graduated with a degree in engineering before joining the aerospace industry, holding a variety of positions in research and development before running an aerospace structures business. In 1989, he moved to McLaren to lead design operations, becoming managing director of McLaren Racing in 1997. In 2004, Whitmarsh was appointed chief operating officer of McLaren Group, and at the beginning of 2009 he took over as team principal of Vodafone McLaren Mercedes and became chief executive officer of McLaren Group.

McLaren launched the P1 at the Paris Show. Will it race?
We don't have a racing programme at the moment. Progressively we will produce a range of products and the 12-C was one of those, the P1 is another.

Could you have done a GTE car with the P1?
At the moment our racing GTs is based around the 12-C, but you never know. We haven't confirmed that we are going to GTE with the 12-C, but the decision to go racing with the 12-C is an easy one. You only have to walk up and down here to see that this is the best car in the pit lane today, and if we didn't do it, then someone else would have done it, and we like racing. We had no intention of racing the F1 [in 1995], we resisted it for a period of time, but again, it became apparent that if we didn't do it, others would and it turned out to be the right thing to do. We are in GT racing because we like it. There is no money to be made out of GT racing, it generally costs you money, but it is right for our brand DNA, we like doing it, we enjoy GT racing, and you have to ensure that you are out there supporting your customers. Ineveitably if they buy a 12-C and do a track day with it, and it is the finest track day car in the world, inevitably people are going to want to race it and we can give them the product to do that.

Would a GTE car be for customers, or would it be a 'works' programme?
We are trying at the moment to keep GT customer racing. There are a number of works teams here and we are not trying to do that. We are learning, we are back in for the first time for quite a few years, and I think first and foremost it is about customers. The dilemma that you have is when you are trying to be competitive, is to support customers but you are up against works programmes, then that is a bit of a challenge. You should never say never, but we are trying to respect customers, develop a relationship with customers and if you get good enough ones, then it is even more satisfying if customer teams can go out and beat works teams.

What is your assessment of the GT racing world?
There are too many championships, too many GT regulations. It has been like that for quite some time, and I can't see it settling down. We built a GT3 car, but when customers buy that car, and want to race it in GT Open, British GT, LMS, the Blancpain and GT1, ADAC and VLN, you find yourself with very different cars in those championships. So even what seems to be GT1, GT3, GTE, there are many other variants. There is the homologated designation, but it is the BoP that you have the differences. You look at the wing sizes of the BMW, and if we had splitters as quick as that, we would be very quick indeed. It is always difficult for all of these championships. It would be better for the championships and manufacturers and that the BoP was centrally controlled, and that a car could compete in the VLN, ADAC, Open series, national series, Blancpain were all consistent. Customers could move around a little bit whereas at the moment it is complicated to do that. There are too many championships, there are too many balance of performance and too many homologations, but it isn't going to sort itself out any time soon. It is also schizophrenic between customer events and works teams getting involved. In good faith we sold 25 of these cars, 15 more in the winter, so that will be 40 in the hands of customers and if we turned up with a factory team that would be a shame for the customers.

Caterham new boy could become team principal says Fernandes

Caterham boss Tony Fernandes has said that the team's new CEO, Cyril Abiteboul, could eventually take over his role as team principal.

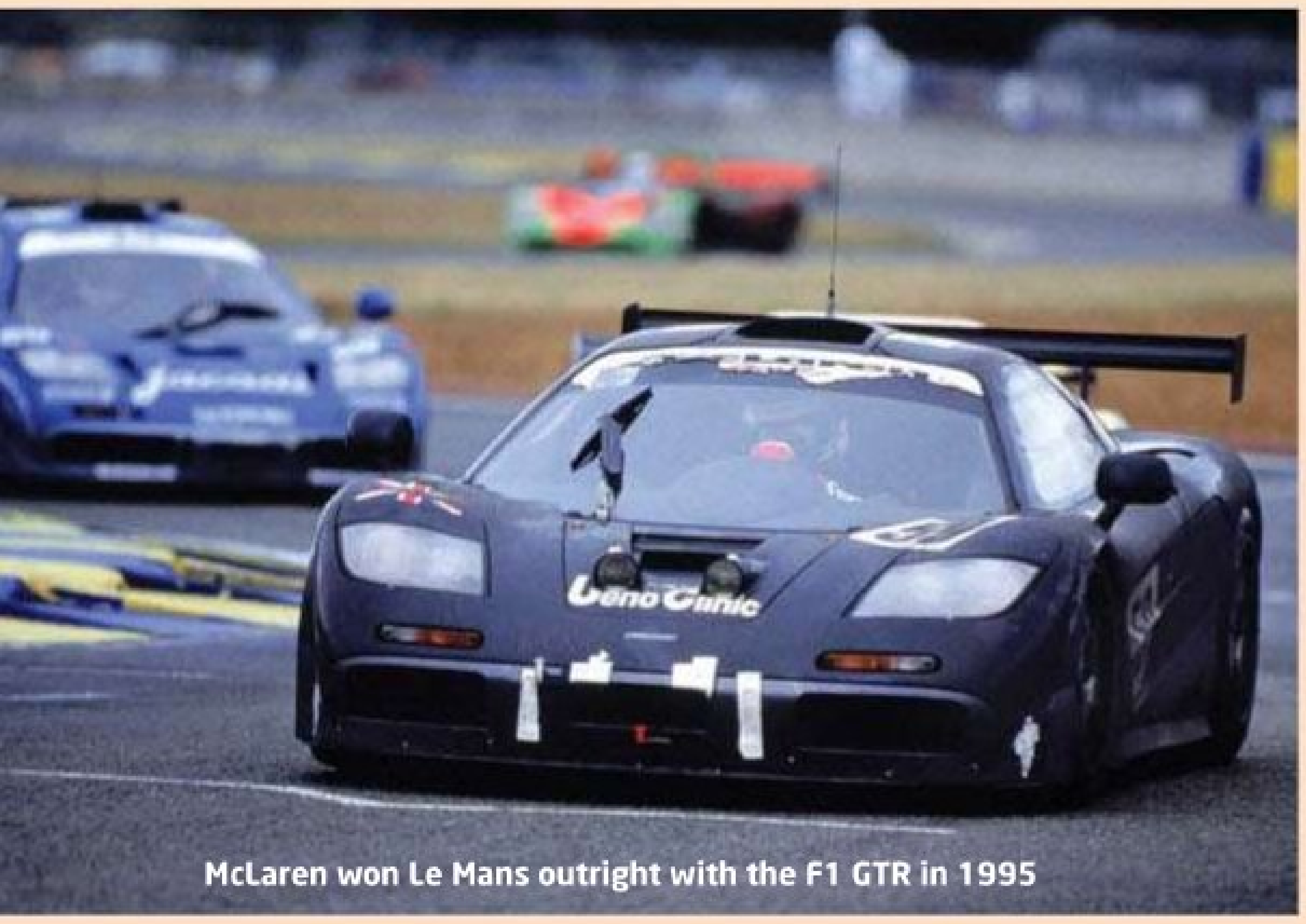
Abiteboul, who is currently managing director of Caterham engine supplier Renaultsport F1, has taken on the responsibility for the team's on- and off-track operations, although he will also remain in his Renault position until January, dovetailing the roles. At Caterham he will report to Group CEO Riad Asmat and chairman Tony Fernandes.

Fernandes says that the reason behind the hiring was to bring leadership to the F1 team as the Caterham group expands: 'I think we're evolving into a little bit of an auto group with the cars division and technology division that we've put together which Riad [Asmet] is looking at, and I am not as involved so the team needs leadership. Cyril has been someone that I've courted for a while and we've finally persuaded him – with Renault's blessing – to come over to Caterham.'

When asked if Abiteboul will become team principal Fernandes said it could happen in the future: 'Not at the moment, no. I will still remain in that job for a while. Eventually, maybe.'

For his part, Abiteboul said he was aware of the challenges the new position will present: 'The vision, enthusiasm and appetite of the shareholders and the whole team will be very precious strengths to help us tackle the many challenges we have ahead as we continue to develop the F1 platform and hopefully make our way up through the grid.'

He added: 'The multi-cultural character of the group of people in the team, together with the business and industrial project that the F1 activity serves under the Caterham Group umbrella made it an obvious choice for me after 11 great years with Renault to whom I can never be thankful enough for all I have been able to learn and experience throughout my time with them.'



McLaren won Le Mans outright with the F1 GTR in 1995

Would you have to do the WEC as a factory?
Audi is here (in the GT World Championship) as a works team. At the moment they are allowed to compete in any of the series. You have to take a view where the customers are going to be. If you are a customer and spend quite a lot of money on a GT car and want support from McLaren, you want to have a reasonable chance to win. Le Mans in 1995 was controversial for some customers because it was a works supported car that won. It wasn't particularly popular with customers. You also find that your customers want you to win. We have won in every championship so far this year bar Blancpain but you are racing against professional drivers in works cars.

Midway through the season there was a threat from Hexis to withdraw from the FIA GT1 World Championship due to the balance of performance with the tubo MP4-12C. How real was that threat?
If you sell cars to customers, I think you are obliged to support those customers and there is no point going motor racing if there is not a balance of performance. There was a fear and suspicion of McLaren coming into GT, and I think we got pretty rough order in balance of performance, and we didn't do a good enough job either, and a combination of those two things leads to an unhappy customer. I think if a customer can't be competitive then he doesn't want to continue.

Greaves launches 3D Engineering services

British racing team Greaves Motorsport is launching a machining arm of its company, Greaves 3D Engineering.

The company has invested in state of the art machine tools, 3D CAD and CAD CAM software. Additionally in 2013, Greaves 3D will be introducing 3D Rapid Prototyping. Greaves 3D Engineering will provide a service that starts at the design consultancy level continuing through to the production of finished manufactured parts.

The company has purchased top of the range DMG Mori Seiki Machine tools. The first is a DMU-50 five axis milling machine, the second a CTX-510 CNC lathe with live tooling. To compliment these machines, two further purchases of an XYZ Machine Tools SMX-3500 CNC Bed Mill and an SLX-355 CNC Lathe have been made. These, coupled with a CMM machine and comprehensive suite of inspection equipment, means that the company is equipped to tackle a range of engineering tasks.

RACE MOVES

The former boss of Chevrolet's European motorsport programme, **Eric Neve**, has joined HWA AG, where he will oversee Mercedes and AMG's Formula 3 and DTM endeavours. Responsibility for the remainder of Chevrolet's WTCC campaign – it withdraws from the championship at the end of the season – has been handed to director of Chevrolet and Cadillac communications for Europe, Vijay Iyer.

Tony Cochrane is to retire from his position at the head of Australia's premier motor racing championship at the end of this season. The V8 Supercars executive chairman will, however, remain involved in the tin top series as an external adviser to the championship board. Cochrane has also made it clear that he will bring forward his retirement if a new chairman is found before the end of the season.

Charles Burns has been named general manager of the Chevrolet Detroit Belle Isle Grand Prix IndyCar race. Burns, who has worked for IndyCar and the Indianapolis Motor Speedway for the past 12 years, will be responsible for the day to day operations of the event, which next year takes place at the end of May. Burns has previously helped to direct 12 Indy 500s, seven F1 grands prix, plus NASCAR and MotoGP races at Indianapolis.

McLaren's pit crew has been honoured by team sponsor TAG Heuer for its record-making pit stop earlier in the year. Formula 1's first sub 2.5 second stop – the time taken to change all four wheels – was achieved by McLaren at the German Grand Prix. Each member of the crew was given a TAG Heuer Carrera watch for his efforts.

A number of tributes were paid to former Formula 1 medical delegate, Professor **Sid Watkins** – who died in September – at the Singapore Grand Prix. There was a minute's silence before the race, while a book of remembrance was made available for members of the Formula 1 community in which people could write their own personal messages of condolence. The book was to be presented to his family after the event. Meanwhile, the FIA has said it is considering an 'appropriate permanent tribute to Professor Watkins, in recognition of his achievements and his unique legacy for motorsport'.

Niki Lauda

LAT

Simon Clark is the new chairman of the British Automobile Racing Club (BARC). Clark has been a member of the BARC council for over 30 years and was chairman of its Yorkshire centre for some time. One of his first tasks as chairman was to begin the interviewing process for a new CEO at the club, after the announcement that long-time chief executive Dennis Carter is to step down at the end of the year. Carter will remain involved with the BARC as a consultant.

NASCAR Nationwide Series team JR Motorsports has parted company with **Tony Eury Jr.,** a part owner of the operation and also the crew chief on Danica Patrick's car. The move came shortly after Eury's father, Tony Eury Sr., also left the team. Team co-owner Dale Earnhardt Jr. said the parting of ways was down to a 'differences in ideas'.

Ryan Pemberton, JR Motorsports new director of competition, stepped in to the role of crew chief on the Danica Patrick NASCAR Nationwide car following Tony Eury Jr's decision to leave the company (see above). Pemberton has served as a crew chief for several organisations since 1997 and has been a winning crew chief twice in the Sprint Cup Series.

The crew on the Roush Fenway NASCAR Sprint Cup No.16 Ford of **Greg Biffle** has won the third-quarter Mechanix Wear Most Valuable Pit Crew award, which is decided by a vote of all the Sprint Cup crew chiefs. The crew, nicknamed the 'Pit Bulls', comprises: **Matt Puccia** (crew chief) **Justin Edgell, Sean Meckelson, Kevin Novak, Bryan Huitt, Curtis Thompson** and **Justin Reissmann.**

Niki Lauda is to join Mercedes GP in a management role. The three-time Formula 1world drivers' champion will become a non-executive chairman of the team's board of directors. The

Williams simulator takes to the streets

An offshoot of Williams has adapted its Formula 1 simulator technology to help with road safety in the Middle East.

The technology that's used by the team's Formula 1 drivers has now been modified by Williams Advanced Engineering, based in Qatar, so it can be used as a training aid for those driving on the road. The new version of the simulator has been developed in partnership with Mowasalat, a transport company in Qatar, and the intention is to help improve the safety, environmental efficiency, passenger comfort and cost efficiency of drivers.

The simulator was introduced to the public for the first time at this year's ITS & Road Safety Forum in Doha, Qatar. It has been developed and built at the Williams Technology Centre, located in Doha's Science and Technology Park, using the skills of local Qatari engineers and graduates.

The equipment is said to be the most technologically advanced road safety simulator in the Middle East, benefitting from a state of the art software package called 3D Doha that accurately maps the roads of Doha and simulates realistic driving scenarios. Drivers sit in an authentic chassis with true to life controls, further adding to the simulator's realism.

Damien Scott, general manager of the Williams Technology Centre in Qatar, said: 'Road safety is an important issue to Williams, and our team in Doha have spent the past three years developing this simulator to help improve Qatar's road safety record.'

SPONSORSHIP

The HRT Formula 1 team scooped a two-race deal with the Tata Tea brand, to cover the Singapore and Indian Grands Prix. Tata Tea is a leading brand in India and is owned by Tata Global Beverages, a company whose products have a presence in over 40 countries. Tata Global Beverages is the world's second largest tea company, with an annual turnover of US$1.5bn.

F1 team Red Bull Racing has extended its partnership with motorsport apparel company Alpinestars. Through the partnership Alpinestars will continue to provide products and support to Red Bull Racing's drivers as well as the team's mechanics and technical staff. Alpinestars was established in 1963.

NASCAR Sprint cup outfit Stewart-Haas Racing has announced that current sponsor Quicken Loans will double its commitment in 2103 to become the primary sponsor on the Ryan Newman No.39 car. The news will be very welcome at SHR, which lost its US Army deal for the Newman car earlier this year.

RACE MOVES

announcement was part of a 'staffing restructure' at the team, Mercedes said. Lauda has previously worked in a race team management role in Formula 1 at the Jaguar team.

Respected American motorsport journalist and broadcaster **Chris Economaki** has died at the age of 91. Economaki began selling single copies of National Speed Sport News at the age of 14 and eventually became the publication's editor, a position he held for 60 years. He was also a well-known broadcaster, covering several Indianapolis 500s, Daytona 500s, F1 grands prix and many other motorsports events.

Jake Humphrey

LAT

Thomas Apostolos is the new president of Ricardo Inc., the US subsidiary of well-known engineering consultancy Ricardo PLC. Apostolos has spent the last 19 years of his career at Magna International and before that he held engineering and management positions at General Motors.

Jess Fack has taken on the newly created position of development officer at the Motor Sports Association (MSA), a role that will mainly involve working on the UK governing body's Go Motorsport campaign.

Jarmo Mahonen has joined the FIA as its rally director. The former managing director of AKK Sports has previous experience of motorsport governance, having run the Finnish Motorsport Federation – where he was responsible for that country's round of the WRC.

Former Renault F1 boss **Flavio Briatore** has taken on the hiring and firing role in the Italian version of TV show The Apprentice, a position made famous by **Lord (Alan) Sugar** in the UK and **Donald Trump** in the US. The series is currently going out on the Cielo channel in Italy.

IndyCar Series transportation manager **Louie Parsons** has received the Championship Drivers Association award for Outstanding Achievement and Service in the safety and care of drivers, after a vote of Holmato Safety Team members. Parsons is in charge of transporting the safety equipment to IndyCar, Indy lights and Mazda Road to Indy series events.

BBC Formula 1 presenter **Jake Humphrey** is to quit F1 and the BBC for a chance to front new TV channel BT Vision's coverage of Premier League soccer from the end of this season. Humphrey, whose BBC contract comes to an end this year, has been in the anchor role since the channel resumed its F1 coverage in 2009. He has been with the BBC for 10 years.

The Motor Sports Association (MSA) has awarded its Lifetime Achievement award to **Ron Smith** in recognition of his contribution to motorsport over the past six decades. Smith became a steward for the RAC in 1952 and since then he has worked on many MSA, RAC and FIA committees, as well as the Motor Sports Council.

The man who represented Kenyan interests on the FIA Rally committee, **Peter Hughes**, has died at the age of 77. Hughes was clerk of the course on the East African Safari rally, an event he won as a driver in 1964.

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

Birmingham gears up for Advanced Engineering Show

The Advanced Engineering UK group of events, scheduled to take place on November 7 and 8, 2012, is already established as one of the fastest growing engineering and technology events in Europe. This year, the show is preparing for a record 2012 attendance, building on an already impressive track record from its hugely successful 2011 offering, where more than 7,000 attendees participated.

The 2012 event line up brings under 'one giant roof' in the NEC Birmingham Hall 1, four individually focused, yet highly synergetic trade shows targeted at key 'high value' engineering and technology sectors – Aero Engineering 2012, the Composites Engineering Show 2012, UK Plastic Electronics Show 2012 and 'new for 2012' Automotive Engineering 2012 – the latter providing an exciting new supply chain 'commercial / technical exchange environment' supporting the UK's highly resurgent and dynamic vehicle engineering sector.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prodrive
Goodridge fluid transfer systems, built to last
lap after lap, race after race
en•dur•ance
noun
the ability or strength to continue or last
stress, or other adverse conditions;
• the capacity of something to last or to withstand wear and tear.
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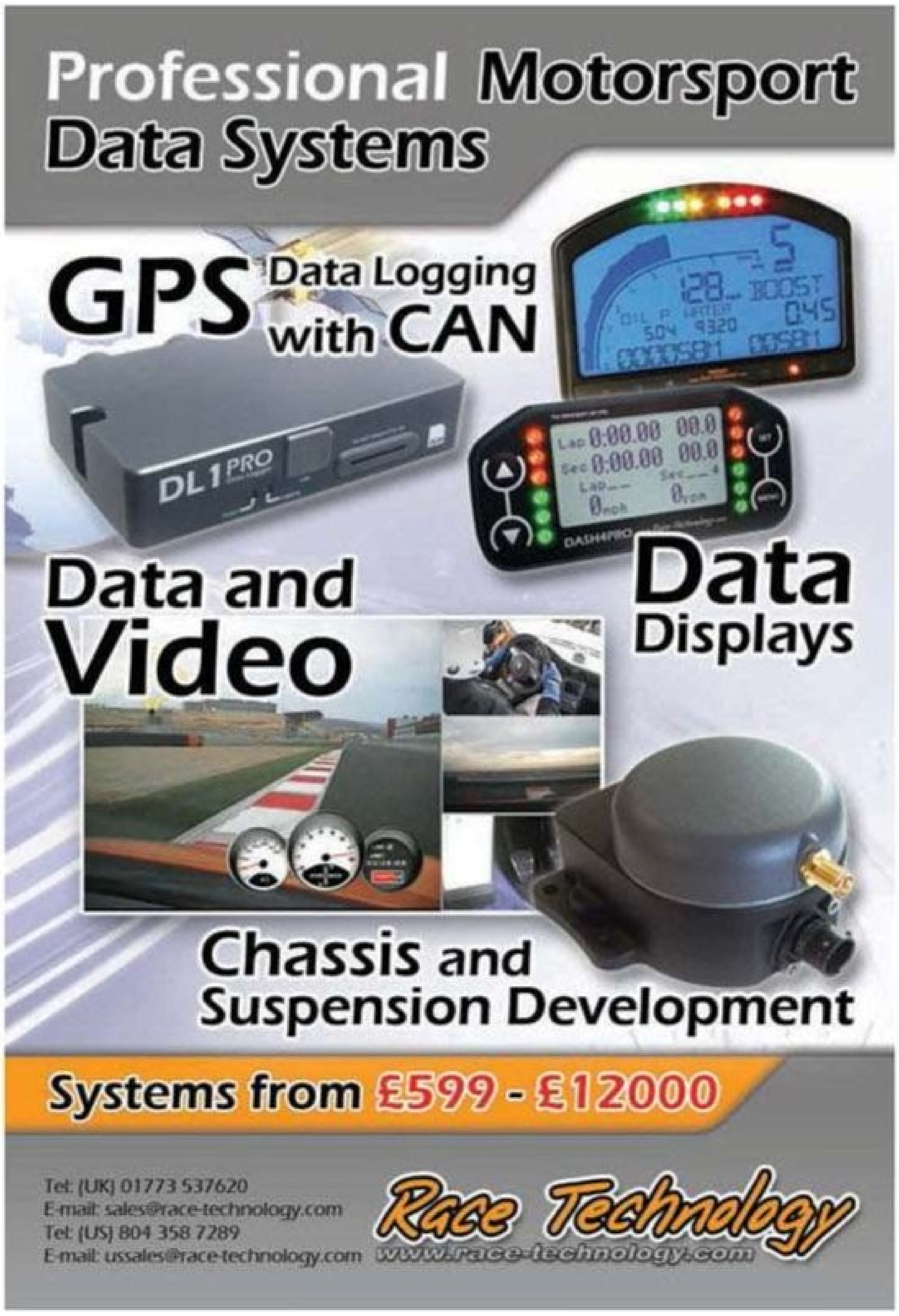
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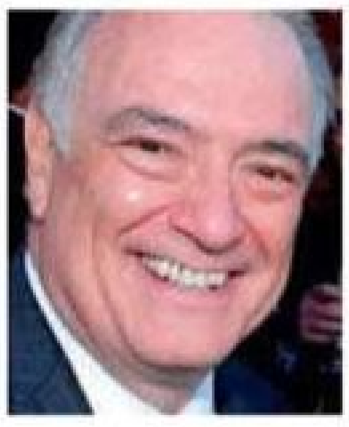
BUSINESS TALK – CHRIS AYLETT



It's Showtime!

Upcoming shows are the ideal place to showcase new technology and kick start the 2013 business schedule

Just as the motorsport competition season comes to a close, so the vital season for new business opens. Everyone is planning how to maximise results from SEMA, PMW, PRI, Autosport International, and finally, Motorsport Expotech in Modena, at the end of January. I am very upbeat and positive about the business season ahead. Plenty of rule changes, new builds for some series and even new series being announced – a very different picture from a couple of years ago.

A great new promoter for World Rally has been announced, with Red Bull involvement promising a fresh approach to rallying - just the shot in the arm needed. This global brand reaches out to the younger generation, and will pull in new audiences and, with them, new sponsors.

In the USA, the mighty NASCAR now owns major sports car racing for the foreseeable future, and will grow the sport over time. They will merge the American Le Mans Series with Grand Am from 2014, and have taken ownership of the famous Sebring and Road Atlanta circuits too. This change must bring new business, once the merged regulations, the calendar, and series plans are unveiled. The next few years in US sportscar racing look really good for business.

GT racing is on a roll everywhere - the amazing online reaction to the stunning new Bentley Continental GT3 racer is proof of this. What a beautiful, yet brutal, car – I can't wait to see this great car racing hard. This substantial new investment into Motorsport Valley® UK will bring new business to many suppliers.

The FIA have announced a promoter for their Formula E Championship, with the rules due any day now. From 2014, this will demonstrate how motorsport leads the world in automotive electric innovation, and promote major brands, right in the heart of major cities of the world. Whether you think this power train option makes for exciting racing or not, it will certainly attract new audiences to motorsport, close to their homes. Racing the internal combustion engine is exciting but noisy , and not emission free, and will always be attacked by 'nimby's – but not so electric racing! Having seen the fabulous Drayson electric sports car at Goodwood, who can say these cars are not exciting. Let's open our eyes, and arms, to the future, and welcome the cars and power trains that are required, and enjoy the new business they will bring.

Automotive OEMs have never, during the past one hundred years, faced such a diversity of choices they must offer to their consumers, nor been so unsure which one, if any, will take the lead. Each one presents an opening for motorsport competition to help capture public attention and sell cars. I recommend all motorsport businesses to "profit from the confusion" and get working now with the OEMs to help them meet their low carbon challenges. Grasp this chance to widen our business into the low carbon world, and entertain new audiences and sponsors, wherever we can.

The enormous success of the MIA Motorsport to Automotive initiative (M2Auto), launched last year, has helped our members to capitalise on the low carbon plans of the UK Automotive industry. This year alone, members have met some 3,000 automotive engineers at just three showcase events inside the technical centres of Ford, JLR and Nissan. Automotive engineers have visited these to better understand capability based on motorsport success, and to encourage the best companies to join the booming supply chain of UK automotive.

Deputy Editor Sam Collins drivers the electric Nissan Leaf at Crystal Palace

Press reports everywhere applaud the phenomenal growth of UK automotive and MIA members are riding high on the wave of this success, with real business being created. OEMs look for suppliers of R&D-based rapid prototypes and pre-production, innovative energy efficient solutions, to meet the demands of their Technology Road Map. They love the fast delivery times from motorsport, and the world-class quality of the end-product.

Some already use motorsport companies to help produce short runs of finished products. The Nissan Juke R is built with RML and the, well-publicised, partnership between Jaguar and Williams F1 will produce the stunning hybrid Jaguar C-X75 shortly. There are many other examples where motorsport is now engaging, profitably with UK automotive. Success of the MIA's M2Auto initiative is evidence.

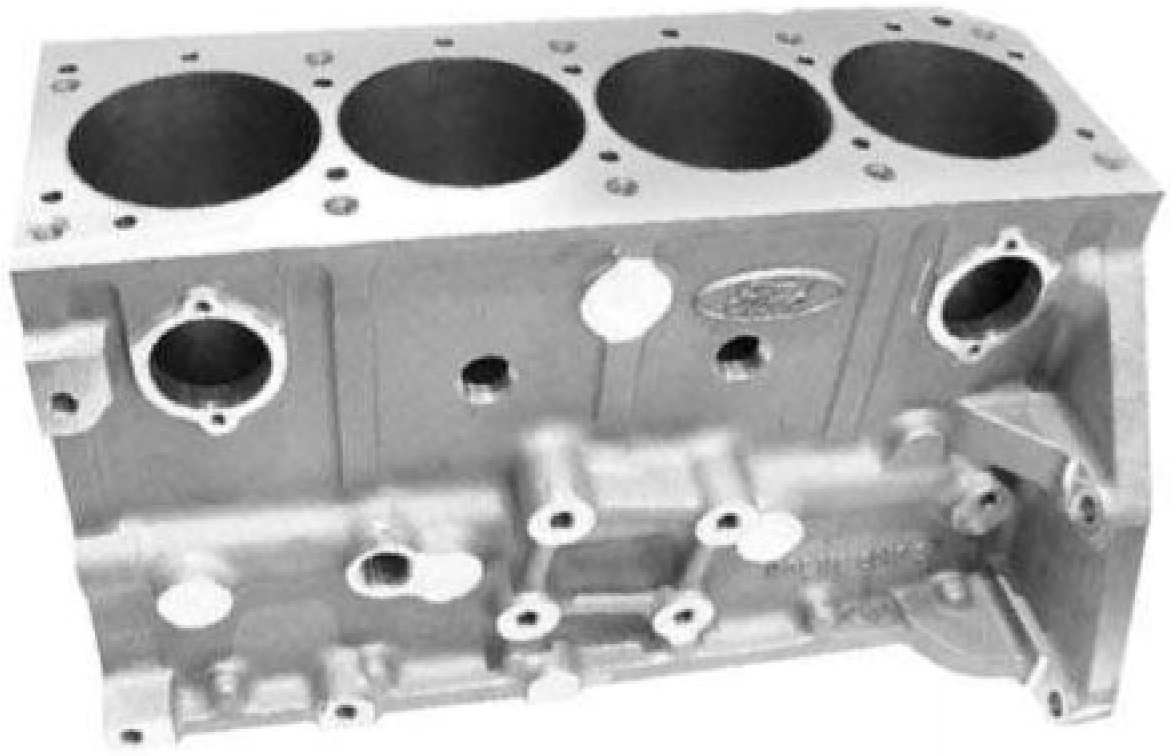
To grow your business during this boom period with automotive, contact the MIA and join us for our next M2Auto event inside the Crewe headquarters of Bentley Motors. Right at the start of their new motorsport campaign and to which all their engineers are invited.

The ongoing opportunity for motorsport companies to supply energy efficient solutions, is really gathering pace. On Wednesday 9th January, the 7th High Performance Low Carbon Racing Conference will take place, the day before the Autosport International Show, at the NEC in Birmingham. This brings together 200 worldwide delegates interested in UK motorsport's ability to produce low carbon solutions to meet the demands of the automotive industry. Over 25 companies will also showcase their latest innovations and developments to this valuable audience. It's an outstanding opportunity to hear from, and directly question, those at the forefront of this new business opportunity. You can discover where the best opportunity may lie for you. As a happy businessman said to me recently – "how can anyone say there is no new business around – just one day at this conference made all the difference to my sales in 2012". That's really satisfying to hear, and shows just how proactive motorsport companies, who make the effort, can shrug off the negative affects of a recession, and make new business happen.

HARDWARE

Alloy Ford BDG 2.0 Engine Block

The Ford / Cosworth BDG engine is legendary in rallying and saloon racing circles, but spares for rebuilds are hard to come by. Fortunately, Cosworth is now re-manufacturing the cast alloy BDG block, an improvement on the original thanks to advances in casting and manufacturing technology. The new blocks come complete with liners fitted and bored to a finished size of 90mm; two bolt type steel main caps are also fitted. The block is available either with Nicosil coated bores or with cheaper steel liners.
To find out more visit www.cosworth.com



HARDWARE

Bosch Throttle body and ECU connector tool

Bosch's motorsport division is constantly developing products for racing use and has recently released a number of new components. First up is a new electronic throttle body, available in a range of bore diameters. The throttle body is designed to control the fresh air of spark ignition engines in combination with an electronic throttle control system. ETB applications with flex-fuel, CNG and LPG are permissible if injected in the air flow after the throttle body. The new body is compatible with most electronic throttle control systems including those incorporated into Bosch Motorsport ECUs.

Bosch has also released a new tool for opening its motorsport ECU connectors in order to access the internal connections. The new tool is exceptionally simple to use and allows for easy servicing or modification of the sealed connectors. Both these products and many more can be seen in Bosch's new 2013 motorsport catalogue. The brochure lists all of the company's motosport specific ECU's, sensors and ancillaries.
For more information log onto www.bosch-motorsport.de

HARDWARE

Jenvey DCNF Throttle bodies

Fuel injection specialist Jenvey has developed a compact throttle body designed to replace Weber 40 DCNF carburettors; the company can also supply 42 and 45mm versions. The triple twin barrelled throttle body assembly pictured here would be suitable for use on a variety of V6 engines. Different arrangements can be specified to suit applications ranging from boxer 4 cylinders to V12s. Jenvey can also supply suitable air filler and fuel rail assemblies to match.
For more information visit www.jenvey.co.uk

GEAR SHIFTERS

Pro-Shift unveil 'Closed Loop' Bump and Blip System

Pro-Shift MD and ex IOM TT Racer, Roy Tansley, felt that a radical redesign of traditional 'quickshifters' was long overdue, and is unveiling a revolutionary, patent-pending, Linear Potentiometer controlled Digital 'Closed Loop' Bump and Blip System. It provides the world's fastest manual flat upshifts (under 25ms shifts are documented). This is allied to super-fast clutchless auto-blipped downshifts, whilst providing gearbox protection with absolutely no requirement for antiquated and potentially gearbox damaging load cells or tension switches.

This digitally programmable, computer controlled device, features wet and dry modes, utilises linear potentiometer feedback providing the fastest possible 'flat' upshift every time. Programmable with integral digital set up screen giving the optimum 'cut' time for all upshifts.

Seamless clutchless downshifts are also provided by the system's electronically powered patent pending remote throttle blipper. Fly by wire throttles can now also be triggered by our GCU to blip.

Suitable for any sequential gearbox (car or bike) this world leading system can be used 'stand alone' or is equally capable of integrating with high performance programmable ECU's.
For more information visit: www.proshift.com

HOSES

Viper Hard Lines

Hose manufacturer Viper Performance has recently released a new range of hard line aluminium tubing. The tubing is designed for producing lightweight clutch and brake lines, and is available in natural colour or anodised in gloss black. The tubing is 5/16" OD tube and supplied in four metre coils. To complement the new tubing, Viper has also produced a new handheld pipe straightening tool, allowing easy manipulation as it comes off the reel. The new tool is capable of straightening hose from 1/8" to ¾" OD.
For more information visit www. viperperformance.co.uk

TOOLING

DeWalt Cordless tools

Cordless tools can prove invaluable in the pitlane and workshop, doing away with the need for power cables and airlines, which invariably get tangled up or tripped over. They are also excellent where traditional power sources are not available, such as on rally or off road events. DeWalt's new cordless range is perfect for motorsport use, and features, among other tools, an 18v impact drive, capable of producing 418Nm of torque, and a reciprocating saw, ideal for rapidly removing damaged bodywork. The new range is referred to as the XR series, and is aimed at harsh duty environments and incorporates the latest battery technology to increase operational duty.
For more information visit www.dewalt.co.uk.

ELECTRONICS

Cartek delivers wireless controls

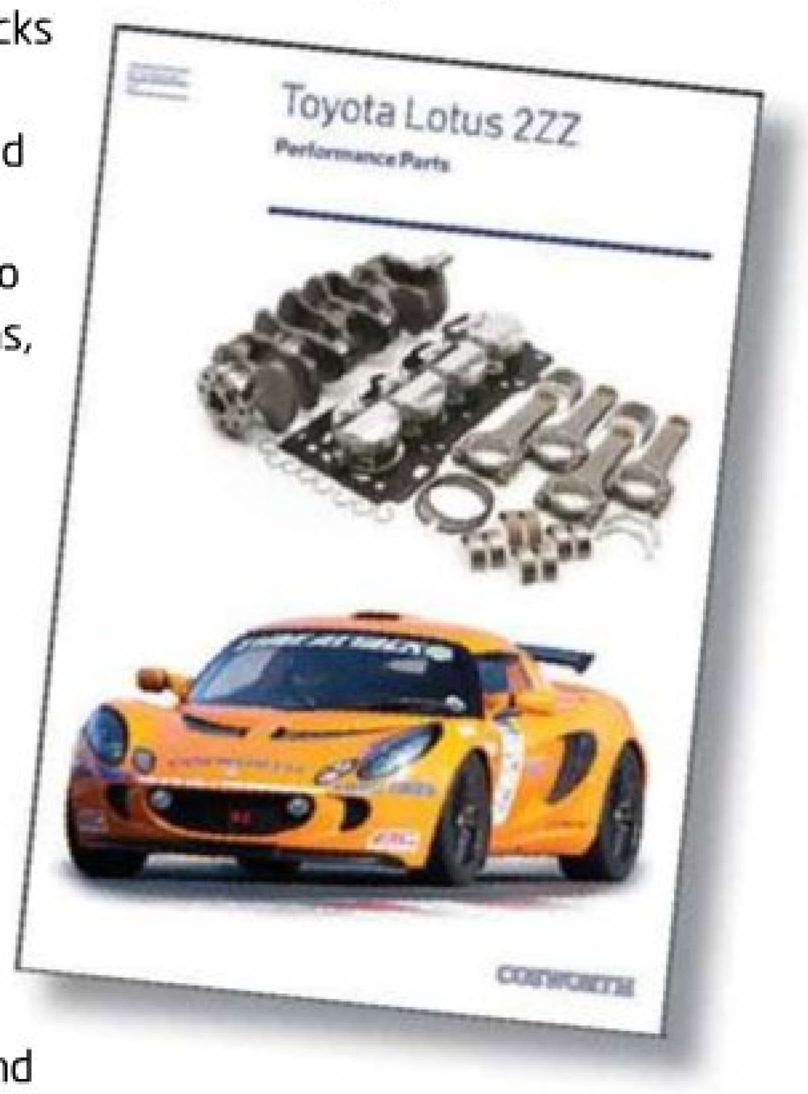
Cartek's new Wireless Steering Wheel Controls removes the need for complex wiring by providing a universal fitting, eight button steering wheel panel which incorporates a tiny, battery powered transmitter. With a receiver mounted beneath the steering column and connected to the 8-channel relay module, many common functions can be controlled including lights, speed limiters, PTT radio, and data scrolling. Each relay can be configured including momentary, latching and flashing modes.

Cartek's next-generation, XS Battery Isolator, is 30% smaller than current versions and measures just 60mm x45mm, weighs only 70g, yet still delivers more than 400Amps of engine cranking current. As with previous versions, the XS also kills the engine, meeting FIA requirements, incorporates alternator run-down protection, as well as interface circuitry for connection to driver and external 'kill' button / switches.
For more information, see www. cartek.biz

HARDWARE

Cosworth Components for Toyota / Lotus 2ZZ Engine

Cosworth has just released a new range of tuning components for the Toyota 2ZZ engine found in the Lotus Elise and Lotus Exige. Included in the range are short block assemblies, forged pistons, forged lightweight connecting rods, engine bearing sets, multi layer metal head gaskets and Cosworth's ingenious thermal guard composite intake manifold gasket.



Cosworth short blocks come complete with a balanced & blue-printed genuine Toyota 2ZZ crankshaft inspected to Cosworth specifications, Cosworth forged H-beam connecting rods, forged high compression pistons and rings and treated bearings. Though the standard engine has forged pistons, the Cosworth high performance replacements have been designed and manufactured using the same methods as their winning Formula 1 pistons, and feature a skirt profile and piston geometry that reduces engine noise while increasing reliability and performance. Oil and combustion gas controls reduce blow-by and oil consumption. Meanwhile, the conrods are precision machined to maintain optimum weight and strength, utilising an H-beam cross section design for increased stiffness and reduced reciprocating mass, allowing higher rpm to be attained reliably.
For more information log onto www.cosworth.com

TECHNICAL EXCELLENCE

Carbon composites

As part of our technical excellence feature ahead of the Autosport Engineering Show in association with *Racecar Engineering*, The FIA's Norbert Singer considers his nomination for the greatest advance in motorsport technology

Norbert Singer was an engineer at Porsche, and his first job was to provide an engineering solution to cool the gearboxes on the 917. Since then, he was involved in every one of the manufacturer's 16 Le Mans victories. He developed the 911 for racing, creating the 935 and 936s, and designed the bodywork for the 956 and 962 Group C cars, which took no fewer than seven Le Mans victories. Having overseen Porsche's last victory to date, in 1998, he concentrated on GT racing with the 996 and 997 cars until he officially retired from Porsche's racing department, and took up a role with the FIA, monitoring the balance of performance in endurance racing.

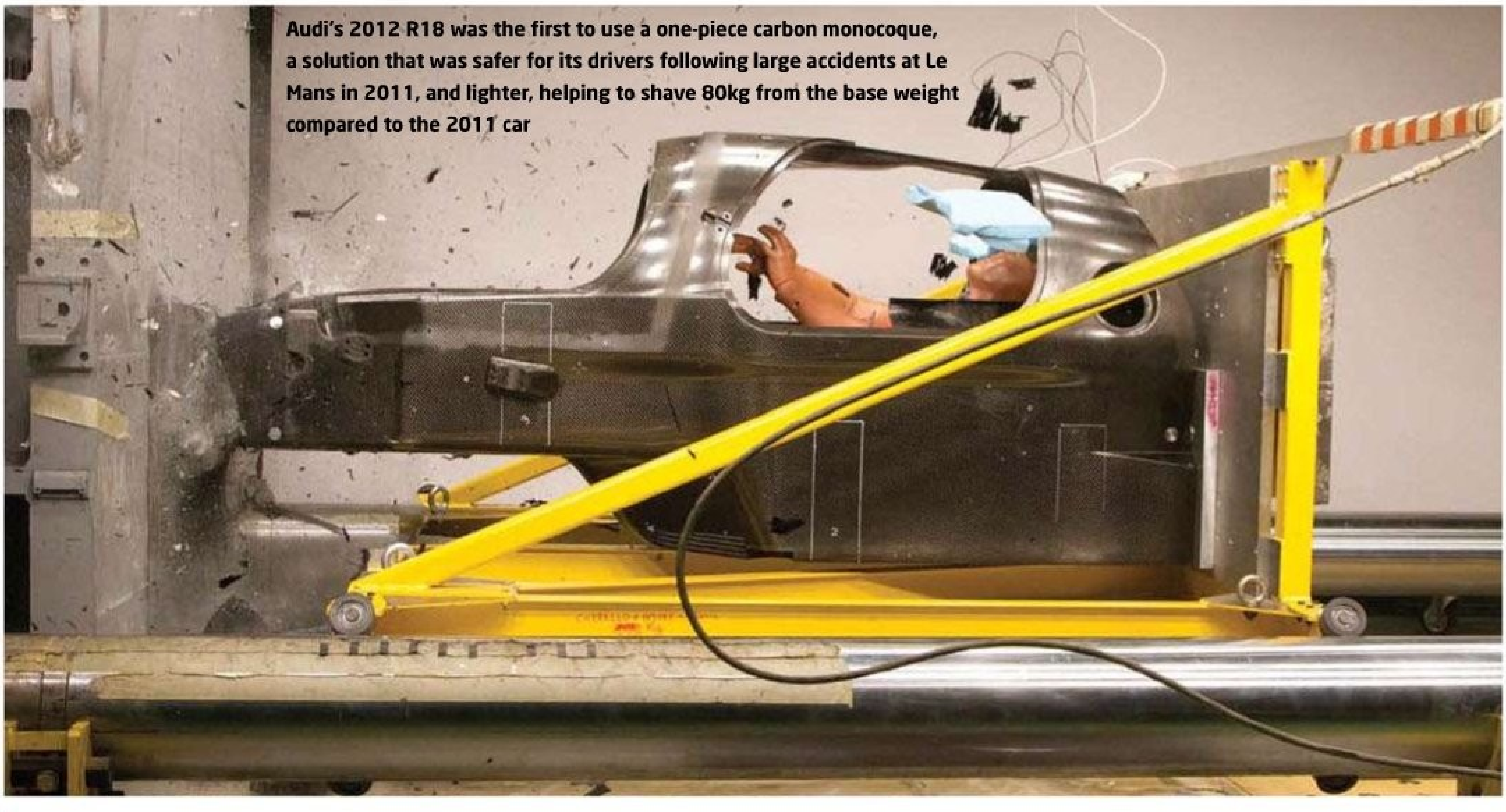
The development of lightweight materials was a key factor in the development of race car efficiency and performance, according to former Porsche engineer Norbert Singer, and in particular the use of carbon composites.

Today, the material is used almost everywhere, from the aerospace to the construction industries, and motorsport effectively follows the trend, using the latest and most affordable materials available.

Carbon is nothing new to Singer. When the company decided to enter the Deutsche Rennsport Meisterschaft in 1977, Porsche created a 'baby' 935. It ran with a 1.4 litre engine, and Singer and his team went through the car, taking out as much weight as possible. At the Norisring, a German track that was notoriously hard on brakes, Porsche tried out carbon-carbon brakes for the first time, borrowing off-cuts of the material from the Brabham Formula 1 team.

They glued the carbon to the surface of the steel discs, and used carbon pads, hoping to create awesome stopping power and long life to the brakes. After five laps, Jacky Ickx pitted, complaining that he had no brakes left. Dunlop engineer Dieter Glotzbach said he couldn't even touch the valve caps because they were too hot, pointing towards a temperature hike to 1000 degrees, and nowhere near enough cooling to accommodate them. The carbon brakes were dropped, and were not tried again by Porsche in endurance racing until the final iteration of the 962C in 1991, which used uprights of welded steel rather than magnesium to generate better cooling.

'This is the most exciting of materials,' says Singer. 'Today it is in use nearly everywhere. It is light, the density is half of aluminium and five times lighter than steel, and has in unidirectional layers four times the strength of steel or titanium. It is not just used in bodywork, it is also used in highly stressed wings, chassis, suspension parts, brakes and some have tried using it in connecting rods. In Formula 1, they use it for the gearbox casing and it is widely used in crash structures and oil tanks. There are so many other examples that for me, it is the most important material and contributed significantly to the safety in motor sport.'



Audi's 2012 R18 was the first to use a one-piece carbon monocoque, a solution that was safer for its drivers following large accidents at Le Mans in 2011, and lighter, helping to shave 80kg from the base weight compared to the 2011 car

ASI just got bigger...

The Autosport Engineering Show, in association with Racecar Engineering, is the largest and most influential motorsport dedicated show in Europe, and has just got bigger, with an anticipated increased number of exhibitors, up 20 per cent on 2012. With more stands, the entire engineering hall at the Birmingham NEC will be filled with companies providing cutting edge services, from 3D Engineering to thermal coatings, from cutting edge engineering technology to the latest in lightweight materials.

In 2012, Racecar Engineering awarded its Graham Jones Award for most innovative product to British company Gill Sensors, who were showing their fuel flow meter. That fuel flow technology has now become the cornerstone of the 2014 technical regulations for both Formula 1 and the Le Mans 24 hours.

This year, with hybrid systems becoming an ever more important factor in the future of motorsport, electronic equipment is developing at incredible speed. The trend is also continuing towards lightweight materials, and metal companies such as S&D Speciality Metals and All Metal Services, new to the show this year, are welcome additions.

In January 2012, more than 28,000 trade visitors, including more than 5,000 overseas visitors, attended the show and over £800m of business was generated over two days. Figures released by the show organisers show that 82 per cent of visitors will place an order, or purchase, with people they met at the show.

For 56 per cent of the visitors, this is the only major motorsport exhibition that they attend, meaning that the show offers a unique opportunity to conduct business. Of the 28,400 trade attendance, a huge 92 per cent were there primarily to network with industry contacts and suppliers, while 55 per cent were looking for new products and suppliers.

The crossover of technology from aerospace, marine, automotive and defence is not an easy sell, but companies and organisations will be at the show to help to facilitate any company looking to expand their business.

PRIZE COMPETITION

Get in the know at Autosport International

We're offering you the chance to visit the Autosport Engineering Show, in association with Racecar Engineering, by giving away five pairs of tickets. To enter, email your name, full address, phone number and answer to the below question to asi-pr@rsm-agency.com. Entries close on **25 November 2012.**

Question

Who was awarded the 2012 Graham Jones Award for innovative product at this year's Autosport International?

Answer

1) DC Electronics
2) Zircotec
3) Gill Sensors

IN BRIEF

- The show continues to attract exhibitors from acrossATL will have an example of both its FIA homologated fuel cell and its ATL Saver and Racell range on display at the show, and will be showcasing a brand new range of high-pressure fuel pumps. The fuel pumps will have enhanced fuel flow to fuel pressure properties, as well as low current draw.

- Following yet another successful Formula One Grand Prix in Korea, AP Racing has confirmed its attendance at Autosport International. The brake and clutch manufacturer, with a strong 38-year heritage in F1, secured all three podium positions, marking its 704th GP success. AP Racing will be exhibiting on Stand 7500 in Hall 7.

- Newly-formed driveline company, 3J Driveline, has announced it will be making its first public appearance at Autosport International. Formed in July, the company has been launched by former TranX CEO Dan Jones, who left the company earlier in 2012 after 13 years.

The company supplies a wide range of products including limited slip differentials (LSD) and half-shafts, steering racks, flywheels and gears. "We're really looking forward to introducing ourselves at Autosport International," said Jones. "It's a great opportunity for customers to touch and look at our products. Everything we bring to the show will be available from stock."

Motorsport Business Week Schedule

7-8 January	*Race Tech* World Motorsport Symposium
9 January	MIA International 'Low Carbon' Racing Conference
10 January	MIA Business Awards Dinner
10-11 January	Autosport Engineering in association with *Racecar Engineering*
10-11 January	UKTI International Business Exchange (IBEX)
11 January	Motorsport Safety Fund 'Watkins Lecture'
10-13 January	Autosport International

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www.racecar-engineering.com

Message disconnect

The Paris show was supposed to have thrown up a wealth of motorsport related stories, but in reality, the stands throughout were virtually bereft of racing machines. Hyundai launched its WRC car, Bentley its GT3 concept and, but for a smattering of racing cars, that was it.

Bentley's challenger, as detailed in the news section of the magazine, has run, slowly, at Anglesea. An engine has been fitted, although a decision has yet to be taken if it will race with the W12 or V8 engine, there was a roll cage and aero package on the car, and it looked mighty. 'That is the car that the crowds will wait to see for another lap,' said observer Martin Brundle.

Notable by their absence were Lotus, Proton, Caterham, Bugatti, and others. Was it that France was in an era of austerity and that manufacturers were shying away from the big cars? Certainly there were more small cars being launched with names like Adam and Zoe, and a plastic thing that cost 15,000 Euros. Ligier had out its LS50 small car, limited to 45km/h with a 500cc engine. Volkswagen launched the new Golf.

Conversly, McLaren attended its first motor show with a full product range, including its P1, a fabulous looking car from all angles bar the rear (yes, I know, and feel free to write in).

Here in Britain, meanwhile, the Department of Energy and Climate Change released figures that made for interesting reading. Even given the fluctuations caused by panic buying and wars in the middle East, the fact that two billion fewer litres of diesel were sold in the first half of 2012 compared to 2008, that the cost of petrol has risen by 38% in five years, and that 496.8 million fewer litres of petrol were sold between April and June this year compared to 2011, shows that motorists are not buying in the same quantity.

That may well bring down the price of fuel as competition, and reserves, increases. Conversely, those in the motor industry think that the price of fuel should rise steeply to apply public pressure on manufacturers to produce more efficient cars. If a gallon of fuel costs £20, but an internal combustion engine can power a car for 500 miles on that gallon, it is still far cheaper motoring compared to current levels. If the cost of fuel drops, more motorists will take to the road, and nothing will change for until the next crisis hits.

With Formula 1, endurance racing and Formula E heavily promoting the electric and KERS route with their new regulations, motor sport is pushing water uphill if the price of fuel drops. If the price keeps on rising, and fuel efficiency remains at the forefront of people's minds when buying a car, racing will be bang on message.

It was interesting, though not surprising, that so many cars were shown at the Paris show alongside their ecology credentials. Fuel consumption figures, hybrid drivetrains and lightweight were themes on almost every stand, confirming the direction taken by top level racing.

At the show, Hall 2 was a graveyard for the media. In there were housed the alternative fuelled cars, including the Green GT that will run at Le Mans in 2013. Press officer Laurent Chertrit was manfully fending off the crowds (of two, including me) looking at the car. There was a design study, backed by mobile phone company Orange, which provides students with 30,000 Euros to create a car for display at the Geneva and Paris shows.

"If the price of fuel keeps rising, racing will be bang on message"

In their media pack, presented in a lovely brown paper bag, they included a snow scraper, a torch, and a tyre pressure gauge. Also of interest were a letterbox-shaped motorbike by Boxx, which looked fantastic, and a track laid out for a run in electric cars including a Smart, a Nissan Leaf and a van. It was a place of innovation and futuristic thinking that only small companies have the versatility to achieve.

And it was here that the synergy with motorsport was most apparent. Throughout the show, people were talking about the changing world, the need for fuel efficiency, and that the culture of motor racing was becoming perfectly aligned. In Formula 1, said one executive, they are effectively producing a new car every two weeks. In production cars, they produce a new one every four years. With speed, efficiency and development, motor racing seems to be perfect for the changing world, yet at the Paris Show, most manufacturers completely ignored it.

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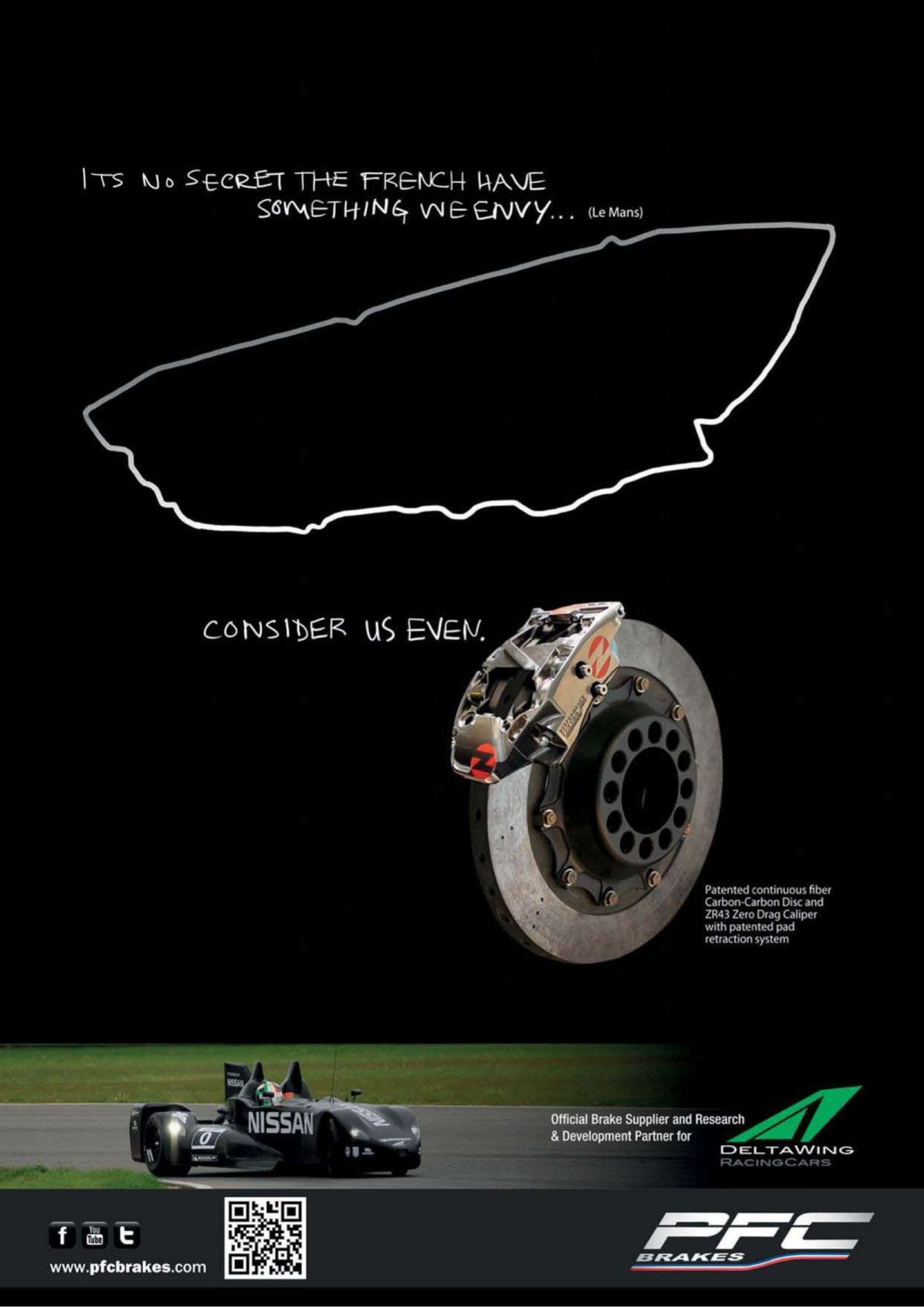
Andrew Cotton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