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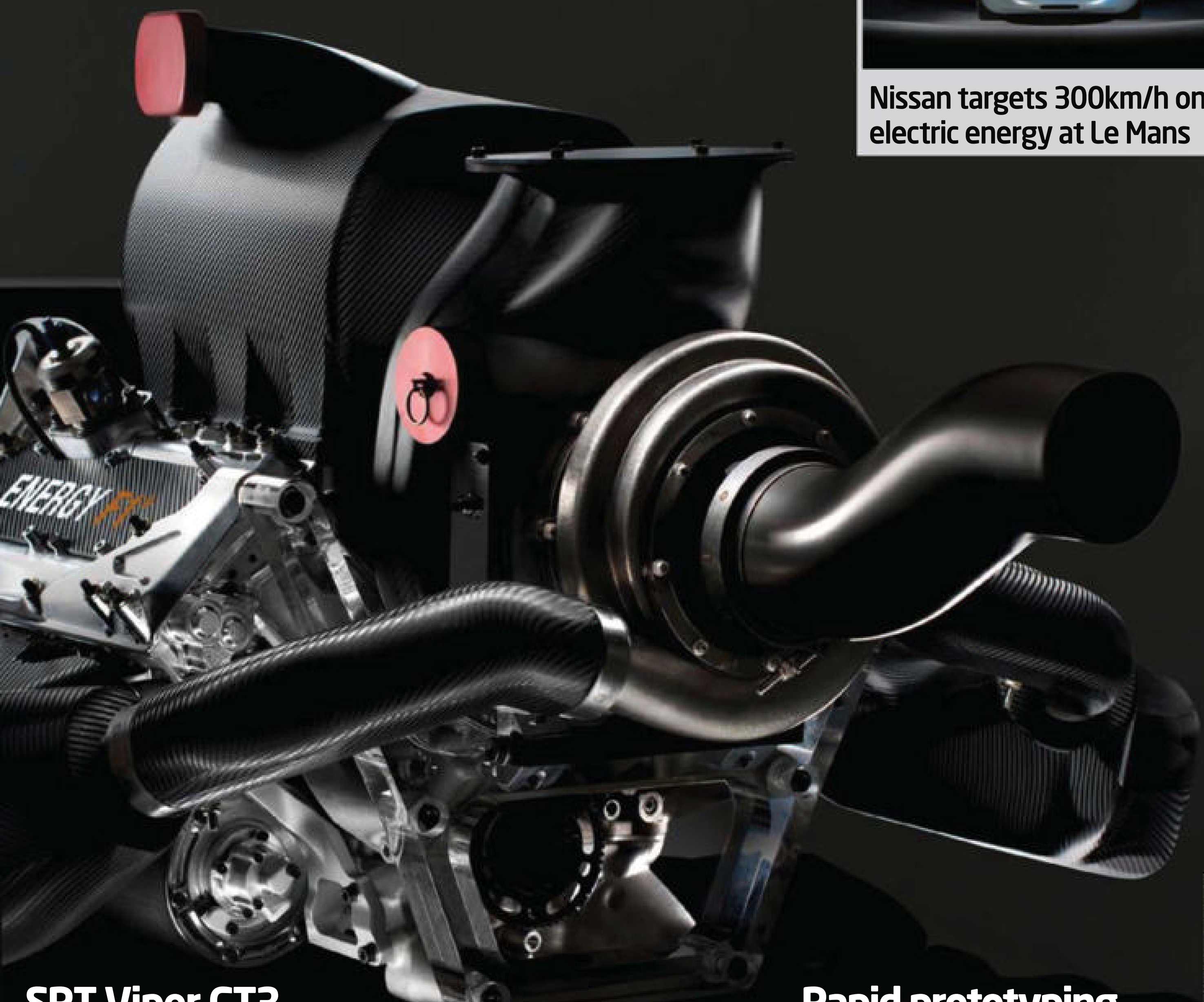
Formula 1 2014

We uncover the challenges facing engine designers next year

Nissan targets 300km/h on electric energy at Le Mans



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BUSINESS NEWS

Sébastien Loeb smashed the Pikes Peak record in the Peugeot 208 T16 as Racecar went to press. See next month's issue for more details

Creative discovery

Experience brings cynicism towards new thinking, but also tired ideas

Let us examine some sayings: ***'No physician is really good before he has killed one or two patients'*** – Hindu proverb

'Experience is the name everyone gives to his mistakes' – Oscar Wilde

'If you do not expect the unexpected, you will not find it; for it is hard to be sought out and inaccessible' – Heraclitus

Experience and a large number of unrelated knowledge items and subjects, coupled with curiosity, can lead to marvellous works of mechanical design. In some cases these might be shaped like racing cars.

ADD is the underlying explanation in my case, where high IQ but low dopamine translates to small working memory, meaning that my thought processes are forever being swamped by an ever-ascending number of new ideas and details until a pretty woman walks by and derails my cortex. Having thought up an idea, examined it for its benefits and gone on to work out how it could be achieved, one then slides off on another interesting, different idea, with a feeling that the previous one's done. I am also extremely modest.

A promiscuous imagination like this is dangerous for engineers. But there are two types of engineers. First are the ones who are good at ideas, but seem to lack the follow through to finish the details and bring the project to fruition. Then there are the types who are good at planning, detailing and painstakingly nurturing all the details of the project. Very rarely, you will get the two at full flower in the same person, which attests to a sort of schizophrenia, as the mindsets for both qualities are a bit antagonistic.

In his essay *The Hedgehog and The Fox*, Isaiah Berlin defined thinkers, scientists and engineers on a 'Hedgehog-Fox' continuum. The Hedgehog is a meticulous and specialised worker, driven by incremental progress in a clearly defined field; the Fox, a volatile, ideas-driven thinker who jumps from question to question, ignoring field boundaries and applying his skills where they seem applicable and moving to a new idea before expediting the old one. On the influential designer Colin Chapman, former Lotus team manager said: 'If Colin had a failing, it was that he always looked for the next thing no one had rather than develop what he had.'

CENTRAL FOCUS

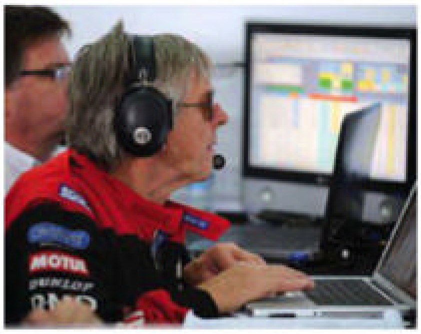
Depth doesn't have to come at the expense of versatility or breadth, but, generally, it seems to. For a project manager, the best results come from yoking these unlikely pairs to the wagon of design, to ensure an innovative but pragmatic racecar. After all, it has to race in a real environment.

One of Chapman's good ideas was to situate the drawing office in the centre of the race workshop, to ensure that all the designers had to walk through the fabricating and assembly area, facing the people who actually built and maintained the cars.

The decoupling of design from fabrication has caused some truly horrendous abortions, when most designers could actually manufacture or machine their designs. Walking the gauntlet of the workers with the possibility of hearing 'Who's the [insert colourful noun of choice] that designed this?' did wonders to the quantity of forethought that went into concept and detail design.

The downside of experience is that you will tend to stick to methods you know, and stop being adventurous, as experience has taught you that new ways have a large sign as in old maps – 'This way lays danger' – until eventually you are paralysed by the fear of the new and just recycle tired concepts, or worse, keep insisting that it is the only way to do it, rather than be dragged kicking and screaming into modernity. Experience makes more timid men, who end up designing on cruise control, than wise ones opening new paths. Don't be a one trick pony.

It is no surprise that the brightest and breakthrough ideas are done by young mathematicians and physicists. Think the 'Knabenphysik' ('boy physics') of Max Born and Wolfgang Pauli, the latter of whom who formulated the exclusion principle before he was 25. Werner Heisenberg was only 23 when he discovered matrix mechanics, and just 25 when he developed the uncertainty principle. Paul Dirac's reconciliation of quantum mechanics and special relativity came when he was 26.



Our resident old dog, mastering new tricks

Likewise, the coupling of young designers with old experimented designers will bring in the spur of new ideas tempered by pragmatism to avoid betting the firm on innovation, without getting bogged down in old ideas. Win-win.

The decoupling of design from fabrication has resulted in some truly horrendous abortions

Even if designing something you can do with your eyes closed, indulge in a few moments of blue-sky 'what if?'. Hans Christian Ørsted, while discovering that electric currents create a magnetic field, was also the first to describe and put a name to a particular technique. It had been deployed by philosophers since the Greeks, was put to good use by Galileo, and requires no special equipment, CAD or even a worksop. Anybody can do it and you needn't move from your desk. You can even do it in bed.

He called it a 'gedankenexperiment', which literally means 'experiment conducted in the thoughts'.

But Ørsted put the technique into words and legitimised a whole new avenue of scientific endeavour, famously explored by the 16-year-old Albert Einstein when he visualised a beam of light and Erwin Schrödinger when he mentally imprisoned a cat in a box and declared that it was simultaneously alive and dead.

In the midst of a global recession, with research budgets under pressure, perhaps it's time to dim the lights, close our eyes and just think: what if? (No, not 'think of England', different context… I knew I shouldn't have mentioned you can do it in bed.)

Ideas can be overrated, but great ideas are rare. On the other hand, having lots of ideas increases the chance of finding that rare pearl.

Be wrong as fast as you can. Mistakes are an inevitable part of the creative process, so get right down to it and start making them. Even great ideas are wrecked on the way to flower and then have to be painstakingly reconstructed. And you might get even better ideas while doing it.

Tyre traumas?

The driver's role has been diminished by telemetry, but they remain in control

It always alarms me when I read: 'It's not proper racing', or 'racing isn't like it used to be'. The current Pirelli-tyred Formula 1 era seems to generate such sentiments rather often. Recently, I came across the following extract from a review of the 1937 Grand Prix season:

'The first race of 1937 was at Tripoli and nine Silver Arrows were on the starting grid, four from Mercedes and five from Auto Union. Because of the heat and speed, tyre wear was expected to be a problem and each team tried a different strategy. Mercedes' drivers raced conservatively hoping for only one (or possibly no) tyre change. The Auto Union team drove very aggressively and pitted as necessary for new tyres. As a result 35 tyre changes were made by the Auto Union pit crew, Hans Stuck having seven alone. This provided a great experience for the spectators who watched the top nine positions change on every lap.'

1937, Mercedes v Auto Union - not 'proper racing'? So what is the problem?

If one disregards all comments by team owners, ex-drivers, spectators and the like, and just note what current Formula 1 drivers have to say about racing in 2013, one can discern a genuine dissatisfaction with the way they have to go about their race driving, even if it becomes muted when they win.

Of course a racing driver wants nothing more than to drive flat-out from lights to chequered flag, preferably faster than anyone else, but while this may be possible in hillclimbs and drag racing, I don't believe that it's something we can expect to see regularly in circuit racing. Something on the car has always been a limited resource, to be managed by the driver in a way that running short does not slow him too much. Of course fuel and tyres can be replenished, but accompanied by a time penalty for doing so. So, strategic driving has always been a part of racing, and indeed some drivers excel at it. Juan Manuel Fangio was renowned for winning at the slowest possible speed, and he was definitely a 'proper' racer.

So what has changed? I believe it is the dominance of telemetered data and strategic software. It is taken away a large part of the skill of driving a racing car, leaving the driver the single role of controlling the car. When he is told to drive below the limit and not to defend his position, it doesn't leave much that justifies his pay cheque, let alone providing him with any real satisfaction.

Prior to the current computerised era, the driver was given a car with a tank full of fuel and a set of tyres and brakes. There may have been some discussion about pit stops and the need to finish the race without running out of fuel or incurring an extra fuel stop, but there was no fuel gauge, and consumption under any given set of conditions was at the very best an estimate – running out of fuel often affected race results. Even with the introduction of carbon brakes, they were sometimes consumed before the end of the race with spectacular results. All this had to be managed by the driver, advised by pit board messages, which were often ignored. Above everything else, he had to manage his tyres. It was the driver who decided when to change them, if needed, due to wear or changing track conditions, not the team.

Tyres are the sole force generator on a car, and the magnitude and direction of those forces are controlled by the driver through pedals and steering wheel. However, the force generating capacities are limited, either through wear or temperature, which leads to accelerated wear. It is a major part of a driver's skill and experience, gained in the years in karting and junior formulae, to be able to manage tyres in qualifying and the race. It is not a coincidence that multiple world champions are thinking drivers.

ALASTAIR STALEY/GP2 SERIES MEDIA SERVICE

A Pirelli tyre from GP2 this year, slightly past the point of no return

Now that has all changed. Everything is measured and sent back to the banks of computers in the pits and onwards to a race control centre back at the factory. Fuel consumption, brake temperature and wear, engine and gearbox parameters, wheel and tyre temperatures ... these measurements are way beyond anything that the driver could possibly sense. The regulations state that none of them (bar RPM) can be indicated to the driver such that it assists with the way he drives. Instead, they are analysed, strategically assessed in conjunction with knowledge of what competitors are doing in terms of pit stops, tyre fit, track position etc, much of which is not available to the driver. Instructions are radioed to the driver by his race engineer to micro-manage the highest-paid employee. He is told to change engine settings, adjust differential and KERS settings and, most frustratingly, he is advised how to drive and even how to race.

Managing tyres in qualifying and race conditions is a major part of a driver's skill and experience

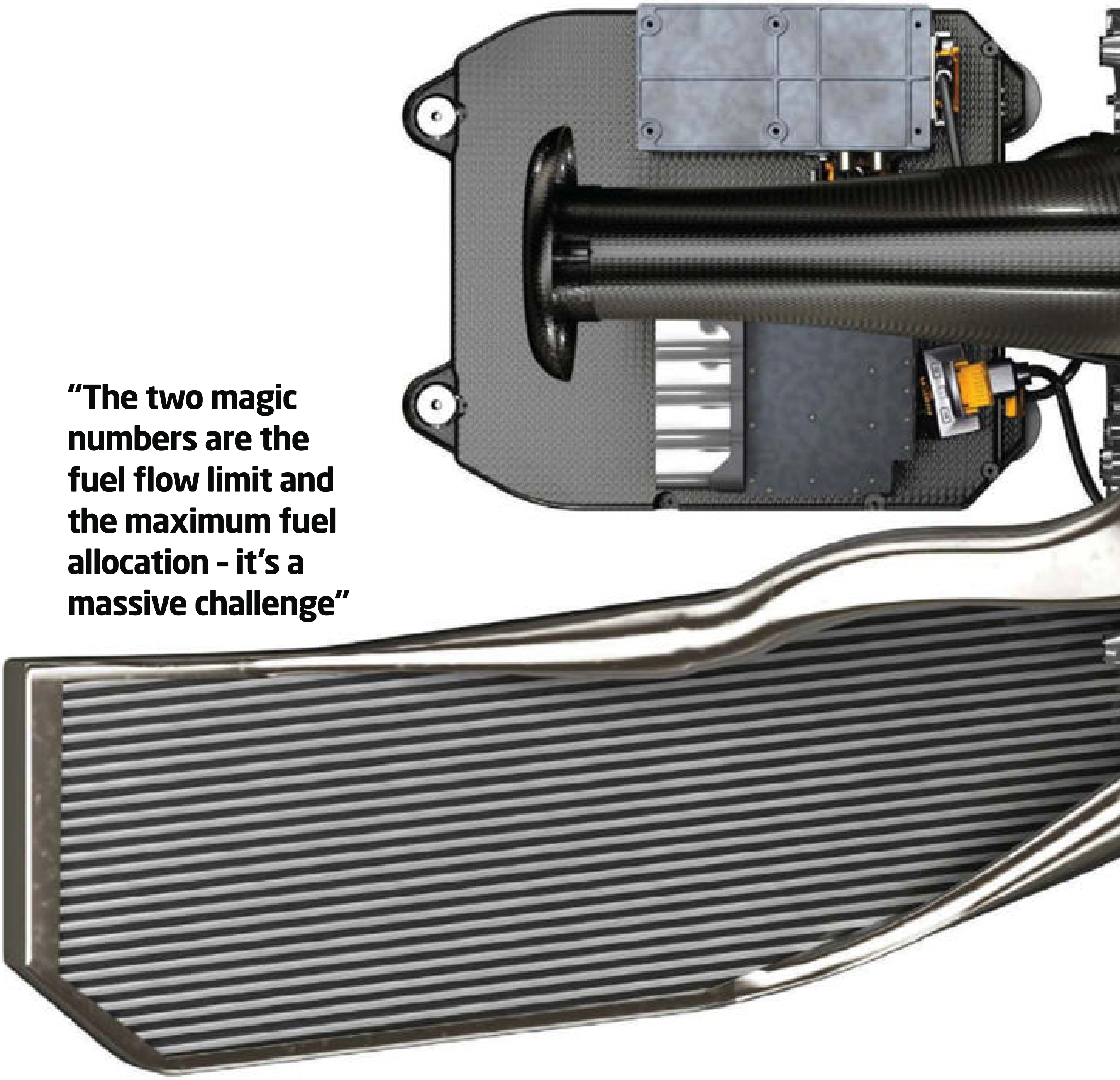
Pirelli tyres have a characteristic that causes them, above a certain temperature, to fall off a cliff never to recover. This is so critical that many key parameters have to be measured, analysed, and used as the basis of instructions to the driver about how hard he can push the car. Delivered verbally, it is not surprising that some drivers react emotionally and negatively: 'Leave me alone, I know what I am doing,' says it all!

Fortunately, humans are the best species at consciously assessing changing conditions and adapting, and whether 2014 brings back race-duration tyres or not, I have no doubt that the drivers will come to terms with the constraints imposed on them by technology and find ways to make them work to their competitive advantage. At least, some will. There is no doubt that the driver's job has been diminished, but it is neither Pirelli's nor their tyres' fault. Rather, it is the elimination of much of the driver's role in controlling the car over a race distance, and handing that task to engineers and strategists. It was probably inevitable that Formula 1 had to resort to restrictive regulations to ensure entertaining races, with the unintended consequence that teams used technology to minimise the effect of those constraints. Whether drivers can grab back the initiative and again take control of events, remains to be seen. I rather suspect that Vettel, Alonso and Räikkönen are already well on the way to doing so.

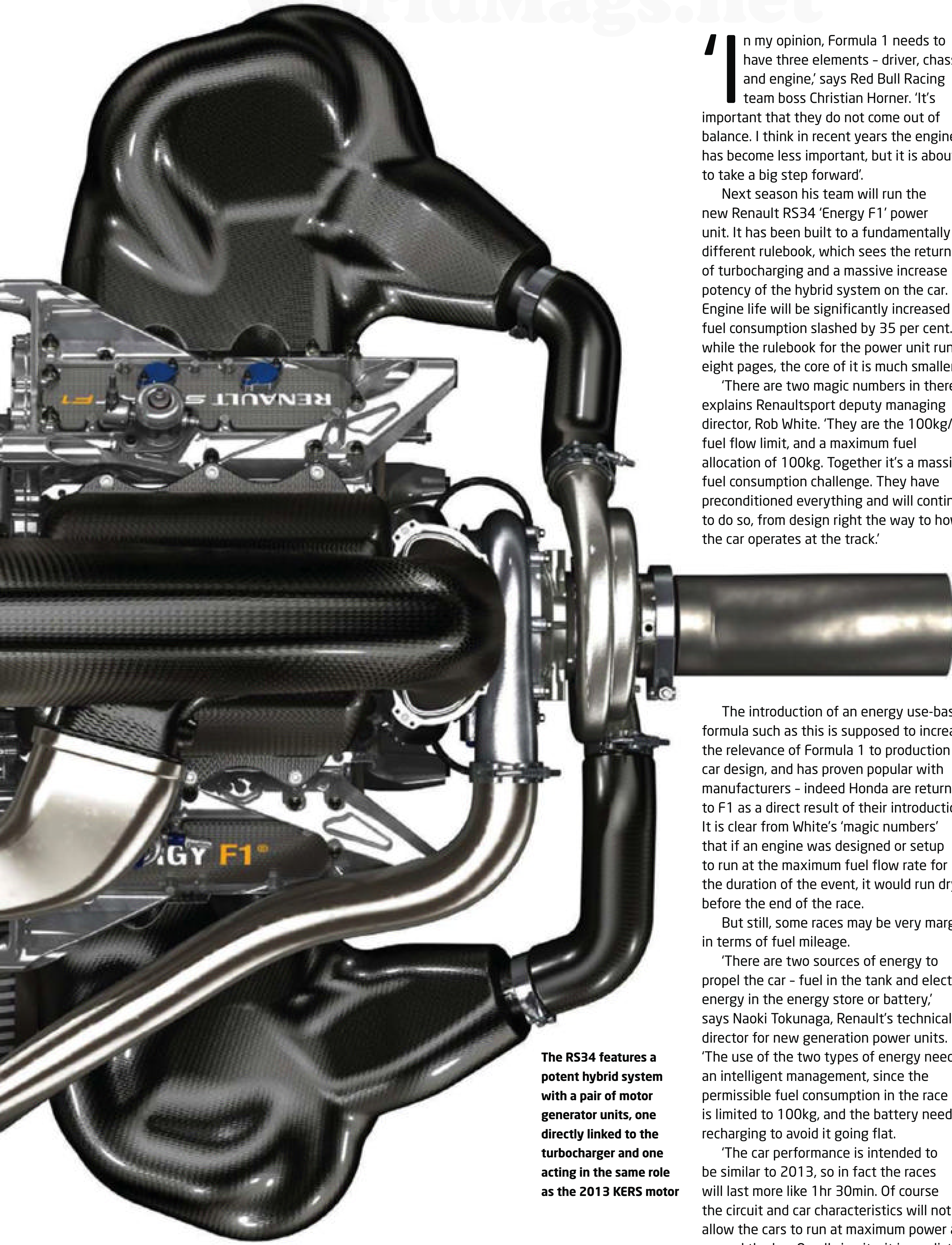
The third element

2014 will see a new breed of F1 engines. And, as Renault explains, a whole host of new obstacles...

BY SAM COLLINS



"The two magic numbers are the fuel flow limit and the maximum fuel allocation – it's a massive challenge"



The RS34 features a potent hybrid system with a pair of motor generator units, one directly linked to the turbocharger and one acting in the same role as the 2013 KERS motor

'In my opinion, Formula 1 needs to have three elements – driver, chassis and engine,' says Red Bull Racing team boss Christian Horner. 'It's important that they do not come out of balance. I think in recent years the engine has become less important, but it is about to take a big step forward'.

Next season his team will run the new Renault RS34 'Energy F1' power unit. It has been built to a fundamentally different rulebook, which sees the return of turbocharging and a massive increase in potency of the hybrid system on the car. Engine life will be significantly increased and fuel consumption slashed by 35 per cent. But while the rulebook for the power unit runs to eight pages, the core of it is much smaller.

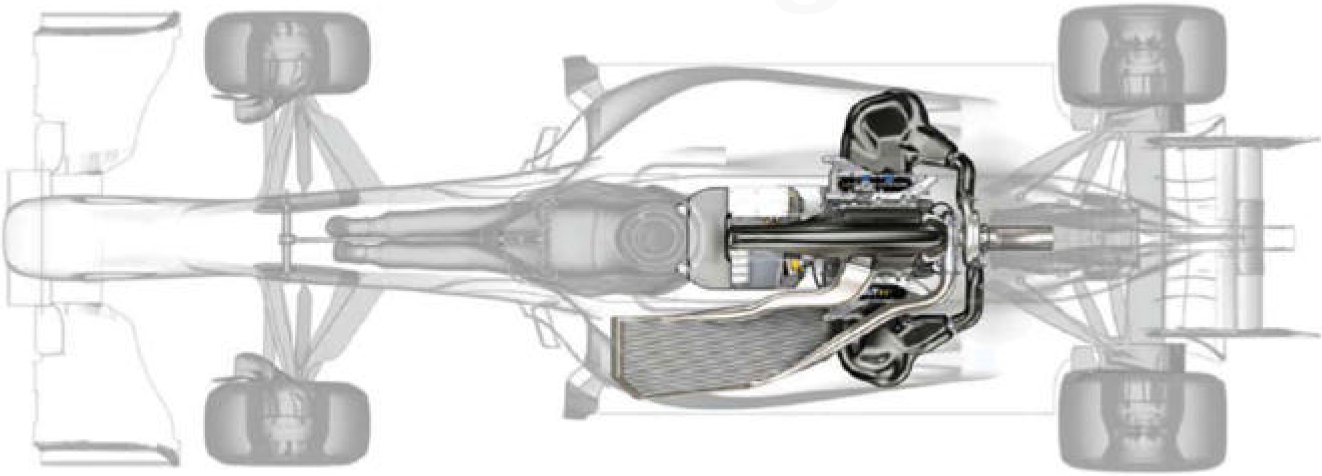
'There are two magic numbers in there,' explains Renaultsport deputy managing director, Rob White. 'They are the 100kg/h fuel flow limit, and a maximum fuel allocation of 100kg. Together it's a massive fuel consumption challenge. They have preconditioned everything and will continue to do so, from design right the way to how the car operates at the track.'

The introduction of an energy use-based formula such as this is supposed to increase the relevance of Formula 1 to production car design, and has proven popular with manufacturers – indeed Honda are returning to F1 as a direct result of their introduction. It is clear from White's 'magic numbers' that if an engine was designed or setup to run at the maximum fuel flow rate for the duration of the event, it would run dry before the end of the race.

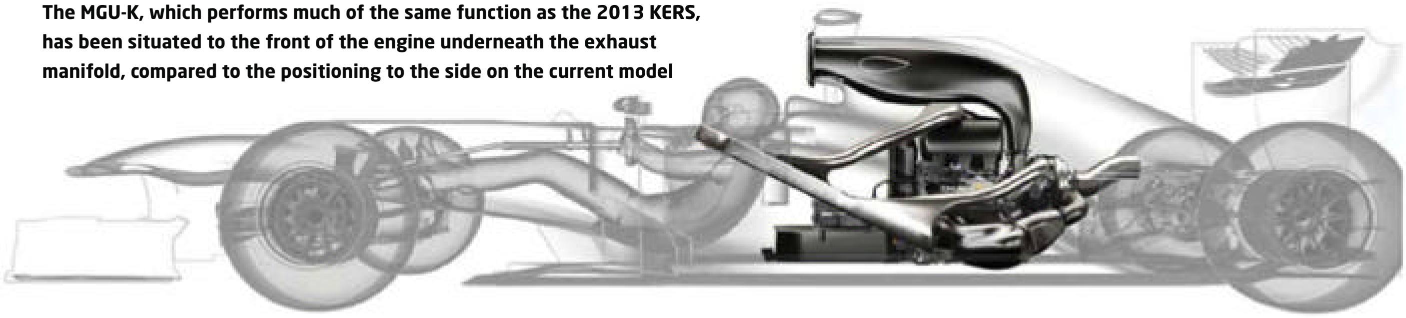
But still, some races may be very marginal in terms of fuel mileage.

'There are two sources of energy to propel the car – fuel in the tank and electrical energy in the energy store or battery,' says Naoki Tokunaga, Renault's technical director for new generation power units. 'The use of the two types of energy needs an intelligent management, since the permissible fuel consumption in the race is limited to 100kg, and the battery needs recharging to avoid it going flat.

'The car performance is intended to be similar to 2013, so in fact the races will last more like 1hr 30min. Of course the circuit and car characteristics will not allow the cars to run at maximum power all around the lap. On all circuits, it is predicted that the natural fuel consumption for the race distance will be close to the allowed 100kg, in some case just under, in some



The MGU-K, which performs much of the same function as the 2013 KERS, has been situated to the front of the engine underneath the exhaust manifold, compared to the positioning to the side on the current model



cases just over. If just over, then it will be necessary to decide how to use the available fuel.'

Of note is the fastest race of the season, the Italian Grand Prix at Monza, where the cars are at full throttle for 70 per cent of the lap. In 2012, the race distance was completed in 79 minutes which would, in theory, give a maximum average fuel flow of just under 76kg/h.

But at Monaco, the slowest course of the year, the race can take much longer due to having a far lower average speed. There, based on the 2012 event, the maximum average fuel flow rate is down to 56.6kg/h.

Singapore, one of the longest races of the year which often lasts two hours, has been highlighted by some as the most marginal race in terms of fuel mileage. There, based on a two hour long race, the maximum average flow rate will be 50kg/h.

In 2012 that race was time-limited rather than distance-limited due to safety car periods. The flow rate is calculated by time rather than distance, so in these scenarios teams could have to adapt their fuel use strategies in real-time. Indeed, if a safety car is deployed or weather conditions alter, the energy use strategy will also have to change.

'Everything we do to decrease the fuel consumption increases the power because of the flow limit,' White adds. 'Because of this we are all trying to make the power at the lowest possible RPM.'

This will have a significant impact on the aerodynamic design, meaning that teams will have to rethink how the car generates downforce. Notably this will fall due to the effective ban on blown diffusers, the single exhaust exit location being tightly controlled.

'There are lots of things that cause you to burn fuel and lots of things that give you lap time,' explains former Lotus technical director James Allison. 'When you design the cars for any year, you are trying to find the optimum combination of all of those things to make the fastest race time coupled with the best qualifying lap. It is certainly the case that you will have a different response next year to this year in terms of how dirty (in terms of drag) a downforce device you can use. But that does not mean that you will see the cars just scissoring downforce off it compared to what you are used to.

'There will certainly be opportunities. I suspect things like the front wing and the diffuser will follow similar paths to recent years, and the hunting ground will be how you cope with the low nose chassis and how you integrate what is a very fierce cooling requirement into the chassis without haemorrhaging downforce.'

Qualifying should be very interesting. With no regulation on fuel load, teams can exceed the maximum average flow rate, which would in theory give the engines more power. Indeed, in qualifying trim the power units should be more powerful than the current V8 engines. Teams could also run a driver-selectable map for overtaking or quick laps to make up time during a pit stop phase.

A further complexity is that the maximum fuel flow cannot be used below 10,000rpm.

'The maximum power of the engine will be at around 10,500rpm, and above that the power curve will be relatively flat,' says White. 'But they wanted them to run faster, which is perceived as a good thing to improve the show. It's about putting boundaries on the absurdity of the law of diminishing returns and stop an arms race to get to places that are extremely unusual. It's also about managing the risk. For a given power, the torque goes up inversely with the speed of the engine, so you would have very different transmissions. I hate to say it too, but it's important to everybody that these things sound good. I think these will, but if there had been no such rule then we would have run at very, very low engine speeds.'

"Everything we do to decrease the fuel consumption increases the power because of the flow limit"

Of course the RS34 Energy F1 is more than just a small capacity V6 engine. It features a hybrid system far more potent than anything seen in grand prix racing before. There's a pair of motor generator units, one linked directly to the turbocharger (MGU-H) and the other acting in the same role as the current KERS motor (MGU-K).

'The F1 cars for 2014 may be categorised as a hybrid electric vehicle (HEV), which combines a conventional internal combustion engine with an electric propulsion system,

Despite only having a 1.6-litre combustion engine at its heart, the new power units are noticeably larger than the current 2.4-litre V8s, due to all the additional subsystems

rather than a full electric vehicle (EV),' explains Tokunaga. 'Like road-going HEVs, the battery in the F1 cars is relatively small sized. The relevant technical regulations mean that if the battery discharged the maximum permitted energy around the lap, the battery would go flat just after a couple of laps. In order to maintain "state of charge" of the battery, electrical energy management will be just as important as fuel management.

'The energy management system ostensibly decides when and how much fuel to take out of the tank, and when and how much energy to take out or put back into the battery. The overall objective is to minimise the time going round a lap of the circuit for a given energy budget. This might sound anything but road-relevant, but – essentially – this is the same problem as the road cars: minimising fuel consumption for a given travel in a given time. The input and output are just the other way around. The question then becomes where to deploy the energy in the lap. This season, KERS is used only a few places in a lap. But from 2014, all of the energy from fuel and battery is so precious that we will have to identify where deployment of the energy will be beneficial over the whole lap, and where saving will be least harmful for lap time. We call it "power scheduling". This will be decided jointly between the chassis teams' vehicle dynamics departments and Renaultsport F1 in Viry-Châtillon.'

"Next year's F1 cars will probably be the most fuel and energy efficient machines on the road"

This power scheduling – or energy flow – will be a key component in Formula 1 in the future. While it may be a struggle to explain it to the general public, it certainly has the potential to genuinely improve the on-track action.

'Choosing the best split between the fuel-injected engine and electric motor to get the power out of the power unit will come down to where operation of these components is most efficient,' says Tokunaga. 'But again, SOC management presents a constraint to the usage of the electric propulsion. And the optimum solution will vary vastly from circuit to circuit, dependent on factors including percentage of wide open throttle, cornering speeds and aerodynamic configuration of the car.

'There are quite a few components which will be directly or indirectly controlled by the energy management system – namely the internal combustion engine, the turbo, the ERS-K, ERS-H, battery and then the braking system. Each has their own requirement at any given time – for example the operating temperature limit. There can also be many different energy paths between those components. As a result, the control algorithm can be quite complex to develop and manage. What is clear, however, is that at any given time, as much energy as possible – which would otherwise be wasted – will be recovered and put back into the car's system. It would not be an over-estimation to state that the F1 cars of next year will probably be the most fuel and energy efficient machines on the road.'

The current breed of cars all have the MGU located at the front of the engine, under the oil tank, where it acts on the crankshaft directly. At the launch of the RS34 at the Paris Air Show, it was immediately apparent that the MGU-K had been relocated from the front of the engine to the side of it. This is a notable difference, not only to the 2013 layout, but also to the renderings of the 2014 Mercedes power unit which have been released so far.

But White feels that the relocation is simply a case of moving the MGU back to its logical location.

'It's more a case of why was the V8 MGU mounted where it was? And the answer to that is simply because we had to graft it on – it wasn't integrated from the beginning. There is a regulatory requirement – a legality box – that everything has to fit inside. There is a plane in front of the engine and a plane at the back of the engine with additional bits where the oil tank will be. We could have put the MGU on the front, but we chose not to.'

The MGU-K now sits underneath the exhaust manifold and drives the crank via a series of gears on the rear of

NOW AND THEN…

	RS27-2013	ENERGY F1-2014
ENGINE		
Displacement	2.4-litre	1.6-litre
Rev limit	18,000rpm	15,000rpm
Pressure charging	Normally aspirated, pressure charging is forbidden	Single turbocharger, unlimited boost pressure (typical maximum 3.5 bar abs due to fuel flow limit)
Fuel flow limit	Unlimited, but typically 170kg/h	100kg/h (-40%)
Permitted fuel quantity per race	Unlimited, but typically 160kg	100kg (-35%)
Configuration	90 degree V8	90 degree V6
Number of cylinders	8	6
Bore	Max 98mm	80mm
Stroke	Not regulated	53mm
Crank height	Min 58mm	90mm
Number of valves	4 per cylinder, 32	4 per cylinder, 24
Exhausts	Twin exhaust outlets, one per bank of cylinders	Single exhaust outlet, from turbine on car centre line
Fuel	Indirect fuel injection	Direct fuel injection
Number of power units permitted per driver per year	8	5
ENERGY RECOVERY SYSTEMS		
MGU-K rpm	Unlimited (38,000rpm)	Max 50,000rpm
MGU-K power	Max 60kW	Max 120kW
Energy recovered by MGU-K	Max 0.4MJ/lap	Max 2MJ/lap
Energy released by MGU-K	Max 0.4MJ/lap	Max 4MJ/lap
MGU-H rpm	-	>100,000rpm
Energy recovered by MGU-H	-	Unlimited (> 2MJ/lap)

the engine, while the MGU-H is housed behind the turbocharger and is linked by a shaft. It sits between the cylinder heads. Both MGUs are liquid-cooled direct current designs. In 2013 the Renault RS27 V8 is fitted with two different specifications – one developed independently by Williams, and the other used by everyone else.

This kind of team-specific development is unlikely to take place from 2014 onwards. 'Currently we believe that such variations would be forbidden by the regulations,' says White. 'It's not finalised, but there's no more discussion on the subject.' The performance of the new MGUs and the whole hybrid system is substantially higher than the current KERS used on the cars, and can be used in a variety of modes. 'Both MGUs have a much higher duty cycle than current KERS by an order of magnitude,' White explains. The current KERS has a 60kW maximum, but on average it's only a little over six, so it's a very small duty cycle. In 2014 the MGU-K has 120kW. Obviously we use all of the 4MJ allowed from the battery – that's already 10 times more than we use today – and the energy that arrives direct from the MGU-H is unlimited, so that's on top.'

The MGU-K's position on the side of the engine highlights another key element of the new power units: thermal management. 'These higher duty cycle MGUs need more cooling than the current units,' adds White. 'Where the MGU-K is there will be some radiant heat, but it is in our interests to keep as much heat as possible inside the exhausts so it can find its way to the turbine.'

The engine shown off in Paris was the real thing, but it was fitted with exhausts that were only indicative of the team-specific designs that will be run in reality. Each manifold is shrouded to prevent the escape of heat from the pipes, with a carbon fibre outer skin. Carbon fibre is not known as being especially good at dealing with high temperatures, as the amount of scorched bodywork witnessed during the 2011 and 2012 seasons will attest. But there are some new high temperature composites on the market, such as the Pyromeral Systems range, which could have some role to play. On this White will not be drawn.

'The exhausts you see on this engine are typical and representative rather than a definitive spec. They will be different on each car,' he says. 'They will have substantial insulation, but what is next to the exhaust pipe might not necessarily be carbon. Keeping heat in is the priority.'

White also did not want to be drawn on exhaust materials too much, but did admit that they would be nickel-based alloys – materials such as Inconel – although they may have to deal with higher temperatures than the current designs.

Despite only having a 1.6-litre internal combustion engine at its heart, the new power units are noticeably larger than the current 2.4-litre V8s due to all of the additional subsystems. Integrating this complex powertrain into the notoriously compact rear end of a modern grand prix car is going to be a major challenge for both engine suppliers and teams.

RAISING THE VOLUME

'The sound of the engine is the sum of three principal components: exhaust, intake and mechanical noise. On fired engines, exhaust noise dominates, but the other two sources are not trivial and would be loud if the exhaust noise was suppressed and contribute to the perceived sound of the engines in the car.

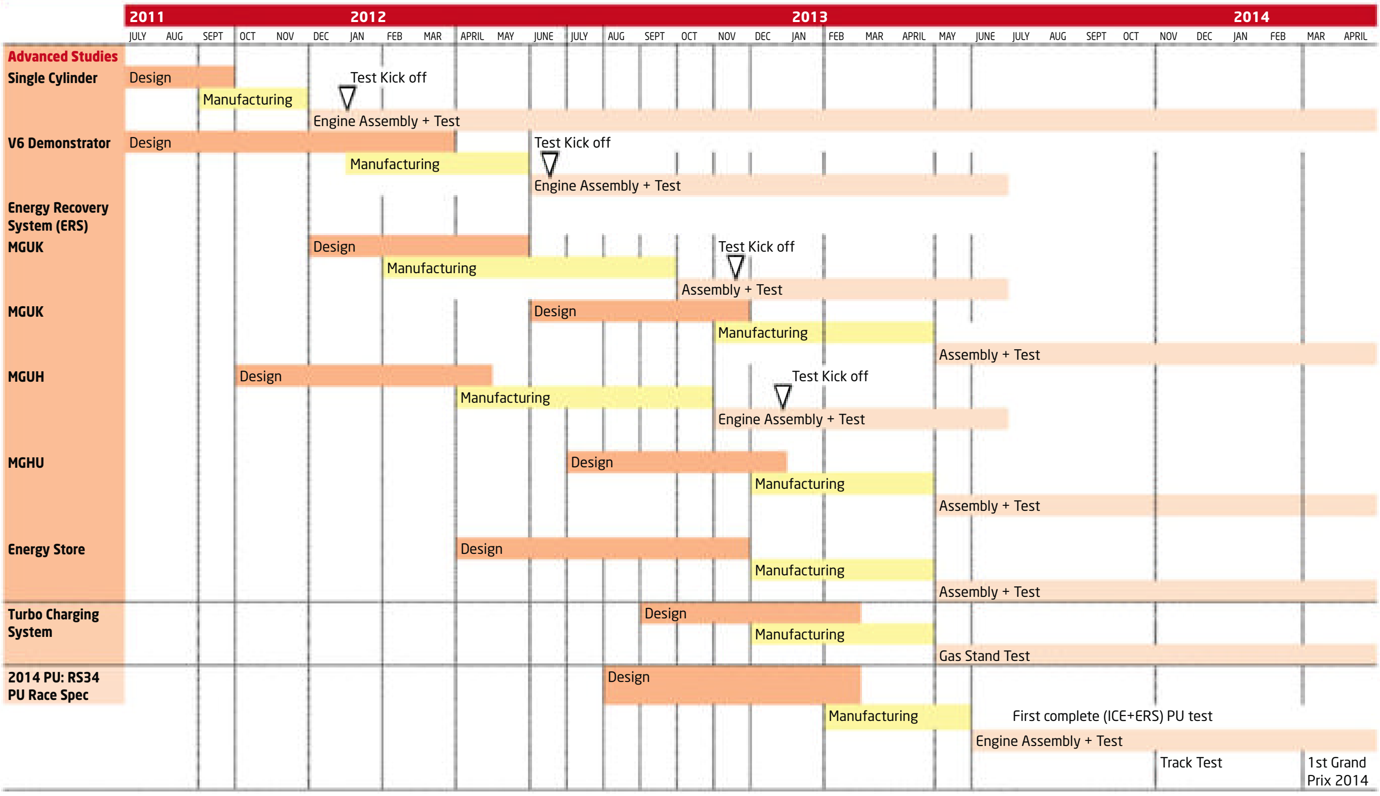
All three sources are still present on the V6. At the outset, there is more energy in each combustion event, but there are fewer cylinders turning at lower speed and both intake and exhaust noise are attenuated by the turbo. Overall, the sound pressure level – and so the perceived volume – is lower, and the nature of the sound reflects the new architecture. The car will still accelerate and decelerate rapidly, with instant gear shifts. The engines remain high revving, ultra-high output competition engines. Fundamentally the engine noise will still be loud. It will wake you from sleep, and circuit neighbours will still complain. The engine noise is just a turbocharged noise rather than a normally aspirated noise: you can just hear the turbo when the driver lifts off the throttle and the engine speed drops. I am that sure some people will be nostalgic for the sound of engines from previous eras, including the preceding V8, but the sound of the new generation power units is just different. It's like asking whether you like Motörhead or AC/DC. Ultimately it is a matter of personal taste. Both in concert are still pretty loud.'

Rob White, deputy managing director (technical) – Renaultsport

You can hear the Renault power unit running on the dyno at **www.racecar-engineering.com**

"The higher duty cycle MGUs need more cooling than current models"

THE CHANGING PACE OF DEVELOPMENT



'Exchanges between chassis and engine teams started at a very early time, before the regulations were fully defined,' explains Renaultsport F1 director of programmes and customer support, Axel Plasse. 'From that stage, one of the key areas we needed to investigate was the packaging of the power unit. The current V8 is 95kg, or 100kg if you add the weight of the MGU. This increases to 120kg when you include the ancillary parts, such as the radiators and other cooling devices. With the 2014 power unit, the V6 turbocharged engine will be a minimum of 145kg, plus 35kg for the battery. At 180kg, this is a 80 per cent increase over the current units, plus a further 20kg for the ancillaries such as the intercooler and other radiators.'

The additional weight is partly compensated for by an increase in the minimum weight of the overall vehicle to 685kg, and the weight applied on the front and rear wheels must not be less than 311kg and 366kg during qualifying, giving a window of just 8kg.

'The power unit is much more integrated and central to design,' says Plasse. 'For example, the turbo overlaps the gearbox so that it intrudes into the space where there was a clutch or a suspension part. The energy store is also much larger, which has an impact on chassis length, fuel volume and radiator position, among other items.'

Every time a major rule change is introduced into Formula 1, it has the tendancy of reshuffling the pack. The Red Bull team, for example, took advantage of the introduction of the current regulations in 2009 and has dominated ever since. But that dominance could end next season. 'At the start of the year there will be people who have got it right and people who have not,' Horner admits. 'The beginning of 2014 is just the beginning – it's all about development through 2014 and 2015. That's where there will be a lot of competition between the engine menufacturers. We think that Renault has the right people to develop the engine and the engine manufacturers have the ability to react. But if it is two seconds a lap slower than the best engine, we are in the shit.'

But that ability to react is likely to be limited in 2014, according to White. 'I think we are heading for a homologation process identical to what we have now,' he says. 'We will have to provide an engine before the start of the season and a legality dossier, and we will not be able to modify the spec of the engine during the homologation period. I think year-on-year change will be permitted within the scope of the sporting regulation though. The scope of the homologation perimeter will be much bigger too, covering the MGUs and energy storage.'

But with teams and engine suppliers still able to work on many areas outside that perimeter, things like the exhausts and installation can be changed. So can the hoses, hydraulics, air intakes and other areas which can directly affect the engine's performance and – most importantly – there will be far more freedom in the car's electronic system than there is currently.

'It's not beyond the wit of man to imagine that there will be significant performance enhancements as we learn more about managing the life cycle of the power units and the life limiting factors,' says White. 'That's not about changing the spec of the engine, but how we use it. Each engine that is built is done so to a unique build spec and there is scope to modify that. We can request permission from the FIA to make changes, but only for certain reasons.'

The final challenge for some teams is financial. The new power units are reported to be very expensive, and with some teams already struggling with costs, it could prove too much. Horner, however, is not overly concerned about it. 'With any change in regulations, the price only ever goes up,' he says. 'Hopefully the costs can be contained. But we do know that for the independent teams it's a big ask at a difficult time.

'But is there ever a good time to introduce new technology?'

"At the start of the year there will be people who have got it right and people who have not. But it's all about development through 2014-2015"

Electric Avenue

Nissan's 2014 Garage 56 car will be capable of 300km/h and a sub 4-minute lap at Le Mans. Well, that's the plan...

BY ANDREW COTTON

It was Nissan's involvement in the DeltaWing programme that delivered a lightweight prototype to the Le Mans grid in 2012, and so it is no surprise to learn that Ben Bowlby has been appointed as director of motorsport innovation at Nissan and that he has designed a new car, still delta winged in shape, as the company's 2014 electric Garage 56 entry – the ZEOD RC.

Bowlby's design, covered extensively in *Racecar Engineering*, has been dramatically changed, with a new chassis, new aerodynamics, a 2014-compliant LMP1 cockpit and a new drivetrain that is still under development. The target for the company is a zero emission on demand drivetrain, capable of powering the car to 300km/h at Le Mans in the course of a sub-four-minute lap on electric power alone.

This may fall some way short of the original target, which was to produce a zero emission car for the 24 hours, but nonetheless is a significant challenge, and one that Bowlby describes as more complicated than putting a four cylinder engine into an existing chassis design to prove lightweight technology, as the original DeltaWing programme sought to do.

The car has been designed solely in CFD and built in mock-up form for its launch at this year's Le Mans. The problem is that the duty cycle of the battery has not yet been decided to produce optimum performance, and there is no battery in existence that will allow the car to run for 24 hours without recharge.

The car will be built in the UK at RML's facility, in close collaboration with NISMO in Japan, which is expected to deliver the electric drivetrain. 'This is a completely new car,' says Bowlby. 'We cannot unlearn what we already know. We needed an incredibly efficient chassis to allow us to cover the

"We have optimised the design to enable us to do zero emission laps, and that's a difficult thing to do"

distance using the energy density of the latest battery technology. Le Mans is the most difficult challenge. When you start looking at the duty cycle of what we are trying to do, you realise how difficult this is. You have to have a very efficient car. We needed an incredible partner like Michelin to provide us with the tyre technology to help us to achieve the goal, and we have to work out exactly how we are going to do it, managing the energy, how we will deliver the power and how we will get the range. We are investigating different routes.'

The plan is to use a small capacity engine, built specifically for the project and based on a unit from Nissan's production range, although Darren Cox, the company's global motorsport director, claims that this will be 'very different to what everyone else is racing today'.

'The car will run as a pure battery electric this year – battery electric motor drive – and we will look at the range extender strategies and engine management strategies for when we come to Le Mans for the 2014 race,' says Bowlby, who hopes to have a running chassis by September. 'It will have range delivered through liquid fuel, that's for sure. We are looking at delivering zero emissions on demand [hence the name ZEOD], and we will use an internal combustion engine to give us range. This is an electric and gasoline powered car. It uses the narrow track technology which gives efficiency.

'We have optimised the design to enable us to do zero emission laps, and that is a very difficult thing to do. The car will weigh 700kg with driver, so it will still be a light car, and that is the core of every manufacturer's core essence. It has two electric motors – two powering one differential – so at the moment we are looking at a smaller, higher RPM-geared motor to drive the rear wheels. One of

the great things about having a great rear bias and rear drive is that our regeneration is optimised in terms of packaging. More than 60 per cent of braking and 100 per cent of the drive comes from the rear, so we are in a good situation with electrical recovery and traction.'

It is the numbers that are key to the project, and already they are making some interesting reading. To complete one lap on pure EV, the car will need 40MJ of energy, five times more than the LMP1 cars that will run next year in the highest category of ERS power permitted by the regulations. It is equivalent to around 1kg of gasoline, or just over a litre.

The powertrain will deliver a little more than 200kW of power, just over half that of the LMP1 and more than the four cylinder engine built by RML in Wellingborough in 2012. This will be needed to push the car to the speeds for the time required.

'This will change people's perception of electric racing forever,' says Bowlby. 'If you think of a milk float, this is different altogether. You will hear the tyre noise and aero noise, but this will be a remarkably silent experience and it will change people's perception of electric. It is the same technology as the Nissan Leaf. We are going to be somewhere a little north of 200kW of power, and we will see exactly where we need to go, where the technology allows us to go and the power density of the batteries. Battery technology has not made an order of magnitude leap over the last five years, but the technology, understanding and energy management has moved and we believe that doing all that we can we can pull impressive performance.

The ZEOD's powertrain will deliver over 200kW of power, and will need 40MJ of energy to complete one lap of Le Mans on electricity alone

'The most important thing in any efficiency chase is to reduce waste, and so we are looking to recover as much energy as we can from braking events, and we will use that to charge the battery. So, when we are not running on ICE, we are driving on pure electric which is being charged by otherwise wasted energy. We didn't burn something to make that energy, we are using something that would otherwise be waste.

'We are committed to a battery storage, the same technology as the Leaf, but how we harvest that energy we haven't decided yet. Batteries are the solution that we have at the moment and will be part of any future direction. Whatever powertrain and solution you have there will be storage of electric energy in a chemical system.'

"This is going to change people's perception of electric racing. It will be a remarkably silent experience"

FORWARD STEPS

The old DeltaWing was rushed through the development process and did not race with some of the trick electronics that were intended for use, including the torque vectoring system. It was also built with the tub of the Aston Martin AMR-One, which compromised the aerodynamics and cost the overall design between 20-30 per cent of downforce. The new tub, built by Adess in Germany, sits lower and further back in the design.

'It is still early days, but our goals for aero performance are high – we have to get a dramatic l/d and Le Mans is all about power and drag,' says Bowlby. 'We have worked very hard to deliver an aero package that is an extraordinary step forward.

'Having got Nissan's faith in this whole demonstration of technology, we have been able to get going early enough to get a bespoke chassis. So we will do a chassis that is to full LMP1 safety, with anti-intrusion stuff and so on, and of course it will be bespoke for the aero chassis. So this is a great opportunity.'

The response to the programme in the paddock was, according to the design team, disappointing. The majority of responses were that the theory made perfect sense. For the team, however, this is not the case.

'There is every fear in the world about what we are doing,' says Bowlby. 'It wouldn't be interesting if we could just use batteries off the shelf.

This is very difficult to do. I am much more nervous about this project than popping a four cylinder turbo in a car and demonstrating that downsizing works. This is extremely difficult and the fact that it hasn't been done, as there are many people who would like to have done it, shows the scale of the challenge.

'We will go right in the middle of the range of LMP1 and LMP2. We are not looking to upstage anyone. What we are developing in this programme is the technology that we will bring in the future. You can just switch on an electric traction drive system and know that it will be fine without going to a race environment. There are so many elements of running electric in a car, the safety aspects, being able to disable the systems in an accident, how you are going to crash a car and you will learn so much about this for the future.

'At the moment, you can't run for 24 hours around this track without recharging. But people's personal mobility does not require travelling huge distances every day. More big cities will require zero emissions, and this will be your daily driver.

'The duty cycle that the car has to perform is a function of tyre grip and performance. This is not simple. We have to find exactly that duty cycle and optimise the battery, the ICE and so on.'

GAMES AND GREEN ISSUES

There are many who lay claim to pushing Nissan's involvement in the DeltaWing Garage 56 entry, but none were more visible than Darren Cox, the company's global motorsport director, who pushed the programme from Nissan's perspective throughout, and was the public face of the manufacturer's involvement.

Nissan generated a staggering amount of press value from the programme, more than any other at Le Mans in 2012 bar Audi, and at a fraction of the cost, and Cox is determined once again that this is the start of a major four year programme at Le Mans. The LMP programme, like the Garage 56, will take electric power, a public demonstration of a technology into which Nissan has invested an estimated €5bn.

'We at Nissan have bet heavily on electric,' says Cox. 'We are not going to say that 100 per cent of our vehicles will be electric, but 10 per cent by 2020, which is a reasonable aim. Battery and electric motors will allow us to do other things. Electric is a solution, and will continue to be a solution, and we are in a change phase. Audi itself said that nobody knows where the industry is going. We have just invested more in electric, but that is not necessarily where it is going. Electric is part of the solution.

'At the Petit Le Mans [in October, 2012], there were a number of people talking to us about bringing this car to the Asian Le Mans Series, and to use it as a school car. There is a desire to see this sort of car in this championship. The ACO should be applauded for bringing it to the show, but if we get a knock on the door to bring it to Asia, we can do it.

"We have bet heavily on electric. The aim is for it to account for 10% of our cars by 2020"

'Don Panoz has licensed the DeltaWing with the Nissan Le Mans colours to the makers of Gran Turismo, so millions of people will be able to drive a narrow track car in a video game. Talking to developers, they are having to change the model and how it works, but already they have data on the ZEOD. They are very interested in it. As soon as you get millions of kids driving a car that looks so crazy, who knows what's going to happen.'

What may happen is that the project ends up in court, however, as the IP for the design may not be clear cut. Nissan is confident of its position, while Don Panoz – who developed the car for the ALMS this year – has handed his case over to his lawyers and refuses to comment until he has heard back from them.

'The DeltaWing partners fully own the concept of the car,' says Cox. 'Don Panoz [who with Dan Gurney brought the project to life in 2012], is not involved – this is a separate project. Both sides shook hands at the end of the year, we both tried but we had different objectives, we wanted to test new technologies and Don wanted to sell racecars.

'There is not one thing on the car that is the same as the previous car. Narrow track has been used in racing for decades, including drag racing and everything. This is narrow track, but everything is different to a previous car.'

Entry to the Garage 56 category automatically leads to a three year commitment by the manufacturer to LMP1, and Nissan is committed to bringing electric technology to the top category at Le Mans as soon as possible, although the chassis will be more conventional.

'We will test the theories that we have for P1 in this car,' confirms Cox. 'We have a commitment with the ACO to try to get an alternative drivetrain into P1 in the future. You can't buy the bits that we need to make a P1 – we have to start from the ground up. The LMP1 chassis rules are very clear, whereas the ACO is very open to discussing balancing technologies, and very keen to bring in new drivetrains.

'There will be more links to what we are doing from a road car point of view than you can guess now. The petrol bit will be very different to what everyone else is racing.'

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The year of the snake

By public demand, the Viper is back in a GT-spec guise. And it could be ready for action at the 24 Hours of Daytona...

BY SAM COLLINS

When the Viper returned to top level sportscar racing last year, it took many people by surprise. In June, the GTE-spec car hit Le Mans to contest the 24 Hours where, creditably, both cars went the distance. But the GTE car was not the one to grab the headlines – the day before the race, SRT – Dodge's high performance subsidiary – took the wraps off a new GT specification Viper.

GT3 is largely seen as a European class of racing, but it has gained traction in recent years in North America in both the Grand-Am Rolex series and the Pirelli World Challenge.

'We looked at the Daytona Prototype programme, but decided to go with the GT car instead,' says Ralph Gilles, president and CEO of SRT. 'GT3 is where the customers are at and I think that there is a lot of momentum there with ALMS and Grand-Am coming together, so this should work beautifully. There has been a lot of interest too – since we wound down our last programme, the customers have been asking for one. Most of that interest has come from outside of the USA.'

Without a proper rulebook, it can be hard for some manufacturers to know where to start with a GT3 car. Some, like BMW, have also used the GT3 designs that they've developed to upgrade them to a GTE specification requiring many waivers. But SRT did things the other way round, and started off with its GTE car as the basis for the GT3. Many components

have directly carried over as Bill Riley, whose Riley Technologies firm was responsible for the car's development, explains; 'The suspension is a direct carry over from the GTS-R,' he says. 'It's the same upright, and the same wishbones. There are a few things to take the cost out, but otherwise it is a direct replacement, including the double wishbone front and rear. The production Viper has that too, which is why it can go into GTE and GT3.'

But while the GT3 car is based heavily on the GTE, it is not a straight copy. Many areas have had to be revised in order to keep the cost down. One area this is particularly notable is in the engine, which is larger and much closer to production specification than that found in the GTE variant.

'Once the homologation was frozen for the GTS-R, we threw everything into this car,' says Riley. 'It is a bit of a different spec to the GTE, so it is a bit more cost-effective. The GT3 car has a front gearbox, rather than the GTE that has a transaxle. There is a lot of weight up front, but the engine on the production car is already quite far back to start off with, so we were OK on that. With the GTS-R we have near perfect weight distribution, and if anything we are trying to shove a little weight up front.'

SERVICE INDUSTRY

GT3 by its very nature attracts customers of mixed abilities from both the perspective of running and driving a car. This means that plenty of focus is placed on the car's servicability

The 2013 SRT Viper GTS-R (left) and SRT Viper GTS

RICHARD PRINCE

Close-up view of the Viper's control console. Squint a little and note the inspired choice of icon for 'drink', second row, right-hand edge...

and running costs, something that has certainly not escaped Riley's attention.

'GT3 is a different mindset – you have to make things simple and cost-effective,' he says. 'If you try to make a car that will kill everything else in terms of performance, you will fail. Here you are trying to make a car that is comfortable to drive. It will cost $459,000, which is a lot cheaper than a GTS-R. Since it takes a lot of technology, tooling and design from the GTS-R, it won't take us long to make the money. It has tube frame production chassis, Xtrac gearbox, the internals are off the shelf, but the casing is special. It helps to lower the engine. We haven't built the first prototype to gauge the weight, but we are aiming for 1250kg. We know that will be tough, and we are probably looking at closer to 1300kg. We will save weight by simplicity – simple plumbing, simple electrics, simple layout of the car and simple water system.'

Although the GT3 is not yet ready for testing, Riley hopes that cars will be available for delivery by the end of the year. 'I would like to see a couple of cars on the grid at Daytona 24 hours,' he says. 'We will be testing throughout the winter.'

Meanwhile, Gilles has other motivations to see the new Vipers on track, and not just for marketing reasons. 'We will continue with the GTE car – what customers do with this is really up to them,' he says. 'It's going to be an organic development. We are going to be the winners because of the coverage – the more Vipers on track, the better. There are technologies on the Viper that will see their way on to production cars too, things like composites and hot forming aluminium.'

Indeed, technology transfer is one of the keys to the whole Viper competition project for the SRT brand. 'We need to go racing as it makes the car better,' states Russ Ruedisueli, head of motorsports engineering and vehicle line executive for SRT. He means it too – components developed specifically for use at Le Mans and on the ALMS schedule over the years can now be found on the street car.

'The engine compartment cross-brace is a great example,' enthuses Jeff Reece, vehicle integration engineer for SRT Viper. 'We did that on the early racecars but it became a production piece and you can see it on the street cars now.

> **"If you try to make a GT3 car that will kill everything else in terms of performance, you will fail"**

Another example is way back in the early days of the Viper – we found an issue with the engine block on the street car, so we used the racecar tooling on the production cars.'

In recent years a number of manufacturers have made fairly wild claims about how they have improved production car technology via racing. On further inspection, more often than not you find that the development of the competition car has been outsourced and the manufacturer's development engineers had nothing to do with the on-track product.

While both the GTE and GT3 specification Vipers have been developed by Riley Technologies, SRT has been involved all the way through the gestation of the racing models.

'The Riley car was not designed in a vacuum – it was designed alongside the street car,' says Reece. 'The chassis is basically the same that we use in the production car. We shipped two early prototype chassis of the Viper down to Riley when the project started, and other than the modifications allowed in the rules on things like pickup points, its basically the same.'

BACK AND FORTH

Having engineers working actively on both the street and race products allows for a very rapid exchange of knowledge, according to Ruedisueli.

'The transfer is in both directions. We have been racing Vipers since 1996 in various forms and we have found that the stuff feeds back and forth all the time,' he says. 'Things like a chassis pickup point or a transmission bit that tends to get improved – and that gets rolled back into the production cars or the other way round. The process is not instant. While the current Viper has parts on it that come directly from the track, they do not come from the current GTE car – they're from the last racecar. What we develop now in racing improves the next generation street car.'

Much of what the SRT engineers learn, however, is about methodology rather then direct design improvements. The motor

A peek inside the SRT Viper GT3-R

racing projects can sometimes not only improve the engineering design of the street cars but also the tools and methodology used to develop them.

'We started using a particularly good data acquisition system in racing a while back and now we use that for production car development,' says Ruedisueli. 'There are a whole list of things that we can run through – you just learn so much from racing.'

RACING PHILOSOPHY

SRT stands for Street & Racing Technology, and it's clear that it's an apt name as something of a racing mentality runs through the whole company. Indeed, one member of staff decided not to have a bachelor party and instead hired out the local track for him and his collegues to go and have a private day of running. Typical behaviour for an employee of SRT, it seems.

'The wider corporation does find us a bit odd, but they support and encourage us,' says Ruedisueli. 'A lot of the guys in the SRT design office are racers themselves so they often have half an eye on what would make it a good car on-track. They look at the bits they have put on the production car and think "how can I make that work on the racecar?"'

RICHARD PRINCE

The SRT crew await the SRT GTS-R Viper during March's 12 Hours of Sebring

ENDURING MEMORIES

In Ohio there is a little track called Nelson Ledges, which hosted a 24 hour sportscar race for many years. Although far from a big international affair, it was still an important race for many in the North American sportscar racing community.

A day and a night on the fast bumpy course proved hard on the cars and it was seen as a real challenge, but over time the event faded into the history books.

However, the staff of SRT Dodge's high performance brand have not forgotten, and a couple of times each year they head down to Ohio to hold their own private 24 Hours of Nelson Ledges.

'All SRT models have to do it as part of a list of tests to be completed before we are happy that the design is ready for sale,' says Russ Ruedisueli, SRT's head of motorsports engineering. 'One of those tests is the 24 Hours of Nelson Ledges. It is good for testing things like the dampers, bushings, exhausts and frame mounts.'

Further testing goes on at tracks like Gingerman Raceway in Michigan, part of the same evaluation for all SRT-branded cars, from the Cherokee to the Viper. 'It's important that our cars can run well on tracks without overheating or running out of brakes,' says Ruedisueli.

But another event has just returned to the SRT R&D programme after years of abscence – the Le Mans 24 Hours. SRT contested it with a pair of GTE-spec Vipers built by Riley Technologies. The Viper is not even for sale in Europe, but this was seen as an integral part of development of the brand's new models.

'We need to go racing as it makes the car better,' says Ruedisueli. He means it too – components developed specifically for use at Le Mans and on the ALMS schedule over the years can now be found on the street car.

The strange class of 1923

Ninety years ago, variety was the spice of GP racing life, with the contenders of the day pointing the way to the cars of the future

BY IAN WAGSTAFF

An aerofoil-based, semi-monocoque racecar from an aircraft designer, a streamlined rival and a rear-engined contender – it may sound like current technology but this is the year 1923. The Grands Prix at Tours and Monza that season brought forth three cars, the like of which were never to be seen again but which, in their respective ways, influenced the future of the racing car.

It is difficult to see much difference in the shape of the cars that contested the first post-war grand prix from those that raced before 1914. Likewise, after 1924 there is merely a steady progress in appearance that will not dramatically change until the advent of the Silver Arrows a decade later. However, in 1922, there was an indication that cars did not necessarily have to look the same. Both the Ballots and Bugattis of that year's French Grand Prix have been described as sporting cigar-like front cowlings. Perhaps barrel-like would be more appropriate. Both featured a cooling aperture in the front, the Bugatti also having one in the centre of the tip of its conical tail. The streamlining was the only thing that was really different about these cars, the Ballots simply being re-bodied versions of the previous year's cars.

The following year is best remembered as the only victory for a British-built car in a major grand prix – a grande epreuve – prior to Vanwall's win at Aintree in 1957. There was nothing radical about Henry Segrave's winning Sunbeam. Some unkindly called the Wolverhampton cars 'Fiats in green paint', as they been designed by Vincent Bertarione, who had been lured away from the Italian manufacturer. Even the streamlining of the exhausts pipes in the body sides seemed similar to the Fiats. Interestingly, the Fiats at Tours, the first grand prix entries to use superchargers, had been designed by the company's aviation department, but they did not look that much different to the Sunbeams. When it came to radical aviation influence, one had to look at the Voisins.

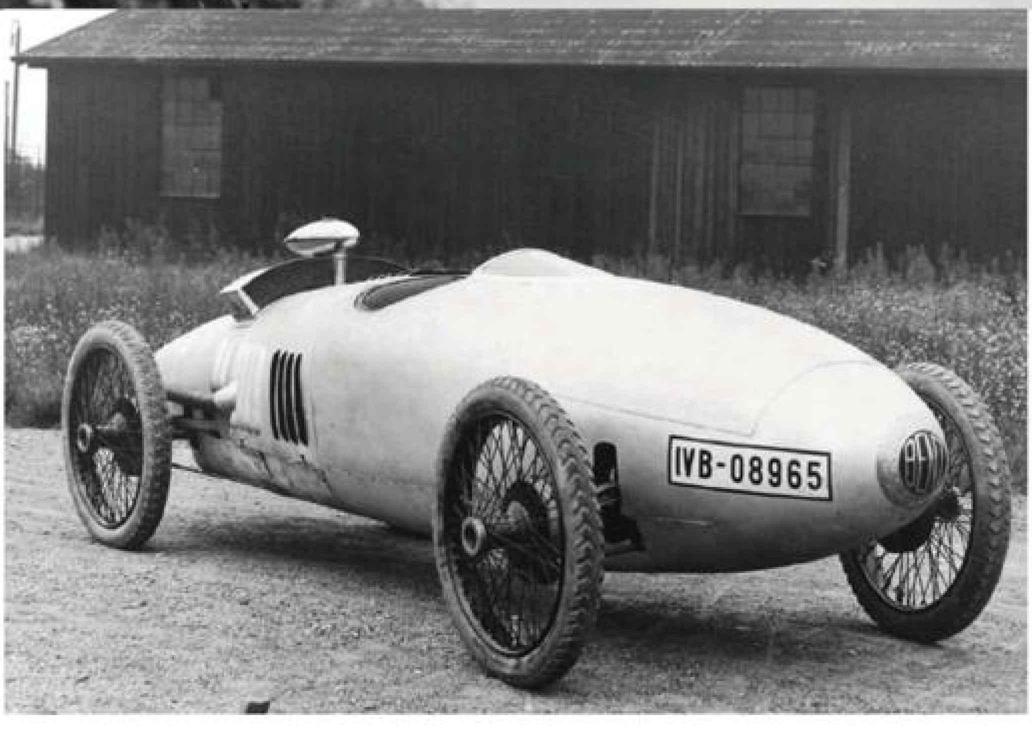
The Voisin brothers, Gabriel and Charles could claim to have been the first commercial constructors of aircraft in Europe, having established their manufacturing operation in 1906. Given Gabriel Voisin's later foray into motorsport, it is perhaps surprising to learn that they preferred not to risk the uncertainty of experiment, preferring to produce reliable but unspectacular machines. The first of their planes to achieve powered flight took off in 1907, an early customer being the future Lord Brabazon, one of Britain's first grand prix drivers. During the Great War, their planes formed the nucleus of France's reconnaissance and bomber force. After the war, Gabriel started producing luxury road cars.

He had not deserted his roots though, railing against the conservative body styles that the regulations for the 1922 Lyons Touring Car Grand Prix ordained, even though one of his cars won that event. As far as he was concerned, car designers would be better off studying wind resistance for six months than engine design for six years. It was not surprising then, that when he produced a grand prix car, the C6 Laboratoire, the result was obviously the work of an aircraft designer, even to the very visual propeller on the front of the radiator grille, which drove a water pump.

Working with André Lefebvre, better know for his time with Citroën, Voisin built the C6 in six months using the front axle from his C5 road car. Its six-cylinder, Knight-type sleeve-valve engine was developed from the four-cylinder unit found in the earlier C4 using an aluminium block, and with a high compression ratio and extra cooling for racing. However, the tempestuous Voisin had a problem. It produced only 80bhp, well down on the 110bhp of the winning Sunbeam. He would have to find speed by other means, and this he hoped would come with the one-dimensional aerofoil bodies of the day, which enveloped their very narrow-tracked rear wheels. The underside was flat and smooth. Famed technical writer Laurence Pomeroy was to describe the C6 as 'carefully calculated... of good aerodynamic form'. The wheels featured aluminium discs while even the steering wheel was shaped in such a way that the highest part did not project above the scuttle line.

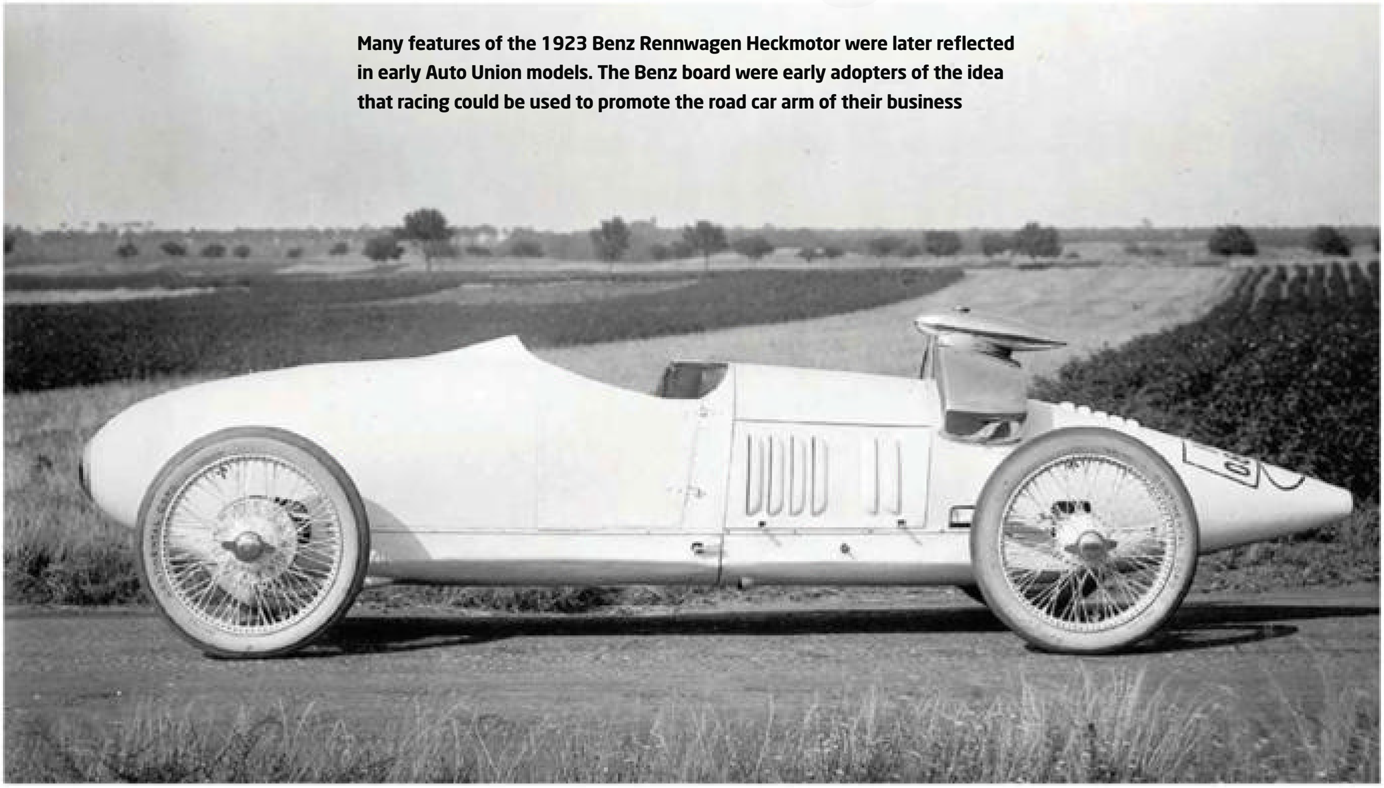
The Voisin produced 80hp, well down on the Sunbeam. It would have to find speed by other means

(Main pic) The innovative, teardrop-shaped Benz Tropfenwagen – pictured left of centre on track – in action at the 1923 European Grand Prix in Monza.
(Below) The positioning of the Benz's engine, behind the driver, was revolutionary for the time



The just less than 750kg Voisin can be said to have been the first monocoque grand prix car – there was nothing really new when the Lotus 25 rolled out of its transporter at Zandvoort in 1962. Construction was of sheet aluminium around a wooden framework, reinforced by steel tubes. The rear track was just 2ft 5.5in (75cms), which meant the use of a differential could be avoided and the tail kept narrow. The result was a top speed of almost 106mph despite the lack of power.

Gabriel Voisin's friend, Ettore Bugatti, also entered a radical design, as far as looks were concerned, for Tours. *The Motor* magazine linked the two at the time: 'The Voisin and Bugatti productions were nightmarish



Many features of the 1923 Benz Rennwagen Heckmotor were later reflected in early Auto Union models. The Benz board were early adopters of the idea that racing could be used to promote the road car arm of their business

monsters that fled ventre à terre (literally) over the ground in amazing fashion… the marvellous Bugattis – tank; tortoise; dish cover; beetle; slug and roller-skate – these names were given them in turn.'

The then Captain Malcolm Campbell was to write that they 'looked more like a tank that a motor car' and history was to decide that they were to be known as such, in similar fashion to the Le Mans-winning Bugatti Type 57s of 1937 and 1939. You can also see the look in the 1930s Bugatti railcar, which marque specialist Hugh Conway reckoned was even reflected in the much later French high-speed trains.

Bugatti had turned to another first world war aircraft designer in 1923 for another venture. Louis Becherau, who had been responsible for the Spad fighter planes, penned the off-seat single-seater bodies for Bugatti's attempt on the Indianapolis 500. It was a relatively conventional but nevertheless attractive look, unlike the grand prix cars, as their sobriquet would indicate. What is perhaps less known is that the shape of Bugatti grand prix cars of the year had been sketched out by none other than Gabriel Voisin after Bugatti had complained that naked chassis were his best cars.

The grand prix Type 32s, to give them their correct name, certainly had a very short wheelbase for an eight-cylinder car. However, it was their shape that caused most comment. Rather than separate the air sideways, as in a normal tapered shape racecar, Bugatti's idea was to cut through the air by displacing it vertically with a half aerofoil shape. In profile, the cars appeared as the arc of a circle; from the front, they were a perfect rectangle.

Unlike on the Voisin, the bodywork covered the front as well as the rear wheels. It was built on to a pressed steel platform with riveted cross-members. The wheelbase was 6ft 7in (2m), similar to that of the first Minis, but the length just 3.8m (12ft 6in) meaning that what was gained in handling was lost in stability. The cramped cockpit also led to restricted visibility and claustrophobia on the part of the drivers. The fact that the familiar, eight-cylinder engine was unguarded did not help them either.

The 'tanks' were definitely fast, though, and one was timed over a kilometre course at 117mph. With a platform just 6.3ins (16cm) from the ground, they also raised less dust than their contemporaries, something probably much appreciated in those days of relatively rough terrain.

Bugatti himself wrote: 'The thick aerofoil section of this little car has only been achieved by the chassis and all the rolling mechanism being designed to be totally enclosed by a small envelope, this to reduce the tractive force as much as possible.'

It was just a matter of appraisal that led Bugatti to the type 32's 'simple' lines. Given the way in which the wind tunnel is now such an important part of racecar design, it is interesting to note that he said that he had made no wind tunnel test because he considered it impossible to obtain results without 'very special equipment'. Adding that he had little faith in scale models, he continued: 'It must be remembered that the roadway cannot be considered as a perfectly straight plane and that the car moves about and varies its attitude with respect to the road. Uncontrollable effects will then arise. A car on the road is not under the same conditions as an aircraft in the air.'

Bugatti also pointed out that the more closely a vehicle approached the ground, the less would be its resistance to forward motion. Experiments by Fiat's aviation department however, had shown that it was detrimental to bring the under-surface of the car too near to the road and that clearance should increase as the tail was reduced to release air imprisoned beneath the car.

Back in 1923, German teams were not welcome at the French Grand Prix and so it was not until the year's other grande epreuve, the European Grand Prix at Monza, that the Benz Tropfenwagen made its appearance. While the Voisin and the Bugatti had been radical in

The cramped cockpit of the Bugatti led to restricted visibility and claustrophobia. The fact that the engine was unguarded didn't help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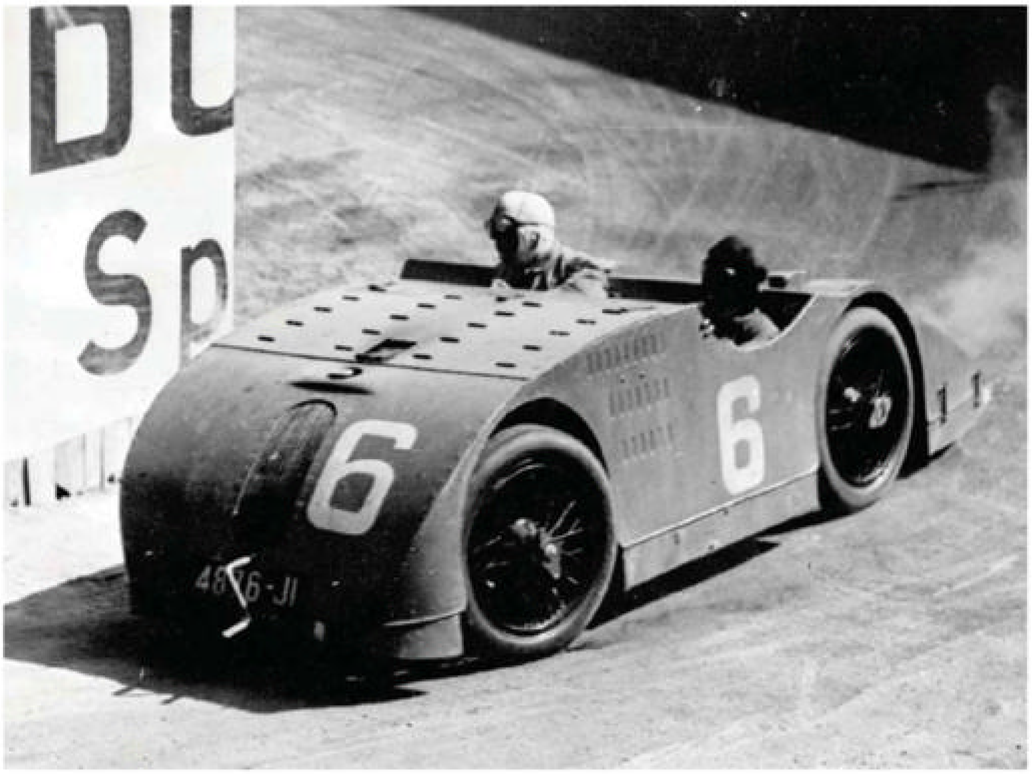

The Bugatti Type 32 – commonly called the Tank – was based on the idea that its half aerofoil shape could cut through the air by displacing it vertically

their appearance, the pear drop-shaped Benz was also notable for the revolutionary position of its engine – behind the driver. This, it should be remembered, was over a decade before the first Auto Union.

Like Sunbeam, Bugatti chose not to enter for Monza but Voisin took his cars to face a field that included the Fiats, three Indianapolis-style Millers and the first appearance of an Alfa Romeo team, although the latter withdrew following a fatal practice accident. The illustrious name of Benz was also returning with the first German cars to compete in a grand prix since the war. Its three 114mph contenders featured a six-cylinder, twin ohc engine mounted in the rear with a torpedo-shaped header tank mounted above the engine and level with the driver's head. Their chassis featured independent rear springing through swing axles and inboard rear brakes, another future vision of Lotus even if the Lotus 72's inboard brakes were also at the front.

Another aviation pioneer comes into the story. Edmund Rumpler's company had been responsible for many of the Taube, or 'dove' monoplanes that had been a mainstay of the German air service at the opening of the war. In 1921 he exhibited a closed version of a rear-engined car that he called 'a teardrop auto'. Benz took an option on its innovative design with an idea to producing a production road car. The company's board also thought it would be a good for publicity to produce a racing version.

Benz, tiptoeing its way through Rumpler's many patents, decided to go its own way with an idea to competing in 1922. The car was, however, not yet raceworthy. The prototype substantially differed from the following year's cars. Its wheels and tyres were larger while all the brakes were mounted outboard. The body was also nearer circular in cross-section – suggesting a different frame design – and it featured a more tapered nose. The low-seated driver looked through a curved transparent screen while the riding mechanic crouched below an arched tonneau with transparent porthole above his head. While 'Tropfenwagen' was retained as a nickname, it and the subsequent cars would officially be known as the RH (Rennwagen Heckmotor) series.

Not having a Rumpler licence meant that Benz's 1923 RH was more conventional than the aviation pioneer's car. However, one carry-over was the use of cantilevered semi-elliptical leaf springs for both front and rear axles. No shock absorbers were fitted to the rear because it was felt that the scrubbing action of the tyres would provide sufficient spring damping with a swing-axle layout. A bespoke, six-cylinder racing engine was designed for the 2-litre formula. A striking feature was the radiator that was attached to a structure above the bell housing in a manner that reminded observers of radiators fitted to first world war aircraft. The driver and mechanic sat higher than in the prototype, but the car did have a rear-hinged door for the latter.

Such was the innovation in the RH that the organisers of the Monza race gave Benz a gold medallion for the most outstanding new car competing. The European Grand Prix was its only major race, but it competed a few more times in its original form before being modified to enter other events and even recreated as a bizarre sports model.

Adolf Rosenberger was to hillclimb a Benz RH in 1924 as well as set fastest lap with one in the Solitude races. By 1933 he was working with one Ferdinand Porsche on a project based on his experience with the rear-engined car. This was to be taken over by a new combination of four Saxon car manufacturers, Auto Union, making the V16 P-Wagens and the subsequent V12 Type Ds the RH's undoubted successors.

Despite their innovation, none of the three designs met with any real success. The supercharged Fiats were really the class of 1923 and, although they failed at Tours, they won at Monza in the absence of the Sunbeams. The radical French cars were outpaced. At Tours, where there were four of each, Ernest Friedrich managed third place in the surviving Bugatti, while Lefebvre, himself, was fifth and last finisher in a Voisin. Three of the Voisins were joined in Italy by a similar number of Benz. Gabriel's cars all retired with engine troubles, while Ferdinando Minoia brought one of the German entries home as fourth and last finisher. Four decades later Voisin described his entry into grand prix racing as 'a piece of indescribable folly'.

With a little use of imagination, it is possible to look at Voisin and his car and see Robin Herd with Cosworth F1 or March 701, to study the front end of the Bugatti 'tank' and imagine a Chevron B19, or, most obviously, see a Cooper Mark III in the Benz. As Geoffrey Chaucer observed some years before, 'There's never a new fashion but it's old.'

The Benz 1923 RH had a striking radiator, attached to a structure above the bell housing that reminded observers of those found on WWI aircraft


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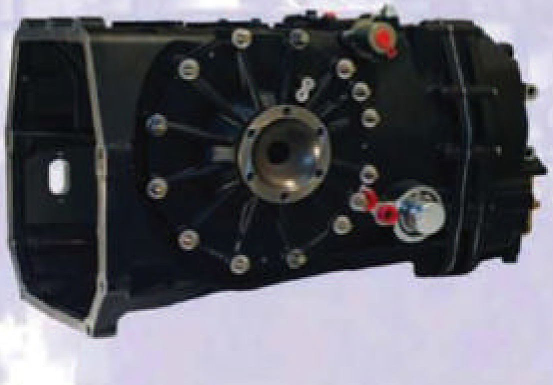

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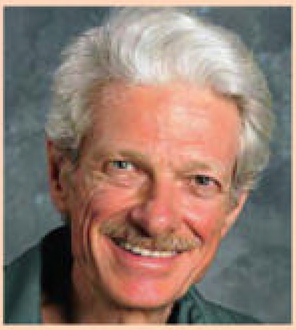

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Aiming for balance in load transfer

An illuminating exchange with our resident chassis expert

QUESTION

I was asked a question by a friend about his short oval car that has me a bit stumped – I wondered if you could guide me in the right direction.

I have been doing some setup work on several cars over the last few years, specifically two formulas of car that are very similar and grew from a common racing ancestor. It is quite easy to make a judgment of equivalency between these cars by comparing wheel rates, because their geometries are so similar. As they have max track width rules, the footprints of the cars are very similar too.

What I normally start with as a setting for wheel positions is to line the inside wheels up, and with the rear track about 20mm narrower than the front. That 20mm shows up at the outside wheels by the outside-rear being inside the line of the outside-front by 20mm at about 6' off the ground (string line) – my theory being that because of independent front and live axle rear, the outside front camber of about 3 degrees will actually negate some of that 20mm in terms of where the front tyre's contact patch averages out. I don't want the outside-rear further outboard than the outside-front.

From what I'm used to, the Ford Anglia should have major understeer, but the driver said it was a bit loose

My friend's new car is actually a Ford Anglia 'classic' version of these other two types that I'm used to dealing with (run to pre-1976 rules), and it has some slight differences. The car builder has made the rear track much smaller than the front track (by 110mm overall), and both tracks are narrower than the more modern cars. This is where I'm having difficulty making a comparison between the car types and I'm not totally sure what it is I actually want to compare to try to get to the similar sort of front/rear grip balance.

Delving in my copy of Milliken: to get equivalency in load transfer in an independent front, I compare wheel rates relative to the track widths of the two cars, because load transfer alters with roll rate relative to the track, and roll rate is relative to wheel rate. Hence WR (narrow car) = WR (wide car) x (wide track/narrow track), at the front. This gives an answer I expected of a slight increase in front WR due to the front track widths of 58.2in and 54.8in (at centres of tyres).

To get equivalency in load transfer at the rear live axle, I compare roll rates based upon track width as before (58in and 50in respectively), but also take into account the ratio of spring bases squared in order to account for the narrower car having a narrower spring base and the effect that this has on roll rate. This gives a reversal in what happens at the front – which I still think makes intuitive sense. The result is that my simple calculation gives rear spring rates that are increased from 200lb/in to 263lb/in. I made the spring bases to be 42in and 34in respectively.

What is really puzzling me is that the calculations would say that – by comparison with what I'm used to – this classic car should have major understeer. However the driver was asking me about the car because it was a bit loose, with about the same diagonal weight percentage I would have started the car on anyway (51.5 per cent).

My main questions are: 1) am I doing all of the above right qualitatively? 2) is the lack of expected understeer due to the positions of the wheels?

I understand that if we take an outside wheel inboard it will make the car loose, but drive straighter. Is that simply what is happening here? I am tempted to think that he would benefit from widening the rear axle to get to a situation not unlike where I would start the modern cars (20mm narrower rear, perhaps). Before I tell him he needs a new axle, I would be grateful for your input.

I'm not wedded to the idea of making the load transfers equal, but I thought it would be a good basis for comparison. The modern cars are slightly lower in CoG, and the classic cars are on better tyres, so load transfer should be greater for the classic. (Racing is clockwise, quarter of a mile flat oval. Both cars are about 48 per cent rear with driver).

THE CONSULTANT SAYS

Right approach qualitatively? Well, partly. It's OK to try to get similar load transfer distribution to the old car as a starting point for the new car. Even if you get that, some adjustment is likely to be necessary. However, to use this approach correctly, you need to calculate total load transfers for both cases, including the geometric and unsprung components, and pick elastic components that make the distribution of those overall totals similar to the old car. Even if the new car has identical roll centre heights to the old car, all load transfer components, including the geometric and unsprung load transfer components, will be different with different track widths.

To keep the elastic angular roll resistance rate Kφ the same for a wheel pair when you change the track, the wheel rate in roll needs to vary inversely with the square of the track, not its first power. Varying the wheel rate inversely with the first power of the track keeps the linear displacements the same, but a given linear displacement at the wheel translates to a greater angular displacement when the track is narrower.

Similar distribution of Kφ to the old car will not give similar load transfer distribution when the tracks are changed by dissimilar percentages, nor will keeping linear displacements the same give similar load transfer distribution. The end where the track was narrowed more will see an increase in its percentile share of the load transfer.

Yes, moving the inside rear wheel inboard (or the outside one outboard) tends to add oversteer, particularly power-on. Exactly how big a factor that is in your case is harder to say, but we can be confident that there is some effect, and it is in that direction.

One other thing that happens when you narrow the rear track is that a given amount of tyre stagger acts like more, or at least the theoretical neutral or least-drag stagger for a given turn radius is less.

Aligning the inside rear wheel to the inside front wheel, and using the resulting line as a datum, is popular but I don't recommend it. Cars aligned this way will run well in some cases, but the method presents problems. It results in changes to the aim of the rear wheels any time you change wheel offsets, track widths or camber settings. I recommend having two parallel strings or lasers, one on either side of the car, positioned from some feature on the frame, not from the wheels. You then measure the alignment of all four wheels with respect to those lines.

From a practical standpoint, I guess you can just be glad the car was halfway decent on the first cut, and adjust from there, even if it was a bit different than you anticipated. Even with the best theoretical basis for an initial setup, you don't expect perfection the first time you run the car.

As an aside, I measured the front geometry for 'roll centre' purposes, and calculated based on your method with a 70 per cent resolution line. The anti-roll height was 3.5in static and 2.9in rolled 2 degrees. While looking at the car (on MacPherson struts) we decided that it could be lowered 1in at the front, which would bring it more level with the rear. So, I recalculated for the lowered condition and got much lower anti-roll heights of 0.5in static and 0.15in with 2 degrees of roll. I know that, basically, independent suspension should have low anti-roll height to

The camber recovery in roll diminishes to a very low value when we lower a strut suspension

John Young's Ford Anglia on the way to winning the 1960 British Touring Car Championship at Brands Hatch

QUESTION

Thanks for your answer – I had a feeling I was doing something wrong! I'll work it through more thoroughly like you say. I was hoping that I could shortcut that, but I guess I can't. The driver did report power-on oversteer as the problem, and he does have quite a lot of inside percentage when he's in the car, so I think we could space the inside rear outboard some more and pretty much stick with the spring rates he has now as a first guess before further testing. The tyres that are used don't have much stagger available, but I will certainly get the driver to check what sizes he has been using on the car.

avoid jacking etc, and I'm not worried by have so little anti-roll, because it has removed a lot of the side-scrub that was happening at the outside front, but this strut layout seems very sensitive to ride height change. I think that by reducing the ride motion (stiffer springing) we might make the car more consistent during pitch motion. I could try to alter the lower links to take the roll centre back up a bit, but that could lead to packaging problems with the rack and tie rods to eliminate the bumpsteer it would give. So my current plan is to stiffen the front springs to compensate for the lower anti-roll from the links, and bear in mind that the whole car may need to go stiffer in the future. Can you see any holes in my reasoning here?

THE CONSULTANT SAYS

It certainly is true that strut suspensions produce big changes in roll centre height with ride displacement. They have what I call a Mitchell index of considerably greater than one: with ride displacement, the roll centre moves the same direction as the sprung mass, and a considerably greater amount.

I don't know if I've mentioned this previously, but Bill Mitchell calls this quantity an 'incline ratio'. For a long time I couldn't understand why, but I finally found out. The term does refer to the slope of a line, as the name suggests. It just isn't a line that would appear on a geometry layout of the suspension. It's the line you get on a graph when you plot roll centre height as a function of ride height.

The camber recovery in roll also diminishes to a very low value when we lower a strut suspension. In some cases it may even go negative – the wheels lean more with roll than the body does.

I would agree with just accepting lower geometric roll resistance at the front, and less camber recovery, especially for an oval track application. Remember that when you only have to turn one way, not only can you use stiffer elastic components to control roll and camber, but you can also set the car up with any static tilt and camber you need to get the body and wheel attitudes where you want them in the turns. On production-based cars, available adjustment range may limit this. That will depend on the car, and the rules.

You can also control wheel load distribution with static settings. The static settings have relatively greater influence on entry and exit, and the elastic values have their greatest influence mid-turn. Knowing this, you can optimise balance in different parts of the cornering process, once you've got the general balance reasonably good.


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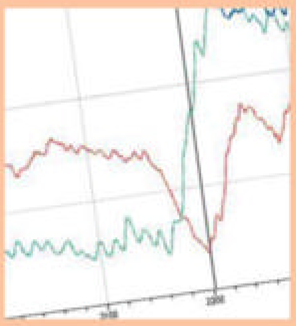


Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

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

The importance of finding the start line

A variety of systems and triggers are available to accurately locate the line on tracks and stages – essential for quality analysis

The most basic form of performance comparison is time. Even a vehicle with no electronics can be timed externally as it goes around a track, up a hill in a straight line or whatever else. But this is obviously nowhere near accurate enough for those interested in the ultimate performance.

Any data system will have some way of determining where the start/finish of a track or stage is. Currently the most common way of doing this is to have a beacon transmitter mounted on the pit wall and a beacon receiver fitted on the vehicle facing the transmitter. It's a tried and tested method that delivers reliable results. Other techniques such as using GPS coordinates have become more popular in recent years. There are also some more exotic ways of getting this information, such as connecting directly to the transponder system of a racecar.

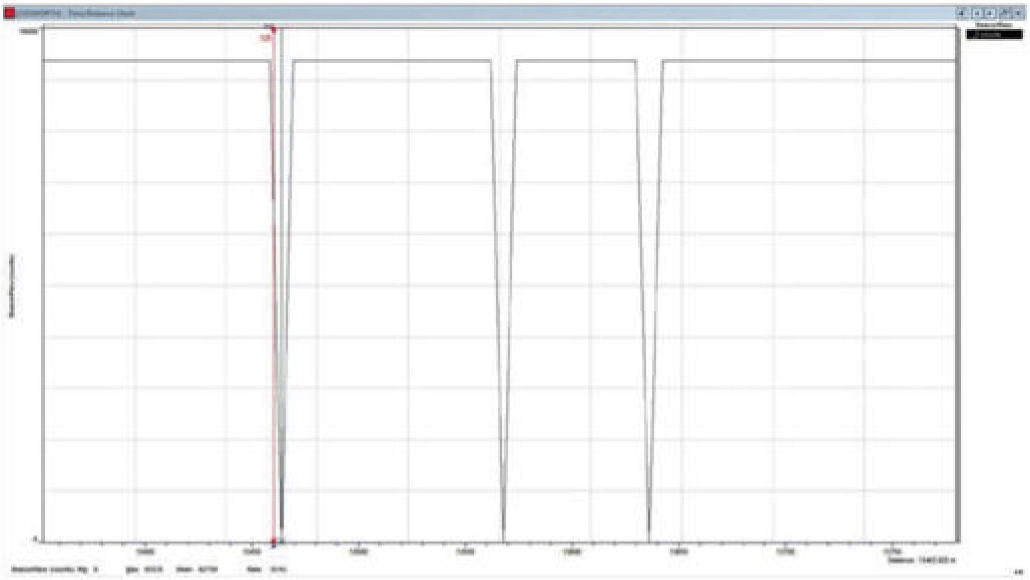
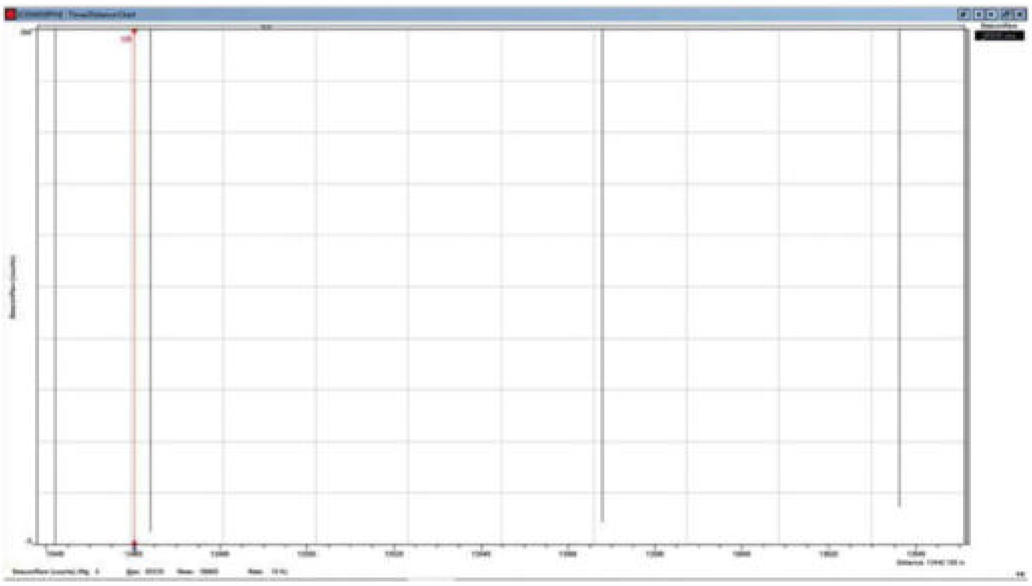


Figure 1: a typical trace of a beacon channel. Note that three beacon transmitters are seen, but only the first one is used as a lap trigger



The principle behind the lap trigger is always the same – a signal is changed based on an event that takes place when the vehicle crosses a certain point. The system then uses these to trigger the lap time count.

Infrared technology has been in use for beacon generation for a long time now and is a proven way of splitting an outing up into laps. A focused infrared beam is projected across the track and a suitable receiver is placed in the car and aimed

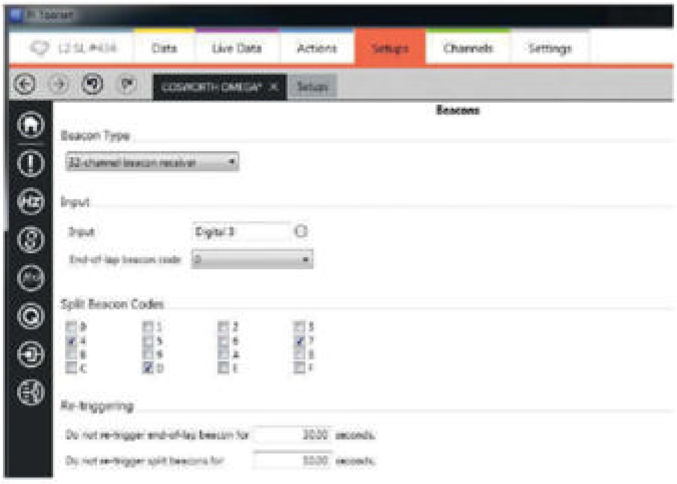


Figure 2: example of beacon configuration for a data system. 32 channels are available for different functions. Start/Finish Line is set to code 0 and splits are available on codes 4, D and 7

at the beacon transmitter. When the receiver sees a signal, the beacon output changes to indicate that the start/finish line has been crossed. This behaviour can be seen in **Figure 1**. There is a bit more to it than meets the eye, however. With some beacon systems it is possible to not just generate a pull-down signal, but also encode a channel in the infrared beam. This means that not only is it possible to get a lap beacon, it is also possible to identify the beacon transmitter in the data. This opens up the possibility to introduce an infrared split beacon around the track, a rally stage or hillclimb sprint. An additional feature is that it is possible to make sure that the beacon receiver only triggers on the intended beacon transmitter. Looking more closely at the BeaconRaw channel from the **Figure 1**, it is possible to see that each beacon pulse has a different identifier. Another method to make sure only one lap trigger is seen while passing a pit wall full of transmitters is to have a mask, or re-trigger time out, so that after one beacon is seen the system will ignore any subsequent beacons for a set period of time. This does, however, mean that the lap beacon seen may not be the one set out by the team.

With advances in GPS technology, more and more data systems have starting using these for track mapping, distance, speed and other functions. One of the great things about

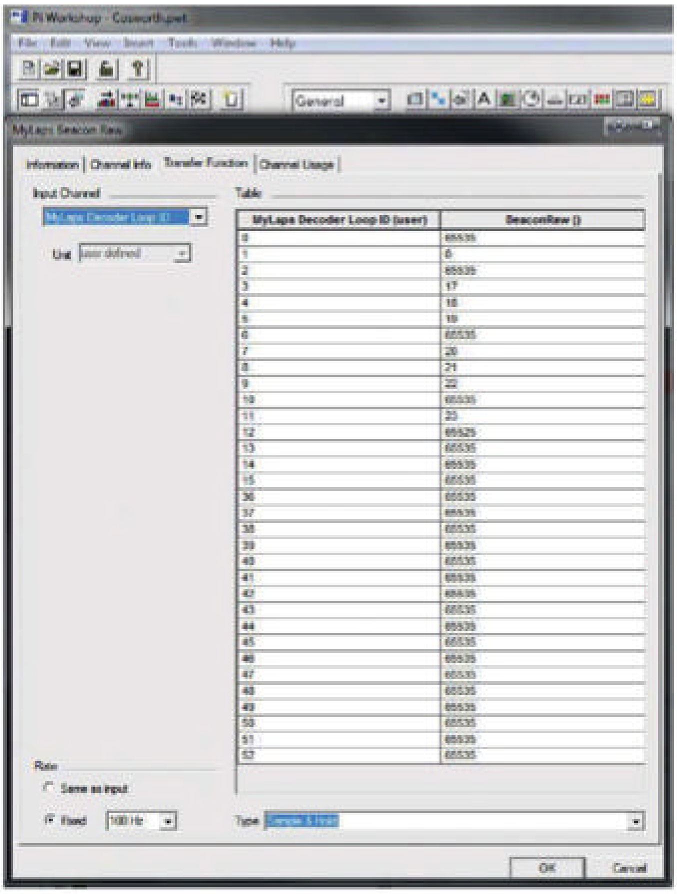


Figure 4: converting MyLaps loop IDs into the BeaconRaw channel. Note that ID 1 is end of lap and the seven split beacons

GPS is that it is possible to generate a virtual start/finish line in the data system configuration software so that no track side beacon is needed.

There is one drawback to any type of data system beacon technology: it is never quite the same as the official timing system. It can get very close, but it is never truly the same. It has always been the holy grail of lap timing to be able to tap into the vehicle transponder and use this as the lap beacon. This exact feature has been implemented by MyLaps in their X2 transponder and is used successfully in Indycar. The transponder sends its information to the data system via CAN and this information is then decoded to represent the beacon. This system goes even further, as the X2 transponder system has multiple crossing points around the circuit, all with different identifiers, which are transmitted to the data system. This means that not only is the lap beacon available, but also the splits.

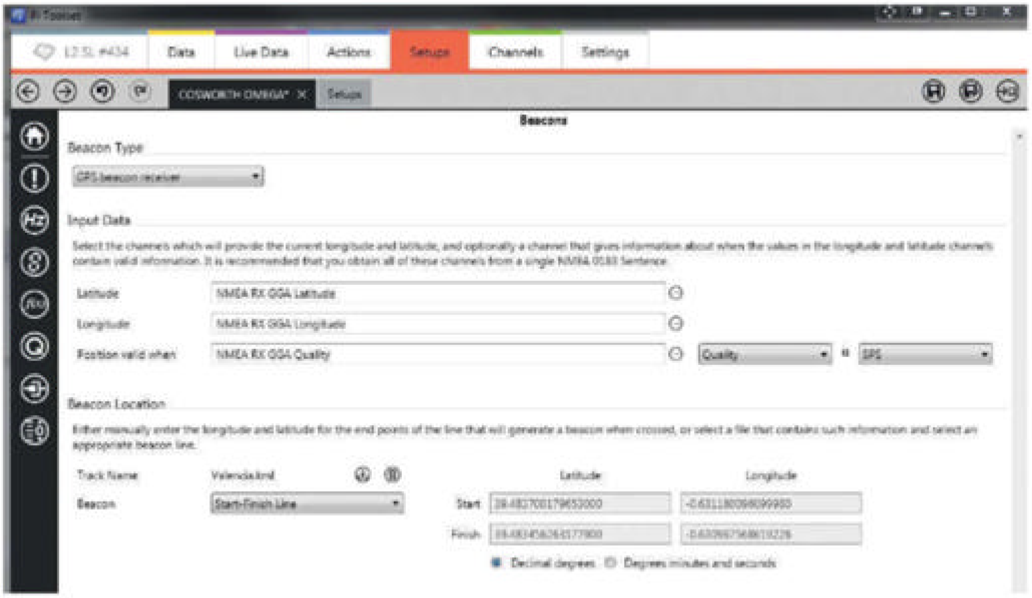


Figure 3: a .kml file can be used for coordinates of start lines. The GPS quality is monitored to ensure accurate readings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Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk. In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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Surprise Attack

Our look at Time Attack aero concludes, with some odd results

The technical regulations in Time Attack are still relatively open with respect to aerodynamics, and – coupled with high power outputs – high downforce without worrying unduly about drag has been the successful approach. *Racecar* has been examining the aerodynamics of these enthralling machines with two very different UK Time Attack cars in a session in the MIRA full-scale wind tunnel.

Jamie Willson's 2012 UK Time Attack Club Pro class championship-winning Lotus Exige was developed on a very modest budget with DIY graft and help from friends. Having recently undergone engine and aerodynamic development, the Exige will compete in the Pro class in 2013. In contrast, the second car was the latest eagerly-awaited creation from Roger Clark Motorsport, Gobstopper II, a sophisticated Subaru Impreza hatchback development. The car's predecessor won the UK Pro class in 2008 and 2009, and RCM aims to at least match that success with the new car.

FRONT WINGS

Both cars feature small chord front wings. The Exige's front wing was part width only and it was located ahead of the upper lip of the radiator inlet, a 'finger in the air' best first guess location, given that no information on this was available ahead of the wind tunnel session. The data in **Table 1** shows the effects of fitting the front wing relative to the previous configuration in 'counts', where one count equals a coefficient change of 0.001.

Table 1: the effects of fitting the small front wing to the Exige, 'delta' values in counts

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Fit front wing	-8	+3	+30	-28	+2.9%	+32

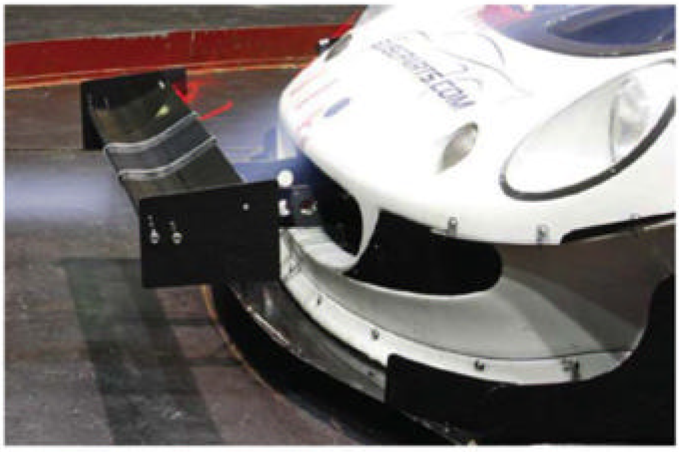
In short, the wing caused a small drag reduction, and a smaller total downforce gain, but it also created a fairly significant and useful balance shift to the front, given that more front downforce was required. But consider for a moment why drag should have reduced, for although the change was not large it was unusual. The smoke plume provides a clue, because it showed that the wing was turning the airflow upwards and robbing the flow into the radiator inlet. This would probably account for the small drag reduction, through less air encountering the restrictive radiator matrix, but this could also create a potential cooling issue, which with the power hike planned for the Exige would not be a desirable outcome. So, given that the front wing demonstrated its potential for adding useful front downforce, the concept itself seems sound, but clearly more work on exact location is required, perhaps with a higher and further forward position offering performance without compromise.

The front wing on the RCM Impreza was full width and evaluated over a small range of angles as well as without it altogether. The results are given in **Tables 2** and **3**.

Like the Exige, the Impreza exhibited modest reductions in

Table 2: the effects of fitting and adjusting the angle of the front wing on the Impreza

	CD	-CL	-CLfront	-CLrear	%front	-L/D
No front wing	0.600	-0.692	-0.090	-0.603	13.0%	-1.153
F/wing at min	0.591	-0.689	-0.085	-0.604	12.3%	-1.166
F/wing at med	0.584	-0.663	-0.123	-0.540	18.6%	-1.135
F/wing at max	0.585	-0.664	-0.130	-0.533	19.6%	-1.135



The Exige's front wing was a useful tool, but its location needs work

The Impreza's front wing – meanwhile – proved to be a potent balance shifter, though not necessarily for the expected reasons

The airflow from the front wing ends on the RCM Impreza may have affected the rear wing's flow field

The 'gills', blanked off with race tape here, in the rear of the Impreza's front end plates produced very interesting responses

The Exige's diffuser skirts behaved very differently to the side skirts

Table 3: the effects of fitting and adjusting the angle of the front wing on the Impreza relative to the no wing case in counts

	CD	-CL	-CLfront	-CLrear	%front	-L/D
F/wing at min	-9	-3	-5	+1	-0.7%	+13
F/wing at med	-16	-29	+33	-63	+5.6%	-18
F/wing at max	-15	-28	+40	-70	+6.6%	-18

Table 4: the effects of covering the gills at zero yaw

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Gills open	0.582	-0.650	-0.122	-0.528	18.8%	-1.117
Gills covered	0.584	-0.690	-0.092	-0.599	1.13%	-1.182
Change, counts	+2	+40	-30	+71	-5.5%	+65

Table 5: effects of the gills open and closed at 8 degree yaw, as changes in counts relative to 0 degree yaw

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Gills open, 8 deg yaw	+38	+7	-16	+22	-2.7%	-57
Gills closed, 8 deg yaw	+20	-79	-12	-68	-0.2%	-170

Table 6: the effect of removing the Exige's skirts, as changes in counts relative to the previous configuration

	ΔCD	Δ-CL	Δ-CLfront	Δ-CLrear	Δ%front	Δ-L/D
Remove diffuser skirts	-3	+4	-2	+7	-0.3%	+17
Remove side skirts	+14	-137	-70	-67	-3.6%	-291

drag with the fitment and – up to a point – the increasing angle of the front wing. Although the Impreza's front wing was mounted higher relative to the radiator inlet than the Exige's, the reason for the drag reduction may once again be that some air was being diverted from the radiator inlet. However, as the smoke plume over the centre of the Impreza's front wing showed, there was still some air emerging from the exit apertures up on the bonnet, and the only place this could have come from on this car was the radiator, so only part of the radiator flow had been diverted.

The response of the Impreza's balance to the different angles of front wing was interesting too. At minimum front wing angle there was very little change from the 'no wing' case, except perhaps a very slight loss of front downforce. However, at its medium and maximum angles the front wing created a significant balance shift, albeit that over half of this actually came from a loss of rear downforce, and with a loss of total downforce and efficiency too. So once again the front wing proved to be a potent balance shifter, but in this instance rather less efficiently. The smoke plume from the outer part of the front wing can be seen to encounter the lower extent of the rear wing end plate, suggesting that it will also have had an influence on the flow field of the outer sections of the rear wing, which may in part explain the loss of rear downforce.

FRONT GILLS

Another interesting feature on the Impreza was the vertical slots, or gills, in the front end plates, aft of the dive planes and just ahead of where the end plates sealed to the wheel arches. The gills were evaluated open and covered, and in both those conditions at an 8 degree yaw angle. The results are shown in **Tables 4** and **5**.

This was not the response that I expected, since covering the gills reduced front downforce while simultaneously increasing rear downforce enough that total downforce increased. Looked at the other way, the gill slots increased front downforce, decreased rear downforce and shifted balance significantly forwards. Clearly the car's yaw response was very different with the gills open rather than closed.

With gills open, the car lost very little downforce from 0-8 degree yaw angles, but it did exhibit a rearwards shift in balance, given that chassis dynamics analysis showed that the car would have mechanical oversteer under power. With the gills closed, there was minimal balance shift at an 8 degree yaw angle, but a significant loss of downforce.

LIFTING SKIRTS

Briefly touching on one last change before we move on to a new project next issue – the Exige had its skirts removed, first the diffuser ones then the side skirts, with the results shown in **Table 6**.

It's interesting that the diffuser skirts made little difference, but the side skirts did meet expectations as downforce reduced when they were removed!

Racecar Engineering's thanks to Jamie Willson and team, and to Roger Clark Motorsport

Against an enormously difficult and emotional backdrop, Le Mans 2013 was a very good spectacle

Strategic calls

Audi clearly had the superior package at Le Mans in the LMP1 category, while GTE went the way of Porsche

BY PAUL TRUSWELL

This year's Le Mans 24 hour race was a clear cut result overall, although the podium ceremonies were muted as the racing fraternity mourned the loss of the popular Dane, Allan Simonsen, who was killed in the first hour of the race when his Aston Martin crashed at Tertre Rouge after just three laps. It was the first fatality at Le Mans since Sébastian Enjolras was killed in pre-qualifying back in 1997.

After a lengthy delay, and following word from Simonsen's family insisting that Aston Martin continue their participation in his memory, the race resumed. And remarkably, set against this enormously difficult backdrop, Le Mans 2013 was actually a very good race.

Repeated safety car interventions and unpredictable weather conditions meant that deciding strategy (and perhaps more importantly, sticking to strategy) became virtually impossible.

Attrition was low - only 13 cars retired - and the Level 5 HPD Honda was also unclassified, failing by just one lap to complete the required 70 per cent of the winner's distance. As a consequence, over 75 per cent of the starters were classified at the finish: a record, if one overlooks the inaugural race in 1923. Never before have so many cars been classified at the chequered flag.

The fact that there were 11 safety car periods - another record - accounting for a total of 5 hours 35 minutes of the race under neutralisation (also a record), undoubtedly contributed to the low rate of attrition, and the distance completed (4743km) was less than any race since 2001.

Through it all, the No 2 Audi R18 e-tron quattro of Tom Kristensen/Allan McNish/Loïc Duval and the No 8 Toyota TS030 Hybrid of Anthony Davidson/Sébastien Buemi/Stéphane Sarrazin both had virtually trouble-free races, but the Audi always had the upper hand and ended up a comfortable lap ahead. The other factory hybrids from Audi and Toyota all had problems of one kind of another: the No 1 Audi losing nearly 12 laps having an alternator replaced; No 3 lost two laps following a puncture and a broken brake pedal; and the No 7 Toyota lost time initially running low on fuel, then with a slow puncture in the early hours of the morning, before Nicolas Lapierre lost control at the entrance to the Porsche Curves in the final stages putting the car completely out of contention.

MAIN PIC: JEFF BLOXHAM/LAT

TABLE 1: PIT STOP ANALYSIS – LMP1

		Average of best five fuel only stops	Average of best three full service stops	Number of stops	Number of fuel only stops	Total time in pits
1	Audi R18 e-tron quattro	58.019s	1m 23.407s	32	18	1h 29m 38.0s
2	Audi R18 e-tron quattro	57.996s	1m 21.367s	34	18	47m 14.8s
3	Audi R18 e-tron quattro	58.261s	1m 27.164s	30	17	46m 16.8s
7	Toyota TS 030 Hybrid	1m 00.243s	1m 27.509s	29	19	1h 07m 59.9s
8	Toyota TS 030 Hybrid	59.002s	1m 24.553s	30	17	43m 20.1s
12	Rebellion Lola Toyota	58.675s	3m 15.484s	26	7	5h 30m 08.3s
13	Rebellion Lola Toyota	59.719s	1m 31.000s	29	12	5h 24m 20.8s
21	Strakka Racing HPD Honda	1m 00.735s	1m 31.927s	29	8	49m 03.0s

TABLE 2: AVERAGE OF BEST 50 LAP TIMES – RACE

No.	Car	Time	Percentage
1	Audi R18 e-tron quattro	03:25.221	100.0%
2	Audi R18 e-tron quattro	03:26.145	100.5%
3	Audi R18 e-tron quattro	03:26.800	100.8%
7	Toyota TS030 Hybrid	03:28.708	101.7%
8	Toyota TS030 Hybrid	03:27.994	101.4%
12	Rebellion Lola Toyota	03:32.974	103.8%
13	Rebellion Lola Toyota	03:33.889	104.2%
21	Strakka HPD Honda	03:35.102	104.8%


ALASTAIR STALEY/LAT

The No 7 Toyota made fewer stops than any of the other top five LMP1 finishers

TABLE 3: GTE-PRO BEST LAPS

Pos	No	Car	Average of Best 50 race laps	Percentage
1	91	Manthey Porsche 911 RSR	03:56.648	100.0%
2	99	Aston Martin Vantage V8	03:56.670	100.0%
3	92	Manthey Porsche 911 RSR	03:56.871	100.1%
4	97	Aston Martin Vantage V8	03:57.015	100.2%
5	51	AF Corse Ferrari 458 Italia	03:57.658	100.4%
6	71	AF Corse Ferrari 458 Italia	03:58.020	100.6%
7	73	Corvette C6-ZR1	03:58.996	101.0%
8	74	Corvette C6-ZR1	03:59.381	101.2%
9	53	SRT Viper GTS-R	03:59.467	101.2%
10	93	SRT Viper GTS-R	04:01.062	101.9%

The big talking point before the race had been fuel consumption, and this had been exacerbated by a late change, allowing the petrol-engined LMP1 cars to carry an extra three litres of fuel.

And so it transpired, with the winning Audi only able to stretch to 11 laps when the average lap time for the stint dipped below 3m 35s. Interestingly, the No 3 Audi of Jarvis/Gené/Di Grassi was able to do 11 laps with an average lap time of 3m 29s, on several occasions, which the other two Audis were unable to achieve. The significance of this is put into perspective though, when you consider that the average lap time for Audi dipped as low as 3m 26s when track conditions allowed.

Toyota was losing around two seconds per lap in the dry, and also had to drop to 11 lap stints, although when it was damp, they could match the Audi pace and get 12 laps per stint. If the race conditions had remained consistently damp, the race might have swung Toyota's way. Having said that, the evidence of **Table 2** removes any doubt that Audi's package was the quicker one at Le Mans this year.

It is also worth noting that the winning Audi was particularly efficient in the pits (see **Table 1**). The ACO asserts that the refuelling rig restrictors are adjusted to ensure that the refuelling times are similar, regardless of the amount and type of fuel. It is hard to argue that this data shows any different. However, it is curious that there are significant differences between cars from the same team. The LMP1 cars were eclipsed, in terms of the total time spent in the pits, by their GTE cousins.

GTE BATTLES

The battle for honours in the GTE-Pro class was far more open and in many ways more entertaining than in LMP1. Unfortunately, the first safety car period broke up the race somewhat, separating the first three cars from the rest.

The graph on page 53 shows the progress, through the race, of the two Aston Martin V8 Vantages (Nos 97 and 99) and the Manthey Porsche RSR (No 91), using the class-winning Porsche No 92 as the baseline. This shows how the Aston Martins could have reasonably hoped for a one-two result, until first Frédéric Makowiecki's accident, and then No 97 falling back at the end with a loose floor, contrived to relegate David Richards's team to the third step of the podium.

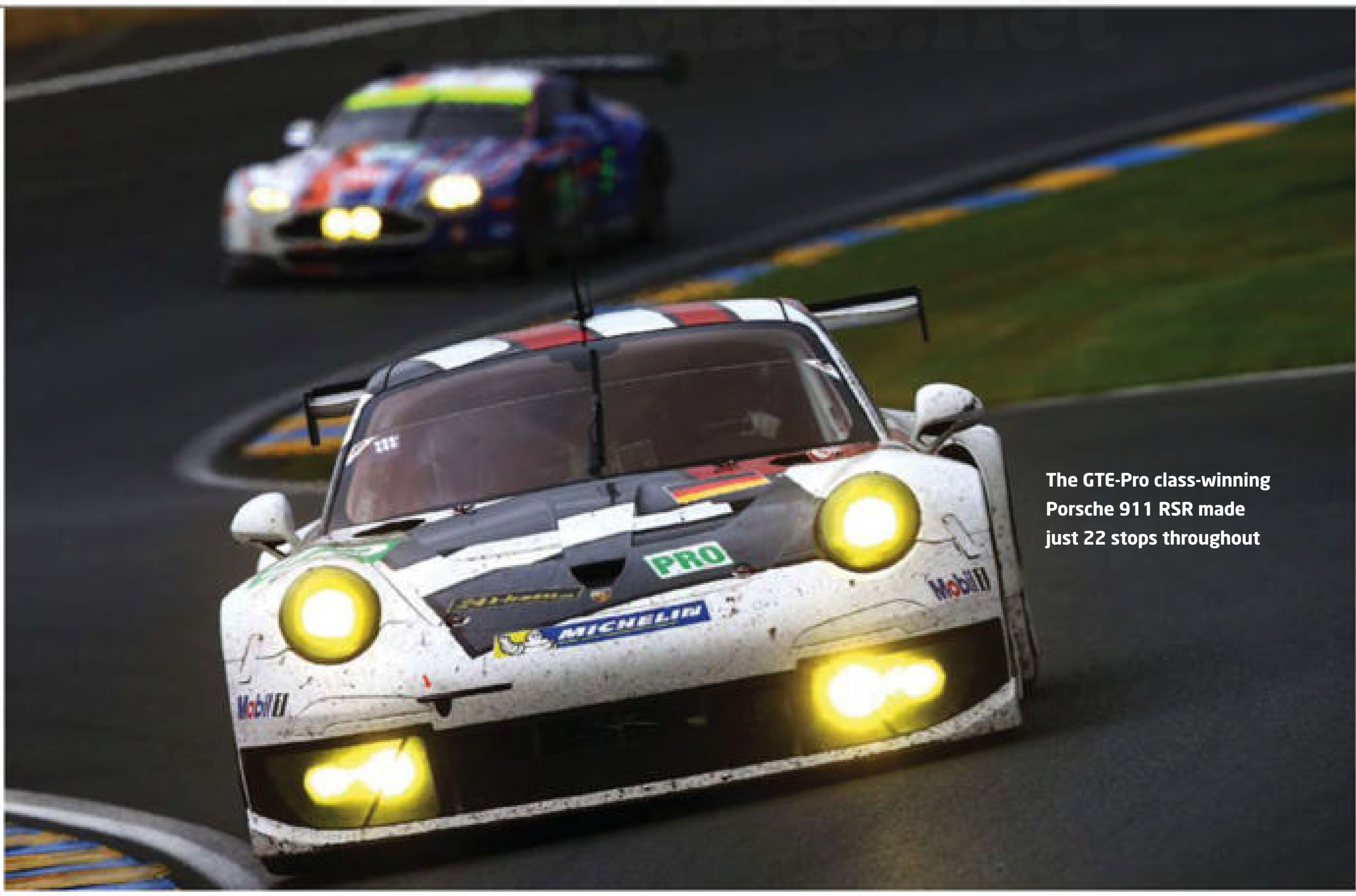
Before we look at what went wrong for Aston Martin Racing though, let's examine the fundamental performance characteristics of the cars. Firstly, there's the ACO's Balance of Performance. Certainly, there has been no shortage of debate and discussion, with changes being made up until the very last minute, in an attempt to satisfy the various lobbying parties.

In terms of outright lap times, **Table 3**, which shows the average of the best 50 laps during the race, seems to indicate that Aston Martin and Porsche are fairly well-matched. Indeed, the fact that the top 10 is separated by less than 2 per cent is a reflection that the Endurance Committee is getting it more or less right.

In terms of top speed though, **Table 8** (page 53) shows clearly that the Ferraris and Porsches have the edge, while the Vipers are disappointingly slow. However, **Table 6** (page 50), which shows the time taken to get through the Porsche Curves, indicates that the Vipers make up time through the fast corners – and also provides a clue as to where the Aston Martin's true advantage lies.

In addition to performance, Le Mans is all about efficiency. With a race that was disrupted by safety car periods and variations in the weather, it was not easy to establish patterns, but **Table 7** (page 50) shows the longest stint achieved by each of the manufacturers in the GTE-Pro class, and the corresponding average lap time.

It is interesting to note that the longest stint from the Viper was just 13 laps (for the purposes



The GTE-Pro class-winning Porsche 911 RSR made just 22 stops throughout

WRI2

TABLE 4: GTE-PRO PIT STOP ANALYSIS

Pos	Car No	Car	Number of pit stops	Number of stops under safety car	Total time in pit lane	'Corrected' time in pit lane	'Estimated box time'	Approx fuel used (litres)
1	71	**Ferrari 458 Italia**	23	2	33m 12.177s	30m 14s	18m 33s	1,617
2	92	**Porsche 911 RSR (991)**	22	1	31m 17.050s	29m 55s	18m 44s	1,726
3	73	**Corvette C6-ZR1**	23	4	38m 49.119s	33m 54s	22m 13s	1,684
4	91	**Porsche 911 RSR (991)**	24	1	36m 25.205s	35m 02s	22m 50s	1,644
5	97	**Aston Martin Vantage V8**	24	4	41m 08.970s	35m 10s	22m 58s	1,878
6	51	**Ferrari 458 Italia**	23	3	45m 41.484s	41m 05s	29m 24s	1,442
7	74	**Corvette C6-ZR1**	25	4	48m 09.916s	43m 14s	30m 32s	1,706
8	53	**SRT Viper GTS-R**	28	2	49m 54.812s	48m 34s	34m 20s	1,913
9	93	**SRT Viper GTS-R**	26	2	58m 57.481s	56m 05s	42m 52s	1,811

TABLE 5: GTE-PRO BOP SUMMARY

	Weight (kg)	Restrictors (mm)	Gurney (mm)	Fuel Capacity (litres)	Height of wing from roof (mm)	Ride Height (mm)
Porsche GT3 RSR (997)	1210	29.6	25	90	0	55
Porsche GT3 RSR (991)	1210	29.6	25	90	-100	55
Ferrari 458	1235	28.3	25	85	-100	55
Corvette C6R	1260	29.2	25	90	-25	55
BMW Z4	1260	29.4	25	90	0	55
Aston Martin Vantage	1225	29.7	None	95	0	50
SRT VIPER	1245	29.6	25	95	-25	55

of this analysis, stints involving safety car periods are excluded), and the Aston Martins were also unable to achieve 15 laps unless the safety car was out. However, Porsche, Corvette and Ferrari all did stints of 15 laps, albeit at a slower average lap time, but without the additional assistance of the safety car to slow the pace. It will certainly have been useful to extend the stint length whenever the weather prevented lapping at the car's full potential.

The implication from this is that if the Aston Martin did not have the additional five litres fuel allowance, then it would not even be able to manage 14 laps at a pace to keep up

The LMP1 lap time table removes any doubt that Audi's package was the quicker one this year

ALASTAIR STALEY/LAT

The No 3 Audi R18 e-tron quattro was able to go 11 laps at a sub 3m30 average, better than the other Audis

TABLE 6: GTE-PRO PORSCHE CURVES

Pos	No	Car	Average of best 50 times through Porsche Curves (secs)	Percentage
1	97	**Aston Martin Vantage V8**	19.755	100.0%
2	99	**Aston Martin Vantage V8**	19.767	100.1%
3	53	**SRT Viper GTS-R**	20.129	101.9%
4	93	**SRT Viper GTS-R**	20.278	102.6%
5	91	**Manthey Porsche 911 RSR**	20.299	102.8%
6	74	**Corvette C6-ZR1**	20.302	102.8%
7	92	**Manthey Porsche 911 RSR**	20.308	102.8%
8	73	**Corvette C6-ZR1**	20.311	102.8%
9	71	**AF Corse Ferrari 458 Italia**	20.437	103.5%
10	51	**AF Corse Ferrari 458 Italia**	20.511	103.8%

with the Porsches. Such is the way of Balance of Performance adjustments.

The rate of attrition in the race was low, no doubt due in part to the record length of time spent behind the safety car. In the GTE-Pro class, there were only two retirements, both of them AMR Aston Martins. But even more astonishing is that those that did finish did so without encountering any serious issues. Not one car in the class spent more than an hour in the pits, as **Table 4** (page 49) shows. Moreover, six of those spent less time in the pits than the Audi R18 that won the race outright.

In **Table 4**, the 'corrected' time is an estimate to take account of the fact that, while the safety car is in operation, cars may only leave the pit lane to join the end of the queue of cars circulating behind the safety car. This means that one can spend up to 2m 30s stationary, waiting for the lights to go green.

TABLE 7: GTE-PRO STINT ANALYSIS

Car	Maximum stint length	Best average lap time
Ferrari 458 Italia	15	4m 06s
	14	3m 58s
SRT Viper GTS-R	13	4m 00s
Corvette C6-ZR1	15	4m 06s
	14	3m 59s
Porsche 911 RSR (991)	15	4m 05s
	14	3m 57s
Aston Martin Vantage V8	14	3m 57s

In the GTE-Pro class there were only two retirements, both of them Aston Martins

I have also attempted to calculate 'Box Time' – this is the time actually spent stationary in front of the pit garage having work done on the car, since the 'pit stop time' that is issued by the race organisers includes the time spent driving down the pit lane at the mandatory speed limit of 60kph.

Refuelling at a rate of around 3 litres per second means that the Astons and Vipers spend more than 10 minutes getting fuel into the car, leaving precious little time left over for changing tyres, brake discs, etc.

But let's get back to looking at the race. Inevitably, it breaks down into a series of phases. In the first phase, the No 91 Manthey Porsche dropped back as the safety car managed to slot into the 5.3 second gap that separated it from the car in front (the No 99 Aston Martin) and that meant that the gap, once the green flag was given, had gone up to a seemingly insurmountable 1m 20s. This reduced the race for GTE-Pro honours into a battle between effectively just three cars – the two Aston Martins and the singleton Manthey Porsche.

The three-hour period of green flag racing between laps 12 and 68 provides an interesting opportunity for analysis: during this time the Manthey Porsche and the two Aston Martins (Nos 97 and 99) each made four pit stops. One was used to change tyres (and driver), the others were fuel only. Track conditions during this period were variable, but under the motto that 'it was the same for everyone', comparing the average lap times for this period is reasonable and shows that the No 97 was quickest, at 4m 00.766s; the No 99 second, at 4m 01.230s; and the No 92 Porsche third at 4m 01.485s. Further back down the road, the No 91 Porsche also made four stops, but changed tyres twice, which cost an additional 25s, but was lapping in any case at a slower pace: its average was 4m 02.168s.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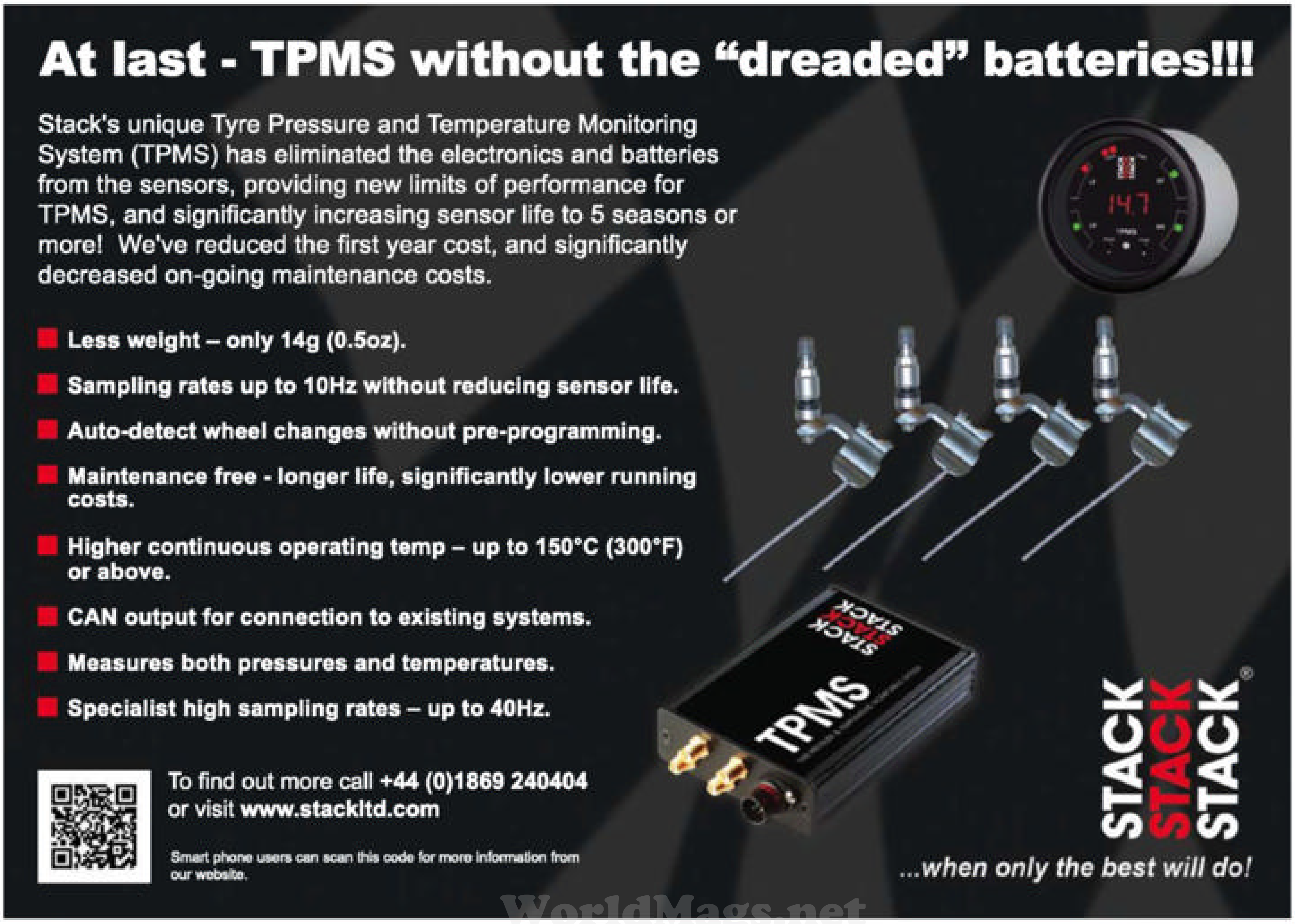
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By the time the safety car appeared for the second time, the race looked to be heading AMR's way, but in the drier conditions, and due partly to the way that the safety cars fell after 8pm, stalemate began to set in.

The cool track and low air temperatures meant that the Michelin tyres would last three stints, and on more than one occasion, both the Manthey Racing Porsches chose to change drivers, but not the tyres, during a stop.

Both Aston Martins fell back significantly just after half distance. The No 97 made four pit stops in the space of 15 laps – firstly to change the brake discs and secondly to resolve a problem with the door. The No 99 Aston also lost ground, making two pit stops in three laps as it had work done on the brakes.

The period on the graph from 4am to 8am was as long a period of green flag running as the race provided (53 laps), and throughout this time the GTE-Pro class was led by the No 92 Porsche. Again the track conditions were extremely variable, as showers swept across the track, but comparing average lap times for the period reveals that the Vantage V8 was quicker. The No 97 Aston Martin's average was 4m 01.006s, No 99 was 4m 01.141s and the No 92 Porsche 911 RSR was 4m 01.800s. The other 911 was still more than a minute behind, but if the safety car periods had prevented it from closing up, it wasn't losing any ground either – its average lap time was 4m 01.188s.

At 8am, the No 99 Aston got a boost, as can be seen on the graph. This came about after Bruno Senna had just completed a 14-lap stint and was on his out lap when the No 98, driven by Bill Auberlen, blew its engine on the Mulsanne straight, causing the safety car to be deployed. The other Aston Martin and the No 92 Porsche both had enough fuel to get to the end of the yellow period, but were caught out as the safety car was then immediately re-deployed to deal with the aftermath of the Rebellion Lola's crash at the second chicane.

This left Makowiecki at 09:40, with a 17 second advantage over Marc Lieb in the Porsche, who was a scant 2 seconds ahead of Peter Dumbreck in the No

The safety car leads the pack, headed up by a Larbre Competition Corvette, through the Ford chicane BLOXHAM/LAT

TABLE 8: GTE-PRO TOP SPEEDS

Pos	No	Car	Top Speed in race (kph)	Percentage
1	51	AF Corse Ferrari 458 Italia	294.8	100.0%
2	71	AF Corse Ferrari 458 Italia	292.4	99.2%
3	91	Manthey Porsche 911 RSR	292.4	99.2%
4	92	Manthey Porsche 911 RSR	292.4	99.2%
5	97	Aston Martin Vantage V8	290.0	98.4%
6	99	Aston Martin Vantage V8	290.0	98.4%
7	73	Corvette C6-ZR1	289.3	98.1%
8	74	Corvette C6-ZR1	289.3	98.1%
9	53	SRT Viper GTS-R	286.9	97.3%
10	93	SRT Viper GTS-R	285.4	96.8%

97 AMR Aston. With little over five hours to go, it was indeed a finely balanced affair.

Then the rain started again and Makowiecki crashed violently into the barriers on the exit of the second Mulsanne chicane, and bringing out the safety cars once again.

The graph of the race shows the remaining Aston Martin gaining the upper hand over the Porsche towards the end of the race, shortly after lap 280. This was due to a longer pit stop for the Porsche at 12:23, as Richard Lietz took over from Marc Lieb, and the tyres were changed. This allowed Darren Turner in the Vantage to lead until 13:16 (lap 295), when he handed over to Stefan Mücke.

After 8pm, cool track and low air temperatures meant the Michelin tyres would last for three stints

GTE-PRO GRAPHICAL SUMMARY

As the race headed into its final hour, a grandstand finish in the class seemed assured, but the weather and fate took a sudden and very serious turn for the worse. With the rain teeming down at all parts of the circuit, but not forecast to last more than a few minutes, decision-making time was short. The Aston was in the wheel-tracks of the Porsche as they arrived at the Ford Chicane to complete 302 laps. Surprisingly, the Porsche continued – it seemed nobody on the pit wall was sufficiently decisive to call Lietz into the pits – but Stefan Mücke brought the Aston Martin in. The Vantage had been suffering from a vibration at speed, caused by a loose floor, and some five minutes were lost while it was re-attached.

Simultaneously, there was carnage at the exit of Arnage, as the TDS Oreca went off, and the safety cars were deployed again. This enabled Lietz to back off and drive with appropriate caution on his slicks, while the Aston waited at the pit lane exit for the lights to go green, having missed the passing of two safety cars. The rain was already abating, and the team chose to put slicks on the Gulf-liveried machine.

Meanwhile, Lietz stayed out until the clock ticked past the top of the hour, enabling him to pit and take on sufficient fuel to get him to the flag, as well as more appropriate tyres. Back at Aston Martin, Mücke had enough fuel to get him to the end of the race, but with the class win now out of his grasp, they decided to stop for wet-weather tyres for the final half-hour.

It was an unfortunate way to end what had been a devastating weekend for Aston Martin Racing. Calling strategy with hindsight is always easy, but had Mücke been instructed to 'copy whatever Lietz does', as they arrived at the end of that crucial 302nd lap, depending on how bad that vibration was, the outcome could have been very different.

TABLE 9: SAFETY CAR PERIODS

Reason	From lap	To lap	From time	To time	Leader laps	Total laps	Time	Cumulative time
Aston No 95 off at Tertre Rouge	2	10	15:09	16:07	9	9	00:58	00:58
Clean-up of debris from Alpine No 36	76	78	20:07	20:21	3	12	00:14	01:12
Debris on track – Lotus No 32	78	80	20:24	20:31	3	15	00:07	01:19
Oreca No 25 off at Porsche Curves	118	120	22:49	23:04	3	18	00:15	01:34
Ferrari No 57 off at Porsche Curves	134	136	23:54	00:09	3	21	00:09	01:43
Lola No 30 off at Porsche Curves	171	175	02:18	02:40	5	26	00:22	02:05
Ferrari No 54 off at Esses – extended owing to rain	181	190	03:03	04:08	10	36	01:05	03:10
Oil on track from Aston No 98	255	259	08:06	08:36	5	41	00:30	03:40
Debris on track – Lola No 13 2nd chicane	260	265	08:38	09:14	6	47	00:36	04:16
Aston No 99 off at 1st chicane	275	280	09:51	10:28	6	53	00:37	04:53
Oreca No 46 off at Arnage	334	340	13:47	14:29	7	60	00:42	05:35


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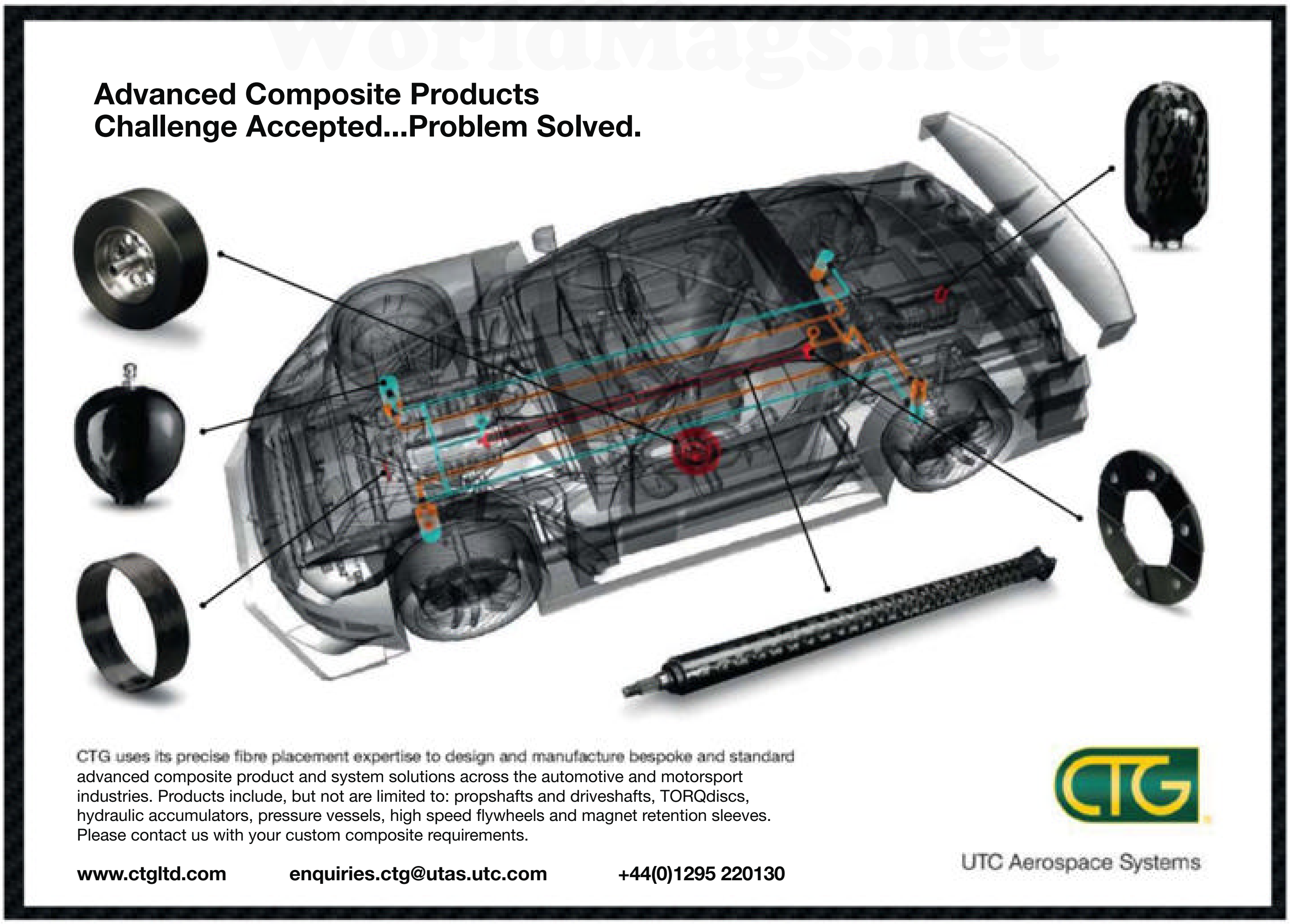
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Taking simulation to the next level

Going beyond simple calculations, software can be a real weapon for engineers

BY DANNY NOWLAN

When most people think about racecar simulation, they usually think about it as a tool you throw springs and bars at to determine the minimum lap time possible. In reality this is barely scratching the surface, because when you use a proper racecar simulation package, it can tell you so much about the car. When used this way, simulation isn't just a tool to predict lap times and refine setups – it becomes a weapon.

The foundation stone of any branch of engineering is to quantify what you are doing. I've had the privilege of working with a number of different race teams, including many champions in their respective categories. The thing that gives them that winning edge is they can quantify what is going on with their cars. If you're serious about winning, having a glorified spreadsheet doesn't cut the mustard – you must know how those numbers got there.

The first case study I'd like to present is when a colleague of mine was provided with two tyre compounds from a supplier. The claim was that there shouldn't be too much of a difference between them. The reality was that one compound provided a good balance to the car, while the other suffered from chronic understeer. This prompted a lot of head-scratching.

To resolve this matter, my colleague ran the ChassisSim tyre force estimation toolbox. This is the kid brother of the ChassisSim tyre force modelling toolbox, and the tyre force estimation feature returns an approximation of the traction circle radius vs load curve. While it doesn't delve into all the computer code that makes this work, what this toolbox does is take race data, calculate the tyre loads, and then using other information such as steer angle, it minimises the following function (**Equation 1**):

$$cf = \left| a_{y\_act} - a_{y\_sim} \right|$$

Here we have:

- cf = cost function – a measure of the error
- a_{y_act} = the actual measured lateral acceleration
- a_{y_sim} = simulated acceleration

Effectively we are performing a number of track replays, and we change the parameters of the tyre model to minimise the error. This is the thing that makes the tyre force estimation and modelling toolboxes of ChassisSim so powerful. We are not using tyre rig data – this is actual track data from real world conditions. It's one of the key reasons that ChassisSim is able to achieve correlation like that shown in **Figure 1**.

This was a tyre model generated solely from race data, using the tyre force modelling toolbox. The actual data is coloured, the simulated is black. As we can see, the steering angles, speeds, accelerations and damper movements are almost indistinguishable. I can't speak for other simulation packages, but I think that this throws into sharp relief some of the criticisms I have seen about where simulators draw their tyre models from.

Both compounds were run through the tyre force estimation toolbox. There was not much difference in the rear, but the front compounds were very different. The overlay is presented in **Figure 2**.

For confidentiality, these have had to be normalised. However, you can see as plain as day that there is a discrepancy between the baseline compound and the revised compound. With this sort of difference, it is no wonder that the car suffered from severe

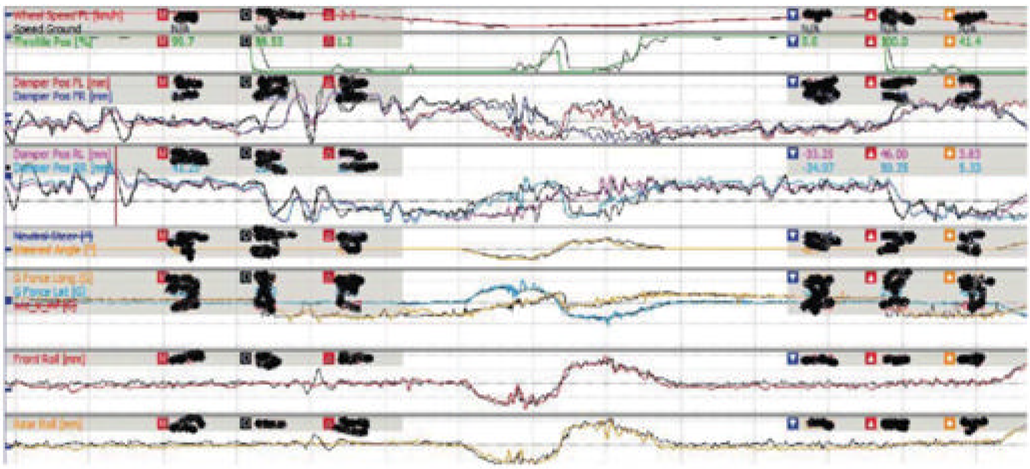

Figure 1: stockcar correlation (actual vs simulated)

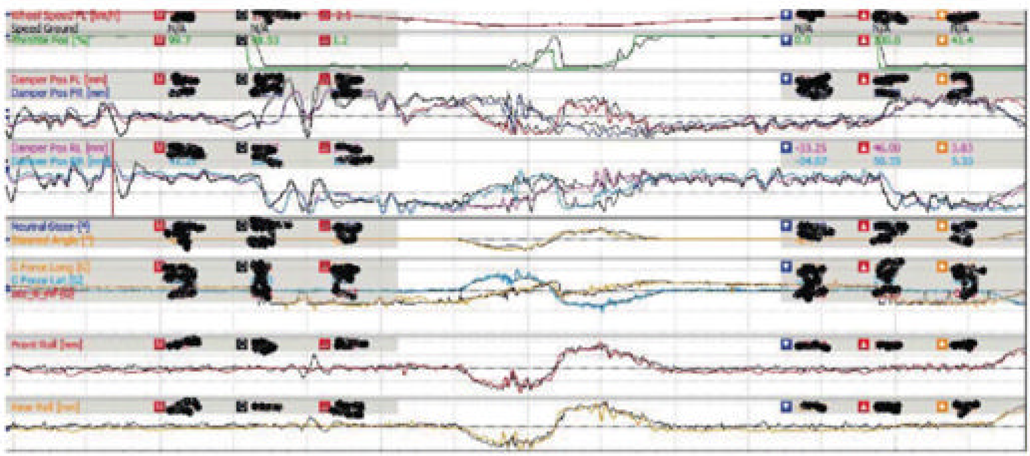

Figure 2: normalised plot of traction circle radius vs load for different tyre compounds

understeer. However, the lesson to be learned is that we can use tools such as the ChassisSim tyre force estimation and modelling toolbox to capture this. Indeed, a colleague of mine compared this to a tyre force dyno. From the correlation we see in **Figure 1** and the results from **Figure 2**, it would be very unwise not to make good use of this.

The second case is using your simulator to pick when a motion ratio is incorrect. In most cases you actually don't need to go as far as a simulator. If you're running a monoshock or a twin spring car with linear ratios, it's pretty easy. This is a good rule of thumb that I follow:

- **Filter the dampers**
- **Note the damper movement on the longest straight**
- **Calculate the spring forces**
- **Use this to calculate the load at the tyre**
- **If you have reliable strain gauges, cross-reference the loads**

By the time you get down to the fourth step, you should know if something has gone wrong – you'll either have an outrageous large tyre load or a very small one. Just as a point of observation, I will only perform cross-referencing on strain gauges if I can put my hand on my heart and know that they are reliable.

Where the simulator comes into play is if you're dealing with a car with high downforce that is using third springs with very different motion ratios to the main ones. This is a situation that a colleague of mine found himself in, and this is where the simulator came to our aid. Before I discuss how we did this using ChassisSim, here's the procedure for doing it by hand:

- **Filter the dampers**
- **Using the main spring motion ratios, convert this to wheel movement**
- **Convert back to main spring and third spring movements**
- **Note the damper movement on the longest straight**
- **Calculate the spring forces**
- **Use this to calculate the load at the tyre**
- **If you have reliable strain gauges, cross-ref the loads**

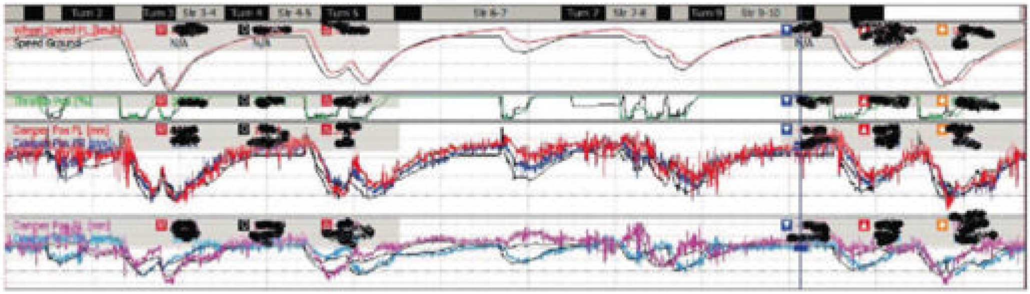

Figure 3: a comparison of actual to simulated data with the baseline motion ratios

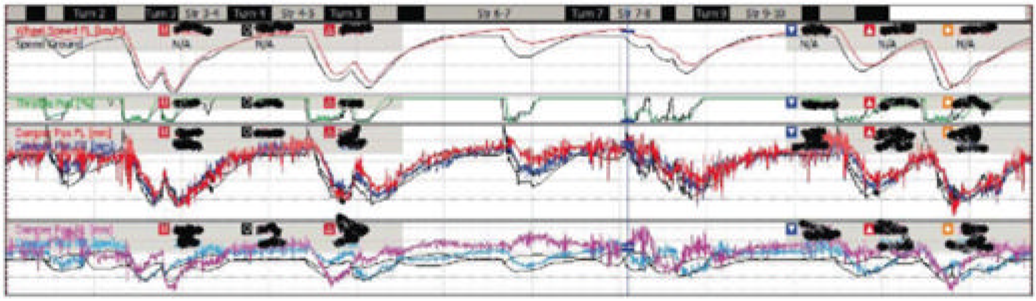

Figure 4: revised simulated comparison

Using ChassisSim, the giveaway that we had a problem was when the aero toolbox was returning outrageous values for downforce. The aero toolbox takes race data and calculates the downforce drag and aero balance. This feature can be used to generate aeromaps from race data. In this particular case, the CLA exceeded a value of 15. When you see something like this, it's pretty clear that something has gone very wrong, and almost certainly points towards something in the motion ratio that wasn't right. I also knew that the third springs were running very aggressive bump stops.

To resolve this issue, we put in some baseline aero numbers that made sense, and looked at the comparison of pitch and roll to real data. What we did here was to run a simulation with curvature only and no bumps. The baseline comparison is shown in **Figure 3**.

The actual data is coloured, the simulated data is black. Again, due to confidentiality, the scales and values are all blacked out (this is also the case for **Figure 4**). As we can see, the front dampers aren't too bad. However, the rear damper traces are not compressing enough on the straights. The giveaway here is in the corners. As we can see, the simulated vs actual roll isn't too bad. They are not on top of each other, but this isn't what we are looking for at this point. This indicates clearly that the main spring ratios are not the problem – what we need to address is the rear third spring motion ratio. As a rough rule of thumb, if there is a big discrepancy in the dampers, the first thing you look at is motion ratios.

So, taking an informed guess we inverted the motion ratios and this resolved the problem. The revised comparison can be seen in **Figure 4**.

As can be seen in pitch, the rear in particular is significantly better. At this point in the analysis we are not looking for picture perfect correlation – we just need to be within a couple of mm. This is what we have achieved in this comparison. At that point, the numbers were re-run through the aero toolbox and they where far more representative.

While this example might border on the trivial, it shows that your simulator can be used to quantify very quickly if there is an error in your car measurement. One of the major benefits of using racecar simulation is that it is the ultimate motorsports calculator that will quickly quantify if there have been any errors in measuring up the car. What we have just seen here is a perfect case in point.

The last case study I want to talk about is the use of the ChassisSim shaker rig toolbox. It wasn't that long ago that I wrote a dedicated article about this, but this toolbox is now starting to get significant traction right across the ChassisSim community. What we are about to discuss has been used in categories as diverse as touring cars, high downforce open wheelers, FIA GT and stockcars/touring cars.

First things first – let's discuss setting up and running the ChassisSim shaker rig toolbox. This is outlined in **Figure 5** over the page.

The comments and filenames are pretty self-explanatory. Just put in something relevant to the setup and store the log file where you are going to remember it. However, the controls you need to pay attention to are the speed of the test and the peak input velocity of the road input.

You choose the speed of the test to choose the corners you want to simulate. If you want to simulate a low speed corner choose, say, 100km/h, or if you are looking at a high speed corner, choose somewhere in the region of 150-170km/h. You'll also notice that you have an option

Simulation can quantify if there is an error in your car measurement

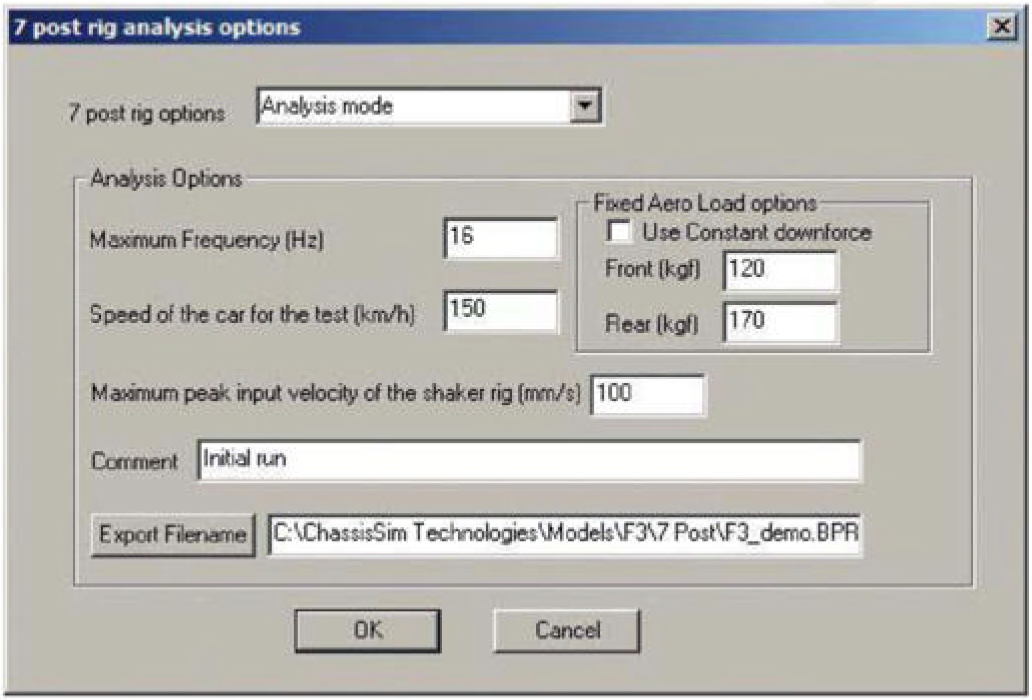

Figure 5: setting up a frequency run

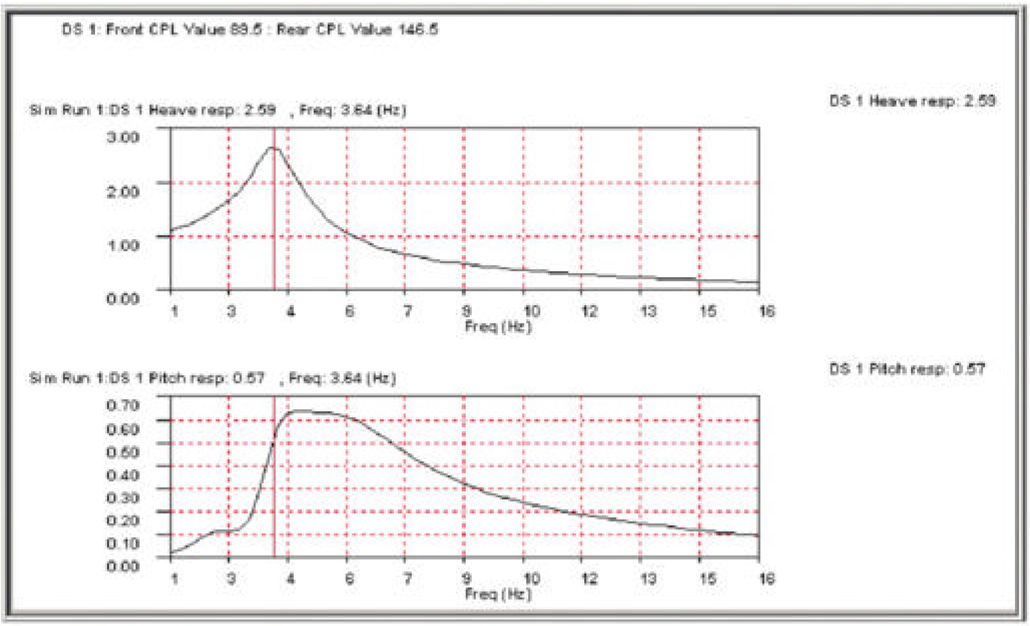

Figure 6: output of the shaker rig toolbox

to set the downforce at a fixed value. This is OK for validation work, but personally I prefer to leave this off. The reason is that the ride height map will affect the frequency response of the car, and in high speed corners this will really make its presence felt.

In terms of the peak input velocity, you choose a value that represents the peak input velocity that is representative of the road input. There are a number of ways you can do this. For a rough rule of thumb, 50mm/s approximates a relatively smooth surface, 100mm/s is middle of the road, and 150mm/s denotes a pretty bumpy circuit. Another way you can do it is to look at the data. Look at the peak damper velocity and divide the results by, say, about 3. It's a rough measure, but it will get you by. If in doubt start the test at 100mm/s.

In terms of what this toolbox is, it will return a plot of output amplitude on input amplitude. The output of the toolbox is shown in **Figure 6**.

You'll see that the Contact Patch Load variation (CPL) is shown in the top of the graph. This is averaged over the whole frequency run and the units are kg. This is the delta load variation from the static load for the conditions specified for the test. The plots below are the ratio of output vs input amplitudes. Here we have shown heave and pitch for a heave input to the car.

However, the real power of this toolbox is tying the CPL figures with the frequency response. This technique was actually pioneered by a colleague of mine – Pat Cahill – when he was engineering a GT car at Bathurst in 2011. The technique is actually breathtakingly simple. The first part of the process is that you play with springs and large damper adjustments to minimise CPL. What will happen is that when you get into the zone, the CPL will hit a minimum and actually won't vary too much. Once you hit this, you start playing with minor spring and damper changes to get the shape of the frequency response that you want. It's really that simple. This technique has been used very successfully in cars with CLA numbers from 1.2-2.7. The result of this has been a marked improvement in mechanical grip without compromising driver feel.

The key to all the examples we have spoken about is this: don't go silly with the simulator, and always look closely at the results. Remember that a simulation package – at its core – is just a glorified calculator. Yes it's a powerful one, but bear in mind that the real power of this is the end user making good use of the results. A case in point was when an apprentice of mine was looking at some downforce sweeps for a low downforce circuit. ChassisSim pointed him towards low downforce and forward aero balance. The numbers it came out with weren't particularly outrageous, but they were a tad aggressive. At this point I reminded him of this principle. The simulator gives you a direction, but you always temper it with experience. This is why we started the car with more downforce and less aero balance. As the drivers got up to speed, we ultimately headed that way. The moral of the tale is that the simulator is just one of many inputs you'll use to make your decision.

In closing, I think that you can start to appreciate that a racecar simulation package isn't just a tool to predict lap times and refine setups. When used properly and appropriately, it can quantify what the tyres are doing, help you nail down motion ratios, and genuinely understand the frequency response of the car. If truth be told, we have just scratched the surface of what we can do with simulation. If you use a simulation package in this manner, it will be a weapon you can't do without.


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Fast access to essential parts

Modern 3D printing and prototyping systems are making key components and prototypes available in a matter of hours – a godsend for the racing industry

BY CHARLES CLARKE

Rapid prototyping was the term given in 1986 to the process of transforming a virtual computer model directly into a physical 3D object that you could hold in your hand. The only company in the market at the time was 3D Systems, who used a laser to change a photo-polymer from liquid to solid in a process called stereolithography. SLA is the acronym for stereolithography apparatus.

Since then we have had other companies and other processes entering the market; Selective Laser Sintering (SLS) from EOS and Fused Deposition Modelling (FDM) from Stratasys. These have introduced new materials and because the components made by these processes were made from 'normal' materials like nylon and aluminium. This has given rise to the term rapid manufacturing (RM), as the components can be used straight from the rapid prototyping machine. RM has variously been referred to as desktop manufacture (DTM), but now the commonly accepted term for the whole technology from rapid prototyping to rapid manufacturing is additive manufacture (AM).

Then, with companies like Z-Corp and Objet entering the market, along came 3D printing in the late-90s. The term 3D printing – otherwise known as solid imaging – was coined because these technologies used a printing head much like an inkjet printer head to create the objects, rather than a laser in a solidifying or melting process.

With the move to 3D printing, there was an effort to bring the process from the workshop into the office and even into DIY or domestic use, the idea being that you would have a 3D printer on your desk alongside your 2D one. Prior to the modern 3D printing movement, all these AM technologies were industrial or semi-industrial processes.

Now there are growing numbers of parts on F1 cars and in other formulae made using AM techniques. In order to save space, much of the pipework for the McLaren F-duct was made this way. The beauty of this technique is that it can make parts with infinitely variable geometry that are impossible to make by any other more traditional manufacturing process.

CRP Technology is a leading producer of the Windform materials and constructor of AM parts for the racing industry. It has offices in Modena, Italy and Mooresville in North Carolina.

'We've had rapid prototyping since the mid-80s, but now there's a strong movement towards using the technology for rapid manufacture,' says Franco Cevolini, Group CEO and technical director of CRP. 'This is particularly the case in racecar situations where the speed of manufacture helps to get the racecar to the track as quickly as possible.

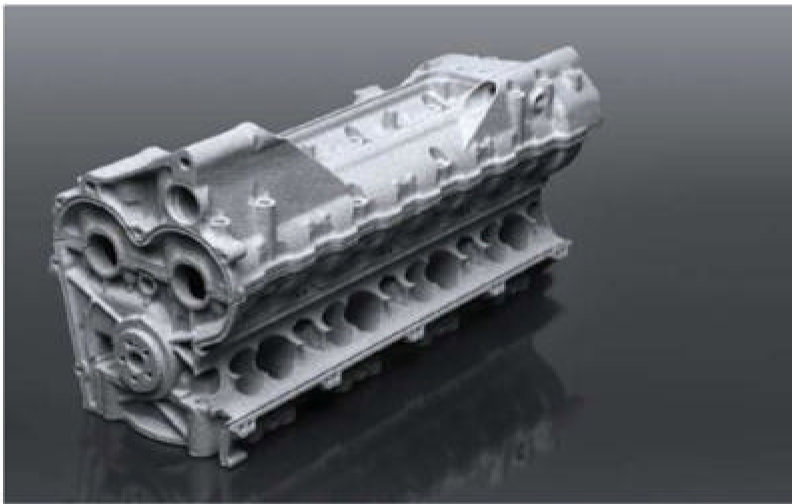
'Rapid manufacturing techniques are widely used in F1, and CRP has two different kinds of technologies,' continues Cevolini. 'There is the technology for plastic composite parts along the lines of our Windform materials, and now we can also make metal parts.'

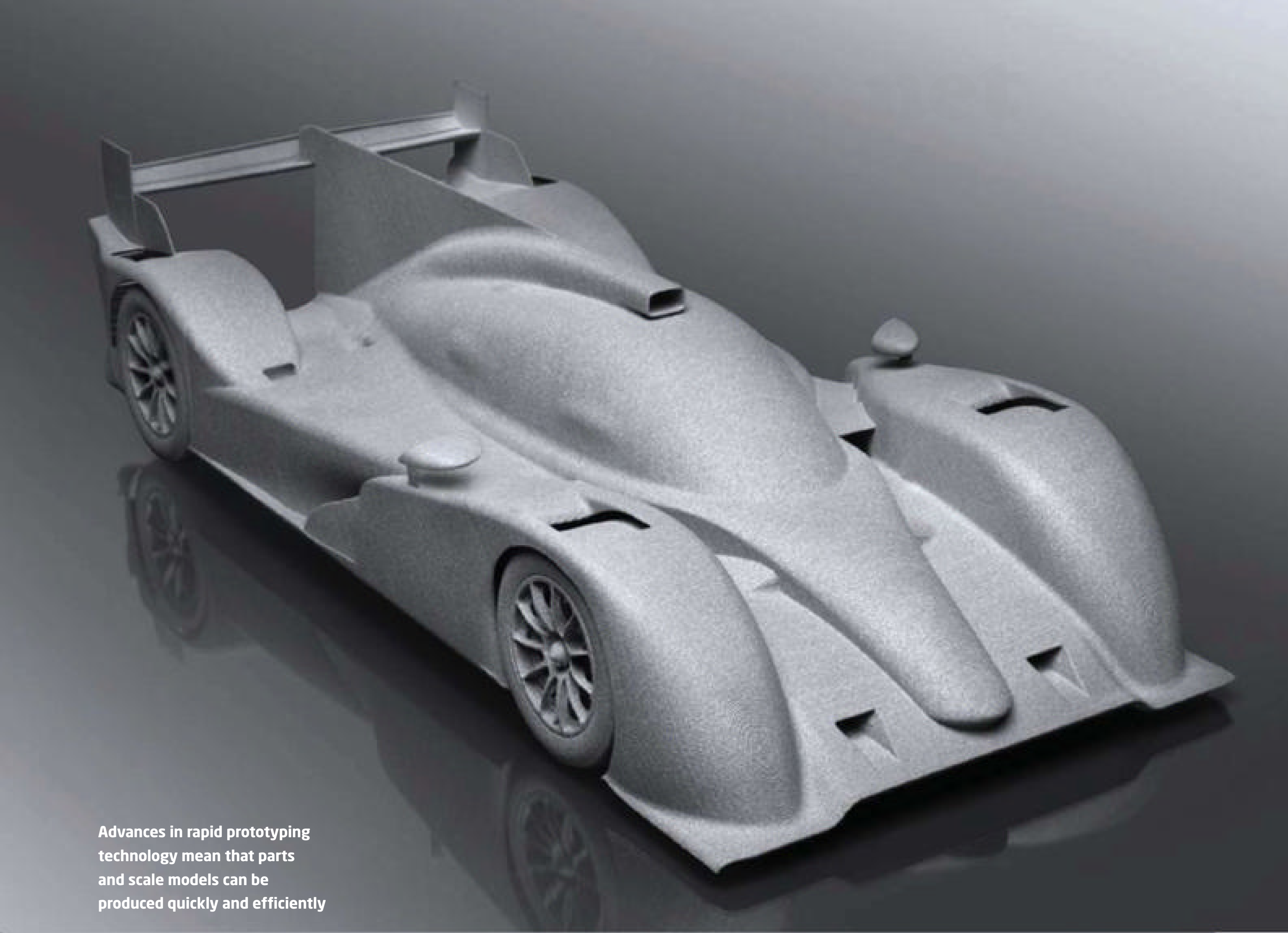
The composite parts are mainly used for aerodynamic features and cooling systems, brake ducts and for other cooling ducting for keeping various components like the clutch or electronic systems at their preferred operating temperature.

'It's also very important to have the right cooling for the new turbo engines in F1 next year,' says Cevolini. 'These engines need to be fitted with a thermal energy recovery system [TERS] that converts the heat generated and usually wasted by the turbocharger into electrical energy, so efficient ducting will be crucial.

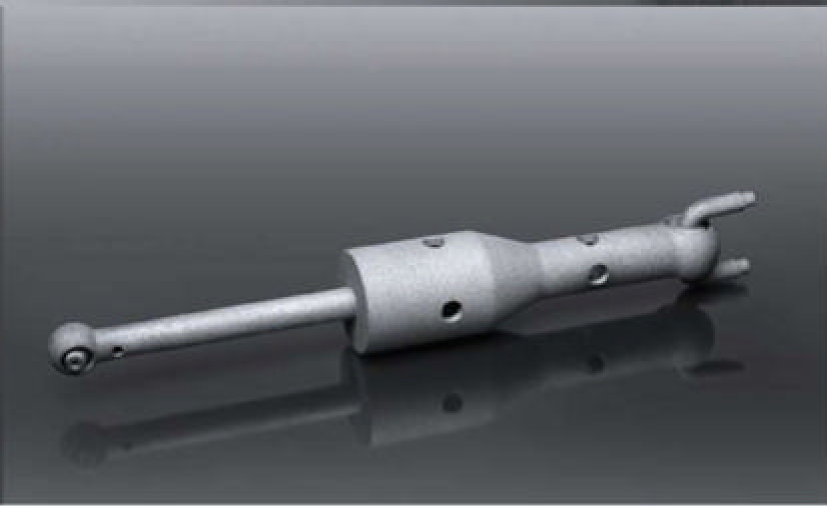
'We use SLS, which is a very free and flexible technology compared to other 3D printing technologies like SLA or FDM. With SLA and FDM you are limited by the fact that the model must be supported while it's being generated. With SLS, the model is submerged in a container full of unsintered powder or metal granules that support the 3D object during manufacture.'

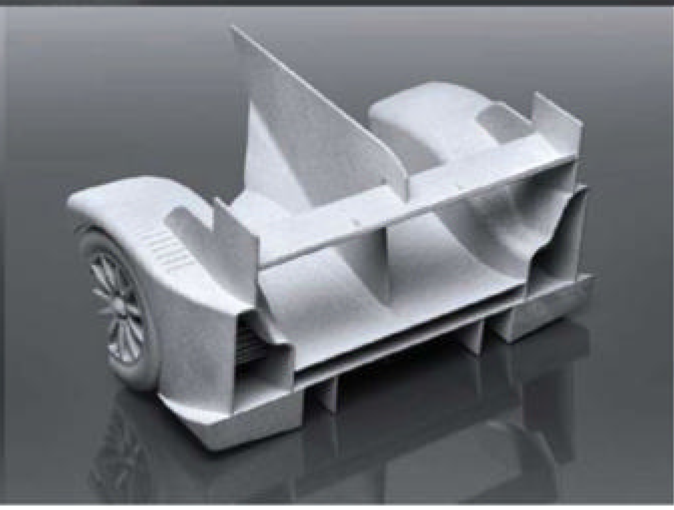
At CRP they also have two technologies for the production of metal parts: Direct Metal Laser Sintering (DMLS) and Electron





Advances in rapid prototyping technology mean that parts and scale models can be produced quickly and efficiently





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Beam Melting (EBM). In both cases, metal powder is melted using lasers or electron beams. These are quite new technologies that have yet to reach their full potential, compared with the other AM processes. Consequently, the process is quite slow and the machines are quite small, so you are currently restricted to making smaller parts.

'We produced a number of roll hoops using EBM technology and titanium,' says Cevolini. 'Inside the snorkel air scoop on an F1 car there is usually a metal or carbon fibre structure that transmits the load of the car, should the car turn upside down and so protect the driver. This roll hoop structure is subject to rigorous FIA testing, so the ability to generate it using rapid prototyping is very beneficial. Also, the roll hoop is mounted very high on the vehicle, so to minimise its inertia it needs to be made as light as possible. With rapid prototyping technology, it's possible to make structures with complex internal voids or honeycomb-like strengthening. These internal structures cannot be made by any other process, so weight for weight a rapid prototyped roll hoop is far stronger than a fabricated one. Using EBM technology it's possible to make the whole roll hoop in titanium.'

Very little additional finishing is required other than tidying the component and milling the location lugs. It can then be bonded to the rest of the chassis and subjected to the FIA test. Taking this technology to the extreme – and with the future availability of larger machines – it should be possible to make a suspension upright this way. However, the FIA decreed in the new rules that all uprights should be CNC machined from solid aluminium, so here we have a technology that could potentially reduce the cost of a fairly expensive component, but it can't be used because of the FIA rules.

'We started to develop the Windform rapid prototyping materials specifically for motorsport applications,' says Cevolini. 'When we started with rapid prototyping in 1996, we recognised its potential, but there were a lot of limitations from a motorsport point of view, because of the kind of materials that were available at the time. So we started to develop our own and Windform was born.'

These materials are now widely available, and since CRP's recent Nasa accreditation they can also be used for aerospace components.

'Every time we develop a new material, we start by maximising its mechanical properties, its strength, abrasion resistance and durability, and now with the new requirements of F1, we're looking particularly at improving the thermal properties of the material,' says Cevolini. 'We already have applications where temperature is an issue, and so we are working to improve the heat resistance of our materials. With the new regulations in F1 governing the V6 turbo engines, there will be lots of heat issues in relation to ducting and bodywork.

'If you look at the calendar for F1, there is often not a lot of time between races, so all our F1 customers are coming to us asking for race-ready parts straight from the rapid prototyping process. The expectation from them is to find a technology that can produce parts quickly that will fit straight on to the car. They should not involve any other process, other than minimal hand finishing and fitting. Rapid casting, or RIM casting, is now too slow for F1.

'What I see for the very near future is a need to improve the reliability and speed of the machines and to develop machines that produce more production-ready parts, rather than prototypes. We also need machines that can make bigger AM parts from "real world" materials quickly without the need for any complex finishing process.'

The history of rapid manufacturing at Enstone began in 1998, when the first 3D Systems SLA 5000 was installed for rapid prototyping. This machine was originally acquired to assist the packaging of the racecar – getting everything to fit within the tight confines of the aerodynamic surfaces. Very soon its potential to assist in the wind tunnel was noticed by the aerodynamicists of the then Benetton F1 team when they saw the complexity and quality of the components coming from the SLA 5000.

Pratt and Miller used a 3D ZPrinter to create a model of their GTE car, but quickly adapted to developing moulds for carbon fibre parts

'Once the team got their first 3D Systems machine, they used it to develop component prototypes with a size/fit function,' says Dirk de Beer, head of aerodynamics at Lotus F1. 'It then gradually expanded from rapid prototyping to wind tunnel model manufacturing, allowing our aero department to grow from 11 to 80 employees. In wind tunnel testing, aerodynamics is an empirical science. We design and compare new ideas and choose directions to follow. The more ideas we can compare and evaluate, the more successful we will be on the track.

'The car model in the wind tunnel features a complex network of pressure sensors. These were positioned by drilling pressure tappings into metal and carbon fibre components before SLA technologies became available. The ability to produce complex AM solids with intricate internal channels has revolutionised our ability to place these sensors and increase their numbers. It's a dream come true for aerodynamicists!'

Lotus now has nine of these machines – five SLA iPro 8000 systems, one SLA 7000, one Sinterstation Pro 140 SLS system and two Sinterstation HiQ SLS systems – which today allow direct manufacture of production parts for the racecars.

"All our F1 customers are coming to us asking for parts straight from the rapid prototyping process"

In practical terms, the Lotus F1 Team can not only test more than 600 components per week in the wind tunnel, but also build some racecar parts directly from digital data using CAD and SLS technology. Using SLS, complex car components are produced in hours rather than weeks, and in some cases the part is ready for inspection before the drawing has even passed through the system.

The Lotus F1 Team's ultimate goal is to use digital manufacturing as a fully industrialised technology to deliver race-ready car parts in volume to reduce cycle time and cost. Lotus is looking forward to the development of materials by 3D Systems that can withstand the intense temperatures – around 250degC – found in an F1 car.

MACHINE HEADS

Joe Gibbs Racing (JGR) has 70 cars running in NASCAR and other series. It boasts a machine shop of 15 CNC machines, busy round the clock making parts for all the cars. It was tough to get machine time for prototyping, and a five-week backlog left new designs stuck in the concept phase longer than desired.

At JGR, new design concepts must balance weight reduction, power increase and control with handling improvement, while adhering to NASCAR's rules. This yields extremely complex part designs. 'When milling these prototypes, we could have as many as seven machine setups. This was an inefficient use of our machines and manpower,' says Mark Bringle of JGR. 'A prototyping system can make these complex parts in one operation, and it doesn't require CAM programming.

'We evaluated nine prototyping technologies, but settled on the Stratasys Fortus fused deposition modelling process for two reasons. FDM didn't require any facility modifications, and because we wanted to model with the strong thermoplastics available for FDM – polycarbonate and polyphenylsulfone. We can build prototypes tough enough to bolt on to the car, even the engine block, and they can take the heat.

'With our FDM machine, we can start building new concepts 15 minutes after CAD work is

complete, and prototypes are ready within a day. Previously, prototyping took a minimum of a week, and the delays became longer when the inevitable design changes occurred. Now, with the FDM machine, we make the changes and build another prototype immediately.'

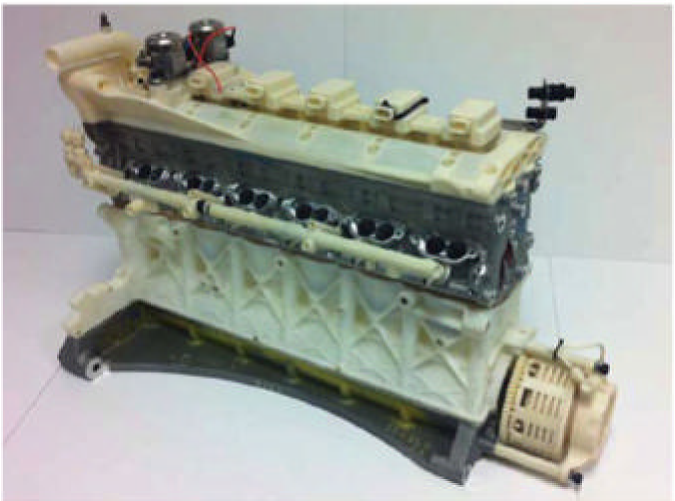
After only a few months of prototyping, JGR cleared its backlog of new design concepts. 'The FDM process allows our engineering team to get great ideas on to the cars quickly,' says Bringle. 'This has been a big factor in our success and FDM has permanently changed the way we do business. The drivers, the crew chiefs and the chief designer are all amazed, even slack-jawed, at what we can do with FDM and how it has changed our process.'

Toyota Motorsport GmbH (TMG), in Cologne has one of Europe's largest concentrations of rapid manufacturing machines under one roof. It boasts 10 stereolithography machines (SLA 5000 and SLA 7000 units) and two large-frame laser sintering machines (P700 and P360 units). This flexible and adaptable technology allows even the most complex objects to be produced as single structures, whether for use as finished parts or wind tunnel models.

TMG's rapid manufacturing systems make as many as 2,000 unique parts a month at peak season. 'No matter where you are in the world, production can begin on your part at TMG within just a few hours of receiving a suitably detailed 3D CAD model or STL file. Then we can quickly turn your innovation into reality,' says Alastair Moffitt of TMG. 'And you can be sure of a smooth and trouble-free process thanks to our machines, which allow round-the-clock supervision and instant reaction to any problems. Utilising video and internet technology, we can make part production faster and more reliable than ever before.'

Pratt & Miller has developed many race programmes, including Corvette Racing, the most successful team in the history of the ALMS. They originally got their full colour 3D ZPrinter (3D Systems) for marketing

Thermoplastics have developed sufficiently to allow heat-sensitive areas of the car, including the engine block, to be created using FDM



purposes to communicate their capabilities and boost enthusiasm for their products.

They soon discovered that they could use the ZPrinter to create wax infiltration moulds for carbon fibre part production. The moulds not only work remarkably well with wax infiltration to produce accurate parts with smooth surfaces, but they can be used for multiple runs.

This unexpected reusability translates into time and materials, saving on moulds and reprinting. This helps teams to focus their energies on more creative designs.

The success of wax infiltration moulds led to yet another innovation in the form of lost mould casting, which has enabled Pratt & Miller teams to achieve extremely complex parts with fully smooth interior surfaces, enhancing airflow.

Effective methods such as these are a tremendous part of the ZPrinter's contribution to Pratt & Miller, enabling the engineering house to produce racecars more quickly. The ZPrinter saves time, and has increased profitability. 'It's ideal for what we're trying to achieve,' says lead design engineer Gary Latham.

Laser Lines Ltd, based in Banbury, has been involved with Stratasys and rapid prototyping for over 20 years. One of the largest applications to emerge is the use of FDM technology to produce soluble core mandrels to aid the manufacture of carbon composite components such as ducts and fluid pipes. The main challenge here was utilising both the equipment and operating software for an application it was not initially designed for. The use of FDM SR-30 soluble cores

"Drivers, crew chiefs and the chief designer are all slack-jawed at what we're able to do with FDM"

has now been adopted by many of the top F1 teams.

The Stratasys FDM technology builds parts in engineering grade thermoplastic materials. Although not normally associated with high performance, many companies have exploited both novel and demanding uses for AM parts, with many examples of FDM ULTEM-9085 components being installed directly on to the car.

Prodrive utilised parts built on a Laser Lines Stratasys FDM system to develop their Mini John Cooper Works WRC and the Aston Martin Racing Vantage GTE. As the Mini was developed, a total of 18 key components were identified for direct digital manufacture, with two further parts made as a result of FDM tooling. The direct digital manufactured parts included various display pods, sensor housings, dust caps and ducting. Even wheel arch extensions proved robust enough to be used on the competition car.

One example of FDM tooling used by Prodrive was a flexible airbox duct. The duct was required for the engine air intake. The fastest and most cost-effective route was clearly AM. FDM masters were produced by Prodrive in just 52 hours with six hours of finishing – compared to traditional methods which would have taken two weeks. 'There were two different versions of the brake ducts for the Aston Martin,' says Rick Simpson, former chief designer at Aston Martin Racing. 'One set were ABS, but we did some rapid tooling by wrapping carbon fibre pre-preg around soluble FDM mandrels.

'The rear inner fender linings on the Aston Martin were produced using FDM thin panel layup tools,' says Allen Kreemer of Stratasys.

For Prodrive, functional prototypes provided durability, risk reduction, fast iterations and 24/7 access.

The end-use parts offer no limitations due to machine tool availability or manufacturability, no tooling costs and no obsolescence. Small wonder then, that these rapid prototype technologies are taking motorsport by storm.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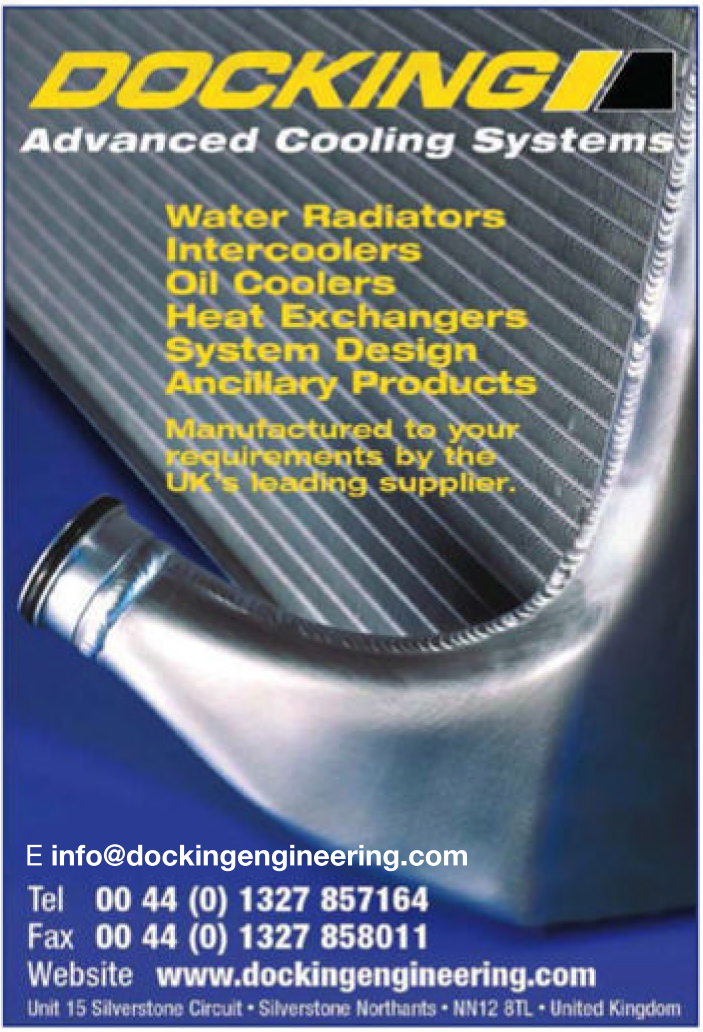
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The cold war

The current crop of heat exchange systems are working harder than ever to help engines provide peak performance

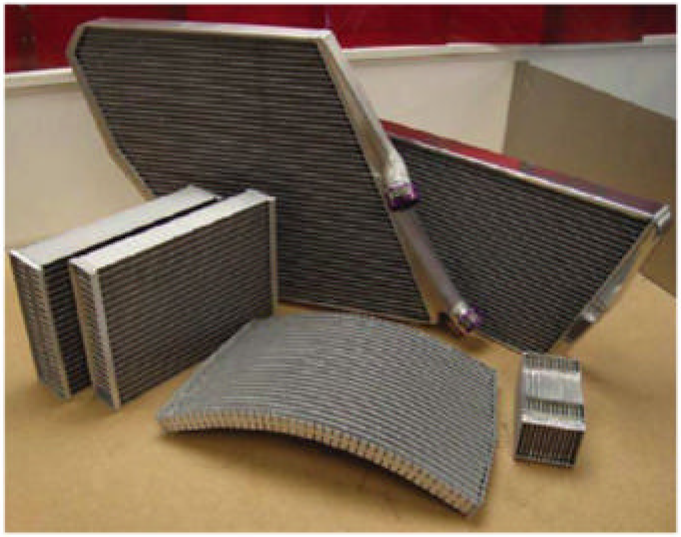
BY GEMMA HATTON

Every racing team in the world is trying to generate more horsepower. It is a function of the pounds of air that is passed through the engine per minute. And when air is cooled, it compresses, becomes denser and increases the rate of airflow entering the engine. Of course, the more air in the cylinders, the more fuel required, the higher the combustion rate and therefore the more horsepower generated.

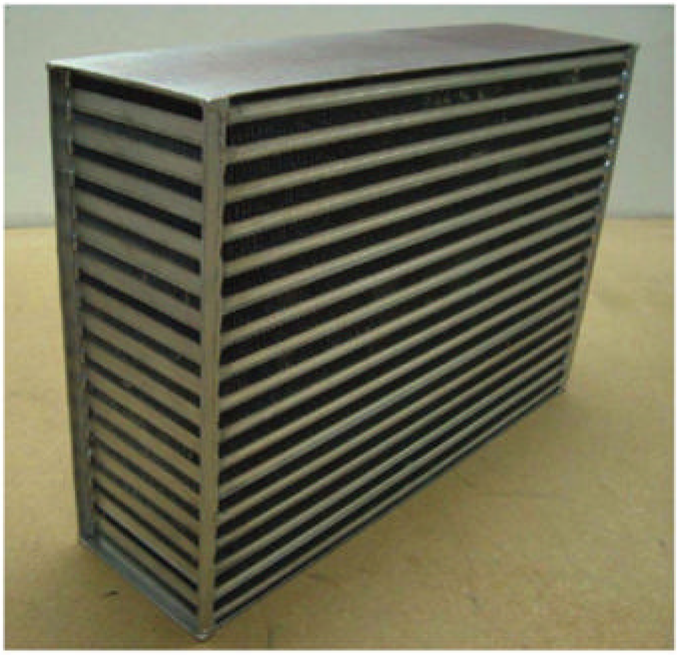
With standard race engines clocking an approximate 35 per cent efficiency, cooling is essential to not only increase this figure but to also deal with the astonishing amount of wasted energy from the internal combustion process. This results in a rather warm engine – 600degC, to be precise, in series such as Formula 1.

If an engine is not cooled properly, the effects can be a race stopper. Thermal expansion of chamber walls, cylinders and pistons results in distortion of their shape leading to gas leakage, loss of power and cylinder cracking. Furthermore, the lubricating oil could be burnt or carbonised causing excessive wear, as the fresh gas entering the piston is heated, the risk of detonation and pre-ignition increases due to the hotter surface of the combustion chamber.

As with most aspects in motorsport, a balance needs to be struck, as overcooling can also lead to damage, because any unvaporised fuel will dilute the lubricating oil, and destroy its properties. Furthermore, the water vapour will condense on the cylinder walls, forming a sludge with the oil – corroding engine parts and increasing wear.



A curved core cooler (centre), surrounded by various samples



A bar and plate intercooler core, typically found in high-end motorsport

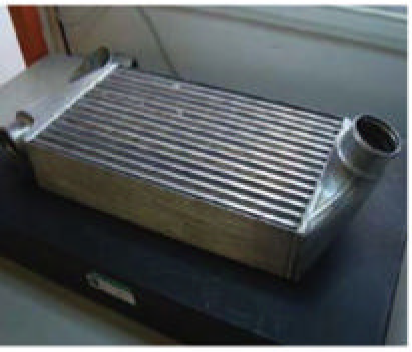
With cooling, as with most aspects of motorsport, a proper balance needs to be struck, as overcooling can also lead to damage

COOLER DESIGN

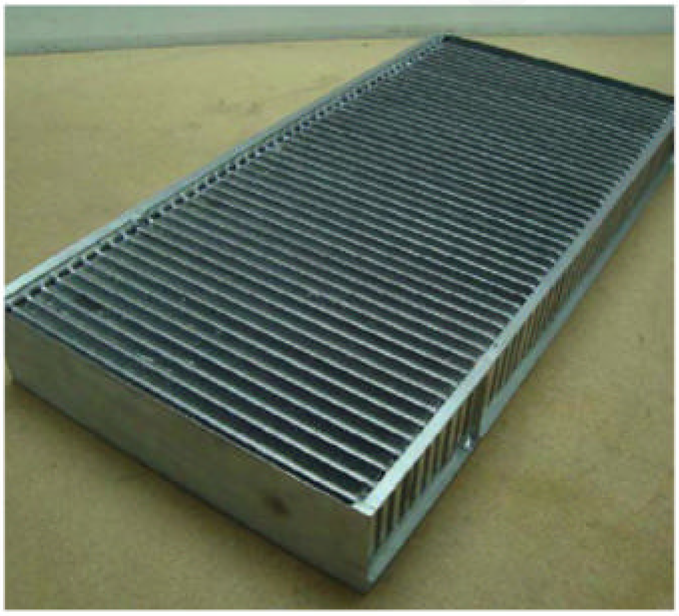
There are two fundamental types of cooler: air-to-air, and air-to-liquid. The 'perfect' cooler would be 100 per cent efficient (cooling the air to ambient temperature) and have no pressure drop across the cooler, two things that are extremely difficult to achieve.

Air-to-air coolers pass the intake charge into the core, which is constructed from thin tubes containing zig zag internal fins, which in turn help to dissipate the heat of the intake air efficiently due to the increased surface area. External fins are placed between each tube, so the heat from the intake air transfers to the internal fins, conducts to the tubes, and then to the external fins, which then dissipate this heat as the outside air passes across the cooler.

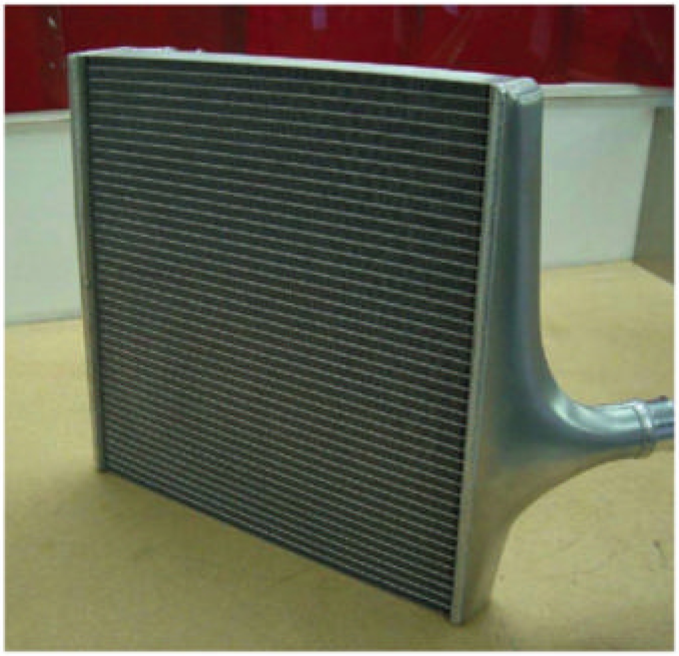
An air-to-liquid cooler transfers the heat of the intake air to a fluid, usually water, which then dissipates the heat to the surroundings. The cooler has similar construction to the air-to-air type previously described, although instead of the intake air flowing through the tubes, this is done by the coolant, usually water. This system requires an additional radiator to cool the liquid as well as a pump, control system and extra plumbing, increasing weight. However, this is a small price to pay for the higher efficiencies that water-cooled systems offer, hence their popularity within the automotive and motorsport sectors. This is down to the specific heat capacity, which is 4.18J for water and 1.01J for air – so for each increase in temperature by one degree, the same mass of water can absorb four times the amount of heat energy than air.



An oil cooler design



Bar and plate oil cooler core. The thickness can be varied as per requirements



An example of the type of radiator found in an LMP1 car

Within each of the types (air-to-air and air-to-liquid) there are two types of construction: bar and plate and tube and fin. Both have a core composed of tubes with a series of fins. The main differences lie within the manufacturing process. The tube and fin construction is formed as one part, as Mel Johnson, engineering director of Docking Engineering explains: 'The whole component is assembled of cladded parts, strapped and as it passes through a furnace. The cladding melts just below the melting point of the aluminium which braises all the parts together, seals all the head pipes and attaches the fins to the tubes and gives the part all its strength. Then it is rapidly cooled.'

Docking Engineering are a world leading supplier of racing radiators and oil coolers and have been developing cooling products since 1984. The debate between tube and fin and bar and plate is ongoing throughout the industry. 'An advantage of a bar and plate type is that the thickness of the core can be varied and the water pressure and air pressure drop can be tuned against each other, so the performance can be matched to the requirement better than with a tube and fin,' says Johnson. 'With a tube and fin cooler, you are restricted to specific tube sizes, but this can be overcome by adjusting the fin density to balance the two flows. Furthermore, this type is much cheaper in construction which is why bar and plate designs are used for high-end applications such as F1 and Le Mans as complex shapes can be created.'

Of course, there is always a trade-off. 'A tighter fin density on the outside air side will increase heat rejection, but also drag, which creates a problem,' says Johnson. 'The engine engineer needs all his cooling, the aerodynamicist doesn't want an intercooler due to this drag, and the chassis engineer doesn't want to add any weight. They are all fighting against each other.'

The effectiveness of any cooler design comes down to the detail of the tubes. As well as the standard internal fins, there are multi-chamber designs and dimpled tubes, all of which increase the surface area. 'The dimpled tubes act as a turbulator because it gives a better wetted area on the inside of the tube. Ideally, you want as much water touching the surface to dissipate the heat.' A major advantage of dimpled tubes is that this allows maximum heat rejection in a thinner cooler design, which is preferred because the thicker the cooler, the higher the water pressure drop. 'Dimpled tubes are becoming extremely popular,' says Johnson. 'They are lightweight, have little effect on water pressure drop and drag, and give higher performance when compared to internal fin designs – it's the decent compromise.'

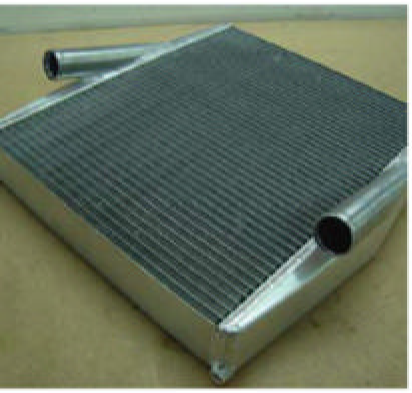
INTERCOOLERS

Prior to the introduction of turbochargers in F1 for the 2014 season, intercoolers will be the subject of a great deal of development. Intercoolers are mainly used in forced induction vehicles to cool the heated air, leaving the turbocharger or supercharger before it enters the engine. It works on the same principal as other coolers: cooling, compressing and allowing higher volumes through to the engine to generate more horsepower while improving the efficiency of the turbocharger.

'Once again tube and fin is a very good way of balancing pressure drop for the intercooler, and has cheaper construction,' says Johnson. 'However, I suspect that most of the F1 teams will be using bar and plate designs to begin with – playing it safe – because it allows the teams to accurately tune the two airflows against each other to get the performance required.'

There will always be a requirement for cooling until engines become 100 per cent efficient – a prospect that seems somewhat far off. So, the future challenge remains to develop the most effective designs. One interesting theory is The Meredith Effect, as Johnson explains. 'In the 1930s FW Meredith realised that you could eliminate the amount of drag from a cooler by careful ducting design to get additional thrust at the back of the cooler. So the hot air coming out of the duct

"The engine engineer needs cooling, the aerodynamicist doesn't want an intercooler, the chassis engineer doesn't want any more weight"



is equal to the drag of the cooler. In the last few years, more F1 teams have been experimenting with this phenomena and the general consensus is that there is a gain to be made.' How long until this technology surfaces, no one knows. Surface cooling, too, is another futuristic alternative. 'This technology may come into F1 eventually. It's a great theory, but I don't know if you can make it work effectively on racecars.'

Different types of motorsport require different types of products. C&R Racing is the largest supplier of radiators for NASCAR Sprint Cup, Nationwide, Camping World Series and IndyCar. 'The big challenge with cooling a NASCAR Sprint Cup car versus an F1 or Indy Car is the wide variety of tracks that they run on,' says Chris Paulsen, president of C&R Racing. 'For example, at Martinsville, top speeds can reach 100mph, whereas in Michigan, Daytona, or Talladega 200mph speeds are achieved. The grill opening on a stockcar is very sensitive for drag and downforce, which is why we work hard to optimise cooling while keeping the grill opening as small as possible.'

Example of a heat exchanger produced by Indiana's C&R Racing

C&R Racing's pressurised cooling systems are highly popular. 'We started offering a kit for all types of racing with a properly engineered accumulator, pressure relief valve, and radiator,' says Paulsen. 'Surprisingly, C&R seems to be the only racing radiator manufacture in America that offers a package like this.'

For NASCAR, the most important factor is to achieve efficient engine cooling but with the smallest inlet possible, which constantly drives C&R to modify the tube and fin design, the tank configuration and inlet/outlet designs. 'We custom build each part per team and the designs change all season long,' says Paulsen. 'It's an ongoing evolution, and probably the only series in the world where cooling is so critical and creates such a large performance advantage. Twenty years ago it took a 95 square-inch grill opening to cool a NASCAR stock car. Now we can do it with 20 inches in some cases.'

The future for cooling systems in NASCAR is driven by the need for cost reduction and is heading towards a spec radiator and oil package for the Truck and Nationwide Series, although this is yet to be implemented. 'I believe NASCAR will keep cooling open in terms of not creating a spec,' says Paulsen. 'They want their premier series to stay innovative, which I certainly agree with.'

AWARD-WINNING MEZZO

In 2010, Mezzo Technologies showed the capabilities of their high-end cooling products by winning the Louis Schwitzer Award of Innovation for their micro channel radiator. This type of heat exchanger outperforms traditional designs due to extremely small channels which increases the heat transfer per unit volume, and the many channels used in this design results in zero pressure drop. Mezzo works in accordance with its partner Triumph Thermal Systems to achieve high quality manufacturing techniques to meet the wide range of customer demands.

'Our most important product currently is micro tube radiators for high performance racing,' says Kevin Kelly, president of Mezzo Technologies. 'Down the road, we're hopeful that other products will also prove popular such as our oil coolers, KERS coolers and intercoolers. We think that a water-cooled radiator coupled with an oil-water heat exchanger might be the best route to go with our technology.'

"A stockcar's grill opening is sensitive for drag and downforce – we work hard to optimise cooling while keeping the grill opening small"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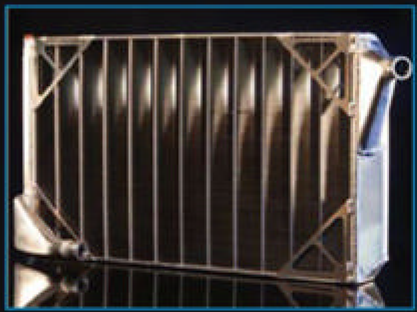


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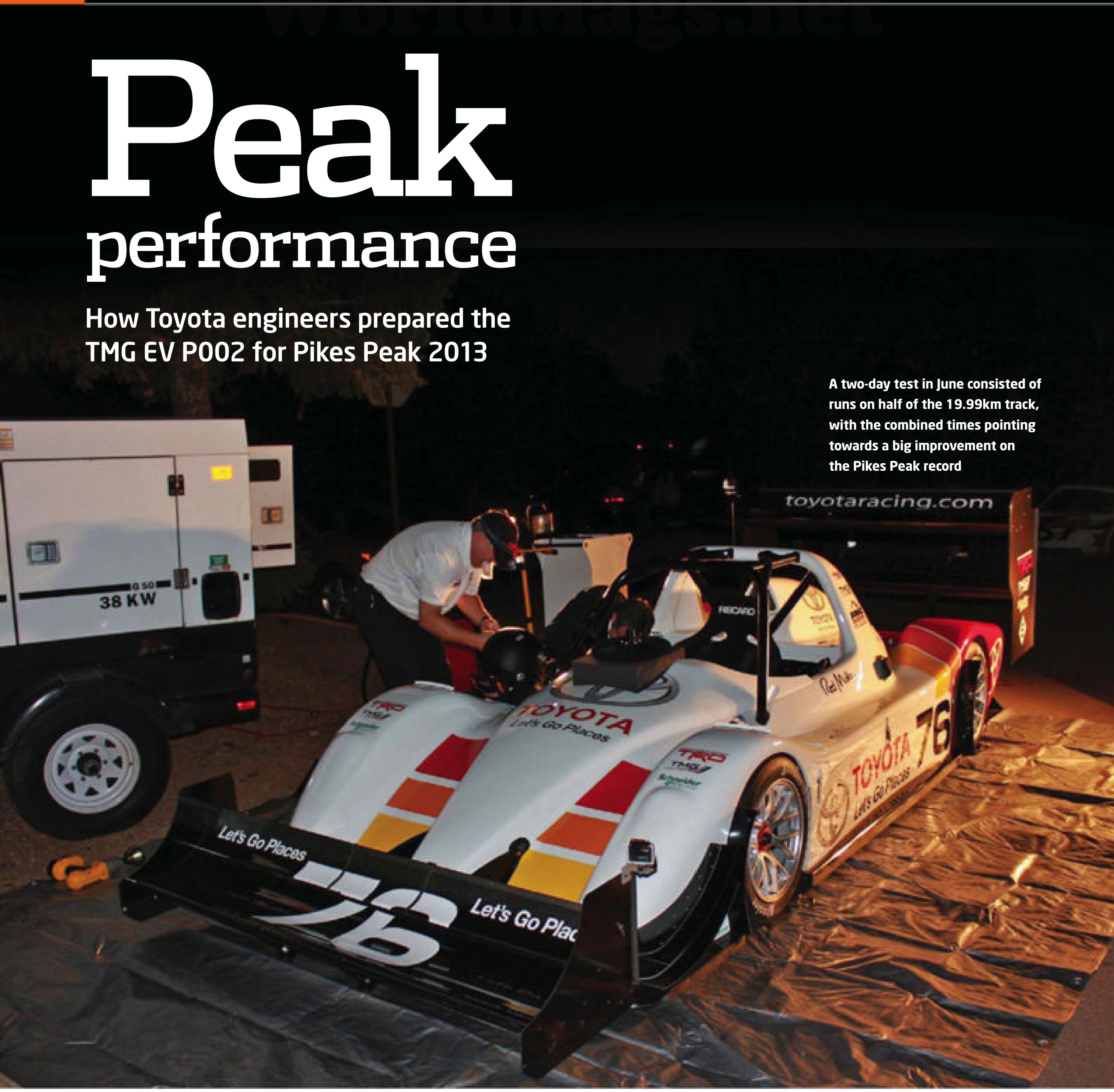
Peak performance

How Toyota engineers prepared the TMG EV P002 for Pikes Peak 2013



A two-day test in June consisted of runs on half of the 19.99km track, with the combined times pointing towards a big improvement on the Pikes Peak record

The TMG EV P002 contested the electric class of the 2013 Pikes Peak International Hillclimb in an attempt to defend its record. To achieve this, the car was heavily upgraded including new aero, and drivetrain modifications, and a testing programme was undertaken.

The test session saw the TMG EV P002 run on half of the challenging track each day, with combined times indicating that the record could be broken on the hill this year.

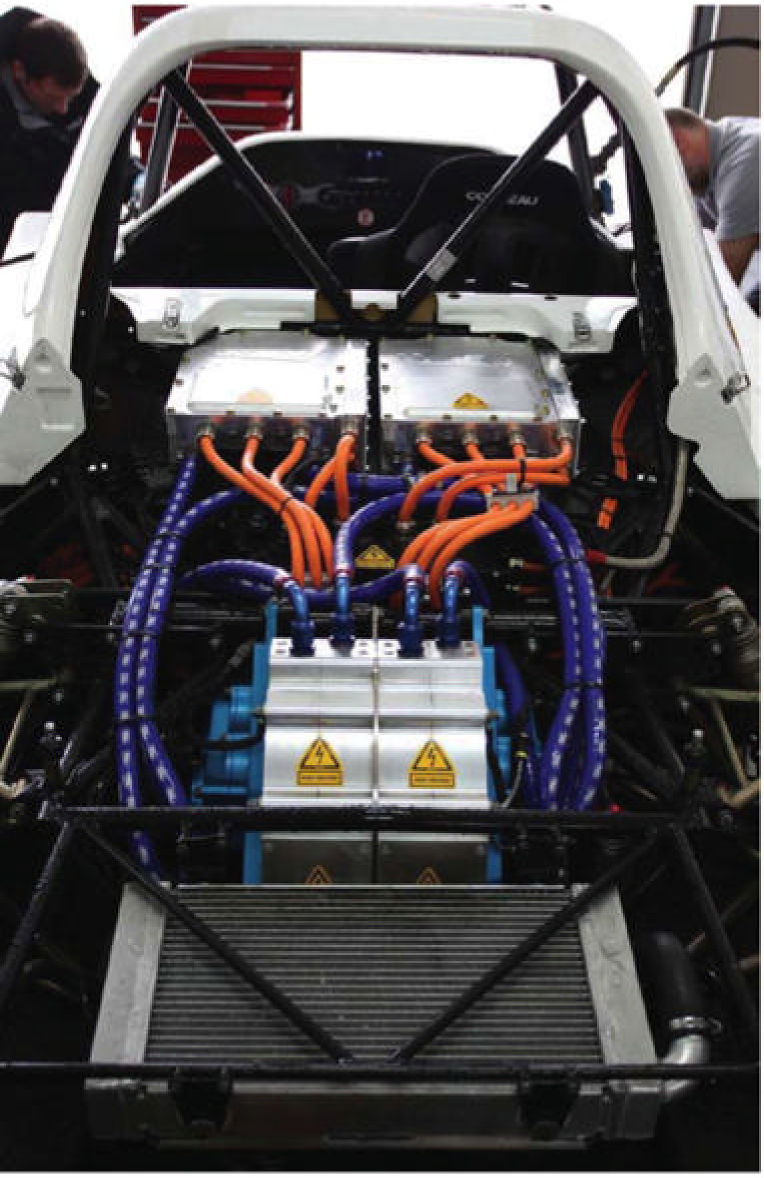
Multiple Pikes Peak record-setter Rod Millen was at the wheel as fine-tuning was carried out on the balance, braking, traction control and cooling, while tyre choice was also evaluated.

Based on data gained from last year's record run of 10mins 15.380secs, engineers at TMG's electric vehicle technology centre in Cologne, Germany made enhancements to the electric powertrain while TRD in the US worked on the aero.

Motor speed and torque increased while the powertrain's operating parameters have been tuned to better suit the challenge of the unique 19.99km (12.42miles) Pikes Peak track. It delivered 400kW of power and 1200Nm of torque in 2013 trim.

Between their arrival in the United States in May

Motor speed and torque have been increased, while the powertrain's operating parameters have been tuned to better suit the 19.99km track



A charger mounted in a HiAce includes a 42kWh lithium ion battery, which can deliver power to the EV P002 where no power grid connections are present

and the Pikes Peak meeting, engineers at TRD USA performed aerodynamic and other upgrades to the chassis. With a three-fold increase in downforce and new carbon ceramic braking system, combined with the electric powertrain upgrades, the TMG EV P002 was readied to take on the challenge of an increasingly-competitive electric class.

TMG used its pioneering off-board battery-to-battery charging technology, including Schneider Electric EVlink DC Charger, to charge the TMG EV P002 from the mountainside, where there is no reliable connection to the power grid. Mounted in a Toyota HiAce, the TMG DC Quick Charger includes a 42kW/h lithium ion battery, which charges directly from the AC power grid. After an overnight charge, it delivers high levels of power to the TMG EV P002 without additional installation or infrastructure.

With varying current and voltage output, the TMG DC Quick Charger is an independent source of power for rapid recharging in any location and it is being used to charge the TMG EV P002 throughout the Pikes Peak event.

In the run-up to race weekend, Claudia Brasse, TMG executive coordinator strategic EV development said: 'This has been a combined technical effort, with TMG and TRD USA engineers working to generate more performance from the TMG EV P002. Electric powertrain technology is advancing on a daily basis so even as TMG won the electric class last year, we were planning how to generate more performance for 2013.

'We have met our targets for the powertrain and I'm delighted to hear that our colleagues at TRD USA have extracted additional performance from the chassis. Our development and testing programme has gone well and we have seen once again that the TMG electric powertrain is not only very powerful, it is also incredibly reliable and durable. The race event itself will be is another showcase for TMG's electric powertrain technology.'

Due to poor weather conditons on race day, it was hard to gauge if the upgrades worked, and the car ran 10 seconds slower than it did in 2012.

'Electric powertrain technology is advancing on a daily basis. The TMG powertrain is not only powerful, but reliable and durable'

TMG EV P002 Technical Specifications

Performance	
Top speed	230km/h (142mph)
Maximum torque	1200Nm
Maximum power	400kW
Maximum revs	6000rpm
Powertrain	
Electric motor	2 axial flux
Inverter	2xTMG inverters
Gear ratio	3.13
Transmission	Single-reduction gearing
Battery	Lithium ceramic
Battery capacity	42 kWh
Charging technology	Off-board DC charging
Dimensions	
Length	4.10m (13ft 5in)
Height	1.04m (3ft 5in)
Width	1.79m (5ft 10in)

TMG DC Quick Charger Specifications

AC grid connection/input	
Grid Connection	400 V AC CEE 16 A
Nominal input power	6.6kW
DC vehicle connection	
Output voltage	400 VDC
Maximum DC output power	25kW
Storage	
Battery	42 kWh, lithium ion
General	
Technology partner	Schneider Electric (EVlink)
Operating temperature	0 to 40degC
Storage temperature	-30 to 60degC
Protection	Short-circuit protection, output fuse, over-current and over-voltage protection, under-voltage shutdown

Lotus files record losses for a Formula 1 team

The Lotus Formula 1 team made a loss of close to £57m last year, thought to be the heaviest ever recorded by an F1 team filing accounts available to the public.

The £56.8m loss significantly eclipses the team's 2011 loss of £20.9m, and beats the previous huge losses by BAR in 1999 (£41.9m) and Marussia in 2011 (£46.3m).

Lotus reported a decrease in year on year turnover from £115.6m in 2011 to £92.7m in the year ending 2012, coupled with an increase in operating costs of £12m.

The team says the decrease in revenue (of 19.8 per cent) was 'mainly due to lower sponsorship revenues', while the increase in operating costs was 'mostly due to higher driver and race-related costs'.

Both of these points are related, as the pay for 2012 and current drivers Kimi Räikkönen and Romain Grosjean will surely be higher than previous drivers Bruno Senna and Vitaly Petrov, while both of the latter were known to have brought money to the team – Senna in the shape of sponsorship from Gillette and Petrov with Lada.

LAT

Lotus branding still appears on cars despite Lotus having no stake in the team

Sponsorship revenues will have also been hit by the withdrawal of Group Lotus as a backer in 2012. Group Lotus now has no stake in the team at all, and pays nothing for its space on the car – even though its name is in prime positions on the wing and nose. Team owner Gerard Lopez admitted as much, saying last year: 'The sponsorship agreement and the obligations of Lotus have been terminated. We are happy to carry the Lotus name as we believe it is a good name for F1.'

The current owner of the team is Genii Capital, a private equity firm founded by Lopez, who made his fortune investing in Skype during its early days. British property tycoon Andrew Ruhan is also said to have a small stake in the team, reckoned at two per cent.

Despite its revenue being down, the team did invest heavily during 2012, hiring 20 additional staff. It also spent £6.4m on its factory and machinery.

At the time of writing Lotus was fourth in this year's constructor's standings while Räikkönen was third in the drivers' championship, with one win to his name.

Hyundai opens new motorsport headquarters

Hyundai has moved in to an all-new purpose-built motorsport base in Germany as it gears up to its World Rally Championship return next year.

Work on the new building, in Alzenau, has been continuing throughout the year, in tandem with the development of its 2014 challenger, the i20 WRC. The new headquarters was formally opened in June, with Hyundai inviting rival teams and others involved in the WRC to the event.

Hyundai Motorsport team principal, Michel Nandan, said: 'Today marks another important step forward in our thrilling task of developing a motorsport team from scratch as we inaugurate our headquarters. We have a challenge ahead of us and we have the perfect facility here to prepare for it.'

The Korean car giant's motorsport president, Gyoo-Heon Choi, said: 'I'm very proud to officially open Hyundai's new home of motorsport. Hyundai Motorsport acts as a performance engineering platform for the global business as well as a brand platform, helping to raise expectations and perceptions of the brand in a relevant and exciting way.'

The new Hyundai HQ in Alzenau, Germany

Hyundai's i20 WRC has now started an intensive test programme as it prepares for its WRC debut at the Monte Carlo Rally in January, where the marque will make its return to the sport after an absence of 10 years.

Meanwhile, Hyundai is also set to open a new research and development site at the legendary Nürburgring. The €5.5m facility will give the manufacturer a permanent base at the circuit, which is regarded as one of the toughest test tracks in the world and is a favoured venue for automotive and motorsport testing for many manufacturers.

Due for completion in August, the new test centre will cover four floors and 3622sq/m, it will include new workshops, office space and a VIP hospitality area.

Prost warns of cost problems for smaller teams as engine deals firm up

Former F1 team boss and current Renault ambassador Alain Prost has said that engine costs will be a problem for the smaller teams from next year, but he insists that Renault is not overcharging for its new powerplant.

Prost, a four-time world champion as a driver, has previously made it known that it was engine costs that forced him to close his eponymous F1 team back in 2002, and when asked if there was a chance that some teams might also go out of business because of the cost of the new engines, he acknowledged that there are genuine concerns.

'It is a problem,' Prost said. 'With my team I was paying $28m for the Ferrari engine in the first year and I was supposed to give $32m the year after. I had to pay this money but I had to give a guarantee and pay almost cash before. That was in September, October or November.'

There is already some disquiet among the smaller teams about the cost of the new turbo engines. The manufacturers have committed vast sums to develop the V6 units and they now want a return on their investment, but most teams outside the big four feel that the price is too high.

However, Prost came to the defence of Renaultsport when it was suggested that the company will be charging between $20m and $25m for its 2014 units, an increase of 250 per cent on the current price.

'The price you've said is much higher than it is in reality, but again, I'm not the one negotiating,' Prost added. 'You need to know that the budget of Renaultsport F1 is €150m per year, and if you just make a very quick calculation about the price you can imagine divided by four teams, for example, and you will realise that Renault is paying a big contribution.'

Meanwhile, the engine market for the new formula has started to take shape and at the time of writing the team-engine partnerships were as follows: Red Bull will stick with Renault (branded Infiniti), while Ferrari will naturally use its own units. McLaren will race with Mercedes for 2014 before switching to Honda in 2015, while Mercedes will stick with its own motors.

There is a question mark over which engine Lotus will use, but many expect it to stay with Renault. Williams will switch from Renault to Mercedes and Force India is sticking with Mercedes, while Sauber retains its deal with Ferrari. Toro Rosso has switched from Ferrari to Renault, while Caterham will probably stay with Renault. Marussia is expected to field Ferrari engines.

Alain Prost reckons deals are to be had, but he is not the one negotiating

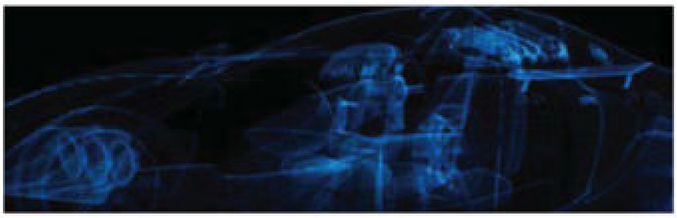
SEEN: PORSCHE LMP1 HYBRID

Porsche's 2014 LMP1 challenger has broken cover, completing its rollout in front of the entire Porsche board at the company's Weissach test facility. The hybrid car, which is set to race in next year's World Endurance Championship and Le Mans 24 Hours, was shaken down 'several weeks' ahead of schedule, according to Porsche.

The head of its LMP1 programme, Fritz Enzinger, said that this should allow the team to complete some extra testing as it gears up to its 2014 campaign: 'We are well on schedule. Our newly-formed team has worked with utmost concentration on getting this highly-complex vehicle on the track as soon as possible.

Porsche has revealed very few technical details on the car, and there is not even a type number as yet, but it has said that its LMP1 will be powered by a petrol-engine.

The driver market has been shaken up Swiss Neel Jani the first to join Romain Dumas and Timo Bernhard, while current Red Bull F1 driver Mark Webber announced that he is to join the team.



Composites Innovation Cluster receives funding

The Advanced Manufacturing Supply Chain Initiative (AMSCI) has been set up by the UK Government to help existing supply chains to grow and achieve world-class standards while encouraging new suppliers to come and manufacture in the country.

The Composites Innovation Cluster (CiC) has been awarded over £11m from the initiative as part of AMSCI Round 2. It will deliver 13 integrated capability projects across 25 partners from the first quarter of 2013 and will aim to deliver a holistic supply chain model which will extend throughout the composites community.

The CiC project is led by the new Cytec Industrial Materials (Heanor, UK), partnered by Axillium and Composites UK in response to the demand signals of all UK industry sectors. This underlines Cytec's commitment to the UK's advanced manufacturing sector and economy. The CiC brings academics, suppliers and primes together with the endorsement of the National Composites Centre. The collaborative cluster project will be delivered by materials specialists, manufacturing and process businesses, and tooling and systems providers, all working with academic support from experts in the field.

£22m of joint funding from AMSCI and industry will support the creation and safeguarding of over 200 jobs and create £190m growth by addressing market failures which challenge the wider adoption of composites in the UK markets.

Williams and Bluebird commit to Formula E 2014

Williams Advanced Engineering is to supply the battery power units for the FIA Formula E Championship for electric racecars, while British manufacturer Bluebird has committed to producing a new chassis by September.

Despite the FIA announcing Dallara as the sole chassis supplier to the series, Bluebird has been encouraged by the governing body to continue developing their car and may still be granted approval for a multi-manufacturer series from the first year. Bluebird, in conjunction with Bamboo Engineering, will have the capacity to supply 16 cars for 2014.

Williams has signed a deal with Formula E constructor Spark Racing Technology to design and assemble the batteries for the championship, which is to be launched next year. The deal is thought to be worth around £10m to Williams Advanced Engineering (WAE), which is based in the same Grove facility as the F1 team.

Formula E looks more promising with the lure of a multi-chassis formula

WAE head of commercial operations Kirsty Andrew said of the tie-up: 'This is an exciting new racing series that will play a key role in highlighting the growing relevance of technologies originally developed for motorsport to the wider world.

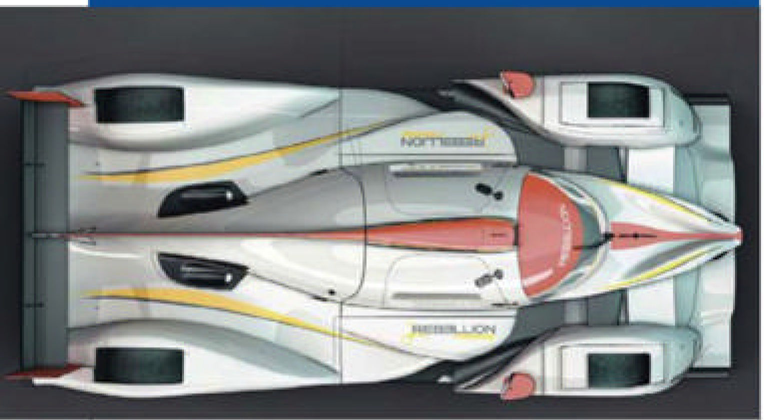
'Energy efficiency is an important issue for Williams and while our work in this field is now spanning a number of market sectors beyond racing, motorsport will always be the ultimate proving ground for our technologies.

'Electric vehicles are becoming an increasingly important part of the automotive industry, and Formula E is the perfect opportunity for Williams to validate the latest developments in battery technology.'

Frédéric Vasseur, president of Spark Racing Technology, said that Williams' involvement is a further boost to the credibility of the series, which has also recently unveiled Renault as a technical partner, while last year it announced McLaren will provide engines, transmissions and electronics. He said: 'The vast experience from Williams in the field of hybrid systems and electric engine power guarantees quality. Spark Racing Technology is extremely proud to bring together some of the biggest names in motorsport and expects no less from Williams as they accompany us in the highest level of the first championship for electric cars.'

The championship is to race on street circuits in 10 cities, with Beijing the latest to be confirmed.

SEEN: REBELLION R-ONE



Swiss sportscar team Rebellion Racing is to field this all-new LMP1 car next year. The Rebellion R-ONE will be designed and built from scratch by French concern Oreca, and work on the car, which will pack an updated Toyota RV8KLM powerplant, has already begun. Bart Hayden, Rebellion Racing team manager, said the new regulations for 2014, as well as the possibilities they present to non-works teams, convinced Rebellion it was worth building a new car: 'The new regulations for 2014 provide a great opportunity for privateer LMP1 entrants to challenge for overall race wins. At Rebellion Racing, we are motivated by the prospect of those victories, and having truly established ourselves in the LMP1 category over the past seasons, we want to build upon our success and reach an even higher level.'

The R-ONE is one of a number of new-for-2014 P1 projects, with Kodewa-Lotus, Oak, Dome and Perrin saying they intend to build cars – in the case of the latter two if customers can be found – to challenge the works entries from Audi, Toyota and Porsche.

Ricardo gets the green light for research centre

Motorsport and automotive engineering company Ricardo has secured planning permission for a £10m research centre for green technology.

The Vehicle Emissions Research Centre (VERC) will be built at Shoreham in the UK, and the company has managed to pick up Government Regional Growth Fund support to help with the build costs. The aim of the centre is to help with the development of the next generation of clean, low carbon vehicles.

The brand new building will incorporate two vehicle test cells with four-wheel-drive chassis dynamometers and advanced emissions testing equipment. The vehicle test cells will be capable of testing passenger cars and light trucks of up to three tonnes, including advanced technology hybrid electric vehicles and their associated energy regeneration systems. VERC is scheduled to be completed and open for business in the second half of 2014.

Ricardo UK managing director Martin Fausset said: 'The securing of this planning approval enables the launch of this significant investment and is a crucial milestone in this major project for Ricardo.'

Ricardo also announced that a contract has been placed with Horiba UK covering the detailed design, construction and completion of the VERC centre, using the company's next generation of vehicle testing equipment.

Almost a quarter of top US companies use NASCAR for marketing

Just under 25 per cent of the best performing American companies use NASCAR as a marketing tool, according to recent analysis by the sport's governing body.

The analysis, based on the influential Fortune 500 list of leading US companies, showed that nearly one in four of them (117) used NASCAR as part of their marketing strategy – a figure which surpasses any other major sport in the USA. There has also been an eight per cent increase in the number of Fortune 500 companies involved in the sport since 2008.

Steve Phelps, NASCAR's chief marketing officer, said that the brand loyalty of the NASCAR fan was key in attracting such blue chip sponsorships: 'There's a reason the number of Fortune 500 companies invested in NASCAR remains higher than any other sport. Our fans are among the most brand loyal in all of sports. Some of the world's biggest, most recognisable and profitable brands utilise NASCAR as a critical and powerful part of their marketing mix because it works for their business.'

Findings from a study commissioned by NASCAR and conducted by Toluna prior to the start of the 2013 season back up Phelps's claims, showing that approximately one out of four NASCAR fans 'strongly agree' that they support NASCAR sponsors more than sponsors of other sports.

Michael Waltrip, founder and co-owner of Michael Waltrip Racing, said of NASCAR's ability to attract top level sponsors: 'The current sponsorship landscape is as competitive as it has ever been. Our partners continue to choose to use our team to drive their brands because we have had success demonstrating value in their investment, proven by our recent partnership renewals with NAPA Auto Parts and other major corporations.'

To be eligible for the Fortune 500, a company must be based in the US and publicly traded.

BRIEFLY

Testing changes

During the Canadian Grand Prix weekend, the F1 Sporting Working Group agreed to a change in the sport's testing arrangements from next year, bringing in a series of two-day tests after four of the European Grands Prix – Silverstone and Barcelona plus two as yet unnamed events. Eight of the 11 teams voted for the new measures – which also include a reduction in aerodynamic straightline testing and promotional days – and at the time of writing the changes were due to be rubber stamped. The Young Driver tests have also been axed.

Billion-dollar Xtrac

Famed UK motorsport and automotive transmission company Xtrac has now achieved total sales of $1bn over the company's 30-year history. Of these over $600m were directly exported to customers all around the world, primarily to China, France, Germany, Italy, Japan and the United States, where Xtrac has facilities in North Carolina and Indianapolis. Peter Digby, managing director of Xtrac, said: 'Engineering and manufacturing in the UK has had its difficulties in recent years, so it makes Xtrac's performance all the more significant.'

Industry funding

Innovative UK motorsport engineering companies could be in line for a slice of a £1m government research and development fund, courtesy of the Technology Strategy Board – the first time such a significant investment from the body has been made available to companies in the UK's Motorsport Valley. R&D projects valued between £50,000 and £200,000 are eligible for up to 60 per cent funding. For more details turn to Business Talk, by the MIA's CEO Chis Aylett, on page 91.

V8 cost-cutting

The Australian V8 Supercars series is looking at a number of ways it can cut costs as teams struggle with the expense of switching to the all-new Car of the Future at a time when revenues from sponsorship are down. Among the ideas being considered are a limit on brake consumables, reverting to a single compound Dunlop tyre, and the introduction of a flexible splitter mount to limit damage. The series is also looking at cutting down on aggressively-angled chicane kerbs, which have caused expensive damper and wheel damage at some tracks.

Indy future

IndyCar has announced its long-term technical development plans, which include aero kits, engine upgrades and more technical freedom. Aero kits, which were meant to be a key part of the new IndyCar from its inception last year, will now be introduced and used for all races from the 2015 season onwards, with manufacturers being given the freedom to develop both speedway and road or street specification packages. Exactly which aero parts will be open to development is still being finalised, but it might include the engine cover, sidepods and front and rear wing endplates.

More gongs for McLaren

Just a month after it scooped a coveted Queen's Award for Enterprise, McLaren Electronic Systems (MESL) picked up another gong at the inaugural European Awards for Innovation. The award, which was given to the company in recognition of its years of innovation, was given to MESL at a ceremony in Dublin. MESL is the official ECU supplier to Formula 1, NASCAR Sprint Cup and IndyCar, while it also supplies control and data systems to many markets outside of motorsport, including transport, aerospace and healthcare.

Thai hopes

Hopes for a grand prix around the streets of the Thai capital Bankgok appear to have been scuppered with the news that new laws have banned motor racing in the historic part of the city, where the race was to take place.

The Grand Prix was set to join the F1 calendar as early as 2015, and as recently as April this year the proposed circuit was approved by Kanokphand Chulakasem, the governor of the Sports Authority of Thailand.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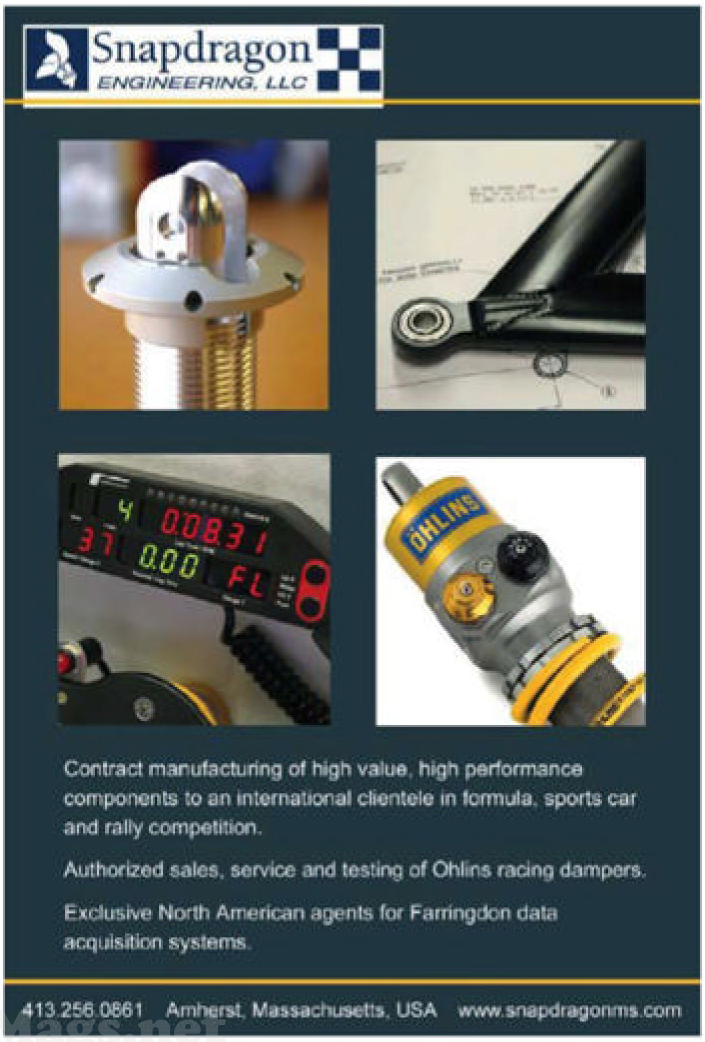
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Stepping stones

No longer the definitive feeder formula for F1, Formula 3 racing needs rejuvenation. We examine the business case behind competition and look at possible solutions

BY MIKE BLANCHET

It could be argued that much of the ongoing concern about Formula 3 – and in particular the British Championship – is largely emotive, based on past values and a certain element of nostalgia. After all, its traditional role as one of the key steps to F1 for aspiring drivers can, and has been, filled by other categories. So, one might ask, 'what is the fuss about? Accept that things change.' Taking the current F1 grid, Kimi Räikkönen famously went straight from F Renault 2.0L to F1, Alonso never raced in F3 and neither did Massa, Pic nor Maldonado, and it clearly didn't hurt their careers.

Nonetheless, the other 17 drivers on this year's F1 grid did all come at some stage of their upward mobility through F3. Despite moving on from F3 to more powerful, but one-make, formulae such as Renault 3.5 and GP2, the drivers, their backers and management at some stage made the decision that F3 was a necessary step on their planned way to F1. Why?

Speaking to a cross-section of drivers at the recent Silverstone FIA F3 European and British F3 Championship rounds, their reasons for choosing F3 were clear.

- **Level of competition**
- **Exposure: for the sponsors, to media including TV; for the drivers, to teams in next-level categories (including hopefully F1 management)**
- **Unrestricted testing**
- **Freedom to make changes to the chassis, unlike with one-make formulae, and opportunity to understand the effects and develop good feedback for engineers**

With a number of teams indicating that they'd welcome an alternate chassis provider, there is a case to be made for breaking the Dallara status quo

Regarding the British v the FIA Championship, universally it was simple – it's a matter of budget. Given the choice, all would prefer to participate in the European series because of its added prestige, the opportunity of gaining F1 circuit experience and racing in support of the DTM.

Therefore we must deduce that British F3, like other national series, is now a feeder for the FIA Championship, as well as providing some valuable extra race experience for those whose budgets allow them to compete in both. This is unlikely to change, and therefore promoters and organisers should accept and accommodate this. No point to go against the FIA flow. Something like a six-round championship, with three races per event, is the way to go to help reduce budgets, yet provide a meaningful racing programme. Also, possibly, expand linkage with the International F3 Open, surely one of the best-kept secrets in motor-racing. With spec Toyota engines, it boasts entries of over 30 cars, runs mainly on F1 tracks and requires relatively modest budgets despite surprisingly good TV exposure.

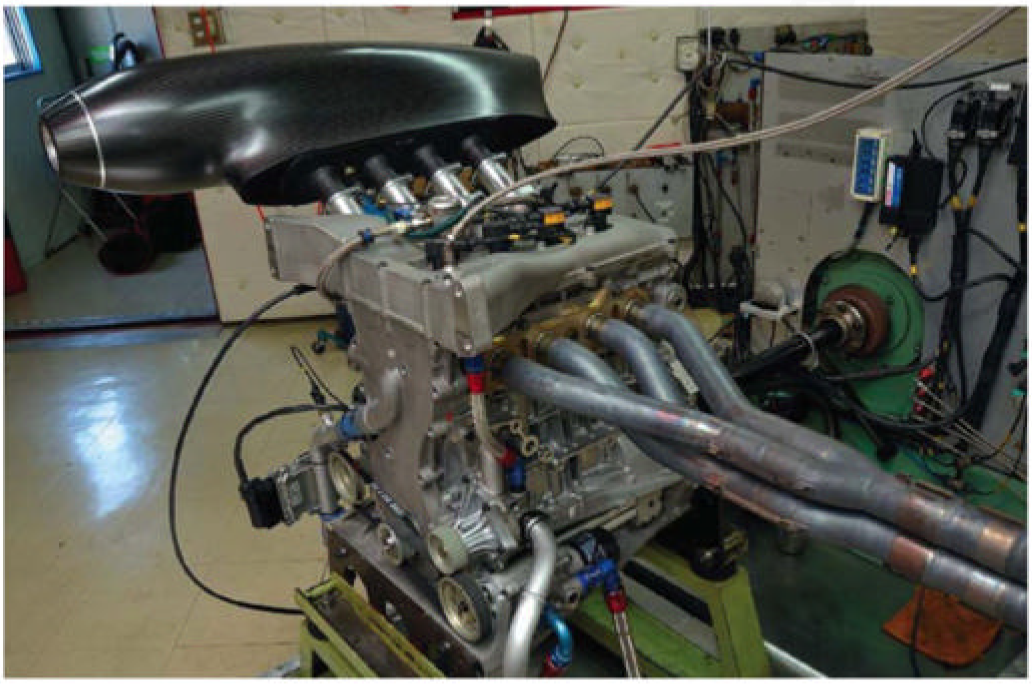
Returning to F3 in general, when drivers and their backers are considering where to spend their money after graduating from junior formulae, are there actually so many alternatives? Most regard going straight to Renault 3.5, for instance, as being too big a step financially and for the limited experience they have so far gained. F Renault Eurocup might be a viable alternative with 15 teams, 40+ drivers and good credibility, but in 2013 it races at only two F1 tracks and has the usual one-make formula restraints for young drivers. GP3 can also be an option, and has a lot more power, but testing is severely limited in the view of aspiring drivers and, again, permits only very limited setup changes. This is not what many youngsters keen to develop their overall skills really want, despite its winner's prize of €200,000 and a GP2-test and being a supporting event at European F1 Grands Prix.

Is there a case for suggesting that teams are complacent and too reliant on backers and pay drivers?

From recent very thin grids, the European Championship, now with its FIA endorsement, has blossomed to over 30 entries – largely at the expense largely of British F3 – but it's a case mainly of the same base of entrants moving to greener pastures. Team owners are not as optimistic as the above healthy grid might indicate. The costs (€650,000+ per driver seemingly typical) are still difficult to cover from the driver budgets that are available. As one principal recently pointed out to me, behind the majority of teams lies a wealthy backer of some description (sometimes a close relative of one of the drivers) prepared to put money in to make up the shortfall, but only as long as it suits, and not long-term. But is there a case for suggesting that teams have become complacent in relying totally on these backers and paying drivers? Difficult as it may be now with even F1 struggling, raising a level of commercial team sponsorship not only gives more stability to a team, but may also enable it to subsidise a seat for a driver with limited means but outstanding talent. Now wouldn't that be refreshing?

It's logical to assume that teams would prefer to maintain the long-standing Dallara chassis status quo. However, a surprising number would welcome an alternative supplier. It would bring benefits such as price competition, more motivation for team engineers (but with expensive development controlled via homologation rules as now), greater media and fan interest and an opening for deserving team and driver support from rival chassis constructors. Again, this would aid drivers with real ability rather than just money.

Moving in on Dallara's territory is made difficult by the excellent job that the Italian firm has done in establishing and maintaining



With a bespoke engine which has no other racing use, the current F3 engine doesn't have great interest for tuners

its monopoly. Their engineers have certainly not sat on their hands. Consequently, it is tough for another constructor to take on and beat them due to the investment required (estimated close to €1.8m), not least in getting at least one top team and driver combination on-side in its first year at least. It would be the only way to persuade a team – and the paying drivers – to invest in a different chassis, and as teams are multi-car operations and running two different makes alongside each other doesn't work, the deal would have to extend over three or four cars, not just one.

Treating F3 as the first move of a long-term plan to break into single-seater markets overall as a genuine rival to Dallara is probably the only plan that makes business sense, and would need a great deal of determination and commitment before sales volume and therefore profits could make the project self-supporting. Not impossible, but certainly a considerable challenge.

Some four years ago, the concept of a Global Racing Engine formula was put forward as the future for almost all FIA championships up to and including F1. The GRE was to be a tightly-regulated inline four-cylinder 1.6-litre unit, turbocharged at different pressures to meet the required power and torque figures. The reasoning was that this is the way that the majority of production car powertrains are trending, so manufacturers would see an association between motor racing and their products at almost every level. Such mechanical commonality would save costs across the board. I confess I found the likelihood of the latter point actually working in practice to be questionable, and subsequently with F1 engine suppliers such as Ferrari waking up to the fact that a four-cylinder turbo wouldn't reflect their heritage and image, as well as sounding plain boring – which itself begs the question

The cost of competing in F3 at national and international level still needs reducing significantly

of just why did they and the F1 teams sleepwalk into it in the first place? – the GRE idea has faded away.

Quite why the GRE didn't at least continue to be promoted for F3's 2013 revamp is not entirely clear. There was resistance to the formula going to a turbo engine, but 1.6 litres unblown – down from 2.0 litres – wouldn't produce the extra 25/30 PS identified as being needed without high revs. More RPM equals more money, diametrically opposite to the intended aim. Maintaining the use of production engines as a basis could have been an option, but the momentum to move in favour of purpose-designed powerplants had taken hold. This approach has allowed the imposition of very strict homologated technical parameters to curtail excessive manufacturing and development costs as well as price-contained 'spec' items such as ECU, clutch, alternator etc. Coupled with mandating a longer 'life' between rebuilds, all at a capped annual lease fee for teams, one of the major escalating costs of competing in F3 has – in theory at least – been addressed.

Spare a thought for the engine tuners. Formula 3 has ended up with a bespoke engine with currently no other racing use in which to amortise the expensive design, tooling and initial development costs – the polar opposite of the original GRE concept.

And will the desired cost savings for competitors be realised? Once the cost of the changeover has been covered, the longer life of the engines between rebuilds and the lower leasing costs should have an impact, but the order of magnitude won't be fully assessed by teams until the end of 2014, at earliest.

Meanwhile, a major bone of contention among the specialist F3 engine tuners originally targeted as being the exclusive suppliers has been the late arrival of Mercedes-Benz and VW to the engine homologation and provision process. Quite why these manufacturers continue to be involved is not clear – F3 success doesn't sell road cars and can only marginally promote their already well-established brands. The manufacturers themselves say it is in order to develop young driver talent, the inference being that they would find it hard to put money and effort into a racer to whom their identity was not intrinsically attached. The trouble is that it skews the results against the private tuners because (a) the car companies don't have to make a profit from their engine sales and can test more, and (b) they deprive the tuners of the best teams and drivers and, overall, push up the budgets further. Perhaps instead the manufacturers should be persuaded to put their resources into healthy F3 championship prize and promotional funds which would benefit all competitors, and still allow them to form relationships with drivers that have caught their attention.

The cost of competing in F3 at national and international level still needs reducing significantly and it is mainly the peripheral activities – travel, team staffing levels, F1-copy driver comforts – that need to be addressed as they don't make the racing any better and haemorrhage money. Without doubt the FIA getting behind F3 through Single-Seater Commission President and former F1 driver Gerhard Berger and giving the former EuroSeries an official FIA title has revitalised the formula's profile after recent decline. It's also highlighted its importance on a driver's CV for his or her sponsor pitches. It has made the path forward clearer for aspiring F1 drivers and should assist in providing the viable and stable platform that teams need by reinforcing F3's reputation once more as a step on the way up that cannot be missed.

INTERVIEW: SAM ROACH

Sam Roach is managing director at RacingLine and championship manager of Formula Ford Championship of Great Britain. Roach a former Formula Ford 1600 and saloon racer, set up motorsport and event management company RacingLine in 2001. The company originally ran the VW Polo Super 1600 championship in rallying, and now organises the UK F-Ford Championship as well as the hugely successful VW Racing Cup. This year's UK Formula Ford is running to the new Formula Ford 200 regulations, with 200bhp EcoBoost motors and a wing package.

How pleased are you with the new-look Formula Ford?
I'm really pleased. I think it's working really well. The feedback is good. What we've got here is a car that is very much quicker than it was before, and I think that is a very important thing; this is a fast car now. And yet the downforce isn't immense. It's around about 150-180kg at maximum speed, which really is a very, very mild and light touch aero package. So, the thing I'm very pleased about – not just in terms of the spectating point of view, but also because of how we're protecting the Formula Ford ethos – is that the cars still move around an awful lot. They still have more power than grip. Chassis balance and the mechanical grip is still clearly very important. We were very keen to have a car that was not stuck to the road, where grip massively outweighs any power available.

What was the thinking behind the move to a turbocharged engine last year?
I think we've gone quite early on turbo in terms of the world of motorsport but I absolutely believe, without a shadow of a doubt, that we will see turbos becoming more common in all forms of motorsport, just because that's what road cars have to be doing. There is no choice.

Have you experienced any technical problems with the new car?
Very few, because we've effectively had the last year running with this engine on the car, though we had a few issues last year – the cooling systems needed changing and we made some changes to the dry sump system. But what this effectively means is that we've gone into this year with a relatively known product. Yes, we've slightly changed the power and characteristics of the engine, but it's through using the same control system and all the same hardware. Nothing mechanical or electronic has changed bar the software.

What is the budget for a year in Formula Ford?
The cheapest deals will be under £100,000, and a full budget to include perhaps 30 days testing with a top team will be perhaps £130,000, so that's the spread.

While Formula Ford remains open, the two cars currently competing do look similar, is that a worry?
I don't think it is a worry, I think there's enough room for character for each manufacturer – the nose is free, the tail is free. What we wanted to do is to ensure that the frontal areas were equivalent across the cars, so that's really why there have been aspects of the design that have been locked. We have to ensure that the cars have got the width to take the safety requirements. To ensure that nobody is disadvantaged by that or tries to trim it to a minimum, we have imposed a mandatory cockpit width and mandatory front profile of sidepods and roll hoop.

What's the future for Formula Ford 200?
We've got a three-year programme supporting the BTCC, and Ford is committed to it, and there's regulation stability within that three-year window.

New Williams CEO to take group overview

Williams has moved to unite its F1 team and the Williams Advanced Engineering arm of the company under a single management structure with the appointment of Mike O'Driscoll as group CEO.

O'Driscoll, a former managing director of Jaguar Cars, has been a non-executive director at Williams since 2011, but now steps up to a newly created role as a result of the departure of former CEO Alex Burns from the organisation.

Williams says O'Driscoll's mission will be to 'guide the team's long-term future', while the new role means the F1 Team and Williams Advanced Engineering will now be united under one single boss. O'Driscoll nows lead the executive committee, reporting to the board as well as founder Frank Williams.

Frank Williams said: 'Mike has been a valued member of our board since 2011 as a non-executive director and I am delighted that his day-to-day involvement in the company is to significantly increase. This new role strengthens the company and will help us achieve our goals both on the racetrack and in diversification.'

Williams also said that O'Driscoll will now work closely with Claire Williams – deputy team principal and Williams's daughter. 'Mike brings with him significant skills and a wealth of experience. Working with Claire, I am in no doubt that the future of Williams is in safe hands,' Williams said.

'I am honoured that the board has entrusted me with the position of Group CEO,' O'Driscoll said. 'I have been proud to serve as a non-executive director since 2011 and in my new role, I am very much looking forward to helping Sir Frank and Claire achieve the ambitious goals we have set ourselves.'

O'Driscoll is also chairman of Jaguar Heritage, and serves on the Global Advisory Board of JMI, the motorsport marketing company. He retired as managing director of Jaguar Cars in March 2011, having held the post since 2007.

He started his career in the UK with Jaguar Rover Triumph as a business student and held various positions in finance, product development and marketing, prior to a move to America in 1987, where he held a number of executive positions, including senior posts at Ford.

Our job is just to continue to grow this. The first year of any championship is hard because there's the financial cost of entry, you're setting up a new team and it's all new cars, new parts and new spares, so that's an expensive year. But in years two and three those cars become one and two years old respectively, and that opens the door to people who perhaps couldn't afford to get in during year one.

Why do you think RacingLine's other championship, The Volkswagen Racing Cup, has been such a success?
It's an engineering formula. There is a lot of freedom on chassis modifications and engine tuning, within a very strict set of regulations. It's really flourishing, it's really taken off in the last few years and I think there are now a number of drivers coming to this with the mindset of one day wanting to get to the BTCC, because they've now got to learn how to set a car up, and engineer a car against different types of cars, albeit all with a Volkswagen badge.

BRIEFLY

Cable calamity

A TV camera cable fell on to the track during a Coca Cola 600 Sprint Cup Series race at Charlotte Motor Speedway, damaging four cars and injuring 10 fans. The cable for Fox's overhead camera can normally travel at 85mph, but broke away and fell, before being struck repeatedly by the field. The Joe Gibbs Racing Toyota driven by Kyle Busch received the most damage. Some spectators were hurt trying to haul in the cable from the track as the cars struck it.

NASCAR red-flagged the event and gave teams 15 minutes to make repairs before resuming the race.

An investigation by Fox and the Austrian company that provides the equipment is under way.

CAUGHT

Sprint Cup crew chief **Paul Wolfe** has been fined after the Penske Racing Ford he tends failed to meet the required minimum front car height during post-race scrutineering at the Dover round of the championship. The car's owner, Roger Penske, and driver, Brad Keselowski, have been docked points in the owners' and drivers' championships as a result of the infraction.
FINE: $25,000
PENALTY: 6 points

Penske's IndyCar team has also fallen foul of the scrutineer's tape measure recently, with the winning car at the Texas Motor Speedway event, driven by **Helio Castroneves**, failing a test for under-wing height at post-race inspection. The team was fined and docked points in the entrants' championship. Castroneves was, however, allowed to keep the win.
FINE: $35,000
PENALTY: 15 points

Doug Randolph, the crew chief on the No 29 Ford in the NASCAR Camping World Truck Series, has been fined after the Brad Keselowski Racing-run truck's roof failed to meet the minimum height requirement at post-race inspection after the Texas Motor Speedway round of the championship. The team has also been docked driver championship and owner championship points.
FINE: $5000
PENALTY: 6 points

NASCAR Nationwide Series crew chief **Adam Stevens** has been fined and placed on NASCAR probation for the remainder of 2013 for illegal modifications to the body and underside of the Kyle Busch Motorsports Toyota at Darlington Raceway. Car chief Christopher Landis has also been placed on probation for the same period.
FINE: $10,000

RACE MOVES

Renowned NASCAR engine wizard **Maurice Petty** will be inducted into the sport's Hall of Fame in 2014. Petty, who is the fourth member of the famous racing family to be admitted to the HoF, is the chief engine builder at Petty Enterprises, and was responsible for the powerplants that propelled older brother Richard to the majority of his 200 top-level NASCAR wins. Driving legends **Tim Flock**, **Jack Ingram**, **Dale Jarrett** and **Fireball Roberts** are the other four inductees this year.


Red Bull F1 team principal **Christian Horner** (above) has been awarded an OBE for services to motorsport in the Queen's Birthday Honours list. Horner, 39, has headed the Red Bull team since its inception, when the energy drinks company took over Jaguar in 2005, and before that he was successful in Formula 3000 with his own Arden outfit.

Norman Howell is no longer the director of communications at the FIA. Howell, who has been with the world motorsport governing body since 2010, has taken up a position as vice president of corporate communications, EMEA Division, at the UFC (Ultimate Fighting Championship), based in London.

Replacing Howell is **Pierre Regent**. Previously FIA International Relations Adviser and Action for Road Safety Project manager, Regent will continue to fill the former role alongside his new duties. Before joining the FIA, Regent spent five years working closely with former French president Nicolas Sarkozy as his press and communication advisor.

UK race driver training facility iZone has signed up well-known performance psychologist **Dave Collins**. Collins is the former performance director for UK Athletics (2005-2008) and has worked with over 60 World and Olympic medallists, as well as other high achieving athletes across a broad spectrum of sports. iZone has also signed up 2012 GP2 championship runner-up **Luiz Razia** to its driver coaching team.

Max Welti is the new head of motorsport at Lamborghini. Welti, who has vast experience in the sport – including heading up the Swiss A1 GP team and the Le Mans-winning Sauber sportscar squad – will report directly to **Maurizio Reggiani**, member of the board for research and development. Welti's role will be to manage the company's Squadra Corse, the team which runs Lamborghinis in GT3 and in the Super Trofeo series.

Richard Agnew has been appointed to the role of global PR director for Jaguar, replacing Paul Chadderton in the position. Agnew, who has 16 years of experience in the premier market automotive industry, has most recently worked as acting global PR director for Land Rover.

Former McLaren technical director **Paddy Lowe** has now joined the Mercedes Formula 1 team as executive director (technical) after McLaren released him from his contract earlier than was expected following an agreement between the two teams. He will now work closely with team principal Ross Brawn and Mercedes motorsport boss Toto Wolff.

Red Bull technical boss **Adrian Newey** exited the recent Lamborghini Super Trofeo race at Silverstone in a rather embarrassing fashion, the renowned aerodynamicist failing to make the start of the second race of the double-header after spinning into the barriers on his out lap.

Tony Fernandes, the co-owner of the Caterham F1 team, has admitted he might have held back the progress of the outfit during his time as team principal by taking too much of a hands-on management approach. He said: 'I don't think that I spread myself too thinly, but I should have delegated more.'

SEEN: FORD FIESTA R5

M-Sport has unveiled its Fiesta R5 rally car. The R5 class of the WRC is for four-wheel-drive cars with 1600cc turbocharged engines, each rally car cost-capped at £160,000. Peugeot, Citroën and Skoda are also working on R5 cars, the Peugeot example expected to break cover soon. The Fiesta is based on the new 1.6-litre EcoBoost-engined Ford Fiesta ST road car, but M-Sport told *Racecar* that 90 per cent of the car has been designed and manufactured from scratch. The Fiesta R5 is expected to make its first appearance in the WRC at Rally Finland in August and M-Sport has already received 18 deposits from customers keen to get their hands on the new Ford.

M-Sport managing director, Malcolm Wilson, said: 'It's been a long time since I've been as excited about a project as I am about the Fiesta R5. A great amount of time and effort has gone into this car and our designers have done an incredible amount of research and development to get the car just right. Looking at the testing so far, it certainly looks as though that hard work will pay off. It is fantastic to see that the rallying world has such faith in M-Sport to produce a highly competitive and reliable car.'

PEELING BACK THE STICKERS: NUMBER 16: PDVSA

When Hugo Chávez died earlier this year, it was a news story that registered in the world of F1. This was because Chavez was closely associated with the deal between state-controlled Venezuelan oil company Petróleos de Venezuela SA (PDVSA) and Williams, a tie-up said to be worth €30m a year to the British team. The oil money came to Williams by way of its willingness to take on Pastor Maldonado, whose career was backed by Chávez.

With Chávez's death, some thought the deal would fall through, but PDVSA will now remain on the cars for the rest of this season at least.

PDVSA – the result of a nationalisation of the Venezuelan oil industry in 1976 – is one of the country's chief sources of income. It is thought that from 2004-2010, PDVSA contributed $61.4bn to social development projects.

As far as its F1 commitment is concerned, €30m is small change, with PDVSA's 2011 revenue recorded at $124.7bn.

RACE MOVES

According to reports in the Finnish press, former Lotus technical director **James Allison** will not be heading to Red Bull or Ferrari once his gardening leave has expired, but will instead be signing up with Honda, as it works towards its re-entry into the sport as McLaren's engine supplier in 2015. The reports suggest he will design a test car in which the Japanese manufacturer will develop its new V6.

Williams has signed up **Chris Murray** as its new marketing director. Murray is a sponsor finder of some repute, and was formerly a senior account director at well-known Formula 1 sponsorship agency Just Marketing.

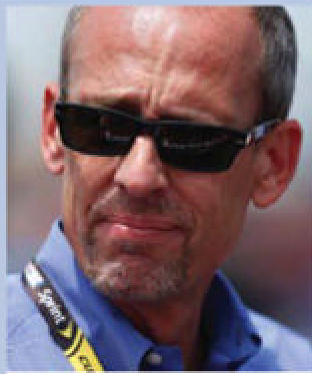
Banbury, UK-based motorsport, technology and automotive PR marketing agency **Propel Technology** has scooped a prestigious Chartered Institute of Public Relations (CIPR) Excellence Award. It received the accolade in the category of Outstanding Small Consultancy.

NASCAR Nationwide crew member **Robert S Harrison** has fallen foul of the US stockcar racing governing body's strict substance abuse policy and has been suspended from all NASCAR competition for an indefinite period. **Beau Wilkes**, a crew member in the NASCAR Camping World Truck Series, also been suspended for a similar violation.

To mark the growing relationship between Le Mans organiser the ACO and the new-for-2014 United SportsCar Racing Series – the merged GrandAm and ALMS – Grand-Am boss **Jim France Jr** was given the honour of starting the Le Mans 24 Hour race.

The Heads of the Valleys Development Company, the organisation behind the **Circuit of Wales** project, has appointed what it calls 'youth ambassadors', all from the local area, to help promote the proposed motorsport venue to the youth in the area around the Ebbw Vale development.

The Society of Motor Manufacturers and Traders (SMMT), the organisation representing the UK automotive industry, has announced that **Michael Hawes** will be joining as its new chief executive in the early autumn. Hawes joins SMMT from Bentley Motors, where he held a number of PR, corporate and public affairs roles, while he has also worked for both Toyota and, more recently, Bentley's parent company Volkswagen AG.



David Wilson (above) is now the acting president and general manager for Toyota Racing Development (TRD) USA, taking on the position vacated by Lee White, who has stepped down due to family health concerns. Wilson will also continue in his role as senior vice president with the organisation, in addition to overseeing the daily operations of the company, which supplies NASCAR engines to Sprint Cup teams Joe Gibbs Racing and Michael Waltrip Racing.

The Association of Scottish Motoring Writers has presented its prestigious Jim Clark Memorial Award to Ford's gasoline calibration manager, **Andrew Fraser**, for his work on the motor giant's smallest petrol engine – the turbocharged, direct injection 1.0-litre EcoBoost unit. The award recognises Scots who have excelled in the fields of motorsport and automotive development and is presented annually. Previous winners include motorsport legends **Jackie Stewart, Allan McNish, David Coulthard** and **Colin McRae**.

Former F1 driver **Mark Blundell** has stepped down from the driver line up at GT team United Autorports in order to concentrate on building up his sports management business. Blundell will, however, remain with the team in an ambassadorial role.

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

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INDY

BUSINESS TALK: CHRIS AYLETT

Got a winning solution?

Entries encouraged as £1m prize fund is announced for Motorsport Valley R&D

Motorsport engineering companies constantly develop many projects which incorporate the efficient use of energy, light-weighting, aerodynamic improvement, increasing engine efficiency and suchlike, both to keep delivering winning solutions and – more often recently – to meet growing demand from automotive and other sectors. These are the main technology themes covered by the Motorsport Valley Launchpad, a recently announced R&D competition from the UK's Technology Strategy Board (TSB), which closes on 24 July. Winning SME applicants will get 60 per cent of their investment confirmed in advance, for eligible projects with a total project cost between £50k and £200k.

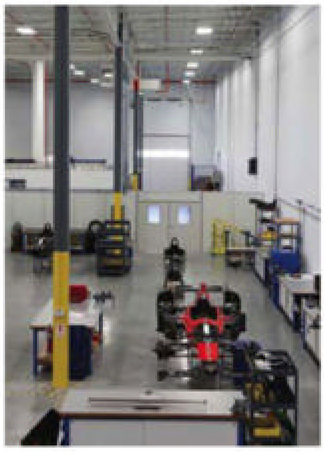
This is great news for British motorsport engineering. A no-frills, simple-to-enter, fast decision competition to which, I know, UK motorsport companies will rise. A company can submit several separate, relevant project proposals, each with a two-minute video to explain the project and how they meet the funding criteria. Winners will have funding confirmed by October, then time to secure the remaining 40 per cent, and then to deliver the project inside 12 months. A great idea – congratulations to the TSB!

SMEs often ignore such competitions as they generally need to have funds in place to complete the work before they apply. But that's not the case here – access the Motorsport Valley Launchpad competition through www.the-mia.com, where you'll also find the MIA Motorsport Technology Road Map. The TSB ask that most projects refer to this Road Map and demonstrate how they are relevant to it.

The strength of the Motorsport Valley business cluster is central to the improvement and growth of UK motorsport business, according to the TSB, who have recognised the MIA as the 'Cluster Champion' for this Launchpad competition.

With R&D tax credits probably applicable to the remaining 40 per cent of investment, this valuable scheme will help all innovative SMEs in Motorsport Valley. It clearly shows Government commitment to motorsport-based R&D investment, and encourages collaboration with others.

Bringing together collaborators, large and small, to deliver parts of the projects is central to the TSB approach, as is the chance to link the R&D outcome to other sectors, in particular projects linked to automotive, defence and marine.



This competition is just one tangible result from new, welcome, engagement by the Department of Business, Innovation & Skills, with the UK motorsport industry through the MIA – just the beginning of an exciting, valuable journey of business growth.

Just recently, the MIA was invited to represent the UK supply chain through a seat on the Automotive Council Technology Group, where we meet all the technology decision makers from UK automotive OEMs. We explain the unique capability of our members and our wider industry to meet the urgent R&D prototype demands, on which their substantial low carbon programmes rely. These multi-million pound buyers are now looking for fast response advanced engineering supplies from innovative UK companies – an exceptional situation for motorsport SMEs. Some have already benefited from this new business, by demonstrating their capabilities through the hugely successful MIA Motorsport to Automotive Showcase engineer-to-engineer events.

Whether from defence, marine or automotive, these new customers are well aware of the proven worldwide success of UK motorsport engineering. They see the motorsport environment as the perfect test bed for advanced, energy-efficient innovations which deliver rapid responses, which is just what's needed to resolve the wide number of 'low-carbon' solutions urgently.

I suggest you take a look at Technology Readiness Levels online, where you can see their relevance to the future of motorsport business. UK automotive urgently needs new suppliers, capable of working within TRL 4-7, where technology moves from blue-sky research to prototype build and test pre-production. In reality, motorsport engineers are ideally placed as they build and compete in prototypes constantly, rarely manufacturing any volume.

UK automotive needs new, UK-based suppliers capable of building pre-production prototypes to a proven high standard. I've really enjoyed being at the centre of this journey in recent years, so take a look at the appropriate websites, or write to me, to grasp your share of this business.

During early summer, you should hear of a UK National Industrial Strategy for growth in the automotive industry, in which I confidently expect motorsport to be recognised. But you may ask how this will help you. Once there is a Government commitment on new growth policies to build certain sectors – in this case automotive and motorsport – then support to deliver the promised results will follow, in many forms. I am proud that the MIA has, unrelentingly and for many years, pressed the case for the UK motorsport industry to be recognised, at the highest levels in Government, as an important sector which will help bring success to the exciting growth plans of UK automotive.

As part of this development, the MIA must shortly define a 10-year business growth strategy for UK motorsport engineering, necessary to secure Government support to achieve success. The MIA will, initially, take the lead on this, basing our plans on responses to the National Survey of Motorsport Engineering and Services currently under way.

I strongly urge you to reply to that survey. I know this seems tedious, but 20 minutes spent answering questions directly helps us to secure the right Government support for your business, for years ahead. Please check our website – www.the-mia.com – and complete the survey now – it will not be a waste of time, I promise you, and could prove absolutely vital to our mutual business future.

The Technology Strategy Board's Motorsport Valley £1m competition is now under way, so why not send in your two-minute video? Consider joining the fast-growing MIA business community and play a full part in the journey which we have only just started. Best of luck in the season ahead with your business growth plans, and let me know if I can help – email info@the-mia.com

BACK ISSUES AVAILABLE

The **Racecar Engineering** back issue archive is now available online, with every single issue **dating back to December 2004** accessible at the click of a button.

Back issues are available from just £2.99 / $4.99 and are readable on PC, Mac, tablet and smartphone devices.

To browse our archive and order your back issues today, go to:

www.racecar-engineering.com/back-issues

HAND TOOLS

UV LED leak detection torch

Finding fluid leaks in a racecar cooling system is often achieved using fluorescent dye traces and UV light to detect any areas where fluid may be leaking. To provide a compact and easy-to-use UV light source, Tracerline has released the OPTI-LUX 365, a powerful LED leak detection torch that provides pure UV light for optimal fluorescent dye response.

The manufacturer claims that the torch is more than twice as powerful as most corded, high-intensity UV lamps, brightly fluorescing all dyes (both green and yellow). The compact torch is powered by one rechargeable lithium-ion battery providing four hours of continuous inspection between charges. The anodised aluminium lamp body is designed to resists corrosion and pitlane abuse and even comes with a lanyard to stop mechanics dropping the torch into the depths of an engine bay.

For more details, visit www.tracerline.com

COMPONENTS

Kistler K-Beam single axis, sensitive accelerometer

The new Type 8315 single axis accelerometer from Kistler Instruments is especially suited to low frequency applications, including automobile ride quality, wind tunnel investigations and aerospace testing where structural vibration and dynamics are used to assess performance, reliability and integrity parameters. Other R&D applications include human motion studies, robotics and platform motion control systems. The Type 8315 K-Beam capacitive MEMS accelerometer is ideal for use in R&D and OEM applications where precision, reliability and durability are demanded.

Six measuring ranges from ±2g to ±200g are available with a frequency response of 0 to 1kHz (0-250Hz for 2g), enclosed in a choice of hard anodised aluminium or welded titanium housings. The sensor design is optimised for low frequency applications common to aviation/aerospace, automotive, civil engineering structure, seismic and other R&D studies. A temperature output is provided for use where external temperature compensation of the output signal is required. A choice of adhesive, threaded stud and magnetic mounting bases and connection options facilitate installation.

For more information go to www.kistler.com

BRAKING

New AP Racing brakes

AP Racing has unveiled its latest range of competition brake upgrades, dubbed Factory Competition Brake Kits. Intended to replace the company's the older Formula Big Brake Kit range, AP says the kits focus on the firm's OEM partnerships and ongoing development of high performance components for specific vehicles. The kits are designed to simplify the process of upgrading a car to competition specification and draw upon AP's experience in the upper echelons of motorsport.

The company also offers high performance friction materials and brake fluids to complement the kits.

For more information log on to www.apracing.com

MEASURING

Wenzel CMM

Metrology specialist Wenzel has recently introduced its new four model X-Cite range of CMM machines. The new range has been designed to provide an entry-level manual CMM solution for quality controlling and reverse engineering of components.

The X-Cite range comes with the Renishaw MCP manual probe systems as standard or can be optionally equipped with either the manually adjustable MH20 probe head, the TP20 robust touch trigger probe, or the MH20i probe head. The four models available have measuring ranges from 500x600mmx500mm up to 700x1200mmx500mm. They are supplied with Metrosoft Quartis measuring software which generates measuring results and reports automatically for a range of measuring tasks.

Full CAD import capability is also available to speed up reverse engineering task.

For more details visit Wenzel's website – www.wenzel-cmm.co.uk

SENSORS

Racelogic dual antenna GPS speed sensor

Data logging specialist Racelogic has launched a new dual antenna GPS Speed Sensor which can be used to measure slip, pitch, and roll at a sampling rate of 100Hz. It is the first of Racelogic's VBOX products to include a yaw rate sensor, and has been developed to ensure that slip translation calculations and yaw rate measurements are accurate. To accompany this new sensor, the configuration software has also been revamped to allow users to quickly and easily set the parameters for the application. This product is also compatible with Racelogic's versatile control unit – VBOX File Manager – allowing changes to antenna separation, dynamic modes and elevation mask settings. The sensor also includes advanced lap timing functionality with the option to set start, stop, and split points through the software or via digital input. Additional brake parameters for deceleration, corrected distance, and standard brake tests have also been built in.

More information is available at www.racelogic.co.uk

PIT KIT

B-G pit equipment

UK-based B-G Racing has released two new items of pit equipment: a versatile folding pit trolley and a quick jack. The trolley folds down to take up minimal storage space, but is spacious enough to transport wheels, tyres, tools and even Euro bins round the paddock, pit garage and workshop. It features two fixed and two swivelling wheels and can be either pulled by hand or has the facility to attach a uni-ball towing hitch to the boss in the handle, allowing the trolley to be connected to a paddock vehicle or quad bike. The quick-lift jacks meanwhile have been designed with durability and ease of use in mind. All feature a very low closed height that can position beneath the differential and front and rear chassis members of a range of cars without fouling spoilers or aprons. The jacks will lift the vehicle to a fixed height in one swift movement with minimal effort, thanks to an extra-long operating handle that provides exceptional leverage. The handle is shaped and detachable for extra convenience. The jacks are produced from high grade steel with a durable silver grey powder coated finish for longevity and come with nylon roller wheels for rapid manoeuvrability. Three sizes are available to suit everything from saloon cars to LMPs.

More information is available at www.b-gdirect.com

MACHINING

Edgecam post-processing for Haas machines

In the CNC machining process, a 'post-processor' is a unique driver specific to the CNC controller it's intended to work with. Post-processors are typically written on an as-needed basis to meet a customer's specific requirements and, therefore, may not support all machine functions. To combat this, CAM software specialist Edgecam has created a library of 33 post-processors specifically for the Haas VF series of 3-axis milling machines. By working with Haas, it has been able to ensure that the full functionality of a particular machine is realised, increasing efficiency in customers' machine shops. The post-processors work in conjunction with a graphical simulation interface to help CNC programmers better visualise machining tasks and to avoid collisions during the machining process.

For more information visit www.edgecam.com

How to plan for trade shows and exhibitions

Essential tips from Tony Tobias to help optimise your presence at Autosport Engineering

Once you have signed up for a trade show or exhibition, read over your agreement with the organisers and make sure that you understand what's included in your package. All shell scheme stands in Autosport Engineering are fully equipped with carpet, tables, chairs, lights, power socket and facia bearing your stand number and company name. There will be a range of different tasks to organise before, during and after the event. The latter point is crucial: always follow up on leads and make a database of cards you collected at the show.

Clear, informative displays can be crucial to attracting new customers

BEFORE THE SHOW

- Market and promote your trade show or exhibition attendance through your website and industry newsletters or magazines. Advertising in trade magazines a couple of months before the show can be very effective in letting your customers – and potential customers – know that you will be exhibiting there. It can help them to locate you if you put the stand number on the ad. If you already have a customer database, send out invitations, newsletters or emails about the event.
- When you book your stand, it is vitally important that you send regular press releases to the show media partner *Racecar Engineering*, and the marketing department of Autosport Engineering. This will help to ensure that your news will be communicated to the motorsport industry at virtually no cost.
- Ensure that your products and marketing material – flyers, handouts and business cards – are up-to-date and contain useful information and contact details.
- If you're selling products at the trade show, make sure that your purchasing process is easy for buyers to make purchases there, or in the future.
- Use your unique selling proposition (USP) to market your product or service and consider giveaways or a competition to attract customers to your display.
- Brief staff that are attending the trade show on correct etiquette when speaking with potential customers. Make sure your staff have thorough product and service knowledge, as well as good customer service skills.
- Think about ways to receive feedback and how to improve your offering. Ask customers if they would like to be added to your database and receive regular updates on products and services.
- Try to stick to the budget that you decided on before the trade show.

DURING THE SHOW

- Attract visitors to your stand through visual displays that clearly promote your product or service. Visitors should be able to very quickly work out what you are offering.
- Engage your visitors, make eye contact and smile. Most visitors will respond by looking at the products or services that you have to offer. Show visitors will pass by your stand in less than 30 seconds! If your staff are looking away, sitting down or drinking coffee or a similar beverage, it will discourage visitors from your stand.
- Ensure that your staff aren't too pushy or overbearing with visitors. They need to be informed about your products and services, but be careful of driving potential buyers away with aggressive selling.
- Ask for feedback from visitors to your stand.

AFTER THE SHOW

- Look at the feedback from visitors, have a debrief meeting with staff, check post-trade show sales, review new customer databases, and self-evaluate the effectiveness of the trade show. This will help you to make a decision on attending a trade show in the future.

To book a stand at the Autosport International Show, on 9-12 January 2014, contact Tony Tobias: tony.tobias@haymarket.com

The power behind Autosport Engineering

Powertrain companies see the value in attending Britain's premier motorsport trade show

The Autosport International Show is firmly established as the place to start your business year, as it is the largest trade show dedicated to motorsport in Europe.

Drivetrain companies have remained loyal to the show for very good reason – they get tremendous value from it. Those who have a long-standing relationship with the Autosport Engineering Show include ARE Racing Engine Systems, ARP, Arrow Precision Engineering, ITG, Ferrea Racing Components, Jenvey Dynamics, Newman Cams, Pistal Racing, PMI Performance, Pro-Bolt, Supertech, Total Seal and Westwood Cylinders. Those of you who know these companies will be aware that many of them are foreign companies who are keen to expand their businesses in the UK.

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

Over 200 exhibitors have already confirmed for the 2014 show

Homegrown and overseas companies will be in attendance at the ASE show

NEW FOR 2014

To date, over 200 exhibitors have booked stands at Autosport International, including 18 from outside the UK for the full four-day show, and a further 28 from 11 non-UK countries for the Autosport Engineering Show alone, a reflection of the international nature of the event.

International first-time attendees include:
Uni-Saf, China – race suits
Happy Racer, Italy – safety equipment and rollcages
K-Sport Racing Co Ltd, China – suspension and brakes
Among the UK first-timers are:
Minitec – modular aluminium profiling systems
Omex Technology – engine management systems

First time attendees for the Autosport Engineering Show 2014, in association with *Racecar Engineering*, will include:

Case Liner, Czech Republic – pit equipment specialists
Exzess International, Taiwan – brake manufacturer
SPR, Taiwan – aluminum strut bars, wheel bearing spacers, adjustable fuel pressure controller, sequential blow-off valves, gear shift levers & knobs, adjustable rear double spoiler wing

Among the UK first-timers that will be in attendance:
ML Electronics Ltd – electronics engineering design and manufacture

Racecar Engineering

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Gentlemen, energise your motors

When I sat with designer Ben Bowlby following the announcement of the Nissan ZEOD (Zero Emissions on Demand) at Le Mans, he was profoundly disappointed at the reaction of the paddock to his new venture. Nissan's plan is to create a car that can complete a lap of Le Mans at between LMP1 and LMP2 speed on electric power alone, each stint for 24 hours. Reaching speeds of 300km/h each lap for 24 hours is, says Bowlby, a lot more challenging than last year's DeltaWing project that garnered so much publicity for the Japanese manufacturer.

Everyone in the paddock who I spoke to were pretty much unfazed by the programme. 'Yep, makes sense,' was the reaction, which baffled Bowlby. This is a true engineering challenge and, having defended DeltaWing for many years, a project he was sure would work, he now has the opposite job to do with ZEOD, and convince everyone that this is a bit difficult.

Meanwhile, the man who has championed electric racing more than any other, Lord Paul Drayson, was busy preparing for a new challenge – breaking the electric land speed record in his converted Lola. The former government minister achieved his mission, topping 200mph the week after Le Mans. Several years ago, Drayson stood at the MIA's green conference in Birmingham and delivered a speech that called on the racing community to build electric cars that the Top Gear fraternity could not ridicule. This, he said, was key to changing the perception of electric cars, in general and he has led from the front and put his money where his mouth is.

Bowlby's new challenge is to convince everyone that this is a bit difficult

It was Drayson who was the first to commit his Lola to Time Attack, setting lap records on electric power using a car that featured all sorts of moveable aero tricks. That has yet to be undertaken, but his speed record generated plenty of publicity on its own. Drayson was also the first to commit to Formula E with his own team, fully demonstrating his commitment to electric racing and with the announcement that British manufacturer Bluebird could be allowed to build chassis for the series as early as next year, opening the door for multi manufacturers, suddenly the series looks a bit more interesting. (Mind you, there is a slight issue in that the organisers say that Dallara is building a spec-chassis, while the only two teams committed want to build their own, but that's another column).

On the other side of the world, Peugeot was preparing for its assault on Pikes Peak with a very different car – one that featured its own V6 engine that powered a Pescarolo at Le Mans in 2003, raided the spare parts bin from the 908, and then added a dose of Sébastien Loeb to help the car shift a bit. Loeb promptly smashed the course record, setting a time of 8m13s when no man had previously beaten the 9-minute barrier. Actually, the previous record was 9m46s.

It was an impressive performance, one that was expected by those on the course (actually Porsche factory driver Romain Dumas, also competing as a privateer in his Norma, expected him to attack the 8-minute barrier), but was effectively a hammer used to crack a nut. Beating a record by more than a minute when there are only nine of those available is an extraordinary achievement.

Looking through the results lists, however, that was not the only one of merit. Monster Tajima, driving his own-built E-Runner Special, was on course to beat second-placed Rhys Millen's 9m02 in the Hyundai when the weather turned, and he encountered snow at the top of the hill. He still finished up fifth fastest, despite attacking the last section still on his slick tyres. Just as impressively, Carlin Dunne set ninth fastest time, a 10m00.694, on his Lightning electric bike.

There can be little doubt that the perception of what is possible with electric mobility is changing. We should be careful to remember that Nissan, despite investing €5bn Euro in battery technology, considers that only 10 per cent of its production fleet will use battery power alone by 2020, and the majority of these will be used in the cities and for short journeys only. While top speed, altitude and endurance demonstrations are all fascinating, these are headline projects that are not being heralded as the future of motorsport, or our motoring needs. These are 'just' very impressive bits of engineering.

EDITOR
Andrew Cotton