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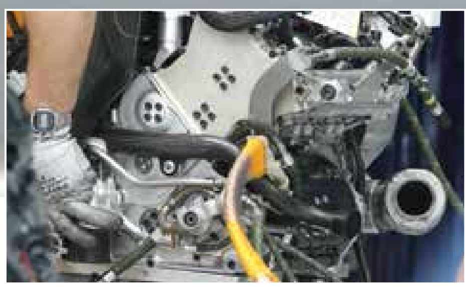
Toro Rosso STR10

Is this really the next-best car in F1?

LMP3 makes race debut

We reveal how constructors are interpreting baby prototype rules



Renault Energy F1-2015

Under-fire manufacturer aims to close the gap to Mercedes

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New regulations lead to innovative aero solutions

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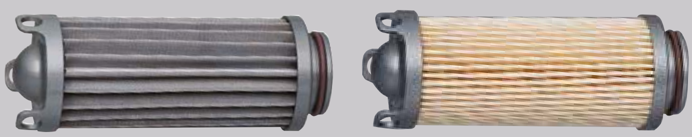

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Peter Wright (P7) says F1 is too predictable and that is turning off the audience which craves unpredictability, and loves wet races!


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The impossible dream

Could the search for the perfect racecar set-up be an insurmountable challenge?

The eternal search for the optimum set-up is doomed to failure, simply because there will be an optimum set-up for each moment of the day, position of the sun, weather conditions such as temperature, humidity and barometric pressure and wind direction. In an extreme case, there's hillclimbing at Pikes Peak. There the altitude change will sap your engine power as you ascend and at the same time reduce your aero downforce as barometric pressure falls from 69.6 kiloPascals to 57.2, a full 17.6 per cent.

Much in the same way, trying to home in on the best set-up can be a nice exercise in topology, as defined by Gottfried Leibniz, who in the 17th century envisioned the *geometria situs*, or topography if you want to visualise it on a graph.

Every parameter you can change will have a non-linear effect, not intrinsically, but because of the 'No Free Lunch Law' – in racing as relevant as the Second Law of Thermodynamics.

Paying the price

You can have more horsepower, but you will use more fuel, giving you a shorter range, or you can have more downforce, which tends to give you more drag, but would also give more spring and tyre deflection, which would mean either stiffer springs to keep from dragging your plank on the higher speed straights or on the banking, or higher tyre pressures to stiffen the sidewalls and change the tyre spring rate, which will then change your mechanical grip level in other places.

There are four corners to a car, where you can change individual tyre pressures, compounds, construction, spring rate, damping low- and high-speed, bump and rebound; all non-linear, all dependent on several other variables and at different speeds.

Several of these elements are temperature dependent, such as damper fluid viscosity, tyre compound grip and engine performance, the atmosphere changing its density, not to mention wear dependent, like discs and pads and tyre thread. Even tyres tend to degrade not so much by thread thickness but by the breakdown of stiffness due to carcass inner cord degradation.

Have enough data and awareness and you can re-set your ride height lower for the afternoon qualifying session, catering for the loss of downforce in the warmer air, thus clawing back some of it, but not forgetting to re-set your tyre initial pressure as the asphalt will be warmer given the three hours of gentle baking if the sun is out. And then the wind might have changed …

This is not so much adding to the complexity arithmetically, but factorially. So if you have six elements, you will have 720 combinations, not all having the same weight. If you add all the factors that will influence your lap time you can easily be into the hundreds.

Plotting this would give the equivalent of a topographic contour map, with the peaks being the best performance and valleys the worst. But beware, the 3d is a simplification; you are entering manifold space with probably more than 50 inter-related dimensions. You could be wandering in the arid valley, no changes make much of a difference; it could be merely that track conditions are such that the grip level is so low that all changes will not impinge on handling very much. Or you could be right in the peak sweet spot where one click of damper will be the Goldilocks tweak, just right.

The best you can do is to try to foresee the changing factors

XPB

At Monaco you need to think about how the track will rubber in

Think Le Mans at the start of the test day, where the road from Tertre Rouge to the entry to the Porsche Curves will be covered in diesel, dust and oil from the year-long normal traffic, and very green, while most of the closed part of the circuit from the Porsche Curves to the Ford chicane, and from the entry to Dunlop up to the right hand Tertre Rouge, will be dusty and slippery, not having been used for a year.

Patience a virtue

Many times the art of being patient and letting the track come to you will be rewarded, as tinkering with the set-up when there is no grip will put you on the back foot when it starts to grip up. At Monaco you would start soft in roll-couple and stiffen it up as the track rubbers in.

Experience will guide you into predicting the behaviour of, say, a new tyre set, so you would know the rear tyres would warm up quicker and have more grip, so for that all important qualifying lap you can take off a sniff of rear wing, knowing the extra grip of the new tyre will balance it out, plus you will be a tad faster on the straight.

Then there's the wind direction at Suzuka. If there is a tail wind on the straight you will be faster, and also the head wind through the esses will give you more grip, 20 or 30kph making a considerable difference in downforce. The fact that Suzuka is by the sea can also allow you to predict the prevailing winds according to season and time of the day.

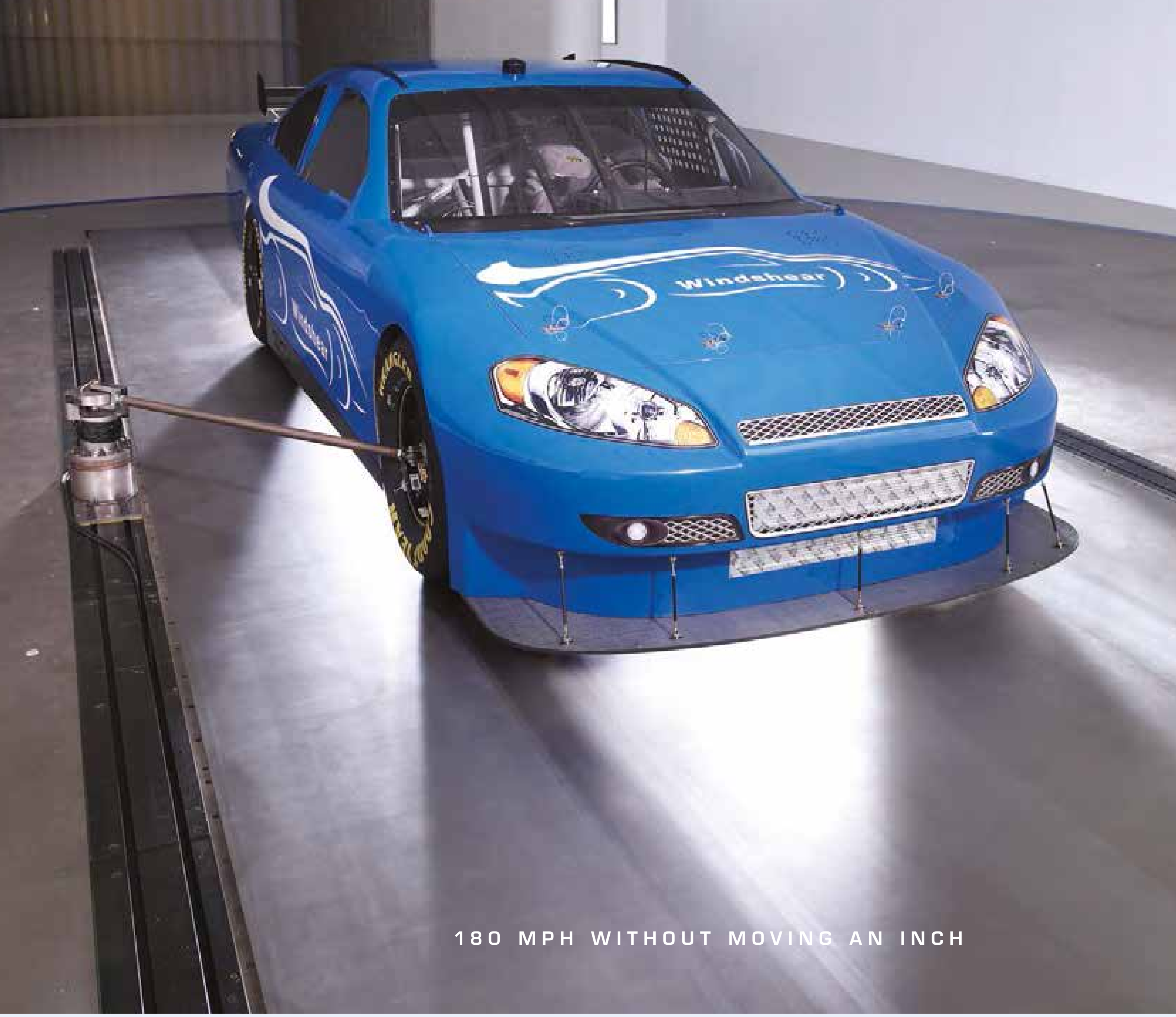
Of course all this is deduced from data recorded by sensors and info from previous tests or races at the particular track, but it is also still very dependent on the description of the handling by the driver, at which stage we can agree on an observation by the philosopher Karl Popper: 'It is impossible to speak in such a way that you will not be misunderstood.' He was obviously referring to racing drivers.

Simulation can give you a precise analysis of settings needed for the ultimate lap, but can struggle to give a perfect description to the driver that is operating the machinery, actually sitting inside the misbehaving car. The common engineers quote is: 'It was fast in the simulation.' Much like the purposely directionally-unstable fighter plane, designed for fast response in combat, a nimble car can be too much of a handful to use between guardrails and has to be toned down a notch, as no driver, or fly by wire computer, can temper the aggressiveness of the response.

Topography being what it is, you could find yourself on a local peak, but missing the higher peak on another combination of parameters some way away from your usual settings. A wholesale change in your paradigms is not something to be taken lightly, especially if your performance is a bit lacking and the qualifying session is in half an hour.

The best you can do is to try to foresee the changing factors, put them in order of importance, refrain from applying multiple changes simultaneously, as the resulting complexity of the interacting factors might throw up something you didn't want.

As Alan Turing once said: 'Machines take me by surprise with great frequency.' Me too. Then again, Johann Wolfgang von Goethe said: 'I love those who yearn for the impossible.' I think he might have been fond of race engineers.


180 MPH WITHOUT MOVING AN INCH

Uncertainty principles

Why have grands prix become so predictable – and just what can be done about it?

If a picture is worth 1000 words, and I could draw, I would save myself a load of time by drawing a cartoon of F1 at the moment. I would draw a picture of F1 in a ring, wrestling with itself. There would be no sign of anyone refereeing the contest or checking for fair play; the spectators would be either shouting out encouragement or advice, while those at the back would be shifting towards the sign that said *Exit*. At the edge of the picture would be a group of well-known high rollers in negotiation with a group of unknowns, with large bags marked '$$' on the table.

Right now, such a wrestling match makes a poor substitute for an F1 race, but at least the outcome is uncertain. And herein lies the problem: F1 has become too certain. By design!

While researching this article, a number of phrases have popped up, either written or spoken: 'Nothing is certain. That's why it is exciting.' (a SkyBet advertisement).' Or: 'We do not read the end of a book first.' Then there's: 'Sport is drama with the ending unwritten.'

Yet the perception of F1 at the moment is that the outcome is all too certain, and that there are many alternatives to divert people's attention and leisure funds, where people can experience excitement through uncertainty. In my pre-season review of F1 following the Jerez test, I concluded that: 'And thus a reasonable prediction for the new F1 season would be for Mercedes and Williams to continue achieving at the level they achieved last year, while the others, er, well, we will have to wait and see …

'… The Ferrari looks good, with Sebastian Vettel obviously revelling in the car's handling. Renault and Red Bull stuttered at Jerez with trivial problems. And McLaren-Honda? The body language of its personnel did not correlate with what was happening on track and so it remains to be seen if their optimism is justified. I have my doubts, but look forward to being proved wrong.'

University of Williams

I am in no way claiming credit for these predictions; they were obvious, almost certain. Ferrari had cracked the new powertrain code; Renault had not and were fraying under Red Bull pressure; and Honda frankly didn't look as if they knew how to. Meanwhile, Mercedes and Williams simply maintained continuity.

It is also now clear that there is a certain factor in running the engineering at a successful team, as the 'family tree' below shows. The technical director of each of the current top three F1 teams has been influenced by Ross Brawn. He, along with Adrian Newey, were both educated at The University of Formula One Engineering (aka Williams Grand Prix Engineering) whose vice-principal was Patrick Head, now Sir Patrick Head. Some legacy!

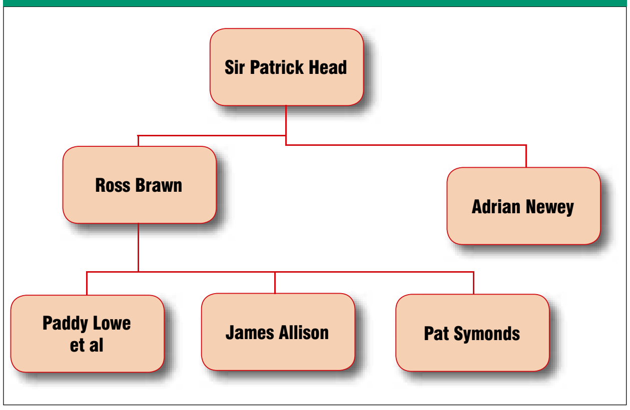
But where else has the uncertainty gone? In truth we don't like uncertainty in our lives. We invest in houses and pensions; we buy cars with multi-year or 100,000 mile warranties; and take out comprehensive insurance to cover much of what we do. We want our mobile phones to instantly connect us, wherever we are. We even demand compensation when something goes wrong. We want certainty in all the important things in life and industries have developed to provide this. Some of these same industries are involved in F1, either as suppliers of powertrains, tyres, fuels etc., or as investors and sponsors, and they too want certainty. Maurizio Arrivabene: 'It is unacceptable that the wheel nut does not go on first time.' Ferrari, again, gave Kimi Raikkonen a car with an uncertain throttle response and now threatens to let him go if he can't do better than spin.

Even Mercedes' strategic glitch at Monaco, which was probably the highlight of the entertainment in that race, elicited the comment: 'We will be taking steps to make sure it can't happen again.' Pity!

So how has F1 slipped from exciting uncertainty 20 years ago, to less exciting certainty now? I believe there are many factors, but first let us analyse what was, and indeed often still is, uncertain in F1 and what has changed.

First, there's reliability. *Powertrains*: when engine development was unlimited, more power, mainly through rpm, was sought for each race, qualifying engines were allowed, and there was no limit on the number of engines blown up in the season. When rpm was limited and the number of engines per season controlled, reliability had to become a science. Cosworth for one developed a reliability schedule based on extensive full powertrain dyno running, such that the life of an engine could be predicted based on its duty cycle and history – just like the gas turbine engines on an aircraft. That technology found its way into Mercedes HPP along with many key Cosworth personnel. *Gearboxes* still give problems, but again, limited numbers per season have led to sophisticated test rigs and much greater reliability.

F1's technical director family tree



Chassis: brakes are the Achilles heels of the chassis, being hot and rotating, but close monitoring of their wear and temperature allows safe use, even if performance has to be curtailed.

Racing certainties

Then there's *tyres*. A lack of competition limits the risks a tyre company will take, and allows the manufacturer and teams to learn their performance and wear characteristics. Temperature and pressure sensors enable them to be kept within their operating parameters, in the same way as brakes.

Accidents: the emphasis following Ayrton Senna's and Roland Ratzenberger's fatal accidents has been to still allow drivers to lose control, but to try and prevent the consequences becoming serious. Extensive gravel and tarmac run-off areas, better barriers, better race control, and driver penalties for aggressive racing and even errors, has led to accidents becoming an infrequent source of excitement.

Drivers: the emergence of the driver-in-the-loop simulator as a substitute for testing has enabled teams and drivers to learn their cars and the next circuit, and practice every scenario and eventuality before an event, such that the chance of the unpredictable happening is greatly reduced. Every driver control on the car, except the brakes, is now power-assisted. Drivers use the very latest physio' and dietary technology to ensure that they are fully fit. It is no wonder that after a two-hour race a driver hardly breaks out in a sweat.

Strategy: the same simulation technologies apply to the way the team conducts the whole event, particularly the race. All possibilities are predicted and the unexpected is unacceptable.

The combined technologies of full powertrain, full race simulation on dynos, 600-plus sensors on the cars, driving simulators, strategy analysis software, Failure Mode and Effects Analysis (FMEA), better design and manufacturing using computer-based technologies, and the introduction of limited life powertrains and gearboxes, reduced testing, driver penalties, and safer circuits and race procedures have all but eliminated uncertainty and the excitement this brings for those watching the racing. This situation is never going be reversed by regulation.

What can be done?

For those that seriously follow Formula 1 and delve into the technical, political and sporting goings-on, it is still fascinating. For an engineer, the technical supremacy of a team or manufacturer is often awesome, but that will not pull in the casual fans or viewers, who are out there casting about looking for something to excite and entertain them.

What can be done to resolve this problem and why is it so hard to bring about the necessary change? An immediate answer is that the problem of Formula 1 (if there indeed is one) has not been defined. All that has happened is that numerous and varied solutions are being chucked at it, from more speed to more difficult to drive cars; from more risky to artificial sporting regulations; from more money for small teams to 'franchised' cars. Then these are immediately batted back by those who believe the problem is different, or who have other agendas. In order to progress F1 must decide what it wants to be, i.e. what combination of: (1) A technical endeavour involving OEMs.

(2) A sporting contest to determine the best car and driver in the world (first define what you mean by car – relevant to road cars and highly complex, or purely a simple racing machine, built to entertain).

(3) A business to attract the cash of the public, sponsors, automobile industry, and other business.

(4) Where the profits should go: investors, participants, or reinvestment in the sport?

(5) An entertainment to compete with the Olympics, football, computer games, reality shows, soap operas etc.

Who decides? I suspect that is the problem the Strategy Group is wrestling with. It used to be Bernie Ecclestone and Max Mosley, working together, emerging from the FISA-FOCA war with a vision. That vision was delivered in spades, still exists, and still works pretty well. But nothing in business is allowed to stand still and a whole new vision for the future is required, one that does not destroy what has already been built, but is adapted for the very different world and demographics we now live in. That is a really tough thing to do, and is why there are clever people in charge.

Returning to the issue of excitement through uncertainty, I personally do not believe much can be achieved through the technical regulations. Yes, the car can be made faster, but harder to drive? I doubt it. The engineers now know how to make engines, chassis, aerodynamics, and tyres with benign characteristics, and they're not going to forget that.

Whether the technical regulations should attract OEMs is one of the business issues to be resolved. The sporting contest between drivers is essential, but must be balanced against entertainment and purity – more on this shortly. I do not know enough about the business side of F1 to comment; it just needs resolving so that the sport is sustainable for the participants.

In the current climate of engineering and strategic certainties, any team or OEM that brings more or better technology to bear on F1 is going to move ahead and win regularly and predictably, which is not entertaining to most people. Mercedes' advantage is currently such that anything unpredictable, such as Hamilton's five-second penalty for crossing a white line in Austria, has no effect on the outcome. If one of the Mercedes drivers falters, the other wins; where is the excitement in that?

The technical supremacy of a team is often awesome, but that will not pull in the casual fans or viewers

XPB

Mercedes running first and second at Montreal this year, a predictable sight in F1 in 2014 and 2015, but what can be done to bring the uncertainty back in to the sport?

The only way to increase the excitement is to bring the performance of all the cars close enough together so that the tiniest uncertainty, those that the teams cannot eliminate, affects the outcome. Every other form of motorsport does that to some degree or other, either through spec cars, spec engines, or highly restricted technical regulations; BoP, EoT, etc. And it works. However, F1 and its pundits look down their noses at such 'non-traditional' measures, even as they claim it is currently boring. They also decry 'artificial' sporting regulations to enliven the show: success ballast, reversed or random grids, multiple shorter races etc.; all these mimic devices that are used in ancient games to make them entertaining: dice, cards, even increasing the number of snakes near the top of Snakes and Ladders to allow competitors to catch up. Chess, that ancient game that does not rely on luck but rather on strategy alone, does not make a good spectator sport. In motorsport, only rain brings the true element of rolling the dice.

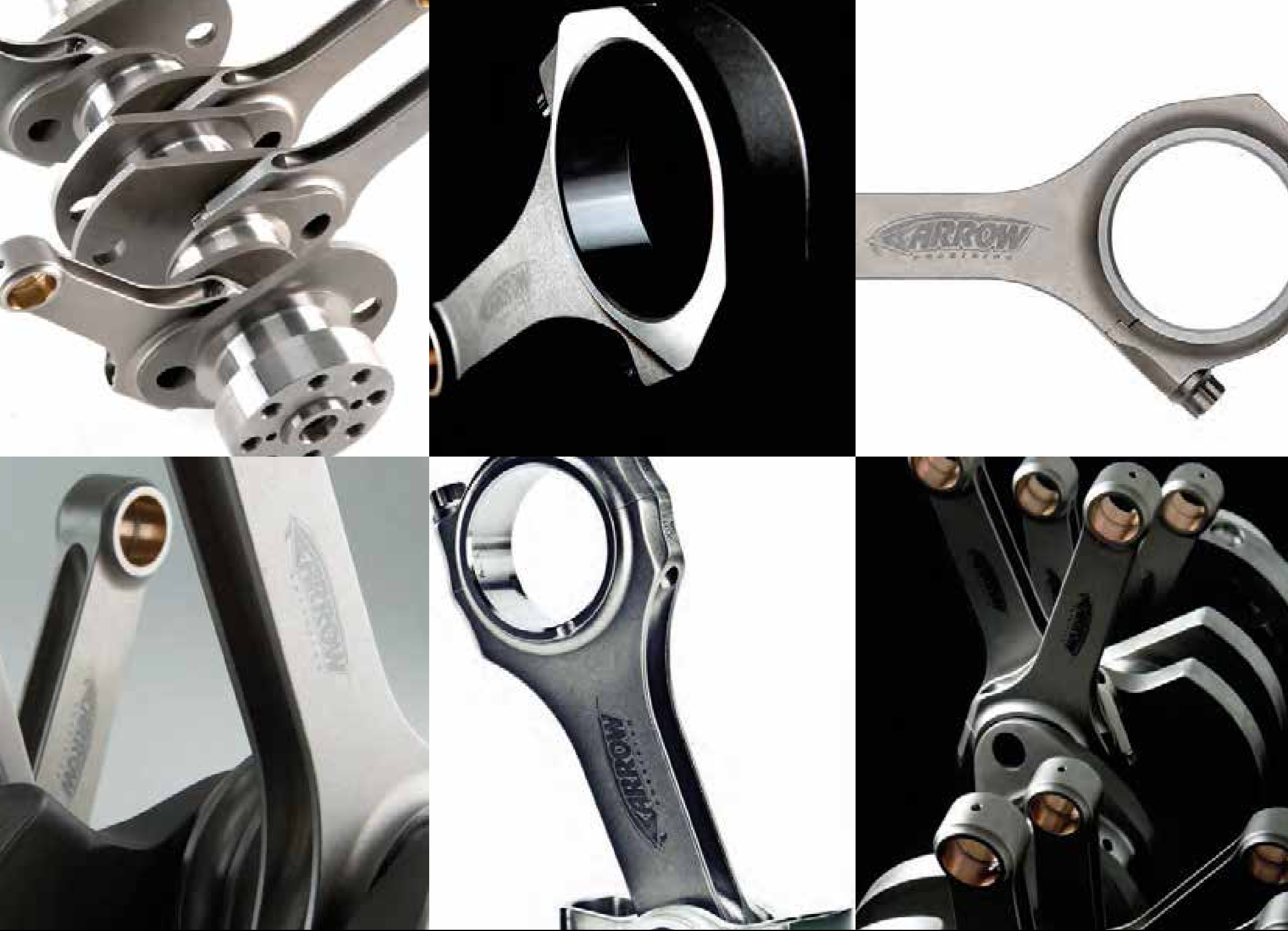
Entertainment has to be balanced against technical contest and human sporting contest. Until the brains that control F1 stop talking about solutions and apply their efforts to defining and agreeing what the problem is and what is the objective for F1 in the future, there is little chance of progress. For me, the future of F1 is the only issue for my mid-season review this year. The rest is predictable, and anyway who knows what each team and powertrain developer is doing? I still believe it is a great pity more technology is not revealed to attract those that are interested in such things. The main technological development seems to be how to make a short nose pass the crash test. Surely other things are happening?

New blood

I recently met with Ron Ayers, the designer of Bloodhound SSC, the Land Speed Record project. Bloodhound has promoted a pioneering educational side to the project, for which it has UK Government support. They have engaged with 6000-plus schools worldwide, including 800 in South Africa. Universities allied to the programme have seen a 100-plus per cent increase in applications for engineering degrees, and some have been able to double their intake.

Bloodhound driver, Andy Green, recently gave an interview to a newspaper in China with a circulation of 175 million. *The Discovery Channel*, a Bloodhound partner, estimates that by the end of the 1000mph attempt Bloodhound will have a worldwide exposure of around 2.2 billion people – just over 30 per cent of the world's population, and nearly 50 per cent greater than F1's exposure! If Bloodhound can engage people, particularly young people, in engineering and technology, surely F1 can too.

I also believe that Formula 1 has missed the point of the Internet. It engages with people through social media, for free, but in exchange for their details. One may be wary of this exchange, but if F1 does not engage by whatever means, with young and old, it will never involve them to the extent that they become that essential part of any business – the customer. There is an old engineering adage: 'If you define the problem completely and correctly, the solution is immediately obvious.'



Sport for all

Is it a good thing that racing is no longer quite as physical as it once was?

Recently driving a car equipped with a sophisticated paddle-shift transmission, shortly after making a cross-country trip to Le Mans and back in my '84-vintage 911, reminded me how much such developments have reduced the effort and concentration required by the driver. This is even more evident in racing. Combined with various other engine and transmission electronic gizmos, it explains the criticism levelled by many that contemporary racing cars are too easy to drive compared to previous eras.

This observation has been especially aimed at F1 cars, which (in common with LMP racers, among others) also have power steering.

My sympathy with this view was reinforced at Goodwood last month. Susie Wolff was demonstrating one of the beautiful 1950s Mercedes-Benz Silver Arrows up Lord March's hill and in the collecting area beforehand I could not but take note of the slenderness of her arms. Now Toto's wife has several times tested Williams F1 cars and achieved respectable performances. But I believe there is no way she could have achieved this before F1 cars gained the driver aids I have mentioned above, short of a serious body-building programme of course. The question is: should strength be a prerequisite for a driver, even in F1?

Back in the day

Prior to the advent of mid-engine F1 cars, stamina as much as sheer strength was essential. This was due to races being significantly longer, and heat from the front engine and the gearbox, often right between the driver's knees, could cause blisters or even burns to hands and feet, while starving him of fresh air. Matters became easier when the powertrain moved behind the driver. Nonetheless, the tiny steering wheels necessary to fit in the much narrower cockpits together with the extremely reclined driving position created a different set of physical requirements. Once ground effect led to serious downforce levels being achieved the picture changed dramatically. Nigel Mansell is often quoted as an example of the muscularity needed to turn in and hold the car on line in fast corners. Some of this was car set-up and driving style, as the diminutive Alain Prost was no sluggard, but there's no doubt that it was very hard work. The amount of sweat evident on drivers' faces and frequent exhaustion post-race clearly showed this.

Driver fitness to professional athlete levels is *de rigueur* these days, despite the mandated reduction in F1 car downforce over the past decade or so and lap times that are correspondingly slower. Fitness, however, does not necessarily imply great strength.

Amazing multiple-amputee Frederic Sausset has already begun his quest to compete at Le Mans. Nick Hamilton, who has cerebral palsy, is competing in the BTCC. Despite losing both legs in a shocking IndyCar crash, Alex Zanardi competes with success in GT and Touring Cars. In the past, Archie Scott-Brown and Jean-Pierre Beltoise, each with one arm severely impaired, were leading drivers in sportscar and F1 racing, as is Robert Kubica now in the WRC. The list just goes on and on.

XPB

Susie Wolff has shown real speed in F1 but our columnist wonders how she might have performed in the old days

Which prompts the question: should F1 be just for athletes? Why, using all the modern aids available, shouldn't a handicapped person who otherwise ticks all the right boxes potentially be a F1 driver? Hard to drive shouldn't necessarily mean physically hard, just difficult. Many sports demand great strength, but motorsport is different because, lo and behold, it uses an engine to do the work!

The attributes that surely should matter most regarding race driving are more cerebral:

- **Competitive spirit and desire to win**
- **Satisfaction in taking a racing car to its limits, and sometimes beyond**
- **Courage and determination**
- **Intelligence and technical understanding**
- **Capability in conserving tyres and fuel**
- **Ability to withstand pressure**
- **Ability to motivate the team**
- **Skill – especially car control and hand-eye co-ordination**

Regarding the final attribute above, although physical stimulation – seat of the pants? – is needed in order to 'feel' the car, it is not otherwise purely dependent on physical condition, if technology can adapt the controls to the particular disabilities of the individual. Medical science and engineering have made great strides in either replicating what would be normal human physiology or enabling alternative parts of the body or brain to achieve similar functions. For example, eye movements can activate computers and give commands.

Brain before brawn

The Paralympics has illustrated how much can be achieved. Motor racing should not shy away from making similar advances, provided that such prosthetics or other aids only 'remove' the disability and do not provide any control of the car that is not instigated directly by the driver. Nor must they give an advantage over able-bodied drivers, an accusation sometimes levelled at Olympic runner Oscar Pistorius with his carbon-fibre 'blades' substituting for amputated legs.

Getting back to the theme of making Formula 1 cars, in particular, harder to drive, the fundamentals apply. More power than grip; achievable either by increasing the former or reducing the latter, with more power (and thus more speed) favoured to maintain F1's status of ultimate performance. A reduction in driver aids and information. Drastically cut down the number of ECU/data-logger channels and command functions allowed; especially ban those that continuously alter power-unit torque settings, creating automatic throttle modulation and thus a form of traction control. Regulate that differential settings are fixed once the car is in motion. Get rid of DRS by adopting the aerodynamic recommendations (away from flat bottoms in favour of controlled ground-effects) put forward some years back, which would allow cars to follow one another much more closely through fast corners without drastic loss of downforce. Together with items thankfully already being addressed such as 'launch control' clutch functions, these would be steps in the right direction.

Brain rather than brawn, skill rather than button-pushing. Isn't this what race-driving should be about?

Should strength be a prerequisite for a driver, even in Formula 1?

Shining STaR

Toro Rosso's F1 challenger has been one of the surprising packages of 2015. *Racecar* lifts the lid on the STR10's speed secrets

By SAM COLLINS

'The aerodynamics of the STR10 are a big step forward from the previous car. We have also achieved a more balanced and stable platform'

‘This car should be in P3 behind the two Mercedes,’ claimed Formula 1 rookie Max Verstappen ahead of the British Grand Prix. It is a sentiment shared by many in the Toro Rosso team. His team mate Carlos Sainz had made a similar claim earlier in the season and went further in quantifying it too: ‘We look at GPS data after every session and compare ourselves with Ferrari, Williams and even Mercedes. I’m convinced that this car, with a very decent engine, will be fighting with Williams and, on some occasions, with Ferrari. At Turn 3 and Turn 9 in Barcelona, only Mercedes was quicker than us.’

The Toro Rosso STR10 is the result of a long project from Red Bull’s junior grand prix team which has extensively restructured its technical team while also improving its facilities in Faenza, Italy. The first fruit of that project was last year’s STR9, which finished seventh in the constructors’ championship.

‘Last year’s car was a 24-month project and a tough time in winter testing meant we started on the back foot, we missed out on a lot of understanding of the tyres and chassis and also our new driver didn’t get the mileage he needed,’ says technical director James Key. ‘Despite this we made a step forward in performance terms in 2014 and the positives we can draw are that. Fundamentally, we produced a more competitive package than we’d seen in some time.’

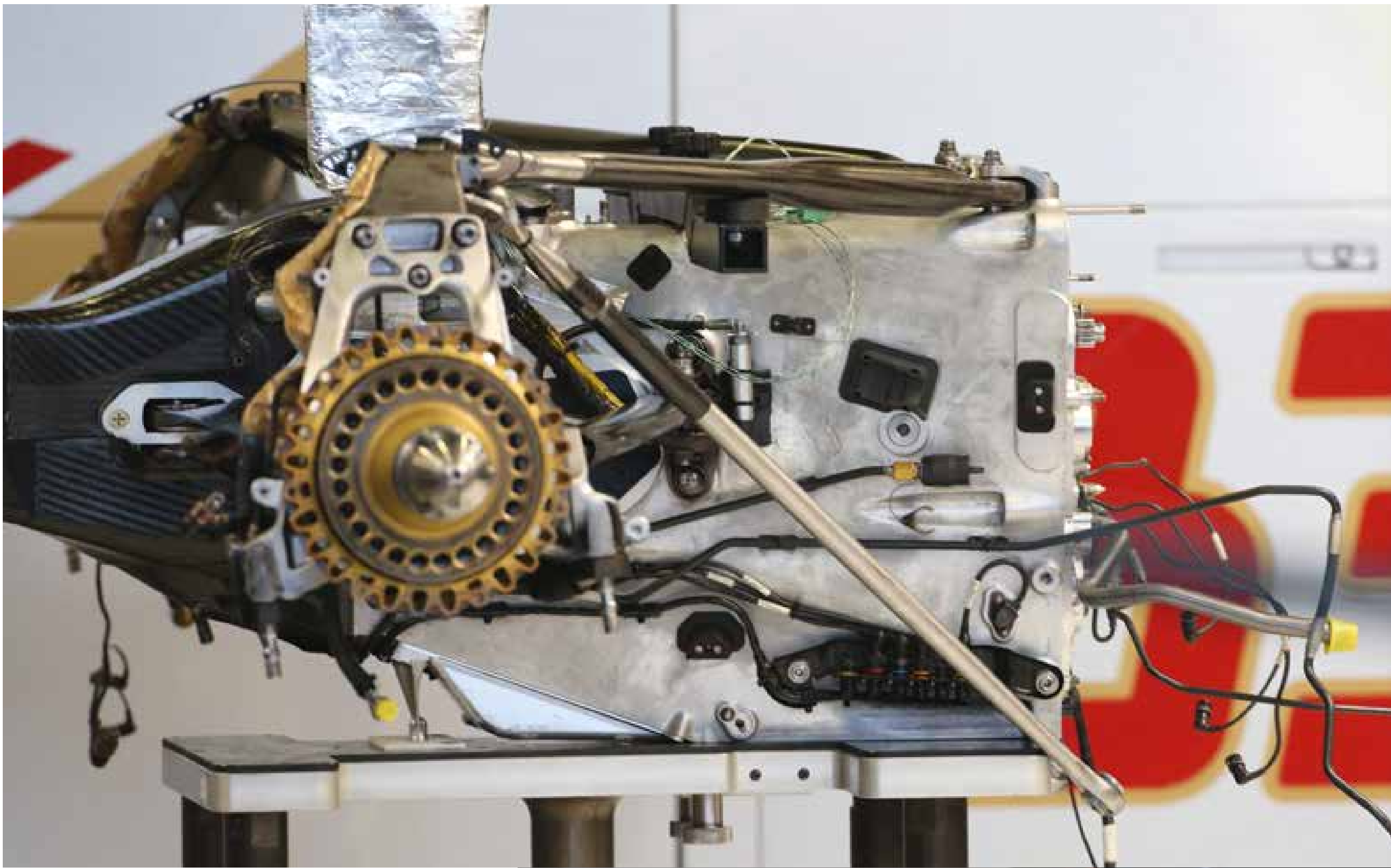
That boost in competitiveness saw Red Bull set its two teams some clear targets. The senior team, Red Bull Racing with its bigger budget and more experienced drivers, was expected to be at least third in the constructors’ championship, while Toro Rosso was tasked with a fifth position finish, its highest ever.

To achieve that Key and his engineering team created a car that has been the subject of many compliments up and down the paddock, but from the moment it made its first shakedown run in Italy it was clear that this car was generally an evolution of the 2014 model. ‘We developed the STR9 quite late into last year, so a lot of that learning carries over,’ says Jody Egginton, head of the Vehicle Performance Group at Toro Rosso. ‘The new regulations have led to an aggressive development programme and in my opinion, development is not cyclical or seasonal anymore. Everyone is trying to bring as much performance to the car as quickly as they can.’

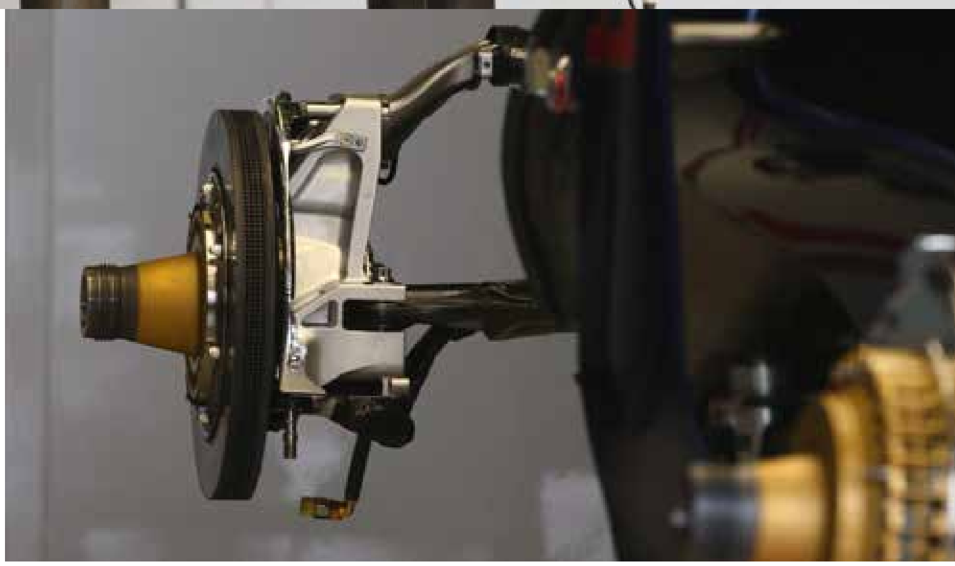
The STR10 was first shown to the media ahead of the opening pre-season test at the Jerez Circuit in southern Spain, and the car presented was on the whole fairly conventional, with push rod actuated torsion bar front suspension and a pull rod actuated rear. The Renault RS34 power unit is mounted directly to the rear of the monocoque and the transmission mounted to the rear face of the V6 block.

‘The car is a real mix of very different approaches in some areas, while also refining and developing what we felt were some of the more solid philosophies of the 2014 car,’ Key said at the launch. ‘We’ve got several very new ideas which have gone into it, which the team is exploring for the first time, which makes it an interesting project. We’ve pushed the limits of timing much more with STR10 than with past cars, and we’re dealing with it really well.’

One of the concepts that carried over from previous STR designs was the centrally mounted cooler concept, resulting in a very large and rather unattractive but clearly effective cooling duct under the roll hoop. This allows the car to have much smaller sidepods in exchange for the central coolers, raising the centre of gravity somewhat. The sidepod ducts are thought to house the intercoolers as well as the water coolers for the V6 engine and the energy recovery system. The large central cooler is reportedly an oil cooler and has a complex shape. This all allows for a very tight rear end on the car, at its launch the rear suspension pullrod passed through the rear



Above: Scuderia Toro Rosso has a proud heritage of building its own gearboxes, which gives it complete freedom when it comes to its rear suspension design. Internals are courtesy of Red Bull
Right: The rear corner has been the subject of development around the upright (pictured) this season as Toro Rosso has striven to attain more aerodynamic benefit from the wishbones



of the sidepod, but with updates ahead of the first race the rear was tightened up even further.

Developing this concept involved a lot of work by the Toro Rosso aero department, split between the main HQ in Faenza, Italy, and its own wind tunnel in Bicester, UK. 'We do a lot of work on underbody flow, with the amount of cooling you have now on these cars you have to do that anyway,' Key says. 'You have exhausts at 1000degC, turbo just above your rear suspension in the gearbox, it's a lot to manage. You have to do a lot of CFD to understand it.' While wind tunnel usage, like CFD, is restricted in F1, work specifically on cooling systems is not and teams are free to develop those areas. But heat generated by hot components under the body is not replicated in the tunnel.

Cool running

Key continues: 'In the wind tunnel you don't really quantify those sort of things, the temperature effects do not really make that big a difference to the overall flow so the fact you have a different temperature of air passing through the bodywork and coming out of the rear of the car does not make that much of a difference in the tunnel. You do the hot stuff with CFD. That's not to say that we do not do cooling work in the tunnel, we do, it's just more related to cooler sizes, pressure drops and bodywork, while CFD will quantify the cooling capability and conditions under the bodywork. It depends on what you are dealing with how you do that testing. You have coolers inside the wind tunnel model, that give you the representative pressure drop and the underbody flows, so there is stuff done at scale.'

The overall aerodynamic concept of the STR10 does vary from convention in a number of areas as a result of the cooling concept it uses. 'The nose is the most significant change for 2015,' says STR's deputy technical director Ben Waterhouse. 'The majority of the rest of the car is just evolution because there is an element of stability to the regulations. However, the nose clearly has a strong influence on everything, so from an aerodynamic perspective, the concept is certainly different to what we had in 2014.'

At the car's roll-out and in early tests it featured a relatively long, Ferrari-style nose, something installed largely to ensure it passed its crash tests at the first attempt and would be ready in good time for the Jerez sessions. For the final test and in time for the Australian Grand Prix a new, shorter nose was fitted.

Much of the aero department's focus, though, was on the rear of the STR10 and

Above: The back of the car is tightly packaged and Toro Rosso is now focussing much of its development on the STR10's rear. The wing support actually passes directly through the tailpipe
Below: The STR10's front bulkhead is pretty conventional as is the rest of the pointy end, featuring torsion bar front suspension. The assisted steering rack is manufactured by the team

that continues. The team has clearly worked hard to achieve the tightest possible rear end and continues to try to get the most out of the benefits that brings. 'The rear end layout is a combination of a lot of stuff: gearbox, suspension, rear wing pylon, cooling layout, exhausts which are really tightly packaged, all of that has a knock on effect to each bit. It all combines to produce the tight bodywork. You can't get the scope for aero development if you don't have that tight bodywork,' Key reveals.

In Austria a new rear suspension layout was introduced which aimed to derive a larger aerodynamic gain from the wishbones, as well as a number of related systems.

'We did a complete new corner, with a new lower wishbone, and some other bits that are not really visible around the upright,' continues Key. 'If you have a second stab at the corner of the car you would want to improve its weight its stiffness, its aero and its kinematics, and that's what we have done. While there is a visible bit there is a lot more to it than that. The objectives in that region are often aero driven. Wishbones get in the way of aero so you can make them sympathetic to the aero or you can actually make use of them. Now, they are quite a big player in terms of airflow, especially with the size of the front wing, same at the rear.'

There is something of a trend in current Formula 1 around rear suspension developments, with many teams trying to optimise not only the way the systems work but also how they are packaged, likely the result of the loss of front-to-rear interconnected systems part way through 2014. 'There is benefit in removing some suspension components and using hydraulic devices. The benefits are that you get very non linear things that you can't do with a spring, and the packaging is much easier. It's something everyone is looking at, but we have not done it yet', Key admits. 'The reason that the focus is on the rear at the moment is that you have a lot of travel and that means you have more scope perhaps for more mechanical devices to help you out. At the front it's harder. You have roll, heave, ride height control and platform control. The rear is easier to tackle first with lots of travel and lots of stroke.'

Trick brake ducts

Related to the new rear wishbone layout are new brake ducts, though to describe them as ducts stretches the word beyond credibility. STR, like all teams, has taken advantage of a free area of bodywork around the inner face of the

The central cooling system has meant STR has been able to get away with smaller sidepod ducts

Toro Rosso has crammed the intercoolers plus the water coolers for the Renault V6 engine and its energy recovery system into its sidepod. In this picture the intercooler is clearly visible. The cooling is a central design theme with STR10

The centrally mounted cooling concept, as used by previous Toro Rosso cars, means the STR10 requires a very large cooling duct under the roll hoop to feed air to its complex-shaped oil cooler

Better facility – better car?

The Toro Rosso STR10 is designed and built at the former Minardi factory in Faenza, Italy, though this has been substantially upgraded and redeveloped. New buildings have gone up around the site and many new staff have been taken on. 'Our new STR4 building here in Faenza is nearly complete and will be fully operational this summer', Franz Tost reveals. 'It will be attached to the STR3 building and it will mean that we are all finally working under the same roof, drastically improving the team's internal communications. If we also add the fact that we've already improved the wind tunnel in Bicester, UK, as well as making sure that all communications with our colleagues over there run as smoothly as if they were here in Italy, we can be sure that we will be making big progress and a huge step forward in terms of technical development.'

rear wheels in order to develop complex devices which can generate downforce which acts directly on the rear wheel. 'Some of it is pure downforce generation, some of it is wheel wake management and some of it is even for cooling the brakes,' Key says. 'It's a very sensitive area and it's going to continue to develop beyond where it is now. If you look at the ducts now they are really amazing. They are fantastic looking things and so intricate, and they are really expensive. You'll see us doing something a bit different towards the end of the season.'

Bespoke 'box

A key part of the rear end of the STR10 is its transmission. Toro Rosso, which was built out of the Minardi team, has a long history of developing its own transmissions and it is not willing to give that up. Even during the post Minardi era when the team used identical chassis to Red Bull it continued with its own casings. In 2015, rather than using the Red Bull Technology transmission, it has again gone its own way with an aluminium casing. The internals are supplied to the team by Red Bull but it is believed that they're manufactured by Xtrac. The hydraulics also come from Red Bull. Having a bespoke transmission casing allows Toro Rosso to have complete freedom over its rear suspension design.

On track the STR10 has clearly impressed its drivers, but also onlookers. It's regularly seen fighting with the Red Bulls, but a best result of seventh up to now perhaps does not really represent its potential. It regularly runs in the third qualifying session and is clearly capable of matching or beating Red Bull and some of the Mercedes powered cars; even more impressive when you consider that the team has one of the least experienced driver line ups ever seen in F1.

'In general the aerodynamics of the STR10 are a big step forward from the previous car,' says Key. 'We have also achieved a more balanced and stable platform with improved mechanical grip and less sensitivity. But, the car also has some weaknesses. The main point is straight line speed compared to many of our competitors, and there is some work to do on tyre management which we are working on.'

Indeed, Toro Rosso has known since the roll out that the way the car uses its tyres is a key area for improvement and it is likely that the suspension updates are part of this process. 'There's been a big push in this area,' confirms Egginton. 'Pirelli has made a change to the tyres for 2015, predominantly on the rears and we've had to react to that and provide data to ensure that the car is configured to get the best from these tyres. Over the winter we worked on improving our simulation tools and methodologies and processes, so that we can do a more complete job in the future, reacting more quickly, in order to bring more performance to the car.'

It is here where comparisons to Rob Marshall and Adrian Newey's Red Bull RB11 become inevitable. Both cars share the Renault power unit and general installation, the transmission internals are identical and crucially the same company foots the bills for both teams. But the suspension layout and overall car design differs between the two noticeably.

'Wishbones get in the way of aero, so you can make them sympathetic to the aero or you can actually use them'

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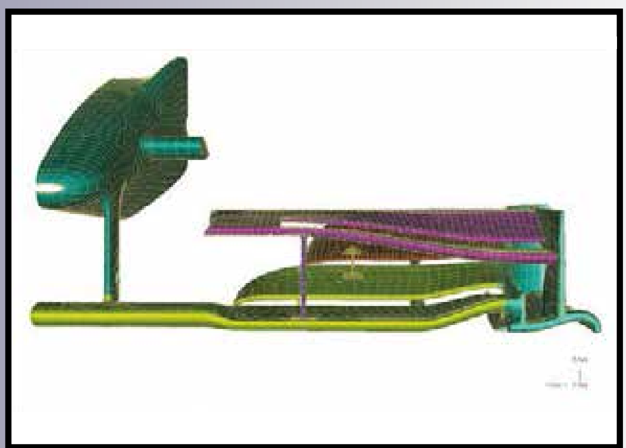

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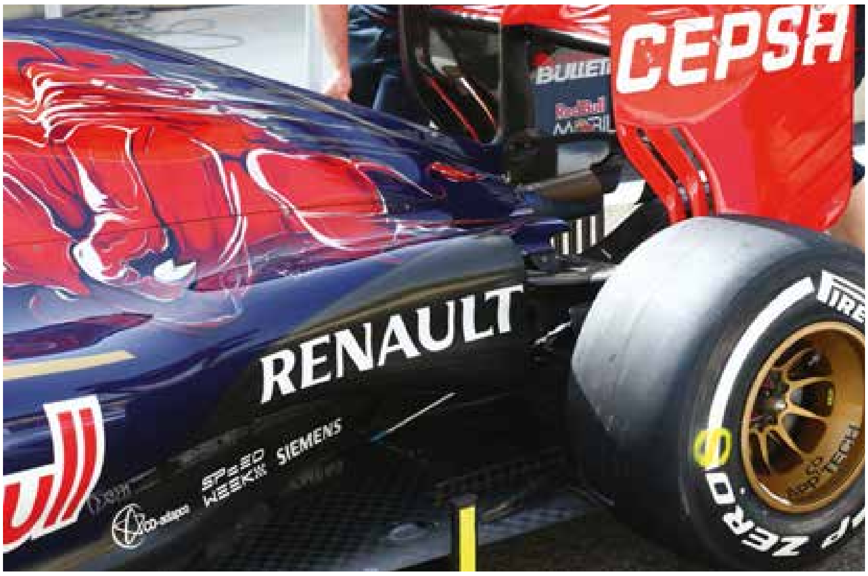

TECH SPEC

STR10

Power unit: Renault Sport F1-2015 (RB34)

Chassis material: Composite monocoque structure

Front suspension: Upper and lower carbon wishbones, push rod, torsion bar springs, central damper and anti-roll bars, Penske dampers
Rear suspension: Upper and lower carbon wishbones, pull rod, torsion bar springs, central damper and anti-roll bars, Penske dampers

Assisted Steering Rack: Scuderia Toro Rosso

Bellhousing: Carbon fibre composite

Gearbox maincase: Scuderia Toro Rosso, Aluminium alloy
Gears: 8-speed sequential – hydraulically operated Supplied by Red Bull Technology

Hydraulic system: Red Bull Technology

Clutch: AP Racing

Exhaust: Scuderia Toro Rosso, Inconel, with turbo heatshield

Brakes: Carbon carbon disc
Calipers: Brembo
Pads and discs: Brembo
Brake By Wire: Scuderia Toro Rosso

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

Cockpit: Scuderia Toro Rosso
Steering wheel: Scuderia Toro Rosso
Driver's seat: Carbon fibre construction, moulded to driver's shape
Seat belts: OMP/Sabelt
Pedals: Scuderia Toro Rosso

Extinguisher system: Scuderia Toro Rosso/FEV

Wheels: Apptech, Magnesium alloy
Tyres: Pirelli

Fuel system: ATL tank with Scuderia Toro Rosso internals

Bodywork material: Carbon fibre composite

Overall weight: 702kg (including driver and camera)

Above left: The rear of the car in launch spec contrasted with the rear post Austrian upgrade (left). The pull rod is now much tighter while there are also blended lower wishbones on newer spec car. Rear suspension features upper and lower carbon wishbones and pull rod torsion bar springs, with central Penske dampers

Max Verstappen, who has raced the STR10 and is familiar with the RB11, believes that the Toro Rosso has a wider operating window. 'I think for Red Bull it is more difficult to find the sweet spot of the car,' he says. 'In general, the whole year, when you go to higher downforce tracks we were strong compared to Red Bull. Sometimes they set up the car a bit better, but I think our car is very close.'

Verstappen's familiarity with the RB11 comes as a result of the link between the two teams. Toro Rosso was set up as part of a 10-year Red Bull motorsport plan, which would see the Italian based outfit used primarily for young driver development. But with that plan reaching its natural conclusion and Red Bull's whole future in grand prix racing cloaked with uncertainty, the future of Toro Rosso is currently a subject of conjecture. The team has been openly linked to a takeover by Renault, and it has been suggested that the investment in both personnel and facilities at the team are part of a project to make it attractive to a manufacturer.

Indeed, Toro Rosso team principal, Franz Tost, has essentially confirmed that discussions for a takeover are underway. 'Renault wanted more brand presence in F1 – that was the starting point,' he admits. 'A yellow and white car with big Renault logos. They can do this with Toro Rosso. But at the moment [Renault Sport boss] Cyril Abiteboul has said that its main focus at the moment is sorting out their reliability problems and not painting a car. And before that is sorted out they will not be thinking in the direction of either taking over a team or rebranding a team. That could change in the next couple of weeks and months.'

Meanwhile Tost has claimed that unlike some teams also linked to manufacturer takeovers Toro Rosso is an attractive proposition, just as long as its links to Red Bull Racing are retained. 'We have a proper infrastructure, we have a good technical team, and we have a lean structure,' Tost said. 'We want to finish in P5, and the next step would be to work together with a manufacturer or to become a manufacturer team – to become a real front-runner. There is no timeline on that. It is a case of when Red Bull and Renault decide. Such a scenario would only work if the close relationship between Red Bull Racing and Toro Rosso stays intact. Red Bull Racing's headcount is much higher, the equipment of the team is more sophisticated – so without the know-how of Red Bull Racing, Toro Rosso would be hurt in terms competitiveness.'

With the current performance level of the STR10 it perhaps could be argued that the Red Bull team could learn some lessons from its smaller stablemate. But both seem to agree that what is holding them back at the moment is the Renault power unit fitted to the back of both cars. Renault, though, believes that it has solved the issues that blighted the first half of the season and will be bringing substantial performance upgrades to benefit both teams in the second half of the year. Perhaps then we will find out if the STR10 really is the second best car in Formula 1.

'In my opinion F1 development is not cyclical or seasonal anymore'

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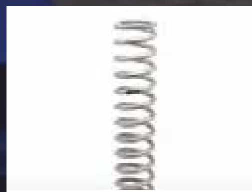

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Fall from **power**

Year two of the new F1 regulations has been painful for Renault – but just what has gone wrong with the multi-title winning engine maker's power unit?

By SAM COLLINS

Renault Sport F1 has been in the headlines a great deal during the 2015 Formula 1 season, but often for the wrong reasons. Despite winning three races in 2014, and the Renault-powered Red Bull team finishing runner up in the constructors' championship, the French marque has so far not enjoyed the current engine formula. The 2015 season has started out in the same way as 2014, with the French firm's Formula 1 power units proving to be unreliable from the first race. But unlike 2014, where performance and reliability rapidly improved, this season has been much more of a struggle.

'Clearly last year was pretty difficult in the beginning, but we made decent headway and it was pretty decent in the middle,' says Rob White, deputy managing director (technical) of Renault Sport F1. 'Our objectives for this year were to bring performance to the cars and sort out the reliability trouble that we had had in 2014. The second cycle of a power unit is difficult, because you end up doing the design and development work before you have really understood what has gone on with the one before. When the one before is difficult it makes it difficult to make the right choices for the next one.'

Perhaps unsurprisingly the 2015 specification Renault power unit, officially called the Energy F1-2015 but still believed to be known internally as the RS34, is in overall design terms quite similar to the 2014 version. By regulation the 1.6 litre V6 engine shares many of the dimensions of the 2014 version, including cylinder bore spacing and deck height, as well as retaining the complete air valve system. Other design concepts and the general layout have also carried over: the MGU-K still sits on the left of the engine block under the exhaust header, the MGU-H residing in the V of the engine but with both compressor and turbine mounted at the rear of the V6. Compared to the 2014 design, the exhaust concept is also similar, though perhaps the turbine entry is positioned slightly lower in the car.

One of the criticisms levelled at Renault is that the design of its power unit is perhaps too conservative, lacking obvious features like a split turbo or log exhaust, but White denies strongly that any of these concepts are really an issue.

'We don't see any power unit reason to do anything other than we have done in terms of layout, and anything else we do or don't do is for chassis reasons, not those of the power unit,' he says. 'We recognise that we are significantly behind the best in terms of flat out performance but we don't believe that the gap lies in the layout of the compressor, turbine and MGU-H."

Peer pressure

'We are behind where we wanted to be a year ago,' White adds, 'and back then people, including *Racecar Engineering*, leant on me to try and justify why I did not have an exhaust that looked like the one used by Mercedes. We could not see from our understanding how last year's [Mercedes] solution could be better than the one we had, but it was their optimisation, and that could have been driven by a chassis demand. The solution they have this year looks a lot more like the one we have, but they are still a long way ahead of us in terms of performance. There is not a silver bullet in any visible area of the power unit. It is the sum of all of the small decisions and clearly our job is to deliver more performance that way rather than find one magic choice.'

One major difference between the 2014 and 2015 V6 engines is the use of a variable inlet, evidenced by the much larger plenum seen on this year's power unit. While variable inlets

From the first race it became clear that almost all of the Renault powered cars were going to be hit by penalties at some point during the season

Renault powered Red Bull has struggled for competitiveness this year after winning three races in 2014 and enjoying a run of four championship wins before that. Some suggest its engine supplier is to blame

have been used in Formula 1 before, they have been outlawed for many years, including 2014. However, the ban was lifted at the start of the 2015 season (something that was long planned).

While it may seem an obvious choice for a manufacturer to take advantage of it, it is not clear if every power unit in use in 2015 utilises a variable inlet, though Renault has been very open in admitting that it does. However, for obvious reasons, White is only willing to discuss this area of the power unit in general terms. 'We have one, I don't know if everyone has one but we do, I can tell you that much,' he says, before explaining the major considerations when installing such a system on a current power unit.

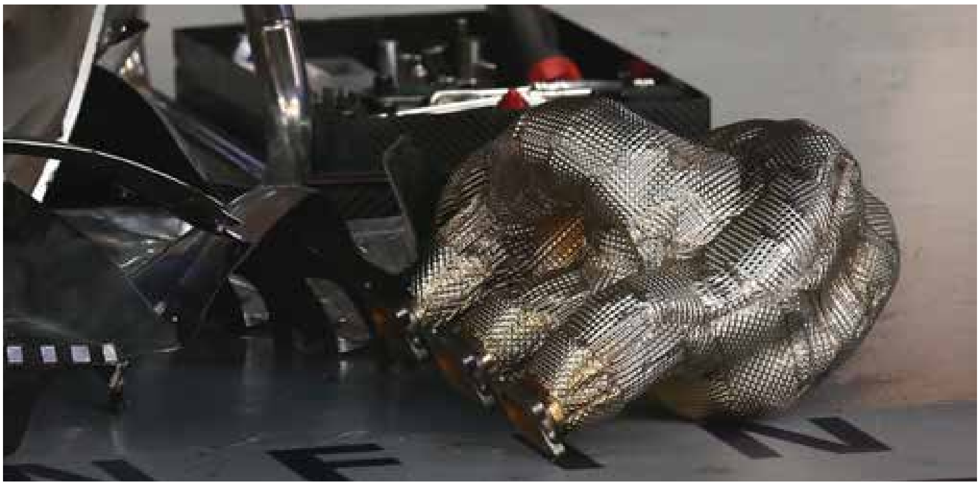
Acoustic tuning

'Its all about the acoustic tuning of the inlet system,' White says. 'A variable geometry system allows you to vary that tuning. But there is a trade off, a variable geometry system has more bits in it and its therefore heavier. There are compromises in the system itself, too, where you have the moving bits you have sliding seals, steps, and there are some real negatives due to that as well as the clear positives. Depending on the engine the outcomes can be quite different.'

In developing its solution, Renault evaluated a number of different layouts and mechanisms before settling on the system it now utilises. 'There are some acoustic solutions for the inlet systems that are easier to implement than others,' says White. 'If you look historically, when we were allowed variable inlets, most people had sliding trumpets that went up and down, that's a solution which is possible for these engines, but the trumpets are much longer and the stroke you need is longer so it takes up a lot more space. Most road cars that use such systems have some sort of rotating device, which is an option but is a compromise for the gas passages. In addition you might choose to have separate plenums, a single plenum, you could choose to join all the inlet runners together and have a single throttle per set of three or set of six. So there are many acoustic solutions and the results of the trade offs probably varies from engine to engine even in Formula 1 right now.'

With the new engine specification largely decided on, Renault Sport went into the winter ready to prepare for the 2015 season, but what at first appeared to be a simple FIA clerical error, resulting in the homologation date for the 2015 power being left out of the technical regulations, became rather more significant and had an impact on Renault's entire season.

'It was probably the only significant unknown in the latter part of 2014,' White says. 'But it all appeared to have settled down and we believed that there would be no in season development allowed. Then, just before Christmas it became apparent that the reverse was the case. We should not exaggerate the importance of that, though it changed our implementation plans somewhat it meant that we spent fewer tokens over the winter than we would have spent in order to hold back tokens for an in-season performance step.' While White makes it clear that the unexpected introduction of in-season development was a setback it was not a major one, though it did have a knock on impact on the Renault programme. 'It's fair to say that the change came late, and as a consequence the first race spec that we ran with came about rather late. Clearly at the time we wanted that spec to be a banker, we wanted it to be safe in terms or reliability, and in terms of performance it would be a modest step, but it would be a springboard to a more significant step later on. It did not play out quite that way.'



Renault RS34 exhaust headers with heat shield. Mercedes moved to this style of exhaust for the 2015 season, which is ironic as last year Renault was widely criticised for not following Merc's lead when it came to the design of the exhausts

The top of the V6 power unit with the plenum removed. This year Renault switched to a variable inlet and this is one of the major differences between last year's unit and the 2015 engine – these were not allowed in Formula 1 during 2014 season

A shot of the V6 engine in its entirety. The MGU-K is visible, as is the turbine inlet and oil tank – the latter of which is a carry over from the 2014 powerplant. The engine is actually officially named the Energy F1-2015, but most call it the RS34

During the 2015 Formula 1 season each car is only allowed to use four complete power units, a significant reduction from 2014, where they could use five units with fewer races. Exceeding the allowed number of units results in draconian penalties being applied. But from the first race it became clear that almost all of the Renault powered cars were going to be hit by penalties at some point during the season.

'We had the first signs of reliability trouble immediately before the start of the season, during the last Barcelona test,' White reveals. 'Then we had a couple of incidents in Melbourne that put us on the back foot, one of which was a failure of a transmission component between the engine and the MGU-K and one of which was a car related issue, something in the gearbox which damaged the engine. So we used up two engines in Australia that we would clearly have not wanted to. Indeed the spares we had to put in were fitted with some components that we would rather have not had to use as there was a late-arriving durability upgrade that was not fitted to them.'

Taking penalties

The replacement engines meant that some of the Renault runners were half way through their season's allocation by the second race and with power units that the French firm knew were not as durable as they should be. The manifestation of further problems was inevitable. 'We knew that those engines would cause us trouble later on,' White says, 'and we knew it was unlikely that we would get away with not having any penalties later in the season. We did not at that stage foresee all that was yet to unfold.'

Pre-season testing did not start well for Renault. Just before the team left for Jerez a manufacturing defect was found with a shaft in the ERS system coolant pump. The defect was enough to limit the running of both Renault powered cars at the test, though they still completed significant mileage.

Renault Sport F1's managing director Cyril Abiteboul explained at the time: 'It is something that was working very well last year, but we decided to change and improve it a bit further with the overall packaging of the engine to also support Red Bull in their attempt to also have very good packaging. That is why we did not really care for that part. Usually you have very specific simulations, design tests, and validation protocol. But honestly we did not do it for this part because it is such a stupid part.'

Things did not improve, with the full 2015 specification power unit only deployed at the final Barcelona test an unexpected issue not found in the test engines used at Jerez and in the first test at Barcelona manifested itself, White tells us: 'One of the issues we saw in Barcelona was with the pistons, so early on we had to change the pistons in order to address that issue, but it was not a sufficient fix and we still had trouble with the top of the pistons in the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A picture of the 2014 V6 engine for the purpose of comparison – it looks as though it has a different MGU-K and turbine entry. This engine powered Red Bull to three wins last year

race engines. This lead to the failures in China and Bahrain. We found that they were failing due to mechanical and thermal loads which were higher than we expected. The design change solved that.'

It's fair to say that Renault felt the pain of the opening part of the season but this seems to have spurred them on to resolve the problems and move forward, and while the situation is clearly not that of Mercedes or Ferrari it is clearly better than it was at the start of 2015. 'It's a Roald Dahl butterfly type thing,' says White. 'When a small number of bad things happened some time ago, we have got those things under control and we are now heading forwards with the nose to the grindstone to get back on track, but it's clear that we have lost time and ground relative to where we wanted to be.'

Moving forward will involve Renault starting to spend some of the performance upgrade tokens it has remaining. The French manufacturer spent the fewest tokens during the winter, just 20 of the 32 allowed, and planned a major upgrade kit for the European season, but by the British Grand Prix no performance upgrades had been made. 'The reliability issues delayed our development programme, as we had not really understood the nature of the problem. Logistically it was extremely challenging. It became necessary to build engines that we did not expect to build in a spec that we did not have confidence in at the time. That is now behind us, the engines we have introduced since Monaco have been completely trouble free in terms of those issues we saw early on. We have now got decent mileage on the engines, and we are reassured that the validation criteria are now the right ones, and that the spec is robust,' White says, before adding: 'Unfortunately we are talking in July and not in March.'

One of the criticisms levelled at Renault is that the design of its power unit is perhaps too conservative

Token gesture

Renault's performance in comparison to Mercedes has sparked some calls in the media and in senior F1 circles for the token system to be abandoned to help struggling manufacturers to catch up. One of the loudest critics is Red Bull's Helmut Marko: 'We are significantly behind Mercedes. They clearly dominate. But because the rules are not open it means that you are only allowed to make changes on a very limited scale which makes it very difficult, if not impossible, to catch up,' he said during the first half of the 2015 season. But White disagrees with this stance and claims that it is not the development restrictions in the rules that it is holding Renault back.

'There is nothing that we have wanted to do that we have been inhibited from doing by the restrictions in the rules. The token allocation at this stage of the power unit development is absolutely not an obstacle to performance development, so we should not get hung up on tokens or homologation restrictions because they are no obstacle to progression. It is not stopping us bringing performance, in the past, the present, or indeed in the short-term future. That may not be the case further down the line, but for the time being it's not an issue,' White insists.

Development freeze

However, at the start of 2015 some areas of the power unit were already frozen in terms of development, and at the end of the season more areas will also be locked in. 'There is nothing we consider to be very sensitive for performance included in the progressive freeze at the moment or indeed by the reduction of tokens,' White says. One of the areas included in the freeze at the end of the 2015 season is the ancillaries drive, which it could be argued also limits the location of some of the ancillary components such as water pumps and similar, which while they do not have an impact directly on engine performance are a key part of the overall packaging of the car. 'You have to be extremely careful about how the rules have been written, how they are interpreted and how they are implemented,' White says. 'It's understood and accepted that changes that are

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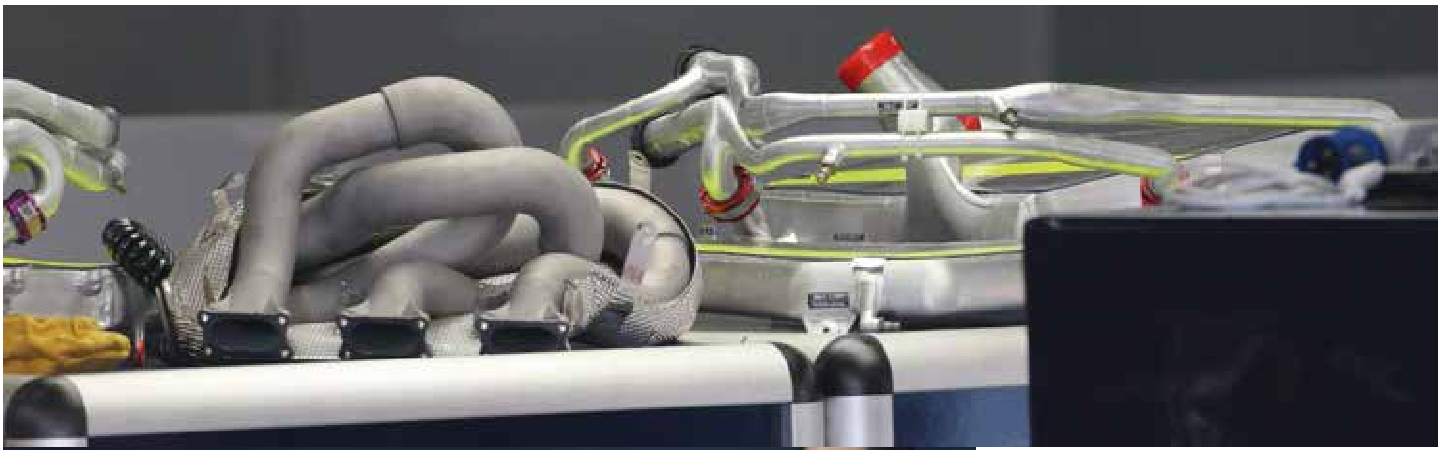

Above: The exhaust header with heat shielding removed – it appears to have been treated with a ceramic coating to further protect against heat **Left:** The Friday press conferences on grand prix weekends have sometimes been uncomfortable occasions for Renault boss Cyril Abiteboul this year

not for performance reasons but are for chassis installation reasons, which indirectly brings performance to the car, are not subject to token spend. But that's a debate to be had with the FIA technical team. It is the case that the whole power unit is in the performance table and there are some things that can't or just don't bring power unit performance. So in essence the tokens that are available for those components can be used for things that do bring power unit performance. That's one of the main reasons that the tokens just are not an obstacle at the moment. We have had discussions about the weighting of the tokens and the scope of them, but it's slightly esoteric and off-line.'

While Renault has, at the time of writing, not spent its tokens or revealed how or when those tokens will be spent, one area in which it is almost certain that either Renault or its customer teams will at least experiment with is the introduction of a new fuel flow meter.

A Renault powered Red Bull was disqualified from a podium position at the opening race of the 2014 Formula 1 season due to a fuel flow meter irregularity and the issue remains a touchy one for all involved. So perhaps then it is a surprise that with a new flow meter from a different supplier, and using a slightly different technology being fully homologated just before the British Grand Prix, that the engineers at Renault's Viry Chatillon base have not tested it. 'The honest answer is that we have not even seen the new one. We can only consider something that is homologated and not something that isn't,' White explains.

It seems that one flow meter is likely to offer a power unit performance advantage over the other but it remains to be seen which will offer that advantage. 'It's one of these cases where a man with two watches does not know what time it is,' White points out. 'The technology of the flow meters is extremely impressive and it's almost a very good piece. But it is slightly flawed in real life, and as it's a fundamental performance driver it's a touchy subject. The meters are troublesome in that they have erratic behaviours. The precision or fundamental accuracy are not in question. I think if the fuel meters respected the nominal specification under all real world circumstances then it would be a non-subject but the sources of trouble are the slightly uncertain inconsistencies at the boundaries.'

The next step

Renault Sport F1 now has to find the right time and the right set of performance upgrades to introduce in the right way to be able to take its customers back to where they feel that they should be, at the front end of the field. But with the engine penalties looming this is far from a straightforward task, especially seeing as the penalty structure will be revised for the power unit-dominated Belgian Grand Prix. White says: 'The fundamental work to generate the performance back at the factory and the implementation of that downstream has become a juggling act in order to have that work complete to make sure that the new spec engines are available at the track, then working out with Toro Rosso and Red Bull how to introduce the engines, bearing in mind that only one of the drivers can get to the end of the season without taking penalties. All the rest now take penalties when new engines are introduced, so there is a trade-off between penalties taken and performance improvement.'

Just how big that performance improvement is remains to be seen, but the Red Bull teams hope that it will be enough to see them at least mixing it up with the likes of Williams and Ferrari and, just perhaps, on the right day on the right track, maybe the Mercedes works team too.

'The reliability issues delayed our development programme, as we had not really understood the nature of the problem'


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LMP3 aims to provide an affordable first step on the endurance racing ladder but, as *Racecar* discovered, producing a tightly cost-capped prototype is not without its challenges

By LEIGH O'GORMAN

This year the triangle was completed: LMP1, LMP2 and now LMP3. But actually it's more of a pyramid than a triangle, as the Automobile Club de l'Ouest (ACO) president, Pierre Fillon, explained at the announcement of the new-for-2015 category in July last year: 'From the base to the summit, we want to make it easy for drivers, teams and constructors to enter endurance [racing]. The LMP3 class is the base of our pyramid devoted to the different LMPs.'

Designed to build a bridge between GT racing and sports prototypes, LMP3 has been prepared to test the limits of bronze badge drivers, while also being user-friendly. Coming with LMP1 safety standards, the LMP3 class has been shaped to offer drivers a prototype experience, but at a reasonable price. Competitors such as Olympic gold medal winning cyclist Sir Chris Hoy and reigning Ginetta GT4 champion Charlie Robertson have made appearances in the category thus far.

Primed to run mainly in continental championships, such as the European Le Mans Series (ELMS) and the Asian Le Mans Series (AsLMS), plans are also now afoot to expand to North America and the United Sports Car Championship, while momentum is gaining to include LMP3 in national championships such as the French GT Series.

Like LMP2, this new class of racing exists under the ceiling of a stringent cost cap, making LMP3 palatable for the slightly less well-off driver. Race teams, too, are benefiting. In the second race of the ELMS season at Imola, the University of Bolton took the LMP3 class honours with Rob Garofall and Morten Dons on driving duties, after Hoy and Robertson had done the same with the Team LNT Ginetta-Nissan at Silverstone.

Considering this is a class that has only enjoyed three four-hour races, then the ACO may be inclined to pat itself on the back for a job well done. But these are still early days, and, for manufacturers, the concept behind LMP3 will prove critical to any success the category enjoys in the future.

With the unveiling of the first draft LMP3 regulations last year the potential of this new endurance sportscar racing category became clear. Framed around steel safety structure and carbon fibre tub, LMP3 has been designed as a stepping-stone to LMP2. Shorn of unnecessary complexities, its regulations

‘Each LMP3 machine must be powered by a 5-litre normally-aspirated Nissan V8 engine’

LMP3 has been designed to offer drivers and teams, and a limited group of manufacturers, a low-cost entry into the world of sports prototype racing. Pictured is the as yet unraced ADESS-03, which is set to hit the race track some time in the autumn

are firmly based in simplicity, but with tightly defined technical and cost parameters, providing manufacturers with an opportunity to address challenges – both technical and administrative – head on.

Seeing an opportunity for new business, the regulations were attractive to Lawrence Tomlinson, owner of Ginetta Cars, and Ginetta's technical director, Ewan Baldry. The Leeds-based group became an early adherent to the category and produced its Ginetta-Nissan LMP3. Between September 2014 and the opening race at Silverstone in April Ginetta produced five cars for competition, with three more delivered and an additional three in the build process. For the famed British sport car group, LMP3 has already proved a success, as an enthusiastic Baldry said: 'Despite taking the cars from concept to competition in less than 12 months, it has proven itself as an incredibly reliable piece of kit.' Acknowledging the miles logged by former Le Mans class winner Tomlinson and Ginetta factory driver Mike Simpson, Baldry added: 'We have been fortunate enough to have some quick and experienced drivers in the car during the development phase.'

Constructor interest

It's not just Ginetta, though. Onroak Motorsport is close to joining the fray with the Ligier JS P3, as is ADESS AG (ADESS-03) and Riley Technologies (Riley-Ave AR-2), all of them adding extra credibility to LMP3.

The LMP3 car concept is a carbon composite chassis with a steel roll over structure and a non-structural composite roof panel, while the bodywork is predominantly carbon fibre in construction. With a maximum overall length of 4650mm (including rear wing assembly) and an overall width of 1950mm, the LMP3 car is a two-seater coupe designed to resemble an LMP2 chassis. However, unlike its bigger brother, the LMP3 car comes with a relatively small diffuser and flat floor.

Each LMP3 machine must be powered by a 5-litre normally-aspirated Nismo Nissan V8 engine (producing approximately 420bhp), prepared and sold by ORECA. The powertrain is mated to an Xtrac 6-speed sequential gearbox via a dedicated cast bell-housing, while gearshifts are handled by a Megaline pneumatic shift system. The tyre is a controlled construction and compound provided by Michelin, similar to the tyre used in the Porsche Cup.

LMP3 cars must use this 420bhp normally-aspirated 5-litre Nismo Nissan V8 engine prepared and supplied by ORECA. The gearbox is a 6-speed sequential unit supplied by Xtrac

Although many parts of the chassis design remain relatively free, the LMP3 operates with a number of standardised parts in order to help keep running costs as low as possible. These include common wheels, brakes, telemetry system, fuel tanks, steering wheel and the ACO's own homologated safety features.

This focus on cost in part attracted Riley Technologies, as its vice president and chief mechanic Bill Riley told us: 'We started looking at the concept of it and it has very good balance between cost and performance all the way through the design. It is a bit of a different mindset when compared to the others things we have done in the past.'

For the protagonists, the primary challenge came not necessarily from design limitations, but rather severe curbs placed by the category's cost cap regulations. This, which ensured a maximum sale price of the car and engine measured at just €195,000 (approximately €135,000 for the chassis and €60,000 for the engine), shaped engineering possibilities early in the life of LMP3, as ADESS AG founder and former F1 engineer Stephane Chosse explained: 'The main challenge is to be able to produce a car in the cost cap. You are quite limited in the engineering you can do.' However, this cap was becoming increasingly difficult to meet and, in July, the cost cap was increased to €206,000. Along with the cost cap, LMP3 is limited to five separate manufacturers and those entities must be able to sell at least five cars every year.

The increase in the cost cap offered manufacturers additional wiggle room to be relatively innovative in ways that are affordable, while also allowing them to produce a quick, reasonably priced and reliable machine. At the same time, however, the additional €11,000 is still low enough to compel manufacturers to take care of the costs for each component, making sure that individual parts meets the tight price parameters set by the regulations.

Making it pay

As well as capping the cost of the car and engine package, the price of spares is also limited, although the cap in this instance is measured as an overall figure, rather than placing specific prices on individual items, with the ACO stating that the total price of the spares list must not be in excess of 150 per cent of the selling price of the new car.

With the cost cap proving to be one of the most significant factors in the regulations budgetary concerns cast a constant shadow over these machines throughout the design and manufacturing process. 'The sales price of each part was the number one criteria for the technical choice once the design giving the required performance had been signed off,' Onroak team boss Jacques Nicolet said.

Yet while the cost cap is stringent, the amount required to run the car over the course of a season is rather more flexible, with Nicolet acknowledging that a season in the ELMS is certainly feasible with a budget of €350,000-€450,000, although when asked if healthy margins are achievable with the LMP3, Nicolet puts his case simply: 'Absolutely not!'

Riley, however, sees the case for LMP3 in a slightly different light, for while success on the track is important to the reputation of Riley Technologies, the expansion of other business opportunities also makes LMP3 an attractive proposition. While selling a respectable number of AR-2 cars is important, maintaining a healthy spares business is key to a longer-term success in the category, Riley says. 'It won't have healthy margins, but you get over that with volume and spares. We'll have an adequate amount of spares and we already have distribution set up in the US, so that's where we see the long-range goal for the car. We have to get the numbers up to get the spares volume up.'

Beyond the cost cap, one of the great limitations of the LMP3 regulations has been the minimum weight requirement. Pegged at just 900kg, it was a measurement that proved tough to meet, especially when the engine came in approximately 35kg overweight. Indeed, so difficult was the target weight due to the excess kilos, the regulation was shifted slightly, with the minimum weight increased to 930kg.

There were difficulties meeting this for Ginetta, and there has been little that Baldry could do. 'The car currently sits very close to the weight limit. In terms of sacrifices, there isn't

As well as capping the cost of the car and engine package, the price of spares is also limited

much you can do as the safety and crash tests are to LMP1/LMP2 standards and include a steel roll-over structure.'

Meanwhile, Onroak used its experience in LMP2 to manage the issue with its Ligier JS P3, the team's technical director Benoit Bagur saying: 'We did a huge job on the monocoque to remain within an acceptable weight limit and all the bodywork elements are in carbon.' Indeed, when finally built, the JS P3 enjoyed enough of a weight margin to utilise ballast.

The technical regulations are set for three years at least and once a car's final plans are submitted for homologation, all constructors must hold station with their respective designs for three seasons, unless safety or reliability prove a significant concern.

The relative simplicity of the aerodynamic regulations have ensured there are few trap doors awaiting manufacturers. With the regulations framed to 'LMP2-style' bodywork – including openings in the bodywork above the wheels, a fin extending to the rear wing brackets and a single element rear wing – there is not a huge amount of room for gains and losses in the aero department. A set tub height and splitter area will likely ensure that cars will evolve in the same basic direction.

Making compromises

Baldry adds: 'The front splitter profile, rear diffuser and rear wing were all developed during Computational Fluid Dynamics with TMG [Toyota Motorsport in Cologne], which were then further refined and validated on the track. The regulations control the rear diffuser shape, and the rear wing is limited to a single element. However, there is a good amount of freedom in terms of the front splitter, so we were able to come up with a strong front end.'

However, it was clear that the story of the design was going to be one of compromise, as Chosse says. 'We decided to go for a known concept with an open front splitter. This is a compromise choice between downforce and cooling, so we need to get these parameters right, as they interact with each other.'

Riley, meanwhile, focussed upon finding a balance with the rear wing element, without overloading the front of the AR-2. 'That's probably the biggest aero issue with the car. In design, we can do things to overcome that and make the rear wing more efficient and look closer to how the air hits the rear wing properly.' Riley then added: 'We worked on the upper body surface area and tried to get the air to the wing and to use the diffuser properly. It still produces more than a tonne of downforce at 250kph. It's still a car with downforce.'

The Ginetta-Nissan LMP3 chassis and crashbox was designed in conjunction with EPM Technology – a highly respected composites firm based in Derby. However, Baldry is already looking at taking this process in-house in order to integrate as much of the build process as possible within Ginetta itself, creating a more efficient project. Baldry chose to use Alcon's six piston monoblock brakes for the Ginetta-Nissan LMP3, while the dampers are supplied by Öhlins.

Ease of use

Baldry opted for a somewhat conventional suspension system for the Ginetta-Nissan. This operates with coil springs, rather than torsion bars and is adjustable and relatively easy to work with. The Ginetta man also confirmed that a torsion bar, while a more compact solution, would also raise the cost of the package unnecessarily, although he did add: 'If a team wishes to, they have the option to carry a range of springs that they can use to play with the handling balance of the car.'

Thus far, Onroak is the only other team to have run their P3 machine, following a recent test at Magny Cours. Working with CFD specialists EXA, the French manufacturer adapted the aerodynamic configurations from the JS P2 into its P3, creating a comprehensive mapping of the interior and exterior flows on the JS P3. The result is a car that hit the ground running. 'The car's quick out of the box. We didn't run into any major problems. Obviously, there's development work to be done to get the best out of the LMP3's potential, but it hasn't got any flaws,' says Bagur.

There were other more practical challenges to designing and engineering the car. Taking into account the needs of the gentleman driver, for example. Onroak was keen to emphasise driver comfort, amidst the cost capped engineering, when they unveiled their effort. Bagur said: 'The attention paid to the driver's comfort and also to his safety was a major element in the design of the Ligier JS P3. Thanks to our partnership not only with EXA, but also with Stand 21, we were able to do a very accurate job on the different areas of air circulation in the cockpit and improve the

Maintaining a healthy spares business is key to a longer-term success in the category

Top: The Ginetta suspension layout is based on coil springs rather than torsion bars and has been designed with ease of use and controlling costs in mind. **Above:** The design process for the Riley-Ave AR-2 has now finished and car build has started


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driver's comfort even further.' The French team hope to debut the JS P3 at the final ELMS round in Estoril in October.

Meanwhile, both Riley Technologies and ADESS are closing in on the next step, with the former working with long-time partner Tony Ave Motorsports to bring the AR-2 to life. 'We are doing the design work on it and Tony Ave will be doing the manufacturing. It is [called] the AR-2, because the AR-1 was a Trans-Am car we designed several years ago – Ave bought the rights to that design and manufactured those cars,' remembers Riley. He adds: 'The design has been finished up and the manufacturing has begun. The chassis and the suspension is being manufactured and we are just finishing off some of the bodywork now. These days the car stays on the tube as long as possible to do CFD work and then it just pops off and we are ready to go.'

According to Chosse, ADESS are a step behind in the process, but are progressing well. 'We have started the [preparation] of the parts for the car. The first monocoque arrived in [mid-July]. We have already got the powertrain in our workshop and we will start slowly the assembly of the first car in the next two weeks. We plan to roll out in September to test immediately after.'

Is it quick enough?

One of the difficulties faced by the LMP3 teams over the opening rounds was their respective pace compared to the GTE competition. According to the initial ACO presentation, the performance of this new prototype class was to be approximately two seconds per lap quicker than a GTE car on a 'normal circuit'. However, in their opening races the LMP3 cars have struggled to break away from the GTE pace and even fell significantly behind the GT field at both Silverstone and Imola.

Having watched his cars tackle these events first hand Baldry is quick to defend the LMP3 project and feels more can come with simple tweaks and developments – in this Baldry praised the work ethic of the ACO in what is very much a development year. 'As with all new projects, minor developments will continue as we clock up the miles on the car. Given the opening round of ELMS at Silverstone was the first time that any LMP3 car had turned a wheel in a comparative sense, the lap times in respect to the rest of the grid was always going to be something of an unknown quantity.' Since the season start Ginetta has made minor adjustments to the cooling system to counter higher ambient temperatures and has also tweaked the fuel system to improve pick up.

One of the great limitations of the LMP3 regulations has been the minimum weight requirement

Top: Onroak used its LMP2 experience to bring the Ligier JS P3 in under the weight limit. The aerodynamics of LMP3 cars are similar to LMP2, with bodywork openings above the wheels and a single element rear wing. **Above:** One of the main criticisms aimed at LMP3 has been its lack of pace when compared with GTE cars. Pictured is the Ginetta-Nissan LMP3

At ADESS, Chosse feels he knows where more time and speed can still be found, suggesting that the power output could be raised to increase outright pace. However, in the same breath he offers a note of caution: 'What we have at the moment is limited to 420bhp, but it can produce up to 520bhp, but this will limit the lifetime of the engine.'

There are other pitfalls to increasing the power output, as the possibility of additional rebuilds and repairs could push the spend higher – a factor that Chosse questions. 'We could gain a little bit of lap-time, but to gain two seconds would be quite difficult in the short term. Let's see where we will go, but at the moment the goal probably may not be 100 per cent achieved.'

Broader market

The LMP3 category is still in its infancy. But with Ginetta on board and three additional manufacturers waiting in the wings, while there are obviously some notes of caution still in the air, there is also plenty of optimism and confidence, as Baldry confirms. 'From the outset, Lawrence [Tomlinson] committed to laying down a first batch of 15 cars, all of which have now been sold and we have orders beyond that. Ginetta has always been about volume and the LMP3 car is no different. This is a viable track car with a worldwide market outside of the ELMS, and this is where we see further sales being possible.'

Riley also sees much potential in LMP3, but like Ginetta, the American is by no means there purely to sell tubs and spares – Riley wants to win. 'We want to run up front, we want to increase our reputation of having fast cars right out of the box so they can win in their classes. We plan on moving that forward with the AR-2, so customers will get the best car and have the best experience as a whole with the car being easy to drive and easy to set-up.'

For Nicolet, Onroak's expansion into LMP3 is the next step in its aim to offer a more comprehensive range of sports prototypes to its client base. 'The LMP3 has become an essential part of the range,' he says, adding that, 'Onroak Automotive's aim is to help its clients climb up the different steps of the endurance pyramid up to the summit – the Le Mans 24 Hours.' Which, when you come to think about it, is just what the ACO wanted from LMP3 in the first place.

Back to the future

Australian touring car racing unveils more details of its new Gen2 regulations, which invite turbo V6s to compete alongside its V8s

By ANDREW COTTON and STEFAN BARTHOLOMAEUS

The Australian V8 Supercar series has taken a radical step and relaxed its engine regulations, opening up the possibility that smaller capacity turbocharged engines will run alongside its V8s for the first time since 1993.

It's a big decision, but one that organisers felt was necessary to attract new manufacturers which may not produce a 5-litre V8 engine, while current trends in production cars also lent themselves to changing the engine regulations.

Cars will have to meet certain criteria, including 5000 must be sold worldwide, be right hand drive, front engine and with four seats. The racing version must have rear wheel drive and the target is that the engines will all have around 635bhp. Where that power is delivered is up to the engine manufacturers as organisers will keep its cumulative horsepower regulation that has proven to be so successful this season.

While the regulations will still allow the current 5-litre V8s, a move designed to protect the existing teams, the likelihood is that any new manufacturers will move to turbos when the regulations are introduced in 2017. 'The far more complex Car of the Future programme was the first step in opening the door, and as a result we now have Nissan, Erebus and Volvo as a very important part of our sport,' said V8 Supercars' CEO James Warburton. 'Gen2 is another option for manufacturers and our race teams should they choose at a time that suits them, if at all. It is not a new direction or wholesale change.'

Rather than take the overall performance parity route utilised for the likes of GT3, V8 Supercars continues to focus on equalising different models in five key areas, leaving ultimate lap speed down to the teams.

The pillars of the parity system are equalising total aerodynamic downforce, aerodynamic downforce balance, aerodynamic drag, engine power and fuel consumption.

With that principle in mind, V8 Supercars released an initial, 75-page homologation guideline document to teams in July, outlining basic requirements for new generation engines and bodies to be adapted to the category.

Led by V8 Supercars technical director David Stuart, the guidelines were put together with input from a working group that included Tekno Autosports manager Steve Hallam, former V8 Supercars team owner Ross Stone and ex-Volvo global powertrain vice-president Derek Crabb.

By Stuart's own admission, there remains much to do before final regulations can be released later this year, with the guidelines at the present time largely a discussion document to be used for further consolation with teams and manufacturers.

Although V8 Supercars maintains that it will assess any engine architecture that a manufacturer wants to run, the bulk of the category's work so far has focussed on paving the way for the introduction of V6 turbos.

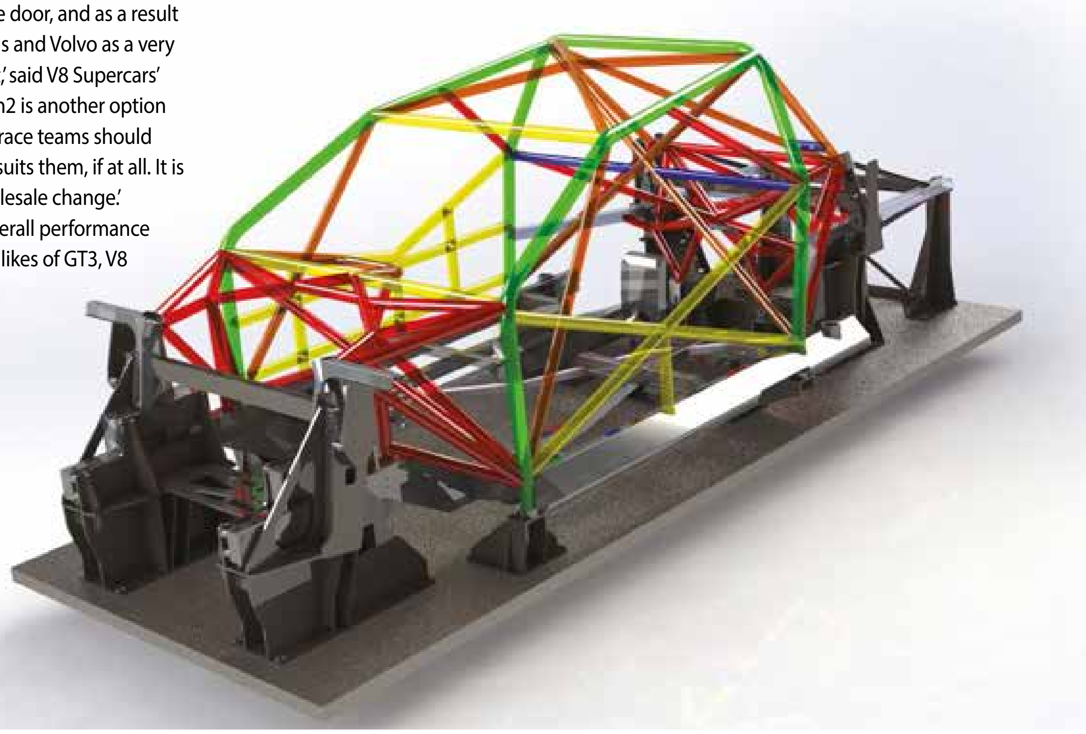
Notably, the likes of Holden (through parent company General Motors), Nissan and Ford all boast V6 turbocharged engines in their global racing portfolios.

Power caps

Holden is particularly keen on downsizing its current racing engines in line with its road car plans and is expected to field a version of the V6 turbo developed for Cadillac's GT3 programme in its next V8 Supercar.

The new engines will need to fit within V8 Supercars' two fundamental engine performance caps, dubbed Accumulated Engine Power and Engine Power Weighted Average (EPWA), which have been implemented under the current Car of the Future era. The AEP measures horsepower at 50rpm increments from 5800rpm to 7450rpm. Each value is referred to as the corrected power (STP); the sum of which is capped at 20654bhp.

The EPWA is meanwhile found by multiplying each STP by what is referred to as the V8 Supercars Percentage Number (SPN). The SPN



The chassis of the original Car of the Future will remain when V8 Supercars changes to its new formula in 2017. Biggest changes are to engines, non-V8s now allowed

is the time spent as a percentage at wide-open throttle at each corresponding rpm site, which is calculated from past qualifying laps at various race tracks. The total EPWA must not exceed 618.81bhp.

The existing system also sees an Engine Specification Document (ESD) created for each team, locking in the specifications of all components. Any requested changes need to be tested on V8 Supercars' dyno and, provided they do not see a breach of the AEP or EPWA, are then homologated via an update to the ESD.

'There will be packaging constraints that a manufacturer will have to work through to put the engine in the car,' admits Stuart of those looking to introduce an existing race engine into V8 Supercars. 'But essentially they will present their engine complete with its turbochargers, intercoolers or whatever, and once we run it, if it falls within the boundary, we'll strip it and create the ESD, just as we do now.'

The maximum capacity has been given as 3.85 litres, although, according to Stuart, bigger V6 turbos will be considered upon application. Compression has also been tabled, with a max of 9.0:1 compared to the long-held 10.0:1 for the V8s.

All engines will be required to run the control Motec ECU, while much of the rest of the specifications are either a work in progress, such as details on the turbos themselves, or will be subject to the individual ESDs.

V8 Supercars' appointed engine parity manager Craig Hasted is currently building the category's own V6 turbo test engine, based on a naturally aspirated, road going Holden block. The engine will go through a dyno test program before being placed into one of the Commodore-bodied Car of the Future prototype cars for track running.

'We've done a lot of theoretical background work on engine configurations,' explains Stuart. 'With the test engine we'll be able to experiment with the turbo, the way it operates with the wastegate and sort out our engine management software so we can balance out the power with the current engines.

'We'll also see what we need to do with component weights and things like that,' Stuart adds. 'We want to cover as many bases as we can. The first iteration of this engine certainly won't be the last.'

Minimum weights for the steel flywheel (2kg) and crankshaft (16.5kg) have been set at current levels to ensure that the smaller motors won't accelerate quicker than the bigger V8s.

Stuart says his technical team has already undertaken significant work on how to package the V6 turbos in the chassis ahead of what he expects will be an 'extensive' track testing programme.

'There's a lot to put into this whole Gen2 engine bay,' says Stuart of the packaging challenge facing manufacturers with turbo engines. 'But we will develop all the parameters of how the engines will fit into the COG box, the weight box and how it will fit into the current cars. All of that will be done in the next six months.

'On top of that we've got to make sure that the engines can be cooled. We've got to balance out the intercooler, all that sort of stuff. There's a lot of work to do.'

A section for four-cylinder turbos is also in the guidelines, although few specification details have been filled in, starting with 'TBA' for critical areas such as capacity, revs and compression. How closely such engines can be matched to the V8s very much remains to be seen. All engines will meanwhile be subject to both maximum (95dBA) and minimum (85dBA) noise requirements as the category strives to ensure the new generation engines won't see tracks fall silent.

'The engine is more relevant,' says Hallam. 'I did my time in NASCAR and they are wrestling with the same issue. They have 5.8-litre V8s and have made the step to fuel injection, and they are really working on how they maintain relevance. On our continent, historically a V8 Commodore or Falcon has been an aspirational car and they are ceasing production.
The message that we are receiving from manufacturers is that they are not going to sell V8s. We are getting more pressure from people asking where does a four-cylinder engine sit

'The first iteration of this engine certainly won't be the last'

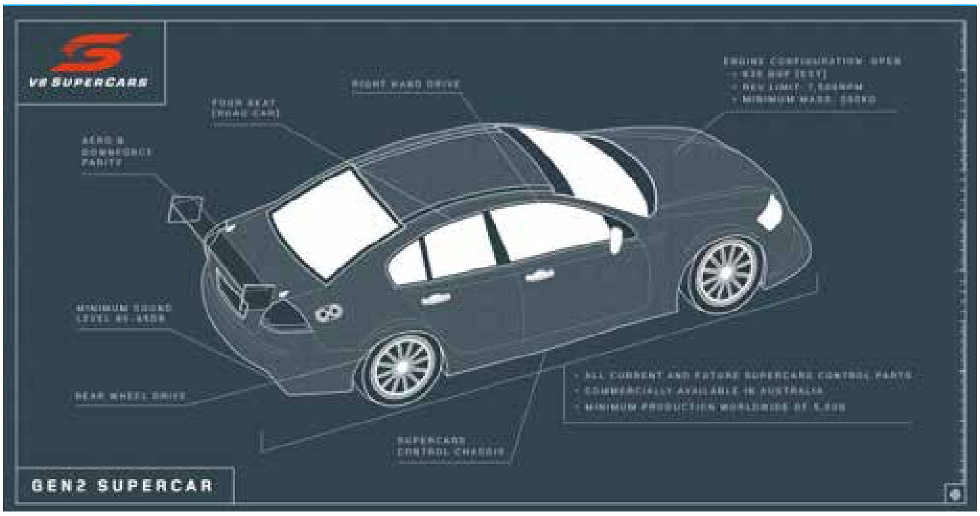
'Historically a V8 Commodore or Falcon has been an aspirational car'

because that is the backbone of our model range. We are working with the manufacturers to ensure we keep the ones that are involved and to open it up.

'For a company like Nissan, or any of our manufacturers, to accept a forced induction V6 makes the relevance debate with the manufacturers an easier one to manage. Turbos will work differently but we don't look at the engine as a specific configuration. We look at the engine as a black box with a specific output. That black box needs to weigh 200kg, have a centre of gravity in a pre-determined window and its output using our cumulative horsepower technique has to be below a certain threshold, or boundary. It is not up to us as a category to design your engine and make you get there, nor is it up to us and nor are we likely to while there are V8s in the category will we bring it down because that would incur cost for our current competitors and we don't want to do that.'

Regulation writers are not concerned that the integration of turbos into the series will have a significant impact on competition, believing that the current rules will be sufficient to balance cars automatically. 'The rules are not difficult to do,' says Hallam. 'The responsibility and onus is on the incoming manufacturer to reach those boundaries inside which the performance of the car is contained, but it is not hard to do. The Gen2 regulations clearly state that if you are bringing a forced induction V6 into the category, the performance is set by our previous experience with the V8, so you have got to get your engine up to that level.

'We are not saying that in ignorance and thinking we don't know whether or not you can do it. We have done it and it is very straight forward to get to those figures. We have made it as easy as possible for a new manufacturer to come and play in our playground if that's what they want to do.'



The bodywork rules will change very little, as both the series and the manufacturers involved wish to keep the cars visually similar to their road car cousins. The number of doors is not stipulated and the body shape will be the same as current cars

Test and repeat

The series will continue its policy of aero balancing using staightline testing, and great steps have been taken to ensure that the tests are both fair, and repeatable, and that any changes are suitably validated.

'In Formula 1 we used wind tunnels, CFD and runway testing,' says Hallam, who worked for McLaren between 1991 and 2008 before moving to NASCAR's Waltrip Racing and then to Australia. 'You need a combination of the three at that level to validate the results. If you take the exclusive CFD route, you can see what happened there. The wind tunnel route still needs full-scale validation, and CFD still needs validation in the tunnel and on the runway. NASCAR has facility to use full-scale wind tunnels, and Windshear is a phenomenal facility, but it is expensive. Toyota was helping us with the cost of it so we were using it once a month. We had a CFD programme and a straight-line test programme. In Australia, to manage our category, no one can afford the CFD clusters that are necessary to run a full CFD programme. I don't do any CFD because I can't afford it, and that's fine. The straight line aero testing that we do is very well controlled. I was involved in setting up the latest version of aero testing which you will see in the Gen2 regulations. It is clear what we have done and it contains from a cost perspective and manageability perspective by the category, cars that are very close and balanced.

'If you read the regulations, you will see that the environmental conditions are catered for. That was one of the big changes that we made in terms of setting viable test conditions before you run a car and decide whether or not you are going to believe the results. Consistency is important, it is not a one-off it has to be repeatable.'

The body regulations have been relaxed slightly too, with the number of doors not stipulated although the overall bodyshape will retain the same track, wheelbase and height as the current cars due to a spec roll cage. Taken from the Car of the Future, the cost-effective chassis, which includes a six-speed Albins transaxle, AP Racing brakes, 18-inch Team Dynamics wheels and a Motec M190 ECU, will remain in use until 2021.

'You have got visibility and stability on the chassis,' says Hallam. 'Because the chassis has a fixed wheelbase and track, and a driver safety cage, it is incumbent on a new manufacturer or an existing manufacturer if it wants to change its bodyshape [to meet the rules]. And no, we are not going to move the roofline down or stretch it, so they would need to adapt their chosen car to that chassis. It would be very straight forward if it was a four-door saloon. In terms of the body shape, the original regulation was for a four-door car and we have relaxed that by not specifying the number of doors, but we are specifying that it fits on the current chassis.'

Road relevance

Retaining body surfaces that reflect that of the road car remains a high priority for the category in its quest to appeal to manufacturers and fans. By contrast to the likes of the DTM, even the spoilers and skirts are required to be 'clean', with dive planes prohibited and any surface openings (for cooling) tightly regulated.

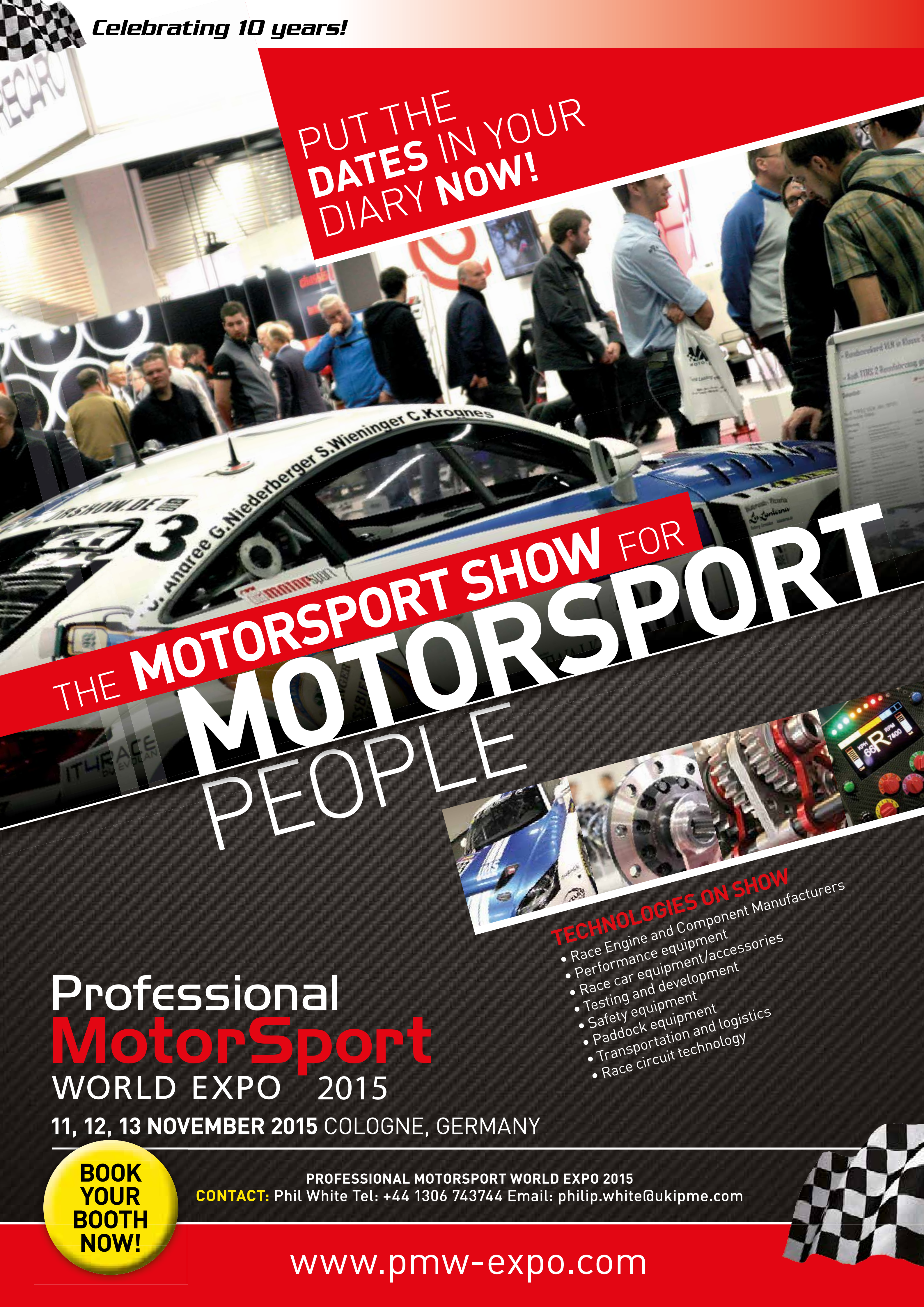
The aero kits themselves feature two key mandatory surfaces; the front undertray and rear wing profile. Alterations to the undertray, wing endplates, wing chord length and Gurney profiles are then made in the process of equating downforce and drag at the open-air aero homologation tests.

The Gen2 guidelines document features the complete test procedure that V8 Supercars currently uses for its homologations, having been the subject of much work since Stuart joined the company in mid-2014. 'If we are presented with a two-door car, we've got the tools to handle it,' says Stuart confidently. The overall minimum weight for the cars will remain at 1410kg.

The name of the category, meanwhile, will receive a trim, with V8 to be dropped possibly as soon as next year to leave the uniform Supercars branding.

Regardless of name, the category faces a tough road ahead as it looks to bed down its Gen2 rules. The devil is always in the detail and the hotly contested nature of the current championship leaves the parity bar set highly.

But if a V6 turbo is enough to keep Holden in the category and the eligibility of a two-door Mustang is able to bring Ford support back, all the effort will be well and truly worth it.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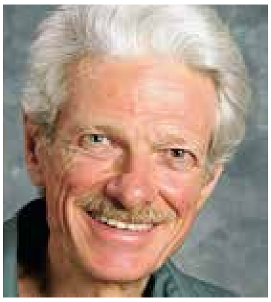


Getting to grips with offroad suspension

Just how do you get a Jeep to behave on the rough stuff?

Question

I was wondering if you could shed some light on designing a four-link suspension for the front of a 4wd vehicle? The vehicle in question is a new style Jeep JK. I'm designing a custom long arm four-link front and rear.

The stock geometry is four longitudinal links and a Panhard bar. What I'm doing is a double triangulated with no Panhard bar. Uppers will converge at the axle and the lowers will converge at the crossmember for the trans. Steering will be full hydro w/double ended ram. No mechanical steering box or drag link (so no bump steer). Coilover shocks will be mounted outboard on the axles.

I will be running this set up front and rear (rear, minus the steering of course). It's actually a pretty standard design in the 4x4/rock crawling world (see graphic page 40).

But I am at a loss as to how the front reacts to the forces. My main question has to do with anti-squat (AS). On acceleration there is weight transfer off the front end, so would designed-in AS actually end up being pro-lift? I'm thinking it would only act as AS during braking. I really don't know how to look at things with regards to the front end of the car.

The consultant says

I have at least gotten wise to this: there is a huge diversity of 'offroad' vehicles and activities. If anything, there is considerably more variety than there is 'on road'. And there isn't any single set of desired properties for an offroad suspension system, any more than there is a single set of desired properties for all vehicles operating on pavement.

Offroad applications include really high-speed events, sometimes with the vehicles running on pavement part of the time. SCORE-style offroad events, many rallies, and Red Bull Global Rallycross are examples. Some events are medium-speed, such as SAE Mini-Baja and truck pulling. Some, such as rock crawling, happen at roughly walking speed. Some events require the vehicle to ford water crossings. Some require the vehicle to float and be truly amphibious. Sometimes there is intense competition, for big money. However, a lot of offroad driving is entirely non-competitive – just people playing with their toys. And needless to say, there's a vast array of offroad vehicles used for purely utilitarian purposes, including agriculture, construction, logging, forestry, search and rescue, warfare, and exploration, including the surfaces of the moon and Mars. Understandably, remote-controlled and autonomous vehicles have seen offroad development before anybody attempted to put them on roads. So, it's a huge field.

Returning to the original question, how do we understand longitudinal 'anti' effects in a vehicle where all four wheels are driven, especially at the front, and what properties do we want in this regard? Taking the last part of this first, there is not a single answer for all applications. It depends on what we plan on doing with the vehicle.

Usually, we do not speak of anti-squat when referring to the front wheels. Anti-squat means a tendency of the rear suspension to jack up under power, countering the tendency for the rear suspension to compress due to rearward load transfer. The corresponding property at the front is anti-lift: a tendency to jack down under power, countering the tendency for the suspension to extend. Under braking, we can have anti-lift at the rear. The corresponding upward jacking tendency in braking at the front is called anti-dive. All of these can be considered forms of anti-pitch.

Negative anti-lift is pro-lift; negative anti-dive is pro-dive – and so on.

One hundred per cent anti-squat is the amount of anti-squat that will make the rear suspension neither extend nor compress in forward acceleration. But that does not mean the car won't pitch. It just means it will pitch entirely by rising at the front; and the rear won't go down.

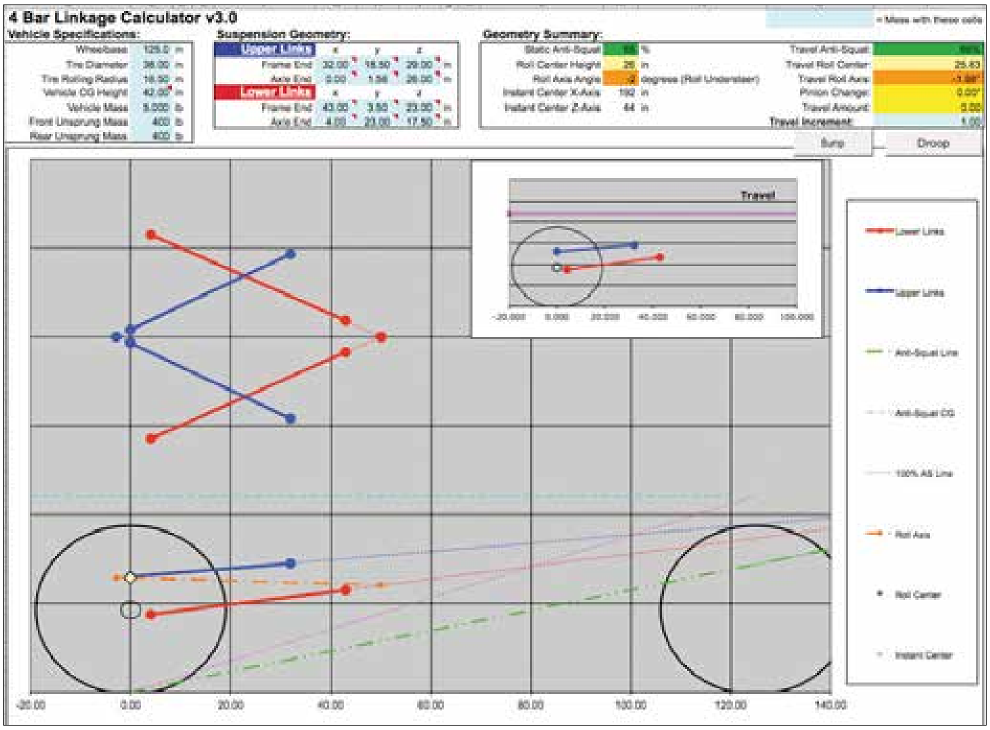
For front wheel drive, 100 per cent anti-lift is the amount that will cause the front suspension to neither extend nor compress in forward acceleration. Again, the car will still pitch, but now it will pitch entirely by squatting at the rear; and the front won't come up.

Likewise, in braking 100 per cent anti-dive or anti-lift is the amount that will result in zero displacement at the end of the car in question when its is braking.

Yet although linguistic evolution has given us four different terms for these effects, they are actually all fundamentally the same thing: that is they are jacking effects resulting

How do we understand longitudinal 'anti' effects in a vehicle where all four wheels are driven?

This month's question concerns the ideal four-link front suspension for a Jeep that will be used in offroad competition



The jacking coefficient corresponds to the slope of the force line, which in this graphic is the green line at the bottom

from longitudinal ground plane forces.

In all cases, including also jacking resulting from lateral ground plane forces, jacking force equals ground plane force times jacking coefficient. Referring to the questioner's graphic, above, the jacking coefficient corresponds to the slope of the force line, the green line lowermost in the frame. The slope of this line equates to the ratio between jacking force induced by the suspension linkage and the ground plane force applied to the system.

The slope of this line is also the inverse of the instantaneous slope of the path that the contact patch centre follows as the suspension moves, when the wheel is locked in a manner appropriate to the situation being considered (i.e. braking or propulsion).

In the case shown in the graphic the force line has about a one in four slope. This means that for every pound of longitudinal ground plane force, the suspension induces a jacking force of about a quarter of a pound. In this case, when the force is forward (propulsion), the jacking force is downward (anti-lift).

The graphic is evidently designed with rear wheel drive in mind. The 100 per cent anti-squat line shown is correct, assuming that the other wheel pair doesn't contribute to propulsion. In that situation, 100 per cent anti (in this case anti-lift) happens when the force line intercepts the opposite axle plane at sprung mass c.g. height (the light blue horizontal line). In that situation, it is also impossible to get any jacking effect at the opposite axle at all, because there is no ground plane force there.

That of course is not the case with four wheel drive, except maybe if drive to the rear is disabled. When both front and rear wheels contribute longitudinal force, as in braking with most vehicles and with all wheels driven, we need a steeper force line slope to get 100 per cent anti at a given axle. However, we can get jacking forces at both axles.

There is considerable uncertainty about what the induced jacking forces are going to be

The procedure when solving graphically is to lay in what I call a resolution line at a location corresponding to the ground plane force distribution between the two axles, and compare the heights of the intercepts of the front and rear force lines and that resolution line to the height of the sprung mass c.g. If, for example, the front wheels make 60 per cent of the ground plane force, the resolution line is 60 per cent of the wheelbase from the front axle. If the front wheels make all the ground plane force, as in the graphic, the resolution line is 100 per cent of the wheelbase from the front axle, as shown.

If the vehicle has a centre differential, we have a known ground plane force distribution, until some locking is imposed on the centre diff'. But, when we have a locked transfer case, we don't have a known torque distribution. We have 1:1 driveshaft speed distribution and highly variable torque distribution and ground plane force distribution.

If the vehicle is running straight and there is similar traction at both ends, we will have close to 50/50 ground plane force distribution. However, if one end has more traction than the other, there will be more torque to that axle and more ground plane force from that wheel pair.

When traction is good at both ends and the vehicle is turning, often the torques and ground plane forces are not only unequal but opposite in direction. The front wheels will follow a longer path and consequently need to turn faster than the rears, but be unable to do this. The rear wheels will then drive and the front wheels will drag. There will be reverse torque on the front driveshaft and extra torque on the rear driveshaft to counter that. The ground will exert rearward force on the front contact patches and forward force on the rear contact patches. In the questioner's vehicle, the front will try to lift under these conditions. When it's propelling the vehicle, its jacking forces will try to hold it down instead.

Jacking and pitch

So there's considerable uncertainty about what the induced jacking forces are going to be, because of the extreme variability of the ground plane force distribution. Do we at least know what we want the jacking forces to be?

Sort of, but that varies with what we're doing with the vehicle. For an application such as offroad racing or Global Rallycross, we want the jacking forces to fight pitch, but not too much. If we get too greedy with our antis, we will get wheel hop on pavement or other high-traction surfaces.

For mud, things are a bit different. There, we want both ends to jack up under power, vigorously. Why? Because when we're stuck, sometimes the momentary tyre load increase when we goose the throttle and the suspension pushes up against the frame will get us moving. It doesn't always work, but in a useful percentage of cases it will.

And for crawling over rocks and things? I'm not sure it matters a whole lot, since the speeds and accelerations are so modest. I think probably the most important thing for a crawling suspension is to have huge travel, and a combination of stiffness in roll and softness in warp.

CONTACT

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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

Alive and kicking

An in-depth look at Cosworth's all-seeing aliveDRIVE performance video and data acquisition system

These days we need data instantly. The same is true of pictures, too. This is especially the case in racing, so it's no surprise that systems that hook up data and video have become a big part of modern motorsport. One such system is Cosworth's aliveDRIVE. This is a performance video and data acquisition system that overlays real-time data on high definition in-car footage. Combining synchronized data with dedicated post-processing and analysis software, its maker claims it's 'a flexible tool that facilitates efforts in driver training and series scrutineering'. Current users include the BTCC, Porsche Carrera Cup Italy and the World Series by Renault (Formula Renault 3.5).

The system uses a custom-built 720p camera that is compliant with OEM regulations to ensure durability and reliability. Camera focus has been adjusted to guarantee that footage clearly displays the vehicle cockpit and exterior track surroundings. At the same time, image enhancement algorithms are applied to compensate for colour distortion caused by significant differences in luminosity between the inside and outside of the car. The camera is typically mounted behind the driver on one of the rollcage's cross-members to provide a clear view of the driver, steering wheel, rear-view mirror and track surroundings beyond the bonnet.

Complimentary to the video, aliveDRIVE overlays a wide range of information that quantifies driver inputs and vehicle parameters. The graphical data display shows steering angle, gear position, throttle position, brake pressure, vehicle speed and engine RPM – the unit expects these channels over CAN, allowing aliveDRIVE to become part of the vehicle's information network.

The 'G bubble' is driven by internal accelerometers that capture lateral and longitudinal vehicle acceleration; as a result, mounting orientation becomes an important factor to be considered during installation, to prevent incorrect acceleration values. These channels are also logged and available for analysis.

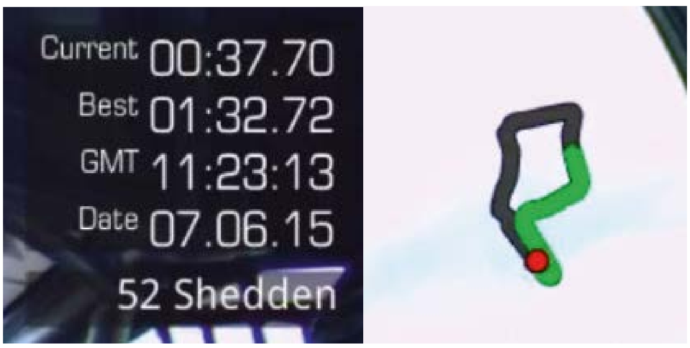
Track mapping

The system is shipped with a 5Hz GPS receiver that provides track positioning, date and time. Track maps can be easily drawn in Google Earth and automatically converted into an accepted format using a simple tool that produces the required '.map.gpx' map file. Together with the track map, live GPS positioning also generates lap time information that becomes particularly useful for post-event analysis.

To provide a clear indication of driver name and car number that ensures footage traceability, it is

The camera needs to capture the steering inputs of the driver so it's usually mounted on one of the rollcage cross members

Everything the driver and car does is logged on the graphical data display, including steering angle, throttle opening, brake pressure, the car's speed, engine revs, etc.



The driver name and car number is displayed – to ensure data traceability – as is current best lap, present time, and the racecar's position on the circuit

The software has been developed for use with tablets as well as PCs

The system comes with an Intelligent Battery Backup (IBB) which provides power once the car's engine is off – vital for crash investigation

The map and video view in Cosworth Toolbox (above) and the map and trace view (below)

Driver and vehicle data is combined with a visual representation of the line taken

possible to edit the text that controls the bottom field shown on the right-hand side image on the previous page – this consists of a standard text file of up to 25 characters.

The recording is triggered when engine speed exceeds 500rpm for five seconds and stops as soon as the engine is turned off. Video files are written to a USB portable device and the video and data are stored together in a single MP4 file that can be opened in Cosworth Toolbox. To prevent data loss due to sudden loss of power, the system is shipped with an Intelligent Battery Backup (IBB) that is installed in-line with the box to provide an additional 15 seconds of power once the car is turned off. Fuelled by a requirement to capture footage of crash events (it is used by many race series for policing driving standards) the IBB allows aliveDRIVE to keep recording and successfully write to the USB if battery power is lost.

In synch

Cosworth Toolbox software has been developed specifically for aliveDRIVE to display logged data that is fully synchronised with in-car footage. The software has been developed for use with tablets as well as other PCs and allows the user to overlay multiple laps and toggle between 'time-based' and 'distance-based' mode to determine where time was gained or lost in comparison to a reference lap. Through combined use of GPS positioning and accelerometer data, Cosworth Toolbox is able to identify track features and provides the user with a one-click corner-by-corner navigation through the video.

In a nutshell, by combining driver and vehicle data with visual representations of line and track position, the aliveDRIVE/Cosworth Toolbox tool-chain is a robust video system with an added entry level data-logging solution.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Classic club racers in the wind tunnel

Part two of our examination of Mallock aerodynamics

Since 1965, the Clubmans category has been a bastion for front engined, rear wheel drive sports racing cars. One of the first Clubmans manufacturer names likely to come to most minds would be Mallock. Its first car designated for Clubmans in 1965 was the Mk 5, and under the late founder Arthur Mallock's son Richard, they have now reached Mk 36. We have tested a trio of Mallocks representing some of the popular models still running: the 1977 Mk 18B (this one being the ex- Barry Foley 'Catchpole' car for those who recall his humorous motorsport cartoons); the Mk 28B from 1990 and a second Mk 28 that had been clad in 'Mk 36-esque' bodywork and therefore represented the current era.

The 'classic' Mk 18B featured the archetypal full width nose, cycle-type front wheel covers, enveloping rear bodywork and a full width, high-mounted single element rear wing. The Mk 28B was longer, having originally been powered by a longer engine, and featured a rear diffuser, absent on the Mk 18B, but otherwise was an update of the theme. The Mk 36 was distinctive in having all-enveloping bodywork rather than a separate nose and 'mudguards', again it had a rear diffuser connecting to the long, flat underbody and a lower mounted rear wing.

Last month we looked at some common alterations and adjustments made to Mallock noses over the years in order to quantify their effect in the MIRA full-scale wind tunnel, and learned that on the Classic Mk 18B 'nose Gurneys' were found to give useful benefits with varying levels of efficiency, depending on where they were located and how tall they were. We also discovered that the so-called 'high downforce nose' really did generate much more downforce than the 'low downforce' offering!

Classic modifications

For reference, **Table 1** shows the Mk 18B's aerodynamic coefficients and balance data with the high downforce nose and, for comparison, with the low downforce nose fitted with the most efficient nose Gurney set that was tested. Evidently the high downforce nose was a more efficient means of getting greater overall downforce and, importantly, nearly enough front downforce to obtain a reasonable aerodynamic balance (we were looking for around 40 per cent front).

Another oft-asked question about the full-width shovel-type nose over the years has been whether it should be open underneath or whether fitting it with a floor panel would be better, so we decided to test this out. The low downforce nose with the most efficient Gurney set was used in this instance, and our **Table 2** compares the results.

There seems no doubt then that fitting a floor to the nose is certainly beneficial, with a very efficient front downforce increase and even a small gain at the rear, presumably because the whole floor was working better. One cannot help but wonder why so many Mallocks ran without nose floors!

There wasn't time to try a floor under the high downforce nose, but if we apply the delta values in **Table 2** to the coefficients with the high downforce nose in **Table 1**, the theoretical numbers might look something like those in **Table 3**. This would provide a reasonably well-balanced car with a decent level of downforce, supposing the floor worked as well on the high downforce nose.

For our last quick test on the Mk 18B we tried a device rarely seen these days, but seemingly permitted in Classic Clubmans because they were used in period – side skirts. To prevent interference with the car's vertical movement on the load cells, the skirts were held out slightly with race tape. The results, as delta values 'with skirts', are shown in **Table 4**. The gain in downforce, while relatively

One cannot help wonder why so many Mallocks ran without nose floors

The Classic Clubmans Mallock Mk 18B sporting 'low downforce' nose with Gurneys

The floor panel under the nose made a significant difference to the aerodynamics

Table 1 – coefficients and balance data with the high downforce nose compared to the low downforce nose plus outer and medium height inner Gurneys

	CD	-CL	-CLfront	-CLrear	%front	-L/D
High Df	0.529	0.793	0.287	0.506	36.2%	1.499
Low Df+	0.525	0.719	0.152	0.567	21.1%	1.372

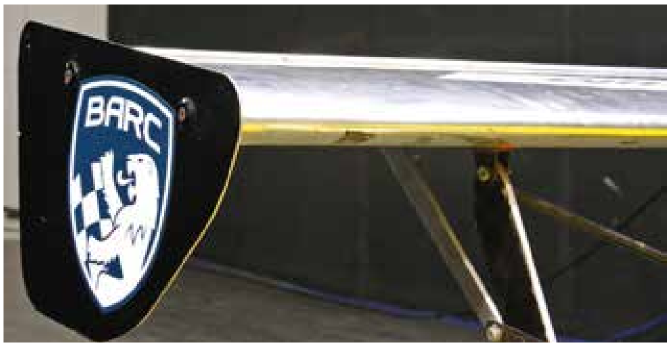
Table 2 – the effect of fitting a floor panel under the nose, with the difference (Δ or delta value) in counts (1 count = a coefficient change of 0.001)

	CD	-CL	-CLfront	-CLrear	%front	-L/D
No floor	0.525	0.719	0.152	0.567	21.1%	1.372
With floor	0.520	0.791	0.222	0.569	28.1%	1.521
Δ, counts	-5	+72	+70	+2	+7.0%	+149

By whatever mechanisms, on this flat bottomed car with no rear diffuser, side skirts provided useful benefits with a modest increase in downforce and a decrease in drag

Rear wing with popular part-span Gurney behind the driver's head and roll hoop

The more modern Mallock Mk 28B was better balanced than the Mk 18B from the outset



Rear wing without the Gurney – the Gurney proved to be an effective modification

Table 3 – theoretical data with a floor fitted to the high downforce nose

	CD	-CL	-CLfront	-CLrear	%front	-L/D
High Df + nose floor	0.524	0.865	0.357	0.508	41.3%	1.648

Table 4 – the delta values produced by fitting side skirts

	Δ CD	Δ -CL	Δ -CLfront	Δ -CLrear	Δ %front	Δ -L/D
With skirts	-37	+34	+20	+12	+1.5%	+166

Table 5 – baseline coefficients and balance on the Mk 28B

	CD	-CL	-CLfront	-CLrear	%front	-L/D
60mph	0.529	0.820	0.288	0.532	35.1%	1.550
80mph	0.526	0.852	0.321	0.530	37.7%	1.620

Table 6 – comparison between the Mallock Mk 18B and Mk 28B at similar balance values

	CD	-CL	-CLfront	-CLrear	%front	-L/D
Mk 18B	0.529	0.793	0.287	0.506	36.2%	1.499
Mk 28B	0.526	0.852	0.321	0.530	37.7%	1.620
Δ, counts	-3	+59	+34	+24	+15%	+121

Table 7 – the effect of the part width Gurney on the rear wing

	CD	-CL	-CLfront	-CLrear	%front	-L/D
With	0.526	0.852	0.321	0.530	37.7%	1.620
Without	0.515	0.817	0.342	0.474	41.9%	1.586
Δ, with	+11	+35	-21	+56	-4.2%	+34

modest (four per cent overall), was potentially beneficial. Drag also reduced fairly significantly too (5.3 per cent), and in the guise tested, which included some additional nose modifications, this was the highest downforce and lowest drag configuration tried. So even without a profiled underside or rear diffuser, skirts had some benefit.

Mallock Mk 28B

We'll round off this month with a first look at the next car, the 1990 Mk 28B. As usual we started with baseline data at 60mph and 80mph, and the numbers are in **Table 5**. This car was much better balanced from the outset than the Mk 18B, which with its low downforce nose initially had just 10 per cent of its downforce on the front. Interestingly, the front end of the Mk 28B improved quite significantly as speed was increased. This could be down to the flows in the front diffusers becoming better attached at the higher speed, or perhaps to the ground clearance reducing as actual downforce increased at the higher speed. Curiosity demands a comparison between the Mk 18B and Mk 28B at comparable balance values, and **Table 6** provides it. It would be more than carefree to suggest that this table gives a complete idea of the two cars' relative aerodynamic performances, but it's impossible not to calculate that the Mk 28B had 11.8 per cent more downforce, slightly less drag and an 8.1 per cent better –L/D value in these configurations. Not bad progress.

Finally this month, we'll take a glance at another regularly seen device on Clubmans cars – the part width Gurney behind the driver's head. Presumably intended to compensate for the loss of wing effectiveness caused by the helmet and roll hoop ahead of it, just what effect did this part width Gurney have? **Table 7** provides an answer: the Gurney was surprisingly effective and efficient considering its narrow span. Rear downforce increased by 56 counts for a drag increase of 11 counts, not a bad ratio and certainly worth having.

Next month we'll look at the latest car and compare it with the others, and with other sports racing cars we have previously tested.

Thanks to James Kmieciak, Orex Competition and owner/drivers Chris and Morris Hart and Chris Lake for providing the cars for this session.

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Splash and dash

Whether it's Formula 1 or Formula Student the same challenges are faced: new rules, new technologies and, of course, dealing with unpredictable weather…

By GEMMA HATTON

This year's Formula Student UK event was the most exciting by far

This year's drastic rule changes guaranteed Silverstone a weekend of dramatic racing, tough competition and some astonishing results. Some 135 teams turned up, but not all passed scrutineering, with teams such as Chalmers (2012 winners) not even making it through. Those that did pass were then faced with the brake, noise and tilt tests, which saw many of the big teams fail several times. They then had to spend hours fixing the cars before they could try again, pass, and be ready to compete.

Saturday morning came, and problems from the previous day's tests meant that many of the top teams where not ready to race at all. UH Racing (Hertfordshire) was rebuilding its engine; Rennteam Stuttgart, TUfast Racing (Munich) and Ka Racing (Karlsruhe) were all queuing for re-scrutineering; Team Bath Racing was repairing broken wishbones and Oxford Brookes was fixing its suspension rockers. Even last year's winner, TU Delft, was cutting it fine, only giving itself a few hours to complete the acceleration event. The starting lines for the dynamic events were all looking rather empty.

One problem which had first manifested itself at Formula SAE a few weeks earlier related to the noise levels of some of the combustion cars. With the majority of the top combustion cars now using single cylinder engines, the 2015 rules aimed to reduce the noise of these engines by changing the maximum noise limit from 110dBA to 110dBC. This apparent minor change caused many of the top combustion teams to fail the noise test several times, causing such problems that the rules committee are now looking to modify this regulation for next year.

'We thought we were fine as we had done some tests back at our university and measured 104dBC but they measured 114dBC which is a big difference especially as dBC is a logarithmic scale,' Tom Pierson-Smith from Team Bath Racing said. 'It turned out that it was the direction of the silencer that was the issue as it was aimed at the rear wing and so the whole car was vibrating.

PHOTOGRAPHY BY ETHAN GARDNER AND SAM COLLINS

Main picture: Typical English summer weather arrived at Silverstone just as the top cars were running the endurance test **Top:** The tiny electric car from UAS Zwickau was a design finalist and finished second overall behind TU Delft – the Zwickau car was able to make the most of the dry running before the rain started to fall **Above:** The third element rear suspension layout of the combustion car from Stuttgart. Its original plenum (seen here) was destroyed early in the event leading to a hasty repair and the team missing two dynamic events. The car would have been a challenger for overall victory otherwise

Once we changed the direction we were legal, but this is definitely something we want to look at next year.'

Noise nuisance

LU Racing from Lund also failed noise despite extensive exhaust work. 'We use a Helmholtz resonator which kills one frequency, then we have two mufflers and separate them; one on the front and one the rear so we have half a wavelength between them which also kills the noise,' said a spokesperson. 'The final solution to decrease our design by 2dBC to pass the test was to use smaller pipes to position the exhaust where it created the least sound.'

The first of the main events is acceleration, which is the time taken to complete the pit straight, worth 7.5 per cent of the overall available points. This is where the electric cars come into their own with instantly available torque. After each team had completed several runs, the top five run-off took place to equalise the track conditions. Unsurprisingly, the AMZ Racing car from ETH Zurich took the top spot with 3.72s, closely followed by TU Delft with 3.82s. One of the competition's big surprises was the fact that third place not only went to a combustion car, but to the heaviest car on the grid, with the 215kg, 4-cylinder beast from PWR Racing, Wroclaw clocking an astonishing 3.87s.

Next up was the sprint event, an 800m tight course that tested the cars' manoeuvrability and handling, and which was worth 15 per cent of the overall points. No clever strategies had to come into play during this test as the weather unusually remained at a consistent 18degC ambient air temperature, resulting in consistent track conditions. Therefore, the top 10 consisted of the usual suspects; the combustion Stuttgart car coming first having completed the course in 49.05s, followed by its electric brother finishing in 49.31s. Only three hundredths behind was the Zurich car, which was followed by Delft, TU Graz Racing and TUfast Racing.

Design finalist ETH Zurich headed into endurance separated from Delft by just two points but ground to a stop about 1km from the finish line, costing Zurich a strong overall result

Results

Overall Class 1	
1st	TU Delft
2nd	UAS Zwickau
3rd	Stuttgart (combustion)
Overall Class 2	
1st	Team Bath
2nd	Bristol
3rd	Aristotle University of Thessaloniki
Cost, Manufacturability & Sustainability	
1st	Aberdeen
2nd	Surrey
3rd	Strathclyde
Design	
1st	ETH Zurich
2nd	Oxford Brookes
3rd	Norwegian University of Science and Technology
Business	
1st	TU Delft
2nd	Aberdeen
3rd	Liverpool
Efficiency	
1st	KTH – Royal Institute of Technology
2nd	UAS Cologne
3rd	TU Delft
Skidpad	
1st	ETH Zurich
2nd	TU Graz
3rd	OTH Amberg-Weiden
Acceleration	
1st	ETH Zurich
2nd	TU Delft
3rd	Wroclaw
Sprint	
1st	Stuttgart (Electric)
2nd	Stuttgart (Combustion)
3rd	ETH Zurich
Endurance	
1st	Team Bath
2nd	TU Delft
3rd	Birmingham

The ETH Zurich car is driven by four student-designed hub motors and boasts a neat composite monocoque

Sunday hosts the main event of the competition, and is by far the toughest challenge for both the cars and teams: endurance. This event, worth 300 points, is a 22km course, including a driver change and a hot restart. Every year, both reliability and weather cause havoc with the teams, with many either failing to re-start or simply finishing their weekend stopped on the side of the track. This year, as teams tried to implement so many new rule changes into their designs, many arrived at Silverstone with a lack of testing, so reliability was even more of an issue. Of the 52 cars that started, only 25 crossed the finish line. That means that only 38.5 per cent of the cars took part in the main race and less than half of those actually finished. Then, of course, the rain came, which completely shook up the results of those who had not finished. The Silverstone Formula Student competition once again proving why it is the toughest in the world.

Teams spent the morning before the race analysing and discussing weather patterns, the chance of rain and which tyres should be used. At this point in the competition, AMZ Racing from Zurich were first, with TU Delft less than two points behind – it was all down to the final race. Both were on different strategies; TU Delft were the only team to have developed its own tyres with their new dry tyres approximately a second a lap faster around a 20 second course compared to last year. Unfortunately for them, these tyres weren't ready for Silverstone, and so they only had wets to run on. However, as these were also uniquely developed, they

Bath Innovations

Team Bath Racing had its most successful UK event, finishing first in endurance, securing an overall fourth place in the competition, making it the top UK team. It achieved this with a radical new concept. After four years of using an Aprilia RXV550, 552cc, 2-cylinder V twin that caused them numerous problems and resulted in three DNFs in endurance, the team finally decided it was time for a change. 'Although last year's team finally got the Aprilia to complete the endurance, we decided to move away from this engine,' explained Tom Pierson-Smith, project manager for Team Bath Racing. 'From our dyno testing, we were getting around 70hp with our new KTM 500 EXC single cylinder compared to 48hp from last year for a very similar powertrain weight. This is also our first year of using E85 [ethanol fuel blend], which [helped] with our endurance score.'

One interesting aspect of this car is the fact it has been designed with pre compressor injection. 'We are the only team running a turbo without an intercooler to try and reduce turbo lag, and we also have two injectors; one before and after compression to improve charge cooling.' Although this system wasn't in full swing at Silverstone, the hardware is ready and it will be implemented in the Austrian and Spanish Formula Student events, in which Bath will also be competing.

The talk of the paddock at Silverstone was Team Bath's wheel hub and suspension design. The wheels consist of two pieces; a 3D printed steel centre wrapped with carbon fibre to make the spokes and a carbon fibre rim. 'Splitting the rim into two skins of carbon fibre and having a Rohacell foam core really

Team Bath's wheel design (top) was the subject of much debate. The wheel is made up of a 3D printed steel centre wrapped in carbon fibre (above), which forms the spokes, fitted inside a carbon fibre rim which itself is split into two skins of carbon fibre. The core is Rohacell foam

helped to reduce the weight of the wheel further.'

'Last year's team looked at prototype uprights and we knew that reducing the unsprung mass was a crucial area of performance, because it brings our dampers into play. Therefore, if we have a lighter unsprung mass, then we have less mass to control further away from the car, which will improve our handling,' explained Pierson-Smith. 'We were quite aggressive to secure sponsorship from a new research company, but it meant we saved 30 per cent weight of the uprights from last year. They also have camber adjustments at the top which makes it a lot quicker and easier to adjust. Overall, our wheels are an impressive 50 per cent lighter than last year.'

were actually faster than last year's drys, but to maximise their performance further obviously they were hoping for rain, and so continued their rain dancing. AMZ Zurich knew this, and also knew that its only hope to secure an overall competition win was for it to remain dry so they could finish with a competitive time. Sadly, the surrounding black clouds had other ideas.

Battle of Britain

The first exciting racing of the day was the battle for the top UK spot as both Oxford Brookes and Team Bath took to the track at the same time. Usually this is a three-way fight but with UH Racing's (Hertfordshire) continuing engine problems, it was out of the running. As Oxford Brookes completed its first stint and successfully re-started, Bath continued to lap faster and faster until the inevitable happened and Oxford Brookes was overtaken. Although somewhat irrelevant as points are allocated for overall race time rather than track position, that didn't stop the cheers from Team Bath. Even though its drivers took out 24 cones, its total race time including penalties was an impressive 1484.1s, securing the top position, while Oxford Brookes completed the course in 1577.5s. 'The moment I turned the ignition off, I could feel the rain and I knew we were in a great position,' beamed Ryan Marsh, Team Bath's test manager – and he was right. As LU Racing from Lund and the Ka Racing's electric car battled through the downpour on track the rain got heavier, and within minutes the race was red flagged.

Back on track

After the monsoon was over and the track was cleared the cars could begin running again, and only the top teams were left. However, with teams such as TU Graz, Rennteam Stuttgart combustion, TUFast and Ka Racing all experiencing problems, only TU Delft and ETH Zurich would challenge Team Bath's time. The rain played into the hands of TU Delft who were extremely fast on their wets, yet remained a total of 14s slower than Team Bath, and in second place. Next up was ETH Zurich, but with only two laps to go a safety switch in the high voltage system triggered and the car ground to a halt on the side of the track. Team Bath Racing had not only completed endurance, which its previous teams had always struggled with, but had won it with their brand new KTM engine, and so were the first UK team to win since 2009. The rest of the top 10 was made up of cars that had run in the dry, meaning teams such as Loughborough, John Moores and UAS Zwickau capitalised on some major points.

Of course, ETH Zurich's endurance woes handed the overall competition win to TU Delft, who were once again crowned Formula Student Silverstone Champions for the second year running by over 116 point to UAS Zwickau, who were then followed by Rennteam Stuttgart. Team Bath came in at fourth and claimed top


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Electronics

Electric cars seem to be becoming the norm, but the engineering challenges of designing and building such machines should never be underestimated. Not only do teams have to understand and design the battery and motor layouts but all the necessary related electrical systems have to be implemented as well. With a competition as specific as Formula Student, it is rare to find systems that meet team's requirements and so they have to invest in the technology and build it themselves.

The biggest headache for most teams is the Battery Management System, which monitors the current, temperature and voltage of the cells as well as the overall state of charge to ensure that the battery remains in a safe operating range. The biggest danger with electric cars is the risk of thermal runaway of the battery. Particularly in lithium-ion cells, when the temperature is high, the internal resistance is low, so any residual current is then drawn to the cell with the lowest resistance, which warms that cell up. As its temperature increases, its resistance drops further, and so the current once again is drawn to that cell, generating a positive feed loop as the battery essentially self-feeds itself, which initiates thermal runaway. 'The Battery Management System is the single worst thing,' explains Johannes Tornell, lead design expert at Chalmers, which developed an electric car for this year for the first time. 'We have been trying to find one that fits our car but it is difficult due to communication issues and the noise generated by the converters. We also decided to use a carbon fibre casing, and fixing the cells to this was also challenging.'

The team from NTNU who reached the design finals also developed a bespoke BMS. 'We decided to make it from scratch so that we could monitor the current and temperature of each cell pair. Our 7.45kWh battery runs 144S2P, and after last year's reliability problems, we decided to add laser welds, which improved the reliability and therefore we could complete much more testing,' explained Roy Andreas Iversen, project manager.

Another area that teams such as NTNU decided to develop was the motor controllers and the inverters. 'We bought our own IPT's (Inductive Power Transfer), control cards, completed all the calculations, identified the motor regulations and torque control,' continues Iversen. 'By developing components from scratch, we can get the exact requirements we want.'

Cool solution

NTNU's batteries are air cooled by the ramps besides the driver's shoulders and a fan that pushes the air through the battery. 'By laser welding the mechanical connections we have a lot less internal resistance so we generate less heat to start with. Low resistance in the battery results in less heat, which improves efficiency and therefore the car can be driven for longer and faster throughout the race,' Iversen says.

An issue when developing your own systems is that when something goes wrong you have to re-tune them, and this is precisely what happened to NTNU. 'Four hours before FSUK, nine out of the 20 magnets in the motor came loose due to some misalignment between the stator and the rotor of the motor, which resulted in some grinding and heat. So we sent a guy from Norway to Lithuania to knock on the door and buy new motors. Of course these were a little different, so we have had to do some tuning because the new motor is aligned and so the flux field needed to be modified to the new motor.' Although a shame that the full potential of bespoke electrical systems could not be fully demonstrated at Silverstone for NTNU, it is still impressive. For maximum performance, self-developed electronics is definitely the future.

Bespoke electronics packages seem to be a growing trend in Formula Student. The NTNU car featured a team-built Battery Management System (BMS) which enabled it to monitor the current and the temperature of each cell pair

UK team, with Munchen in fifth, and Oxford Brookes in sixth place.

This year's event was by far the most exciting, not only from a racing point of view but also from an engineering point of view. As Formula Student competitions worldwide continue every year, teams and cars become more refined and more reliable. The big development steps from combustion to electric, spaceframe to monocoque and now the inclusion of an aero package, have already been made, and so designs arguably become less interesting. However, the variety of approaches taken to comply with this year's new regulations resulted in some truly fascinating innovations, some of which took the interest of world class engineers such as Ross Brawn and Paddy Lowe.

But with Silverstone and Hockenheim out of the way and memories of it merely a blur of presentations, judging. dynamics, success and failure and perhaps a little bit of 'flunkyball', the thoughts now turn to the 2016 event, and another round of rule changes.

Rule changes

The FSAE rules committee announced its plans for coming seasons at Silverstone but has decided that after the substantial aerodynamic rule changes for 2015 it would only make minor rules tweaks in 2016. Some rules will be reworded and clarified, and though it has not been revealed which these are the controversial 'weekend racer' rule may well be among them. With all bar one of the cars in the design final featuring composite monocoque chassis (Oxford Brookes used an aluminium monocoque) some believe that the judges had overlooked the fact that none of these cars were really suitable for weekend racers.

Professional drivers

Andrew Deakin, chairman of the FSAE rules committee explained that following FSAE and the events at Silverstone that the noise limit may have been 'too aggressive' and that the situation is being monitored. 'We will have to wait until they've gathered data from other events before we can make an informed decision,' he told gathered team representatives.

For 2017 more changes are set to come, including moves to prevent 'professional' drivers with significant racing experience from taking part in dynamic events, though it seems that this will be hard to police. More significant from a design standpoint may be the introduction of a fifth percentile driver template as well as the existing 95th percentile template. The cost event may also change substantially, as it's felt that some teams do not take it seriously.

It is expected that more changes will come for 2017, so teams will have to keep on innovating to stay ahead.

There are to be moves to prevent 'professional' drivers taking part


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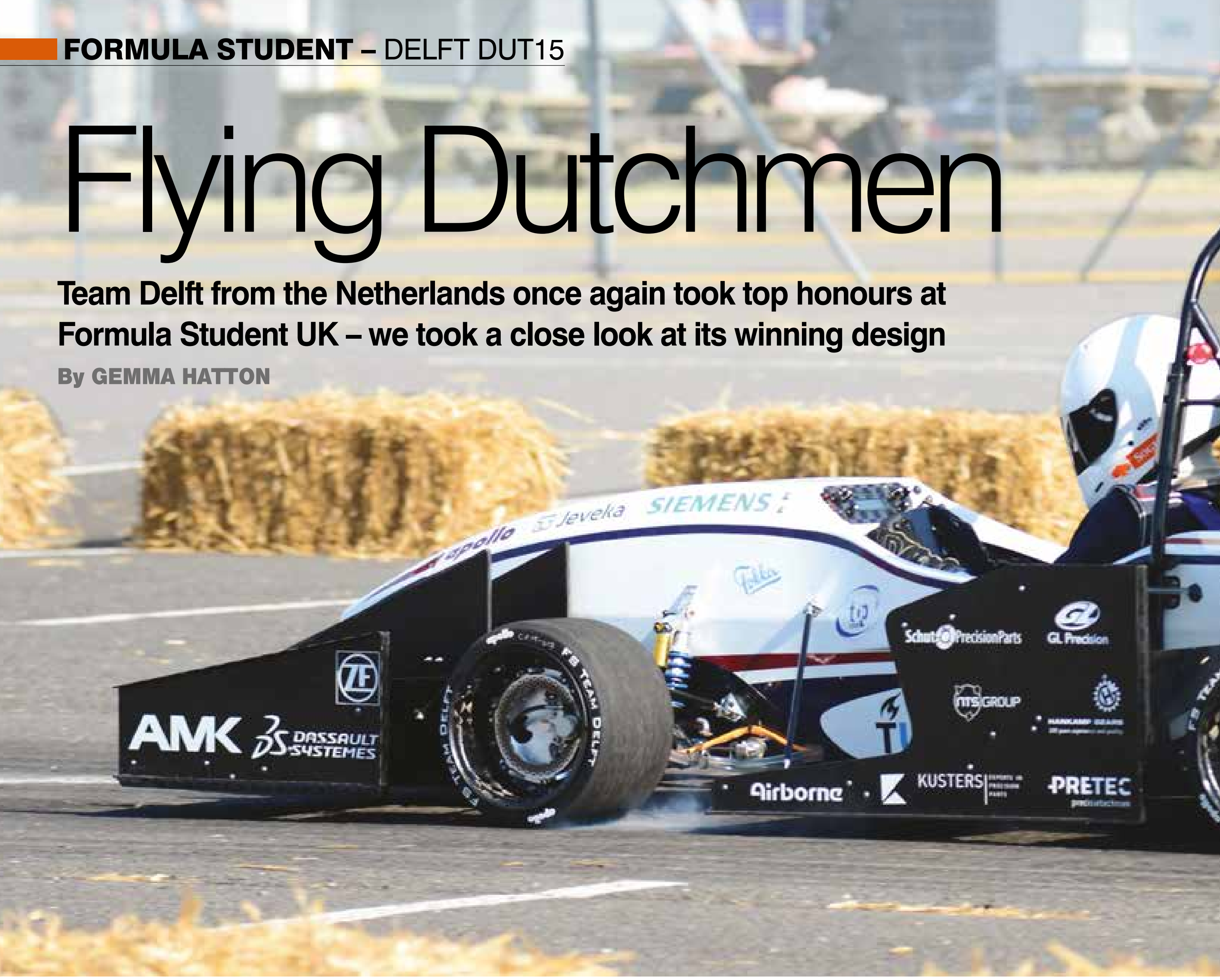

Flying Dutchmen

Team Delft from the Netherlands once again took top honours at Formula Student UK – we took a close look at its winning design

By GEMMA HATTON

Founded in 2000, Team Delft has a rich history in Formula Student. It is currently the second best electric Formula Student team in the world, having won overall at eight competitions, five in Formula Student Germany, and now three in FSUK. So, what is the secret to its great success? The answer is continuous innovation and pushing the boundaries in both engineering and the rules.

Wheels and tyres

One of Delft's most iconic engineering achievements is the unique inner-wheel design, which was first developed for the DUT14 and combined a one-stage transmission with a spoke-less wheel design. This year the concept was developed further and parts of the brake caliper were integrated with the upright, which not only reduced the number of parts but also the length of the load path and thus, the mass. 'Our motor is inside the hub and we have a one stage planetary gear system which is integrated inside the upright as well as one half of the caliper,' explains Stijn Pennings, team manager. 'This means our drivetrain is only 3 to 4cm wide.'

Something else that makes Delft so unique is that it has been developing its tyres with Apollo since 2013, and this year worked on the size and the compound structure. Delft student Daniel van den Berg explained: 'The goal of the vehicle dynamics department is to maximise both car and driver performance in the competitions. The tyres of any car form the only contact the car has with the road. Thus, all forces which accelerate the vehicle in both longitudinal and lateral direction are generated by the tyre. Up to and including the year when the DUT13 was made, the team always used pre-designed tyres. They were a black box, a slip went in and a force came out accelerating the car. Generally speaking not a lot was known about the essentials of tyre dynamics, and how to maximise the performance of the tyres.

'In 2013 this was changed as the team got the opportunity to develop our own tyres. We were able to do this with the support of Apollo Tyres. Daniel Muusers, now chief vehicle dynamics, embarked on this journey to both understand the underlying dynamics as well as design our first very own tyres. The striking results of this year-long research can be seen on the DUT14. The reduction in size meant that the DUT14 could go back to the essence of our team, a lightweight design,' said Berg.

Pennings added: 'In 2014 we made a lap simulator to identify the crucial car parameters, and of course one of the most important is the friction coefficient. We designed four different compound variations, two of which were effective and two that were not. We had to choose between the two effective designs, but this was difficult because one showed significant graining, and the other looked promising but only came to temperature after five laps which was too slow for us. However, these tyres were tested at 5degC which is not realistic. So once we tested at a more representative temperature of 20degC we found that the tyre that was graining at the lower temperature was not at the higher temperature and so we chose this one. We still ordered the other alternative, however, to complete different structure tests on. There is approximately a three per cent increase in performance by just changing the structure of the tyre.'

Another benefit of developing your own tyres is the flexibility in size: 'We also wanted to

Main picture: The Delft DUT15 ran with an unsprung wing for the first time this year while it also used sidewings **Top right:** The accumulator was re-designed for this year, and can now store 12 per cent more than previous example **Right:** Detail work on car was impressive

make the wheels as small as we could to make them as light as possible. There is a little less compound on each tyre, and 1mm less rubber around the entire circumference of the tyre quickly adds up to a large weight saving; each tyre is 1kg lighter than last year,' says Pennings.

Sadly these newly developed tyres were not ready in time for Silverstone, and so Delft could only compete using its wet tyres – however, this year's wet tyres were actually faster than last year's dry tyres due to their unique development process, and as it turned out the British weather played into their hands. 'During the first two laps last year's slicks were faster, but over the whole race distance of the endurance event, this year's wets are actually faster because the dry tyres degraded quicker,' Pennings says.

Accumulator

In accordance with this year's rules, Delft also had to re-design its accumulator, which provides the energy to its four electric motors at each wheel. This year's design can store 12 per cent more energy than DUT14, reaching 7.2kWh. Although this led to a weight increase, the team's simulation demonstrated that the increased energy capacity was more desirable as it results in a higher average velocity throughout the endurance event.

Aerodynamics

This year was the first time the team ran with unsprung wings. This means that the wings are mounted directly on to the wheels instead of the chassis so that the angle of attack of the wings remains as constant as possible, because it is not affected by the movement of the car. The new aero rules reduced the width of the rear wing, and so to ensure it was still effective, the front wing had to remain low. Another consequence of a narrower rear wing is that sidewings could be used, as the turbulence from the sidewings no longer disturbs the flow onto the rear wing because the rear wing simply isn't there. Although Pennings says this was only a rough concept as the team ran out of time to refine it. Main rivals ETH Zurich also ran sidewings, so it seems that this could be a step in the right direction.

Much of the DUT15's aero package was designed in CFD using Open FOAM software. Here Delft has made a big step. In the past its CFD projects were reliant on a privately owned cluster made up of 36 computers, all of which were old university cast-offs. Using this system, solving a case would take around 24 hours which limited the amount of optimisation that could be done. So with this bottleneck in the design process identified the DUT Racing students went looking for another solution and ended up using a cloud based system.

You may think that teams such as Delft with their many students, resources and sponsors, have little more to do than refine their designs each year. However, there is always plenty to work on and Pennings still feels that there is much potential to come from the 4wd system: 'We need to do a lot more control testing and this is something I would recommend for next year's team. This is our fourth year with 4wd where we can independently control all the wheels and we still haven't really exploited the torque vectoring capabilities and so on. The only way to do this is to finish the car early to allow for substantial testing so that you can tune the acceleration, so the driver feels like the electrical systems are actually helping him rather than slowing him down.'

Wings clipped

Big changes to aerodynamic regulations for 2015 ensured there was plenty of innovation on show in the Silverstone paddock

By GEMMA HATTON

One of the first Formula Student cars to feature an aerodynamic package was the 2002 entry from Monash University, and ever since it has been a pioneer in the field of generating downforce. Although it only enters the Silverstone competition every couple of years, there is no question that its monster wings, some of which generated up to 3460N of downforce at 115kph, set a trend.

By 2013, nearly every top team featured large front and rear wings along with large diffusers and undertrays. 'We opened up the regulations about five years ago to allow much bigger aerodynamic wings, but they are probably getting too big now,' said Andrew Deakin, vice chancellor of Formula Student and chairman of the International Rules Committee. 'Having spoken to the design judges it seems that there are quite a few teams that just have a big wing without understanding how efficient it is and how much downforce it generates.' Which is why 2015 saw the most dynamic aero rule changes to date.

The first main change was restricting the width of the rear wing, which can now only be as wide as the inside of the rear tyres as opposed to the outside of the rear tyres as the rules were last year. The next was reducing the plan view size of both front and rear wings, with the front wing now only able to extend 700mm further from the front tyres when it used to be 762mm, and the rear wing reduced from 305mm to 250mm rearward from the rear tyres.

One of the toughest rules by far for this year was the deflection test. If any aero device deflected by a 'significant' amount then the scrutineers could apply a 200N force at any point, in any direction, and the resulting deflection could be no more than 25mm. Although this was rarely implemented, it definitely resulted in teams having to reconsider the stiffness of their designs and is also the reason behind why some teams decided not to run underbody aero. 'To meet those rules with an underbody that doesn't add a lot of weight is very difficult,' highlighted Cole Pearson, chief aero designer at Oxford Brookes Racing.

Sidewings

By reducing the width of the rear wing, several teams such as ETH Zurich, TU Delft and TU Munich designed an undertray combined with a sidewing concept. 'The undertray is an aerofoil shape which we also ran last year,' explains Jonas Abeken, chief executive officer at 2013 FSUK winner, ETH Zurich. 'We gain more downforce with this combination of undertray that extends out the back and the sides of the car, along with the sidewings. These are new for this year's

Karlsruhe once again went for some very neat looking wings on its pair of 2015 cars, but the design had some unintended consequences, including robbing the front brake discs of air. Also, it seemed that the drivers in both cars struggled to see the leading edges and spent a lot of time collecting cones in both the Sprint and Endurance events

TU Munich was one of a number of teams who attempted to recapture lost downforce via the use of sidewings – overall winner TU Delft also used these

The level of complexity of the aerodynamic packages on the 2015 cars went beyond anything seen before as teams tried to claw back aero lost to new rules

Swan neck rear wing supports were used by some teams but derided by others, a number of teams also opted to use these very delicate lattice-like swan necks

Linkoping arrived with perhaps the most wing elements ever seen on a FSAE car. We lost count at 11 in the rear wing alone. Team claims to have optimised wings

rules as last year this would not have been a good solution. The flow onto the rear wing would have been disturbed from the effects of the sidewings, and it would not have worked effectively. But now that the rear wing is no longer in the way, it's an effective solution.'

Cooling Issues

With so much emphasis on the aerodynamic rules, this certainly was the main focus this year. Teams such as Chalmers spent over 50,000 CPU hours in CFD, trying to optimise the airflow around its car. However, some teams optimised their designs too much, which resulted in some highly effective front wings that unfortunately caused problems. 'We found out during the testing phase of our car that the front wing takes too much air away from the front wheels and therefore the brakes,' explained a spokesperson for Ka Racing, Karlsruhe. 'We had to find a solution and integrating a brake cooling fan was the best and fastest. We have now validated this with over 600km of testing.'

Arguably the fact that Karlsruhe's car is a high power concept did not help its brake cooling issues, as this not only means it is heavier (at 200kg), but maximum downforce was the aim. To add to its problems it was running the smaller 10 inch wheels.

Either way, the overall driveability and reliability of the car has to be the main priority. One team that didn't fall into this trap was Norwegian University of Science and Technology (NTNU). 'We specifically designed our front wings not to eat up all the air, as we knew this may be a problem,' Roy Andreas Iversen, project manager said. 'We could have gained much more downforce by having a larger front wing but we wanted a stable car, that was neutral and handled well, so we prioritised the balance of the car.'

This seemed to be another trend for this year. Several teams highlighted that their focus was purely on the aero balance of the car to give their drivers the most predictable and driveable machines. 'The front wing has been limited by the rear wing, as the front can take a lot more downforce, so we tried to get the same downforce at both the front and the rear,' said Iversen. 'Therefore we took a little hit on the maximum downforce we achieved to increase the overall feel of the car.' This was similar to both Team Bath and Oxford Brookes who both worked closely with lap time simulations and the suspension department to achieve a 50-50 aerodynamic balance.

Swan neck mountings

One controversial area that saw many different approaches was the mounting of the rear wing, and a large proportion of the top teams run with 'swan neck' like rear wing mountings, which attach to the upper side of the rear wing. However, the teams say this was not a direct consequence of the rules (and other teams completely disagree that it is an effective solution). 'Essentially, you want to keep the low pressure side, the underside of the wing clear because that produces approximately

'The front wing takes too much air away from the brakes'

The Karlsruhe car sported an apparently Benetton B193 inspired rear wing with a forward element – the German team was one of a number of competitors to opt for this style of wing

The Karlsruhe car also needed to use cooling fans on the front brakes as a consequence of the front wing reducing the air flow over the disc and caliper

Linkoping's front wing was perfect for collecting up the cones – problem was the event was not over

two thirds of the overall downforce of the rear wing,' explains Abeken. 'The moment you mount from the underside, you are creating an obstruction which causes separation and therefore a loss of downforce. We found that there was much less loss of downforce by mounting on the top of the rear wing, rather than on the underside.'

Another team that utilised this technique, and one of the few teams implementing it last year, was Oxford Brookes. 'Compared to a lot of teams we run relatively small mounts. Last year we wanted to mount on the upper surface of the rear wing because it's much more efficient than underneath, so we ran a design that used carbon tubes and joints,' says James Durham, head of aerodynamics for Oxford Brookes Racing. 'Although this gave us much better flow under the wing, it meant we were seeing quite a lot of deflection through the whole assembly and therefore this year we decided to go for a solid carbon swan neck and use a nomex core. It's extremely lightweight and we use the geometry of the roll part to give us an angle to ensure that for side deflection we still have substantial strength throughout the system.' The further advantages of this type of mounting is the fact that it is a single component which is relatively easy to lay up and it remains lightweight. 'The weight of our total aerodynamics package, including the mounting system, is only 10kg and this is helped by the use of hollow carbon fibre wings with an internal C bracket,' says Durham

Unsprung wings

Other teams decided that the optimum approach was to have unsprung wings. 'We ran swan necks two years ago, but I am not a fan,' says Tom Pierson-Smith, team leader of Team Bath Racing. 'To me, the load path needs to go straight into the tyres, so my favourite mounting solution is the unsprung wings that Delft run. If we had had another month we probably would have run that. Instead, we have tried to transfer all the load through the four pillars underneath the main plane and hopefully as much of that into the tyres.'

These swan neck designs are primarily benefiting the airflow on the underside of the rear wing, which may be a result of teams using optimisation software such as CFD. The question is whether this benefits the overall handling of the car, or are unsprung wings ultimately the best way to go? It will be interesting to see which solutions teams decide to develop for next year's competition.

Oxford Brookes' upper cascade

There are always some bizarre wing designs throughout the competition, some of which may not have been entirely thought through. However, one interesting element on the Oxford Brookes car which had been thought through was the upper cascade on the rear wing. 'It helps us generate more upwash and allows us to run higher angles of attack on the upper flaps,' explains James Durham. 'It is something we have seen before and, because we are front limited, we really focused on getting a good balance front to rear because that was an issue last year. Even though the regulations have reduced the working area of the wings, by adding a high mounted cascade, we can gain more working area.'

Cole Pearson, chief aero designer says: 'As long as you keep the separation between the lower and upper elements large enough you don't see the pressure gradients from one element interfering with the other too much. Of course, it will be less efficient then if they were both separate, but as long as the separation is large enough, you can reduce that effect enough to make it worthwhile overall.'

'The correlation between CFD and reality is a well-known problem, but teams try to mitigate this by conducting correlation studies, to improve the accuracy of their simulations,' says Pearson. 'We worked with wool tufts and flow vis during track testing to compare the results with CFD. We use damper potentiometers to the spring rates of the vehicle from which we can read the corner loads. We do both constant speed testing, which models a static vehicle at speed so we can measure the vehicle's lift and front to rear balance, and we do coast down testing where all the forces are taken off the car apart from the aero and tyre drag which we can read through the velocity trace as well as accelerometers.'

All this work amounts to a correlation of five per cent between the team's CFD and its on track testing. Although this still shows CFD's inaccuracies, it is impressive to see teams focusing on such areas and is something they need to work on to continually improve.

Upper cascades on the rear wing of the Oxford Brookes entry were to help balance out the front-limited racecar


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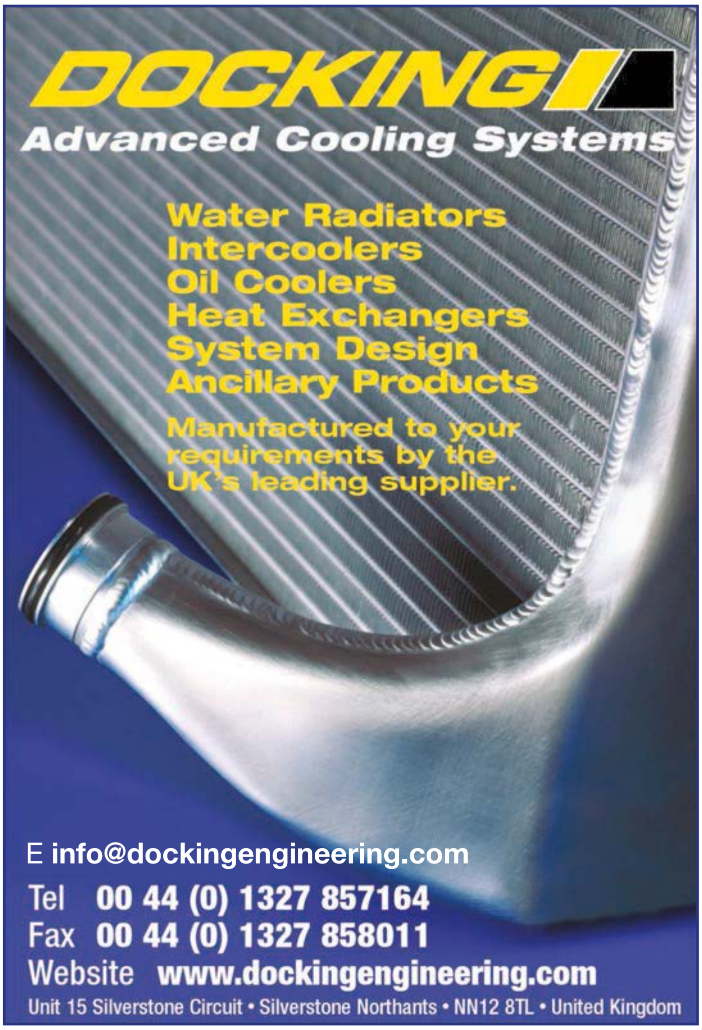
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Taking the **tiller**

Hydraulic power steering *vs* electric – and why has the BTCC been experiencing steering issues?

By GEMMA HATTON

On the left is the standard steering system that contains the torque sensor. On the right is the lightweight unit that has no internal torque sensor. The advantage of the latter is that there is a shorter distance between the input and output splines, to make packaging easier, while a straight through shaft without a torsion bar can be used, giving the driver a better feel of the track beneath him. For these systems an external torque sensor is fitted to the steering column

Whether it's Touring Cars, rallying or rallycross, there is one thing they all seem to have in common this season, and that is problems with power assisted steering systems. Even F1 is having its share of issues, if Fernando Alonso's claims of locked steering at the Barcelona pre-season test are true. In the British Touring Car Championship it's been more openly acknowledged: 'This is the fourth year that our EPAS system has been used in BTCC and until now there have been very few problems,' says David Cunliffe, director of DC Electronics, which supplies the BTCC as well as endurance and rallycross teams. The question is, what is the cause of the problems, and what is the solution?

The first mechanical power steering system can be traced back as far as 1876, although they only became commercially available in 1951, on the Chrysler Imperial. The technology crossed over to F1 in the mid-90s and now almost every road and racecar uses it.

Essentially, power steering amplifies the effort the driver applies to the steering wheel to the turning of the wheels. Therefore only a small amount of lock is required to turn the wheels significantly; making it easier for the driver.

There are three types of power steering commonly used; hydraulic, electric and electro-hydraulic. Hydraulic power steering consists of a hydraulic pump that is coupled to the engine shaft and generates pressure to an actuator filled with oil. When the steering wheel is turned, pressure builds up on one side of the actuator more than the other and consequently applies a force to the steering gear which turns the wheels. Once the turn is completed, a control valve opens and allows the excess oil to return to the reservoir and thus it can circulate through the system again. When no lock is applied, the pressure on both sides of the actuator is equal and therefore there is neutral steer.

Fifty years after the introduction of the first hydraulic system, electric power steering systems came along. 'Electric power steering (EPS or EPAS) uses an electric motor to assist the driver of a vehicle by adding an additional force that is combined with the steering effort of the driver,' says Cunliffe. 'Sensors detect the position and torque applied and therefore rotational force of the steering column and an ECU applies assistive torque via the motor, which connects to either the steering rack or steering column. This allows varying amounts of assistance to be applied depending on driving conditions.' In a normal system there is the steering wheel and then the steering column which joins to the manual steering rack, the EPAS essentially slots in between the steering wheel and the rack.

Electro-hydraulic systems are, unsurprisingly, a combination of the two. Where an electric motor is used to drive the pump of the hydraulic system, instead of the drive belt of the engine. 'The only advantage of this is you remove the need for the engine driven pump and the belts, although you still need the pipes, hydraulic oil and the hydraulic rack etc.,' explains Cunliffe 'The disadvantage of this compared to a pure electric system is the electro-Hydraulic pump runs at all times. An electric assist only draws power in the turns, so when you are going down the straight the electrical draw is next to nothing.'

The first mechanical power steering system can be traced back as far as 1876, although they only became commercially available in 1951

Hydraulic *vs* Electric

The hydraulic system is a simple design that's been refined over the years, but there are still some fundamental disadvantages. The major downfall is the parasitic power losses associated with the hydraulic pump having to run and maintain oil pressure by throttling the entire time the engine is on. This can equate to as much as a 15 per cent engine power loss. Furthermore, the system can leak, which has caused numerous problems for Aston Martin Racing over the last few years in the World

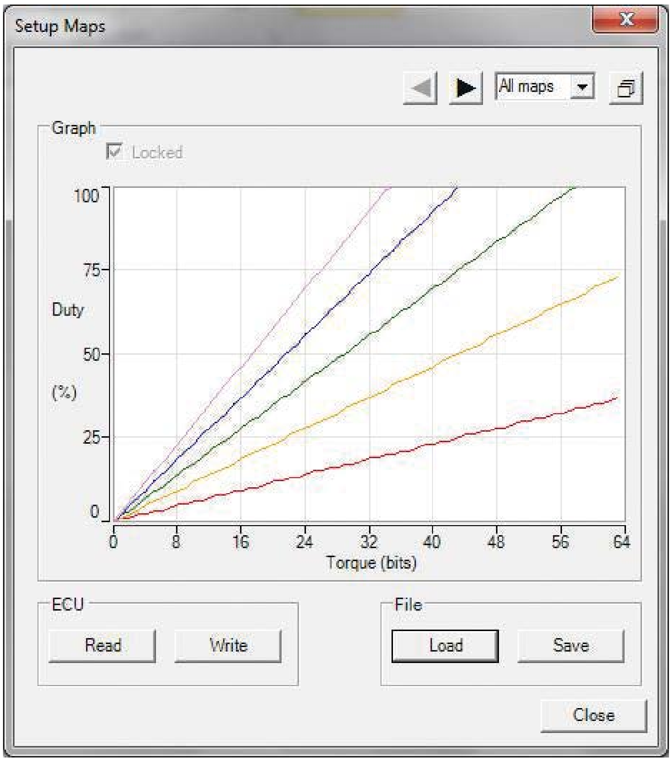


Figure 1: The default power steering maps for DC Electronics EPAS System

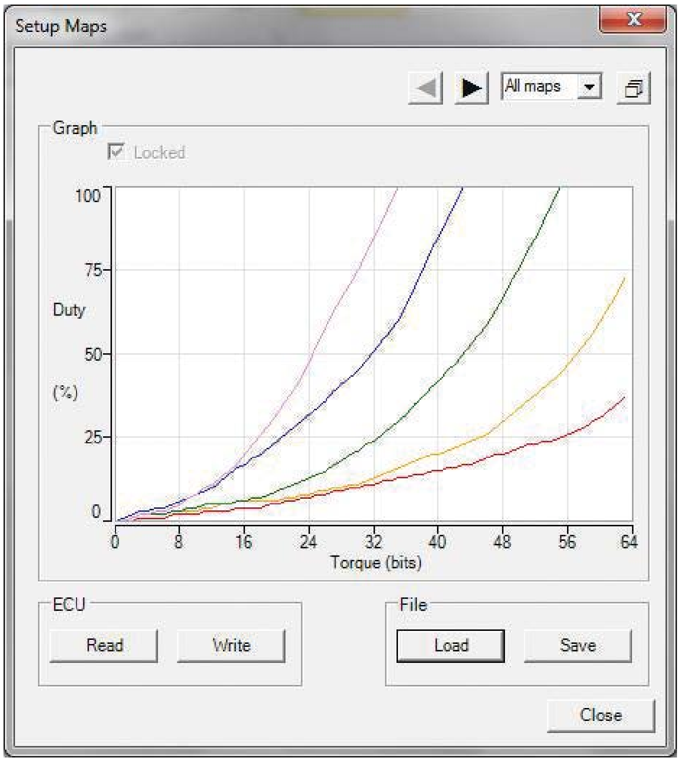


Figure 2: Convex shape maps tuned to the driver's needs; more help in tight turns, less in fast bends. These can also sometimes help overcome mechanical problems

Endurance Championship. The system weighs more than the electric alternative and of course the belt drive can snap and the pumps can fail. It also has minimal flexibility as its location is restricted by the belt drive to the engine and the hoses for the control valves.

'Electric systems have an advantage in fuel efficiency because there is no belt-driven hydraulic pump constantly running, whether assistance is required or not, and this is a major reason for their introduction,' says Cunliffe. 'This elimination of parasitic losses on the engine frees up more horsepower at the wheels. EPAS systems are also adjustable so in championships where multiple drivers are in the same vehicle, such as endurance racing, each driver can set their own preferred level of assistance, making them more comfortable in the car and reducing their level of fatigue over multiple stints.' Some manufacturers claim that EPAS systems use 90 per cent less energy than the hydraulic versions.

'Hydraulic systems are only available as a steering rack and can't be mounted in line with the steering column,' Cunliffe adds. 'This is one advantage of the electric column mount system as it means you can fit a much smaller steering rack if space is tight, plus you get to choose the rack ratio you prefer.' The system also offers minimal lag as it is a closed loop system, so as soon as the system detects a torque demand input from the driver, the motor is activated almost instantaneously.

When EPAS first came along it suffered criticism as driver's complained about the lack of feel and the fact that these systems were poorly tuned. Power steering maps solve this issue and are individually tuned to each driver's preferences. Each steering system from DC Electronics has five factory default maps, illustrated in **Figure 1** which can be modified and then a rotary switch on the driver's dash is used to select the desired map. The X axis is the rotational force on the steering column which is measured in bits and the Y axis is the motor response. Map 1 (red) demonstrates the least assistance and as you can see for a 35 torque bit input the motor switches on at roughly 20 per cent assistance. However, at the same torque input, Map 5 (purple) gives 100 per cent motor duty, making the steering feel much lighter.

Figure 2 illustrates how the default maps can be tuned to a specific driver's requirements and usually take the form of convex-like shapes to provide minimal assistance during small steering manoeuvres, but much more assistance as the amount of lock increases. The gradient of the different maps vary depending on how light or heavy the driver prefers the steering, but these maps also provide other uses. 'A good example of using these types of maps would be to help overcome a mechanical issue with steering geometry. If a car's front end dips down whilst turning in under braking you may find the rack binds up due to less than ideal geometry. In this scenario the curved map would help by boosting the motor output to help push through the tight spot,' Cunliffe says.

As EPAS is designed for multiple championships, the sensitivity of the system can also be tuned by modifying the deadband which is set so that all steering torque inputs are ignored until they exceed a certain value. Therefore, on one side of the scale, the driver will have to put more effort in before the system starts to react, and at the other end the steering can become twitchy.

EPAS and the BTCC

Despite the advances in electric power steering over the years, it can still cause race retirements if not used correctly. One example is this year's BTCC, which has experienced power steering issues this season. DC Electronics has been investigating the causes. 'Our system has been on the motorsport market for 10 years and, to be honest, we have never seen any of the failures that the BTCC teams are currently experiencing, bearing in mind our system is used in endurance racing, rallycross, powerboats and numerous other disciplines,' says Cunliffe.

When a failure does occur it is usually either the motor or the EPAS ECU, both often a result of vibration and heat due to them being mounted incorrectly. 'When motor failures occur the general cause is one of vibration and the ECUs, like any other electronic equipment on the car,

'The bottom line is, the British Touring Car Championship EPAS system works fine if installed correctly and operated within its limits'

A typical column-mounted steering assist unit – the ability to mount on the column is an advantage of EPAS over hydraulic

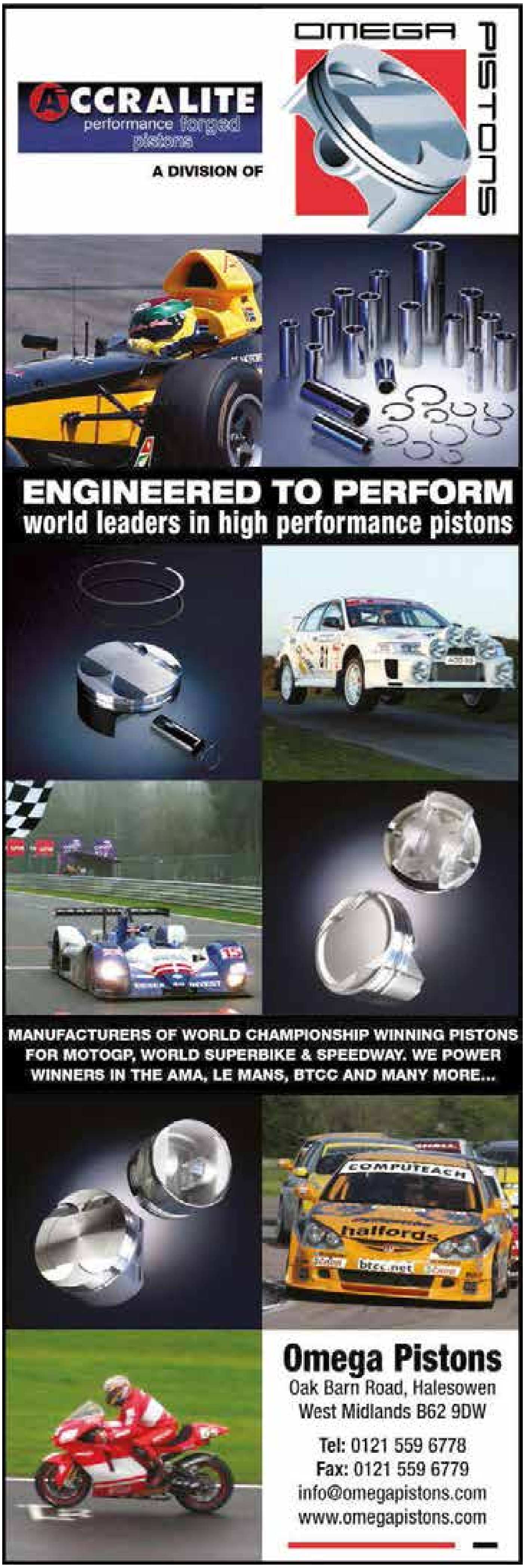
EPAS control ECU. Note cooling fins on the left side – these help keep power control circuits cool.

If a failure does occur, it is usually either the motor or the EPAS ECU. Both of these failures are often a result of vibration and heat due to them being mounted incorrectly

do not like vibration or heat either. Mounting the ECUs in a vibration proof cradle and away from sources of heat such as exhausts all help extend the operating life of the product.'

One new team, in an attempt to lower the centre of gravity, mounted the EPAS motor directly off the block of the engine. Unfortunately this has led to several retirements this season due to power steering failures causing the steering to be unpredictable for the drivers. The cause was high vibrations transmitted from the engine resulting in excessive movement in the brushes within the motor. This had caused arcing, generating heat, and consequently the brushes had completely melted from the plastic housing which had been ripped from the motor and were therefore jammed. This is what caused the lockouts and regardless of how much force the driver applied, the wheels simply would not turn (although Cunliffe pointed out 'There is a clutch mounted between the motor and the gearbox for just this scenario. If the motor was jammed solid then the driver would still be able to turn the steering due to the mechanical advantage of the steering wheel and the internal gear'). A further consequence of the motor jamming is the fact that it then draws huge currents from the EPAS ECU, which can then result in the controller burning out completely. With vibration being the root cause, aggressive drivers suffer more than those who prefer large amounts of assist, causing the motor to work extremely hard. Jason Plato hinted at this at the Croft round of the BTCC, where power steering issues affected his qualifying.

'Another issue that has appeared for the first time this season is the plastic connector that joins the electric motor to the wiring harness melting. There can only be two reasons for this.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There have been power steering issues in the British Touring Car Championship this year, but the supplier of the BTCC system says it's a problem that's largely the fault of teams pushing the components to the limit, or fitting the systems incorrectly

Heat is the biggest enemy of any electric power steering system. As the motor works hard it begins to heat up and as the windings become hot the ability to pass current is reduced and the available power from the motor diminishes. Using a heatsink can significantly improve the performance of these systems

The trend of recent years has been for race teams to switch from hydraulic to electric power steering systems

Firstly, worn connector contacts due to them being connected and re-connected more times than necessary – creating a high resistance which in turn creates heat as the current passes through it,' Cunliffe says. 'Or secondly, higher than expected average current passing through the connector, causing it to exceed its operating parameters.' The issue seems to be that teams are using the system outside of its operating parameters. 'When the power steering system was first specified and tested with GPRM, it was designed for BTCC to work within the recommended camber operating angle of 7.5 to 9.5 degrees. If any teams run outside these parameters it could cause the steering system to work beyond its operating limits and greater current would therefore pass through the connector.'

Although the TOCA technical director sent out a reminder to ensure teams were working within the limitations of the parts, the current competitiveness of this year's BTCC season is making teams push components to the limit. 'We suspect the problem is the teams are operating the systems at a greater camber angle than 9.5 degrees. With the BTCC being one of the most competitive championships in the world, teams are looking for any little advantage and camber angle seems to be one of the areas teams are pushing hard.' This speculation was confirmed by DC after analysing the data and set-ups from the recent Snetterton test and it demonstrates how teams are using the EPAS systems much harder this year than previously, as the motor reaches maximum assistance in several corners. 'The bottom line is, the EPAS system works fine if installed correctly and operated within its limits,' says Cunliffe.

The future

As motorsport continues to exploit the boundaries of efficiency, the trend of recent years has seen teams switch from hydraulic power steering systems to electric, all in aid of reducing power losses and increasing fuel efficiency. However, some teams such as Aston Martin Racing are still persevering with hydraulic systems, but this is mainly due to the fact that its Vantage GTEs, GT3s and GT4s are adaptations from the roadcar, which utilises the hydraulic system, and it would be too big a change to switch to electric. Then again, new releases that try to run hydraulic systems such as the Toyota GT86 CS-R3 rally car had homologation problems and therefore had to wait an extra season and in the meantime switched to an electric steering unit.

It seems that electric units are the way to go, but if so what is the future for these systems? 'EPAS systems will become smaller and use more powerful brushless motors that are designed for working with higher voltages. This will mean drawing less current and therefore increasing capacity which will be particularly beneficial for the integration into Electric vehicles,' concludes Cunliffe.


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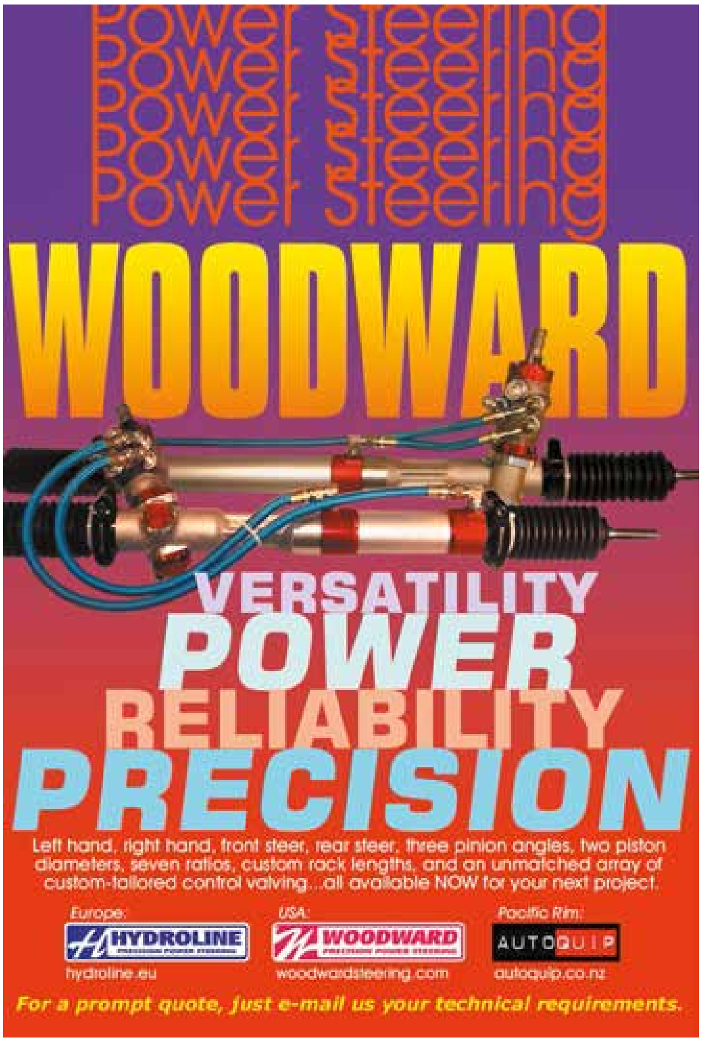
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A V8 Supercar on a hot lap is a sight to behold, but could you explain what's happening in this corner in a purely numerical way?

Racing by the numbers

Just how do you analyse your racecar's performance using mathematical terms? Our very own number cruncher explains

By **DANNY NOWLAN**

One of the things that has always amused and appalled me at the same time about our business is the total lack of quantification of how a racecar performs. Over the last month I've been on the road training with ChassisSim customers and pitching to prospective ChassisSim users. One of the themes I've been seeing is while they want their cars to go faster, they lack the mathematical literacy to describe this. This is what we'll be discussing in this article.

Also, this will probably be the first of many articles I will write about this topic. To be quite honest there is no way I could hope to squeeze it into one feature. Rather, think of this as the first discussion point to get you thinking about car performance numerically, as opposed to waving your hand in the air.

The first port of call in this discussion is classifying the percentage of front lateral load transfer. This has had many names over the years, such as 'the magic number'. While there is nothing mystical about this number the lateral load transfer at the front is a great tool to keep a track of what set-ups work, but more importantly it helps you classify set-up sensitivity. The equations for this, for linear springs and roll bars, are shown on the facing page (**Equations 1-11**). The really useful thing about this is that for a given lateral load transfer we can now approximate the tyre loads.

Tyre model

We can plug it all in to a tyre model and using a simple force balance we can get a handle on set-up sensitivity. Let me remind you of the end result I had for this in a V8 Supercar analysis I completed a couple of years ago. The set-up parameters are in **Table 1** and a representative 2D tyre model for a V8 Supercar is shown in **Table 2**. The load case I put this through was a 1.4*g* turn. The end results are shown in **Table 3** (all three tables top right, facing page).

The predicted speed here is the end result of using a simple force balance. While the equations are very simple it nonetheless gives you a powerful tool to start tallying up what the driver tells you with what the car actually did. As I mentioned in that article, the truth lies somewhere in the middle of all this, but at least you now have the numerical tools to start asking some serious questions.

The next port of call is classifying springs and damper rates. In that regard the quarter car model is your best friend and to refresh everyone's memory let me present this in **Fig 1**.

We can plug it all in to a tyre model and get a handle on set-up sensitivity

EQUATIONS: 1 to 11

rcm = rcf + wdr*(rcr - rcf); (Equation 1)
tm = wdf*tf + (1-wdf)*tr (Equation 2)
hsm = h - rcm; (Equation 3)
rsf = (krbf + kfa)*ktf/(kfa + krbf + ktf); (Equation 4)
rsr = (kfb + krbr)*ktr/(kfb + krbr + ktr); (Equation 5)
prm = tf2*rsf/(tf2*rsr + tr2*rsf); (Equation 6)
prr = (tr/tm)*(wdf*rcf + prm*hsm)/h; (Equation 7)

Here the symbols are,
rcm mean roll centre (m).
rcf front roll centre height (m).
rcr rear roll centre height (m).
wdr weight distribution at the rear of the car.
wdf weight distribution at the front of the car.
h Centre of gravity height of the car (m).
rsf wheel spring rate in roll for the front (N/m).
rsr wheel spring rate in roll for the rear (N/m).
prm lateral load transfer of the sprung mass due to forces applied at the mean roll centre. This is determined by the springs and bars
prr total lateral load transfer distribution at the front. This includes the effects of the roll centres and the springs and bars
tm mean track of the vehicle.

L1 = (wdf*mt*g + Faero_f)/2 + prr*(Fyf + Fyr*)h/tm + other terms (Equation 8)
L2 = (wdf*mt*g + Faero_f)/2 - prr*(Fyf + Fyr*)h/tm + other terms (Equation 9)
L3 = (wdr*mt*g + Faero_r)/2 + (1 –prr)*(Fyf + Fyr*)h/tm + other terms (Equation 10
L4 = (wdr*mt*g + Faero_r)/2 - (1 – prr)*(Fyf + Fyr*)h/tm + other terms (Equation 11)

While the equations are very simple, it nonetheless gives you a powerful tool to start tallying up what the driver says with what the car did

Table 1 – Typical V8 Supercar setup

Parameter	Value
Front roll centre	100mm
Rear roll centre	240mm
Front Wheel rate	60N/mm
Rear Wheel rate	60N/mm
Front bar wheel rate	40N/mm
Rear bar wheel rate	10N/mm
Front track/Rear track	1.6m/1.6m
Front tyre spring rate	305N/mm
Rear tyre spring rate	305N/mm
c.g height	0.45m

Table 2 – Representative 2D tyre model for a V8 Supercar.

Parameter	Value
Initial co-efficient of friction	2.2
Peak Load	850kg

Table 3 – Predictive numbers for a rear roll centre change.

Setup	Load FL	Load FR	Load RL	Load RR	FyR	V_pred
RRC 240	674.96	133.82	694.58	54.47	9993.5	81.47
RRC 250	671.61	137.16	697.93	51.1	9938	81.27

All Loads are shown in kg, the lateral forces are shown in N and V_pred is in km/h.

The thing that I love about the quarter car model is it is a very simple tool that is also easy to understand, but it is very powerful. **Equations 12 to 13** (P74) have saved my neck on more occasions than I care to remember.

Think of equations 12 to 13 as the mathematical language of damping and the first go at describing your car frequencies. That is for a given spring rate and a damping slope you can now classify what the damping and springing of the car is doing. You will also recall my original damping guide that I've discussed on a number of occasions. To refresh everyone's memory I've presented it in **Table 4** (P76).

Table 4 is presented as a guide as opposed to the 10 commandments. It's some good rules of thumb to get you going and to get you ahead of the game. A lot of this will vary with the type of car and tyre. For example, mechanical cars will fall back to classic second order damping systems. However, cars with big downforce packages and wide tyres will have higher damping ratios, because you need to control the aero and put heat in the tyre.

Damper genius

But a really powerful way of using damping ratios is classifying damper set-ups that worked. I had a colleague who would go through and plot what his dampers would do throughout the velocity range. He would wind up with something like **Table 5** (P76).

What he would then do is tally this up to set-ups that worked and then when he changed springs and bump rubbers he would use that table to specify the damper *vs* the velocity curve. To be quite honest, I thought that was nothing short of genius.

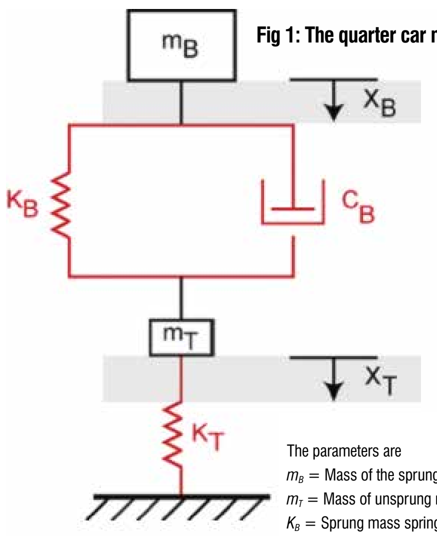

Fig 1: The quarter car model.

The parameters are
m_B = Mass of the sprung mass (kg)
m_T = Mass of unsprung mass (kg)
K_B = Sprung mass spring rate (N/m)
C_B = Sprung mass damping (N/m/s)
K_T = Tyre spring rate (N/m)

EQUATIONS 12 to 13

EQUATION 12

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

EQUATION 13

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

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

Here the terms of the equation are,

K_b = Wheel rate of the spring (N/m)
C_b = Wheel damping rate of the spring (N/m/s)
m_b = Mass of the quarter car.
ω_0 = Natural frequency (rad/s)
ζ = Damping ratio

The next thing to talk about is classifying aero loads using dampers. This is something I have discussed many times before, and a message to any junior engineers and students who might be reading this: if you can't perform this I would fire you so fast you would be supersonic out the door. But to refresh everyone's memory there is a worked example (below, **Equation 14**). This example I have repeated *ad nauseam*, because it still blows me away the number of people who don't do this. However, one point I want to say about this is that it also applies in braking. I have presented a quick example to illustrate this (**Fig 2**, P76).

What we have here is some data from a car that does produce downforce. Since this is a live example from a customer I have blanked out all the scalings. What is of particular interest here is that under brakes the dampers have an initial hit and then they back off. Most people looking at this would think something strange is going on with the suspension geometry. However, here's the trick. You can use the methods in **Equation 14** to see what is going on with the downforce, so you can either see if that is the problem or you can eliminate it.

EQUATION 14

$$FtDownforce = MR_f \cdot k_f \cdot (FL\_Damp + FR\_Damp)$$
$$= 0.9 * 140.1 * (10 + 10)$$
$$= 2521.8N$$

$$RrDownforce = MR_r \cdot k_r \cdot (RL\_Damp + RR\_Damp)$$
$$= 0.8 * 140.1 * (15 + 15)$$
$$= 3362.4N$$

$$C_L A = \frac{FtDownforce + RrDownforce}{0.5 * 1.225 * (220/3.6)^2}$$
$$= 2.57$$

$$AeroBal = 100 \cdot \left(\frac{FtDownforce + \frac{mt \cdot g \cdot a_x \cdot h}{wb}}{FtDownforce + RrDownforce} \right)$$
$$= 100 \cdot \left(\frac{2521.8 + \frac{500 \cdot 9.8 \cdot 0 \cdot 0.3}{2.6}}{2521.8 + 3362.4} \right)$$
$$= 42.9\%$$

$$C_D A = \frac{gr * T / r_t - m_t \cdot g \cdot a_x}{0.5 * 1.225 * (220/3.6)^2}$$
$$= \frac{3 * 200/0.28 - 550 \cdot 9.8 \cdot 0}{0.5 * 1.225 * (220/3.6)^2}$$
$$= 0.937$$

Table 4 - Damping guide	
Case	**Damping ratio**
Low Speed Bump	0.7 - 1.4 . Typically downforce dependant
High Speed Bump	0.4 - 0.5 . You want the car to ride the bumps here
Low Speed Rebound	0.7 - 1.0. Again downforce dependant
High Speed Rebound	0.4 - 0.5 . You want the car to ride the bumps here

Table 5 – Damping ratios for damper presented in Fig 2		
Velocity (mm/s)	**Damping ratio in bump**	**Damping ratio in rebound**
0	1.24	0.95
13	2.03	0.6
25	0.616	0.707
38	0.175	0.31
50	0.167	0.286
63	0.174	0.31

Table 6 – Relevant Parameters for the pitch calculation	
Variable	**Value**
Front Motion Ratio (Damper/Wheel)	0.63
Front spring rate	123N/mm
Front braking force	1224.5kgf
Rear braking force	885kgf
Front pitch centre	50mm
Rear pitch centre	180mm
c.g height	0.43m
Wheelbase	2.794m

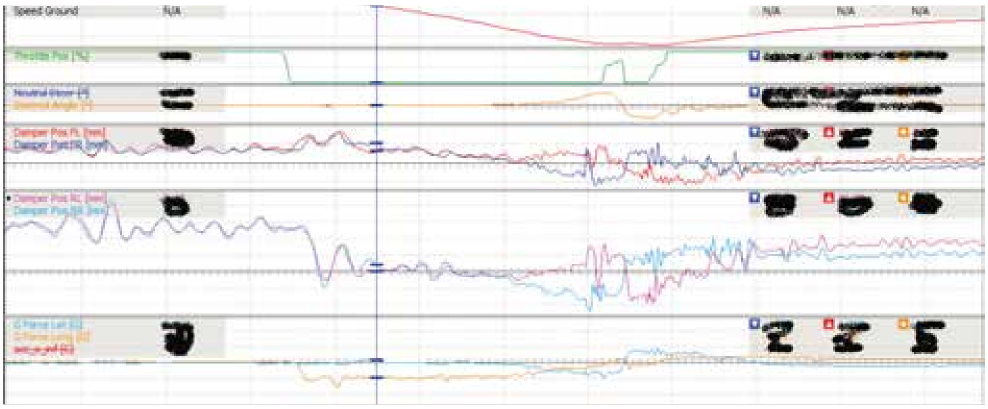

Fig 2: This might suggest there was something wrong with the suspension geometry – which is where Equation 14 comes in

EQUATIONS 15, 16 and 17

EQUATION 15

$$T_{SM} = \frac{F_{BF} \cdot (h - pc_f) + F_{BR} \cdot (h - pc_r)}{wb}$$

$$\frac{9.8 * 1224.5 \cdot (0.43 - 50e - 3) + 9.8 * 885 \cdot (0.44 - 180e - 3)}{2.794}$$

$$2408N$$

EQUATION 16

$$\Delta Damp\_ft = \frac{0.5 * LT_{SM}}{k_f \cdot MR_f} = \frac{0.5 \cdot 2408}{122.6 \cdot 0.63} = 15.6mm$$

EQUATION 17

$$\Delta L = L - filt(L)$$

Here we have,

ΔL = Change in load
L = Actual Load
filt(L) = Filtered load

This is where comparison to simulated data is pure gold, because it will rapidly tell you if something weird is going on. One of the things that drives me crazy about this business is the number of people who throw their toys out of the pram when simulated data doesn't match up to real data. When it doesn't match up, your simulator has just told you where the problem in the car is, because on the simulated model you know what it is doing. This allows you to zero in very quickly to what is going on with the car.

Perfect pitch

Meanwhile, **Table 6** (left) is a great tool to help you see what is happening under load transfer. I presented this in an earlier article on simulation validation but it can be readily used on real data to check if there is something strange happening with the data.

The front and rear braking force and the pitch centres were generated from the data returned from the ChassisSim for a simulated lap from this car. So, for calculating the pitch we should look at **Equation 15**.

What this shows is that at the wheel there will be a total of 2408N applied at the front springs under load. So the expected change in damper movement will be given, **Equation 16**.

So we should see a change in pitch of the front dampers of 15.6mm. What you can do is use this in conjunction with simulated data, or even a few basic hand calculations, to see what is going on with **Fig 2**.

The last particular example I'll discuss is a way of quantifying mechanical grip. It's breathtakingly easy and the equation for it is presented in **Equation 17**.

Loading up

The units of the load can be in any unit you fancy. However, the critical thing that we are doing here is taking the actual load away from the filtered signal. That filtering can be anything that works but my recommendation is a low pass frequency filter. The delta load you get back is a direct measure of mechanical grip because it tell you how much the load is varying. The lower this number the better the mechanical grip is. If you want to get really tricky average it over the lap. In ChassisSim we use a version of this for the contact patch load variation in the shaker rig toolbox and it works very well.

In closing then, as you can see there are many simple but effective ways we can classify the performance of the racecar. This is far from the definitive list. However, we have presented lateral load transfer distribution, damping ratios, using aero calcs in the braking zone, sanity checks for longitudinal load transfer and lastly ways to quantify mechanical grip.

All of the above techniques will get you a significant way down the road to truly understanding what your car is doing. If you start applying this mindset the results will take care of themselves.

Dallara among chosen few for LMP2

Famed racecar builder Dallara is among the four companies to win the right to construct LMP2 cars to the new-for-2017 formula.

Dallara joins one other newcomer, a joint venture between Multimatic and Riley Technologies, plus two established makes, ORECA and Onroak – the latter of which makes cars sporting the Morgan and Ligier badges.

The four manufacturers have won the right to produce cars for the World Endurance Championship, United SportsCar [USC], European Le Mans Series, and the Asian Le Mans Series.

The news came in the latest draft of the 2017 LMP2 regulations, created by the Automobile Club de l'Ouest and the FIA, although these regulations are still subject to final ratification. ACO president Pierre Fillon said: 'Our priority is to supply the teams and drivers entered in this category with the best options and solutions to race in endurance on a long-term basis.

'Thanks to the decisions taken jointly by the ACO, IMSA [USC organiser] and the FIA we have managed to bring together a high-quality pool of constructors that reinforces the interest in the series and its glowing future prospects.'

The decision on the final four was based on a number of criteria, which included the experience and reputation of the company, quality of service to their customers, the amount they intended to invest in the programme, and their engineering capacity.

Constructors known to have missed out on the chassis supply contracts include BR Engineering, Honda Performance Development (HPD), Ginetta and Wolf.

The successful manufacturers will now have to meet a series of strict deadlines, which includes validating their safety structures and monocoques by January 2016, and passing crash tests by June. The cars then need to have been homologated and made available for sale in time to compete at the Daytona 24 hours TUSC opener in January 2017.

A spec engine supplier for the new LMP2 (which will not apply to those P2 cars campaigned in USC) will be named in September.

XPB

Current LMP2 producer ORECA will be joined by Dallara, Onroak and Riley-Multimatic on new list of approved P2 producers

Formula 1 bosses warn that tyre companies should not call shots

F1 team principals have said that it should not be up to a tyre manufacturer to decide on the sort of product it supplies to the sport, and that Formula 1 should not pander to the marketing requirements of either Pirelli or Michelin.

Both F1's incumbent tyre supplier Pirelli and Michelin are known to be in the frame for the F1 tyre deal from 2017, and Michelin's motorsport boss Pascal Couasnon has made it clear that the French firm wishes to supply a 'high performance' tyre to fit a 'minimum' of 18in wheels, which would require low profile rubber design.

XPB

Michelin wants to bring low profile rubber into Formula 1 in 2017 – but the teams say tyre manufacturers should not be allowed dictate terms

However, while not ruling out running on low profile tyres, team bosses have made it clear that the tyre philosophy of the sport should be decided by F1, not its tyre manufacturer.

Eric Boullier, racing director at McLaren, said: 'I think it's up to Formula 1 and the FIA as well to put the conditions of the tender, not up to the potential tyre manufacturer, supplier, to impose what they want. We, as far as I'm concerned, are running our own business and we know what we want to do with the sport. It's not up to others to tell us what to do.'

Force India owner Vijay Mallya said it was also important that teams were asked for their opinion: 'It's probably the optimal solution that all teams be consulted and the FIA then issue an appropriate tender document so that the views of the teams are collectively incorporated and the tyre companies then bid to get the contract for supply. I think it would be wrong to allow tyre companies to dictate what Formula 1 should or should not accept.'

Mathew Carter, CEO at Lotus, agreed but added that he was not concerned about major tyre changes: 'I think Eric probably hit the nail on the head. As a team it doesn't really matter to us the size or the width of the depth of the tyres. We'll put the tyres on as they are and as long as it improves the sport and it makes Formula 1 exciting and better then we're all for it,' he said.

IN BRIEF

Paris in the springtime

Formula E has unveiled the calendar for its second season, which will include a race in Paris. The French capital takes the slot vacated by Monaco – which is unavailable as Monte Carlo's biennial Historic Grand Prix runs in 2016. The Parisian circuit will be built around the historic Les Invalides area, and will open the European leg of the championship at the end of April. The schedule for 2015-2016 will once again be made up of 11 'ePrix' and will begin in Beijing in October, a month later than in 2014.

Making history

The owner of Silverstone, the British Racing Drivers' Club (BRDC), has started a fundraising campaign to raise money for a new heritage centre to be based at the British Grand Prix venue. It is to be housed in one of the two remaining wartime hangars and the displays will outline the history of UK motorsport, as well as the natural and wartime histories of the area. Adjacent to the hangar there will be an accessible archive for the BRDC collection. The 'Silverstone Heritage Live' project already has the support of the UK's Heritage Lottery Fund, which will provide £9.1m, which leaves £9.9m still to be raised by the BRDC. The centre is scheduled to open in 2018.

Andrett-E

Andretti Autosport has set up a new division – Andretti Technologies – to develop its Formula E powertrain for next season; powertrain development is being opened up for the 2015-2016 season of FE. Andretti is one of eight manufacturers approved to produce powertrains for Formula E's second season.

Beefed-up rally cars to feature in new WRC regulations

World Rally Championship cars are to be made to look more aggressive with wider bodies and radical aerodynamics as part of a facelift which is to be contained within the new-for-2017 regulations.

While the new regulations have yet to be officially signed off – there are still talks with the sport's stakeholders that need to take place – the FIA has made public the guiding philosophy behind them. Central to this will be a move to a lighter, faster car, with more power, featuring a wider body and much larger aerodynamic devices, particularly the rear wing.

The FIA said: 'The intention behind the new regulations is to produce a car with a far more dynamic and distinct appearance that exhibits character and diversity.'

Engine power is to be increased to 380bhp, up from the current 300bhp, while the restrictor on the turbocharger will be widened by 3mm (from 33mm to 36mm), which should mean the power hike will not entail a big increase in costs for the manufacturers involved. Boost pressure will be at 2.5bar maximum.

Electronically-controlled centre differentials will also be brought back into the sport, while the weight limit of the World Rally car is to be reduced by 25kg.

The new 'dynamic' aesthetic will be achieved, says the FIA, by allowing a 'free zone defined around the bodyshell of the production car to create a maximum WRC car width of 1875mm [it is currently 1820mm] and greater overhang front and rear'.

There will also be greater freedom on some parts of the front bumper, with the potential for additional aerodynamic devices ahead of the front wheels.

XPB

A World Rally car at speed is a spectacular sight – but the FIA now wants to make them look dramatic even when they're standing still

GP2 bids for all-new FIA Formula 2

GP2 has applied to the FIA for the right to run the all-new Formula 2 category, which the governing body for world motorsport plans to reintroduce next year.

Formula 2 is to be revived in an effort to consolidate and clarify the single seater ladder, and is to be the final rung after the successful new Formula 4 entry level category and the revitalised Formula 3 European Championship.

The new Formula 2 is also to be given a substantial points weighting when it comes to the new points-based superlicence system that comes in in 2016, which should make it more attractive to drivers.

However, this could marginalise GP2, which has filled the space under Formula 1 since it took its place on the grand prix bill in 2005, when it took over from Formula 3000, which itself replaced the original Formula 2 back in 1985. GP2's only current rival as final step to F1 is Formula Renault 3.5.

But the organiser of GP2 has now made a bid to run the new series, significant details of which are still to be made public. It is also not known whether GP2's intention is simply to change the name of its series to F2 or to build a new formula to meet the FIA's requirements.

It is worth noting that there are already plans to change GP2's ageing 4-litre Mecachrome V8 in 2017, and the same is true of its current Dallara chassis – introduced in 2011 but given a three-year life extension last season.

GP2's interest was confirmed by the FIA after the recent meeting of the FIA World Motor Sport Council in Mexico. It said in a statement: 'The FIA has received an offer from GP2 Series Limited to be appointed as the promoter of the championship, and discussions are ongoing with the aim being to secure the best possible FIA F2 Championship.'

F2 made a brief return when it was run as a spec category by MSV between 2009 and 2012.

Grand prix-supporting GP2 has put its hat in the ring for the right to operate the new FIA Formula 2 category

SEEN: TCR VW Golf

Volkswagen has hit the ground running with its new race-developed, customer-focused, Golf, winning a round of the TCR International Series at the Red Bull Ring on its debut with Team Engstler – the outfit entrusted with developing the Golf under competitive conditions. The new Golf had been unveiled just a week before the Austrian round of the series and it features 18in rims, a chassis roughly 40cm wider than that of the production Golf, a front splitter and carbon rear wing.

Volkswagen Motorsport is developing the car in cooperation with the sport department at sister VW Group marque SEAT, which means it can call on the Spanish firm's experience with the Leon Cup Racer, on which the TCR regulations are based.

The 2-litre turbocharged engine with direct fuel injection comes from the Golf R and the racing version of this powerplant generates 330bhp (243kW) and 410Nm of torque.

Jost Capito, Volkswagen Motorsport director, said: 'The newly created TCR category provides a promising platform for customer racing – on a national and international level. With exciting races, production-based technology and reasonable costs, it offers a new outlook for private racing teams.'

TOCA holds on to British Touring Car promotion contract

TOCA is to continue to promote and run the British Touring Car Championship (BTCC) for at least a further five years after fighting off a challenge from Motor Sport Vision (MSV) to take over the leading UK motor racing series.

Current promoter and organiser BARC (TOCA) – a joint venture between the British Automobile Club and long-running BTCC promoter TOCA – were one of the organisations which submitted proposals after the UK sport's governing body, the Motor Sports Association (MSA), launched a tender process for the operation of the BTCC at the beginning of this year.

Jonathan Palmer's Formula 4 and track operating giant MSV also tendered, but after examining each application the MSA's selection panel members decided that BARC (TOCA) should remain in charge.

The BARC (TOCA) multi-year deal begins on January 1 2017 and there is an option to extend for a further five years from 2022.

MSA chief executive Rob Jones said of the deal: 'The MSA British Touring Car Championship is one of the premier titles in UK motorsport and we went into considerable detail before making our decision, assessing all aspects of each of the tenders submitted, scrutinising the business plans in particular.

'As a result of this examination the selection panel decided unanimously that BARC (TOCA) Limited was best placed to ensure the on-going health and success of the BTCC.'

Led by Alan Gow, TOCA oversaw the series from 1991 until the end of the 2000 season. Gow returned in 2003, before BARC (TOCA) Ltd was established and took over management and promotion of the championship in 2005.

Gow said: 'Naturally we are delighted with the decision and look forward to building on the BTCC's continued success into the next decade. TOCA is solely committed to maintaining and improving the BTCC's position as the best in British motor racing and one of the highest regarded championships in world motorsport.'

BARC (TOCA) has won the right to continue promoting the British Touring Car Championship, pictured here at Brands Hatch

Quarter of blue chip companies in the USA now market through NASCAR

More than one in four *Fortune 500* companies are now using NASCAR as part of their marketing strategy, recent analysis has revealed.

The *Fortune 500* is an annual list compiled by *Fortune* magazine that ranks the top US companies in terms of gross revenues.

NASCAR's own analysis has shown that the number of *Fortune 500* companies invested in the sport increased seven per cent year-on-year. On top of this, while one in four *Fortune 500* companies now invest, nearly one-in-two *Fortune 100* companies (top 100 US firms) also invest in NASCAR – this, too, is an increase over 2014.

The US stock car governing body also tells us that the 130 companies now involved in NASCAR marks a 20 per cent increase since 2008 – remarkable given the global economic situation during the last seven years.

Meanwhile, on the heels of a recently announced official partnership with Microsoft – and several other technology brands entering the sport this year and last – the number of *Fortune 500* tech companies investing in NASCAR has increased by 66 per cent since 2013.

NASCAR claims that brand exposure in the sport is especially valuable given the loyalty of its fans. Repucom's SponsorLink tracker shows seven out of 10 NASCAR fans are loyal to a brand when it sponsors their sport, higher than all other major sports properties.

Brent Dewar, NASCAR's chief operating officer, said: 'We are gratified that NASCAR continues to be a place where best-in-class corporations choose to drive brand awareness, preference and purchase behaviour. Our fans are fiercely loyal to our sport and the *Fortune 500* brands that are an integral part of NASCAR.'

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

Although being a *Fortune 500* company is the gold standard of success for publicly-traded companies in the United States, there are several global corporations currently involved in NASCAR that were not included in the analysis because they do not meet *Fortune's* criteria, including Ingersoll Rand, MillerCoors, Mars, McLaren and Toyota.

XPB

One in four of the US's top companies now choose to advertise their brands through NASCAR partnerships

CAUGHT

IndyCar outfit KV Racing has been fined $5000 after Sebastien Bourdais' Milwaukee race-winning car was found to be underweight at post-race inspection. IndyCar said the car was below the minimum weight of 1600lbs for road courses, street tracks and short ovals. It was later reported that the car was just 1.3kg under, which IndyCar president of competition and operations Derrick Walker put down to tyre rubber lost during Bourdais' post-race celebration doughnuts. KV was allowed to keep the win.

FINE: $5000

IN BRIEF

Auto GP on hold

The Auto GP season has been suspended due to the low number of entries so far this year. The single-seater series had a field of nine cars for its opening round at the Hungaroring, but this shrunk to just seven for the next at Silverstone. A statement from the organiser said the season will be resumed if it attracts 'adequate' entries. The series was stopped before its Paul Ricard round, with events at Zandvoort, Brno and Barcelona due to follow, but now also on ice.


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GT World Cup event confirmed for Macau in November

Plans for an FIA GT World Cup, to be held in Macau on November 19-22, are taking shape with a grid of 28 cars now set to compete for the only FIA trophy in GT racing.

Organisers have targeted a grid comprising seven manufacturers each entering three cars, and have left seven spaces for local entries, although

XPB

FIA GT Cup will join established F3 race in Macau in the autumn

Stephane Ratel – who has been appointed to run the event on behalf of the FIA and the local promoter – says this is only a target and highly unlikely to happen in reality.

There are some details to be finalised, including the tyre supplier for the event, but the primary concern is filling the majority of the grid with manufacturer-entry cars. Ratel says that he is talking to teams around the world.

'It is on a short notice, it is in November and I have never organised anything that late,' said the Frenchman at the Spa 24 hours at the end of July. 'The brief that I have been given, agreed between the FIA and the AAMC, is to target manufacturer entries. We are looking for seven manufacturers that will enter three cars each but it will never be like this. Some manufacturers will enter two cars, some three cars. Due to the shortage of time, we are going to the teams and they go to the manufacturers, and they need to organise the teams that are there. What I see from the initial talks are that the European manufacturers will also use local Asian teams.'

Ratel previously organised an end of season shoot-out in Baku, Azerbaijan, with a large cash prize fund, but this was shelved earlier this year. 'Baku proves that the concept was right,' says Ratel. 'Even though we kept it on the calendar this year, because we had a three year agreement and the promoter said we would come back, I always had my doubts because you see the price of oil going the way that it went and with Formula 1 you ask why they would spend the money again. They had proven it, we proved in Baku the concept of an end of year street circuit that can work, and if it is a success it can continue for many years. I don't think Macau will do F1 so we should be protected for a few years!'

The race weekend will also feature the famed Formula 3 event and the TCR series – usual Macau regular the World Touring Car Championship elected to finish its season in Qatar.

De Villota crash investigation clears Marussia of blame

The July 2012 testing crash which eventually led to the death of Spanish driver Maria De Villota has been investigated by a British Government agency, the Health and Safety Executive (HSE).

The HSE investigation found that there were no grounds to prosecute the Marussia team or its parent company Manor Grand Prix, though the report into the incident reveals a number of details about the causes of the crash not previously made public.

The crash occurred during De Villota's first ever test in the 2012 Marussia MR01-Cosworth F1 car, which took place at the Duxford Aerodrome near Cambridge, England. It was not the Spaniard's first time driving a modern F1 car, she had already had runs in a Renault R30 in Spain and France. Additionally, to prepare her for driving what was then a current car the Marussia team arranged for her to have some time on the McLaren simulator.

Marussia had emailed De Villota with some instructions ahead of the test including basic information on the car's controls as well as a map of the track which was to be used, though it later turned out that the map was wrong in the area around the pits.

During a seat fitting in the MR01 ahead of the Duxford test, De Villota found that she could not use the clutch paddle with the steering at full lock but was told 'don't worry about it, you won't need full lock in a straight line test.'

Maria De Villota suffered serious head injuries in accident. She died in 2013

However, to enter the temporary pit area constructed by the Marussia team De Villota would have to turn the car through 180 degrees at low speed. She had not practiced this procedure.

De Villota got up to 240kph on the runway as instructed and then returned to the pits. It was here where things started to go wrong. She slowed the MR01 to about 45kph with the car in second gear. Her foot was fully off the throttle and she was allowing the car to roll in with the engine running at about 5270rpm. She applied the brakes to slow the car even before executing the turn required to get to the 'garage'.

At this point the engine revs dropped to 4100rpm and the Cosworth idle control system activated. In order to protect the engine if the revs drop below a certain level (on the Cosworth, 4100rpm) the ECU will take over throttle control and raise the revs to idle speed (4500rpm on the Cosworth).

She attempted to brake, downshift, steer out of danger and even apply the throttle, none of which worked. The front wheels locked on the wet surface when she braked, but the gearbox controller rejected the downshift request as with the brakes applied and the V8 engine trying to accelerate the torque level on some of the gearbox parts would have been more than double their design maximum, and with the idle control active the throttle pedal was not much help either. Later she claimed to have tried a neutral button on the cars steering wheel, too, but that also did not function.

De Villota thought she had averted disaster, though, and steered clear of all of the vehicles in the area, but she had not seen the open tail lift of a truck and hit it at eye level causing her to suffer serious head injuries. From the moment the engine idle control engaged to the moment her head hit the truck just three seconds had elapsed.

The report highlights the fact that De Villota had not been briefed fully on the procedure for stopping the MR01, or indeed which gear to select on pit entry. During her previous F1 tests she had entered full scale pit lanes which do not require significant manoeuvre.

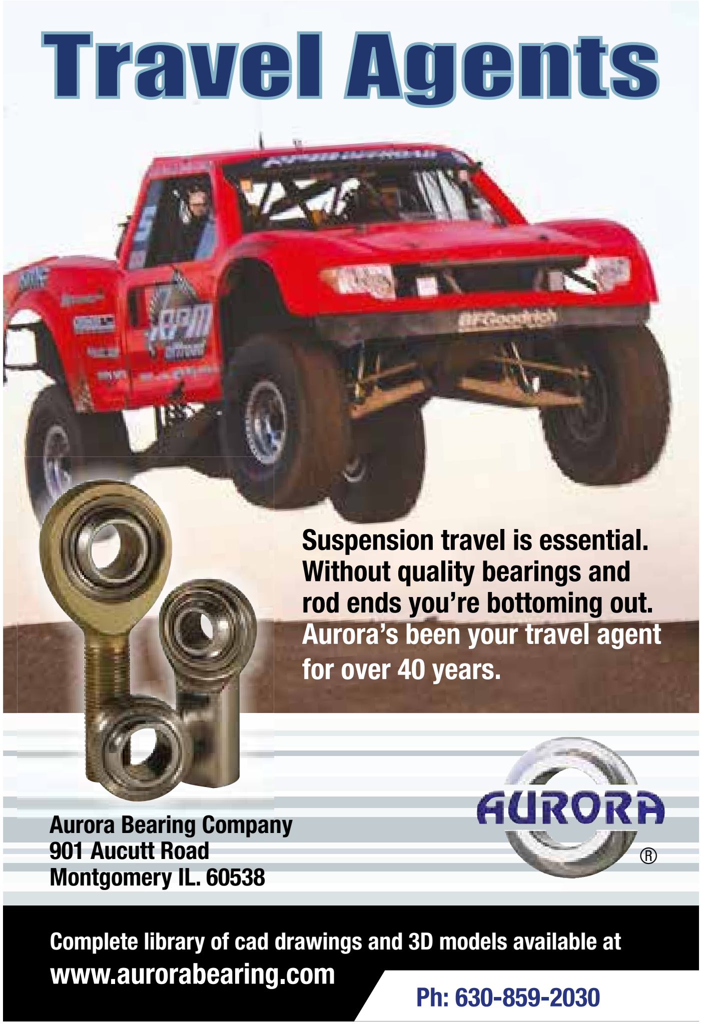
However, it seems that this accident is not unique. John Howett, testing a Toyota F1 car, was caught out by an idle control issue in 2010 and had a minor crash, while Alain Prost, demonstrating a Red Bull RB6, suffered a similar issue in the pits at Le Castellet.

Bianchi crash

Following the death of Jules Bianchi in July more details have emerged about his accident in Suzuka, where he sustained the injuries from which he was never to recover.

After a minor crash by a Sauber, double waved yellow flags were displayed to drivers approaching that section of track, though not all of them slowed adequately. Bianchi lost control on the wet corner and his Marussia MR03 speared off the track and hit a vehicle recovering the Sauber. The car hit the 6.8 tonne recovery vehicle at 126kph at an angle of 55 degrees, the impact with Bianchi's helmet was around 254*g*.

Senior figures within the FIA have commented in the German media that fitting a roof to the car would not have made much difference to the result of the accident. An analysis of the Suzuka crash can be found on the *Racecar Engineering* website.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Australian motorsport commits to circuit development strategy

The Confederation of Australian Motor Sport (CAMS) and the country's premier race category, V8 Supercars, have committed to developing a nationwide track strategy to ensure that Australia's motorsport industry continues to grow.

This follows a recent CAMS-commissioned Ernst & Young report, the brief for which was to determine the contribution motorsport makes to the Australian economy. The report found that it was clear that a lack of tracks in Australia is inhibiting the growth of the sport.

CAMS and V8 Supercars have now made track development and maintenance a priority, and say they will provide advice and support to help clubs, tracks and venue operators. This includes lobbying for new tracks and improvements to current operating venues.

With this in mind CAMS and V8 Supercars have further strengthened and aligned their collaborative relationship to ensure the retention of existing Australian motorsport venues and the development of further tracks.

CAMS CEO Eugene Arocca said: 'Track development and upgrades remain an absolute priority for CAMS and Australian motorsport. Without new tracks and continual improvements in the quality, safety and amenities of existing tracks, the growth in our sport will be restricted. In the last two years the number of licenced competitors and permitted events has grown significantly, however, growth will be impacted in future years by a lack of quality venues.

'We know that Australian motorsport contributes A$2.7bn (£1.3bn) annually to the Australian economy … There is little doubt this significant figure would be higher if more venues existed. It can only result in one thing, and that is greater participation,' Arocca added.


XPB

Australia has some great tracks, including the legendary Mount Panorama, but it needs more circuits if motorsport industry is to grow says CAMS

Strakka to build LMP1

UK-based sportscar team Strakka Racing is to build an LMP1 car for 2017 and has now called time on its Dome-designed LMP2 project.

Strakka will design and build the non-hybrid P1 in-house and has elected to run a Gibson 015S in LMP2 for the rest of this season, while the Strakka Dome S103 it's campaigned thus far will now be used as a development mule for the LMP1 car.

The Silverstone-based outfit says the ACO's decision to limit LMP2 to just four manufacturers was the reason behind its move to P1 – Strakka decided not to bid for one of the four permits to build P2 for 2017 (see lead story).


XPB

Strakka Dome P2 car is now to be the development mule for the team's new privateer LMP1 project, set to hit the track in 2017

Strakka team principal Dan Walmsley said: 'The 2017 LMP2 regulation changes that restrict the number of chassis manufacturers meant we had to evaluate our current business strategy and seriously look at projects that would enable us to draw on the experiences we have from our LMP2 car.'

The team says it plans to use 3D printing and additive manufacturing techniques to keep component manufacturing costs low and to lower production lead time.

INTERVIEW – Mark Miles

Second service

IndyCar's CEO built his reputation in the world of tennis – but how has he brought this experience to bear in the radically different environment of motor racing?

By MIKE BRESLIN

'There is an enormous amount of commonality in the dynamics of the series compared to tennis as a league'

Are there two sports so utterly different than tennis and IndyCar? About the only thing they have in common is that they both take place at three different sorts of venue: in the first case, it's clay, grass and hard courts, with the latter it's road, street and oval. Which puts into perspective the challenge accepted by former boss of men's tennis Mark Miles when he picked up the reins at IndyCar at the end of 2012.

Miles has actually been involved in a number of sports. In 1987 he was the head of the Pan American Games, for instance, while before he took charge at IndyCar – and indeed the fabled Indianapolis Motor Speedway (IMS) – as chief executive of Hulman & Co, he was responsible for the 2012 Super Bowl. But tennis accounts for the most inches on his CV, Indianapolis native Miles having been the head of the ATP, the governing body of men's tennis, from 1990 until 2005.

There's not much motorsport on that CV, though, yet Miles does not believe this is a problem. 'My background fits,' he insists. 'It gave me comfort in taking the position. I have big event experience which is applicable for IMS and relating to our promoters. And while the technical side of tennis is vastly different from racing, the dynamics of running a league are very similar. You have very different stakeholders with different places in life and business: you've got television, you've got sponsorship, you've got promotion, you've got to make a schedule, you've got to make rules and enforce them. So there's an enormous amount of commonality in the dynamics of the series compared to tennis as a league. But the racing itself is certainly different, and happily we have lots of people who are really smart about cars. Derrick Walker, our president operations and competitions, is the lead example.'

Schedule controversy

One of the first notable successes for Miles was the 10-year $100m title sponsorship deal with communications giant Verizon last year. Miles says it 'is the perfect fit' for the series, while for its part Verizon will be pleased with the upsurge in TV viewing figures for IndyCar. In 2014 the sport saw a 25 per cent increase, and while Miles admits it started from a low base, it's worth bearing in mind that NASCAR saw a decrease over that same period.

Yet while everyone in IndyCar welcomes better TV figures, there have been complaints that in the constant quest to improve these the season has been compressed – and this time it's nothing to do with tennis, it's all to do with football. 'Television ratings are vitally important to any sport, and we know by looking at our history that whatever the average television audience was for our racing before Labour Day [early September, when the American football season starts], it has been 30 per cent lower after it.'

This explains the move to an earlier season finish, last year, which has resulted in a shorter season. But this, insists Miles, is temporary. 'We are absolutely not interested in a shorter season. What we're trying to do is slide the season in earlier in the year. We moved on the first part first, which was to have the finale of the championship on our Labour Day weekend. So this year is a shorter season, and last year was a shorter season. But what we intend to do is start at the beginning of February, immediately following the Superbowl. So we will be racing, eventually, February through August, which is seven months. And not just one race a month; we think we can get 20 races in.'

Of course, much of the US is under snow for that early part of the year, which might mean looking further afield. A race in Brazil fell through at the start of this year for reasons outside IndyCar's control, but, undaunted, Miles says he is still looking to South America, the Middle East and Africa, and he envisages up to three international races at the start of each season in future years.

Managed innovation

For now, though, all eyes are on the IndyCar itself, the Dallara DW12, which came on the scene less than a year before Miles did and has thus far provided some good racing. Recently, and in keeping with the original brief, there has been an element of design freedom allowed with these cars, with both engine manufacturers in the sport, Chevrolet and Honda, introducing their own aero kits. But isn't it a risk, changing something that's proving such a success? 'It's absolutely a risk,' Miles admits. 'So let me tell you why we did it. The two principal reasons was because we thought our manufacturers, and I think our fans, would appreciate this real visual differentiation between the cars. Secondly, the objective was to increase performance; this

XPB

means speed. Speed is part of the IndyCar brand.' Since the kits were introduced lap records have tumbled and, it must be said, the Honda and Chevrolets have looked significantly different. 'There are risks; one manufacturer can do better than the other, but we can't have it both ways, right?' Miles added.

There is no plan to move IndyCar to an open formula, although more engineering creativity could be encouraged. 'I think the aero kits were a step towards managed innovation, if you will,' Miles says. '[Derrick Walker] is very much thinking in the near term about whether there could be some discretion in other parts of the car, and we're beginning to think about what we're calling the 'car of the future', which of course will involve another level of development.'

Leaders' Circle

The teams will no doubt be looking forward to more 'managed innovation', as long as it doesn't mean a hike in budgets. Currently, Miles tells us, these are anywhere between $4m and $8m a season. What's interesting is that a fairly large proportion of that is paid by the series through its Leaders' Circle initiative. This means each team receives $1.25m for the season, as long as they enter every race this season. That in itself is a $250,000 increase on last year, while: 'by 2018 our internal goal is to get that to $2m,' Miles says.

Cars and teams are just one part of the show, of course, and while tennis has its Wimbledon, IndyCar has Indianapolis, and as Hulman CEO Miles is also boss of the Brickyard. Part of the changes made at the track recently include a $10m upgrade of the old F1 layout, which has enabled Indy to completely reconfigure its fabled Month of May, with an IndyCar 'Grand Prix' on the road course early in the month. There's more to come, too. 'Our state legislator passed a law and there will be about $95m available for us for reinvestment in capital improvements,' Miles says. 'This means huge changes, I mean $95m is a lot of money – we could have used more!'

So the experience for those going to the Indy 500 can only get better, while if one US publication is to believed there are plenty more who want to visit IndyCar's showpiece event. 'I'm not making it up and we had nothing to do with this,' Miles says. 'USA Today last year ran a survey of its readers, and asked them to name their top 10 bucket list events. What do you want to do, no restrictions: Olympics, World Cup, Superbowl, you name it? The number one event was the Indianapolis 500.' And no mention of tennis…

IndyCar's new bodykits have introduced a measure of 'managed innovation' into the sport says CEO Mark Miles

RACE MOVES

XPB

Sir Patrick Head, the co-founder and former technical chief of the Williams grand prix team, has been presented with the prestigious MIA (Motorsport Industry Association) Award for Outstanding Contribution to the Motorsport Industry. The award was presented to Head at the House of Lords during the MIA's summer reception.

Richard 'Slugger' Labbe is now crew chief on the No.3 Austin Dillon-driven NASCAR Sprint Cup car at Richard Childress Racing (RCR). Labbe is a veteran crew chief with 433 Cup races under his belt, including a win at the 2003 Daytona 500.

With **Slugger Labbe** taking on the crew chief role on the No.3 RCR car (see above) his position in the organisation's research and development department has now been filled by the No.3's departing crew chief, **Gil Martin**.

Peter Clifford is the new president of the National Hot Rod Association (NHRA, the organisation that oversees drag racing in the US). Clifford was promoted from the post of vice president and general manager and replaces **Tom Compton**, who recently announced his retirement after 15 years as president.

Red Bull Racing Australia has restructured its engineering team for the Jamie Whincup-driven Holden in the V8 Supercars Championship, with **Mark Dutton** taking charge of the car. Dutton will still continue in his other position as the team's manager, although RBR Australia boss **Roland Dane** will take on those duties during race weekends.

Ernest Pierce, a crew member in the NASCAR Sprint Cup Series, has been indefinitely suspended from all NASCAR competition after he violated the US stock car governing body's strict substance abuse policy.

Daniele Schillaci, until recently a top sales and marketing executive with Toyota, has joined Nissan as its global head of marketing and sales. Schillaci is now an executive vice president and a member of the Nissan executive committee. He is based at the company's Yokohama, Japan headquarters.

Mark Wilson is the new chief financial officer at Aston Martin. Wilson has previously worked at McLaren Automotive and Lotus Cars, but comes to Aston Martin from renewable energy insurer G-Cube Underwriting.

The Silverstone Classic historic motorsport extravaganza has introduced a pair of new awards in honour of two of the driving forces behind the event, which marked its 25th anniversary this year. The awards are called the **Mervyn Garton** Scarf and Goggles award and the **Stuart Graham** Scarf and Goggles award – The Scarf and Goggles is a pub that's a well-known feature of the event.

US motorsport marketing and management organisation Sunday Group has taken on **Devin Altieri** as the first-ever recipient of the Dr Michael J Cleary Internship. Altieri has already started in her new role and is based at the firm's Indianapolis office.

F1's favoured track designer, **Hermann Tilke**, has now started work on the Baku street circuit layout in Azerbaijan's capital. The construction of the site, which will be the scene of the 2016 European GP, was put on hold while the city hosted the European Games.

The crew chiefs on the Richard Childress Racing (RCR) NASCAR Xfinity Series No.3 and No.33 Chevrolets have been swapped: **Danny Stockman Jr** now tends the No. 33 car and **Nick Harrison** now serves as crew chief for the No.3 car.

Dakar bike racer **Marc Coma** has retired from competition to become the event's sporting director and is now helping to organise the 2016 edition of the legendary desert endurance rally, now firmly established in South America.

Makinen to head up all-new Toyota WRC assault

Former World Rally champion Tommi Makinen has taken charge of Toyota's WRC effort as the Japanese motor giant gears up for its return to the stages in 2017.

Makinen, who won the WRC on four occasions, was named in the new role by Toyota Motor Company president and CEO Akio Toyoda, who will be taking on the role of team chairman himself.

It is understood that Toyota Motorsport GmbH (TMG), in Cologne – the Toyota-owned motorsport subsidiary – will play little part in the WRC Yaris project, with Toyota Gazoo Racing, its motorsport arm in Japan, handling the campaign and building its car from scratch. TMG is expected to help with engine development and it's believed it will continue with its own Yaris project. It's also thought the Gazoo operation will have a base in Europe.

Toyoda said of Makinen's signing: 'Tommi has abundant experience and fresh ideas for vehicle development, both of which will be valuable assets to us. With Tommi behind us, Toyota will forge ahead with our return to the WRC and also our efforts to make ever better cars.'

Makinen won 24 WRC rallies during his 18-year driving career, including four consecutive drivers' titles with Mitsubishi between 1996 and 1999. He went on to drive for Subaru and retired from the championship in 2003.

The Finn has run Tommi Makinen Racing, building and selling Group N Subarus, since he quit driving.

Makinen has been linked to Toyota since building a private GT86 rally car for Toyoda last year, while he has also coached Toyoda, who is a keen amateur rally driver.

Toyota confirmed its return to the WRC, which will end a 17-year absence from top level rallying, at the start of this season.

Makinen (right) has driver-coached Toyoda (left) in the past – now he will steer Toyota's long-awaited World Rally return as the head of Toyota Gazoo Racing's WRC operation

Sauber signs Mark Smith as new technical director

Swiss F1 team Sauber has appointed former Caterham tech boss Mark Smith as its new technical director.

Smith (54) left Caterham in May of last year, shortly before owner Tony Fernandes sold the team – which later slid into administration. He has previously worked at Force India, from 2010 until 2011 (when he joined Caterham); Red Bull (2005 to 2008) and Jordan (2004-05). He joined Sauber in mid-July.

Smith said: 'When I saw the facilities for the first time in Hinwil [Sauber's Swiss base] I immediately realised the possibilities I would have. The wind tunnel, the supercomputer and the machine shop – everything is on a very high technical level. And not to forget the competence of the team. These facts were compelling reasons and arguments for me changing to Hinwil.

'The potential of Sauber is enormous, which is not self-evident in a constantly changing Formula 1 world. The factory in Hinwil has all the requirements to be competitive in Formula 1.'

Sauber's team principal, Monisha Kaltenborn, said of Smith's hiring: 'Mark is an engineer with a lot of experience in Formula 1. Above all, he knows the environment in which privateer teams must work and the challenges that are there – and how important it is to keep calm and keep things in perspective. With us he finds technical possibilities on a very high level.'

RACE MOVES – continued

XPB

Five-time Le Mans winner and former Formula 1 driver **Emanuele Pirro** has joined the panel of stewards for the Formula 3 European Championship, driving standards in which have been under the spotlight recently following a spate of big crashes and controversial clashes.

Steve Byrnes, the popular Fox Sports broadcaster who died in April, is the recipient of this year's Squier-Hall Award for NASCAR Media Excellence. From 2001 until 2014 Byrnes served as a pit reporter for the NASCAR Sprint Cup Series, while he was most recently the commentator for the NASCAR Camping World Truck Series. Byrnes will be honoured during NASCAR Hall of Fame Induction Ceremony festivities in January, and will also feature in an exhibit in the NASCAR Hall of Fame in Charlotte.

Tony Warrener, the founder of the TAFE Smash Repair Team – an organisation that specialises in rebuilding crashed racecars during event weekends in Australia – has died following a long battle with cancer. Warrener was well-known in V8 circles.

High school students joined some of the NASCAR truck teams as honourary pit crew members at the Kentucky Speedway round of the series – their prize for winning an essay competition. The students were integrated into teams during the technical inspections and also took on some duties during race day.

Michael Argetsinger, a founder of the International Motor Racing Research Center and also a respected motorsport author, has died at the age of 70. Argetsinger was a member of the steering committee that in 1997 began planning for the Racing Research Center, which is an archive dedicated to motorsport history.

An Italian court has found former Benetton and Renault F1 team principal **Flavio Briatore** guilty of tax evasion. The case revolved around Briatore's yacht, Force Blue, which has now been seized. Briatore, who is to appeal the verdict, was sentenced to 23 months on probation.

Corvette specialist **John Greenwood**, who as a driver and entrant kept the model in top line motorsport throughout the early 1970s fuel crisis, and was also the man responsible for the much imitated stars and stripes Corvette livery, has died at the age of 71.

Duane Barnes, who drove the jet dryer that caught fire after contact with **Juan Pablo Montoya** during the 2012 Daytona 500, has died at the age of 55. For the past 27 years Barnes worked at Michigan International Speedway, serving as chief jet dryer operator, fabricator and heavy equipment operator.

Jules Bianchi died in late July. The French F1 driver had been in a coma since colliding with a rescue vehicle at the Japanese Grand Prix in October last year.

◆ 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 email with your information to **Mike Breslin** at **mike@bresmedia.co.uk**

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All star cast

Grainger & Worrall, long term supporter of *Autosport Engineering*, and its innovative new casting process

The *Autosport Engineering* show is justly famous for showcasing ground-breaking innovation from the world of motorsport. An innovative technique from Grainger & Worrall could significantly change the design of competition engine blocks, while increasing their performance through the reduction of the risk of porosity.

Any engineer involved in engine or powertrain development will understand the problems that porosity can bring to structural alloys. While preventative design can help to address the issue, a recent project involving Brunel University, Jaguar Land Rover (JLR) and Grainger & Worrall, highlighted the potential for a new generation of grain refiners.

A term used by both engineers and end customers when discussing defects, porosity does not adequately describe the many ways in which the problem manifests itself. Used as a catch-all phrase, it can include shrinkage in the form of micro-pores, sponge type voids, and large macro-voids.

Quality casting

Understanding the subtleties of various imperfections obviously helps to inform the process of casting design – which can reduce defects. While some faults can be fixed during the casting process, others can be reduced through design changes or a combination of both. By knowing the factors that can contribute to the different defects, design engineers can relocate porosity-prone areas to non-structural areas of the part, thus achieving acceptable levels of quality.

Looking at the higher end of the quality casting range, which includes high performance parts for the aerospace, automotive and motorsport sectors, the ideal scenario is 'zero porosity' as opposed to the highly challenging (and time consuming) management of the condition. Using CT scanning technology, Grainger & Worrall has started examining individual cylinder heads used in Formula 1.

'Our motorsport team was the first in the UK to employ advanced CT scanning to gain a better understanding of a casting's integrity and geometric accuracy,' Keith Denholm, head of engineering at Grainger and Worrall, explains. 'Thanks to this ability to examine both the interior and exterior of the parts, we now see a detailed picture of how castings are behaving at every stage of manufacturing. Such an appreciation of the different geometries enables us to calculate differential contraction rates, rapidly validate and define evolutionary changes to tooling, creating more precise castings.'

For several years now, Grainger & Worrall engineers have been interested in the use of additives which are employed in the casting process to reduce the level of shrinkage porosity. Titanium di-boride (TiB_2) particles are good grain refiners of aluminium alloys and have traditionally been used extensively in aluminium foundries, however the grain refining effect of these particles are significantly reduced by one of the most common alloying additions for shape casting – silicon.

Silicon chips

TiB_2 is widely used in wrought aluminium casting, where alloying with silicon is far less common, but its use has spilled over into shape casting where high silicon contents significantly reduce its effectiveness. Without a viable, effective alternative, many foundries have continued to use it. This is a key challenge facing the casting industry, especially in the automotive, aerospace and other high performance sectors as casting complexity continues to increase.

Grainger and Worrall received funding from the British Government to research and develop a better solution and has now revealed that it has

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CT scanning cylinder blocks at Grainger & Worrall; the company was the first in UK to do this


Grainger & Worrall casts parts for a variety of uses, including high end motorsport

had something of a result. 'Our TSB-funded research into the use of a newly developed refiner, which we call NGR (Novel Grain Refiner), has not yet been fully validated, but the early results are exciting. Following our two year-long project, working with Brunel and JLR, we're confident that the NGR we've been testing can significantly reduce the presence of shrinkage porosity in the casting process,' Denholm says.

Working in partnership with Brunel University, JLR, ESI, AMG Superalloys and Innoval, Grainger & Worrall is confident that this type of funded research is crucial to the long-term competitive position of the UK's engineering supply chain. Indeed, similar funding has assisted in the development of the Ginetta-Juno LMP3, and a new chassis manufacturing technique from KWM.

While this new technique could be heralded as a 'game-changer' for engine development programmes, it would be fairer to describe NGR as one of a series of enhancements to the casting process that are required to support the ever more demanding design requirements and development schedules.

According to the team behind it the adoption of this new refiner leads to less shrinkage porosity, which is prevalent in certain types of geometries. Traditionally the use of additional feed metal on the casting external to the final component geometry is used to control shrinkage porosity. The porosity forms in these 'feeders' as they are the last areas to solidify and then they are subsequently machined off. The use of NGR should significantly reduce the size of the feeders required and therefore lead to a leaner more material efficient casting process.

While the emergence of this new family of NGRs will enable much more rapid casting it will also facilitate the development of complex geometries. This final point is of particular interest to engine designers, who will soon be able to realise many of the features previously restricted by the impact of porosity.

'While we are still testing to validate the long-term structural integrity, repeatability and real-world performance of the NGR in cylinder head castings, the future looks bright. Independent testing of the new alloy is yet to be undertaken. However, this significant development in grain refining looks set to fundamentally change the way that engines and other powertrain elements are developed in the next few years,' Denholm says.

Quick and easy 3D printing

Windform materials are found in Formula 1, LMP, NASCAR and even outer space …

Complex shapes can be 3D printed using the Windform materials and be good enough to use as production parts

Creating a prototype is always a challenge, but Italian company CRP has greatly increased the capabilities of 3D Printing to make it much easier. In 1996 the company's R&D department developed the Windform laser sintering (LS) family of materials. These materials made it possible for laser sintering technology to fabricate high performance parts for wind tunnel applications, as well as highly-functional and beautifully finished parts. Today parts made or prototyped using the materials can be seen in Formula 1, Le Mans, NASCAR and also in space.

One of the advantages of the material is that it can be machined if required, and can be painted.

The combination of 3D printing and CNC machining can speed up the production of a part. The additive manufacturing technology is much faster than designing and producing a tool for injection moulding. 3D printing can give engineers more flexibility in the time available to make design improvements. They have only to update the file CAD/CAM and print a new part, while making changes to an injection moulding tool is nearly impossible and expensive, causing a delay in the production of the parts. Furthermore, the technology of 3D Printing allows free-form design and complex features.

The Windform materials can be used to create internal truss structures. Lightness, strength and stability are the main benefits of this approach. This type of structure can be used in several applications, for instance, a reticulated structure can be adopted where weight reduction and high stability are required.

Internal truss structures offer a lightweight and strong solution

Versatile material

The versatility of the Windform materials has seen them used in unexpected locations and this now includes space. Parts used on a recent NASA satellite were made from a Windform material. As part of this process Windform LX2.0, Windform XT2.0, Windform GT and Windform SP all passed the mandatory NASA outgassing tests

Additionally, Windform SP and Windform GT are waterproof. They have excellent sealing characteristics both to liquids (water, oil, gasoline, etc.) and gas, while Windform LX 2.0 and Windform GT are also non-conductive materials, so they are suitable for electronic applications, such as electronic control unit components, electrical connectors and any prototypes in touch with electronic parts.

That's not the end of it, though, as CRP never stops its materials innovation and it's known to be working on a range of exiting new materials, details of which have yet to be revealed.


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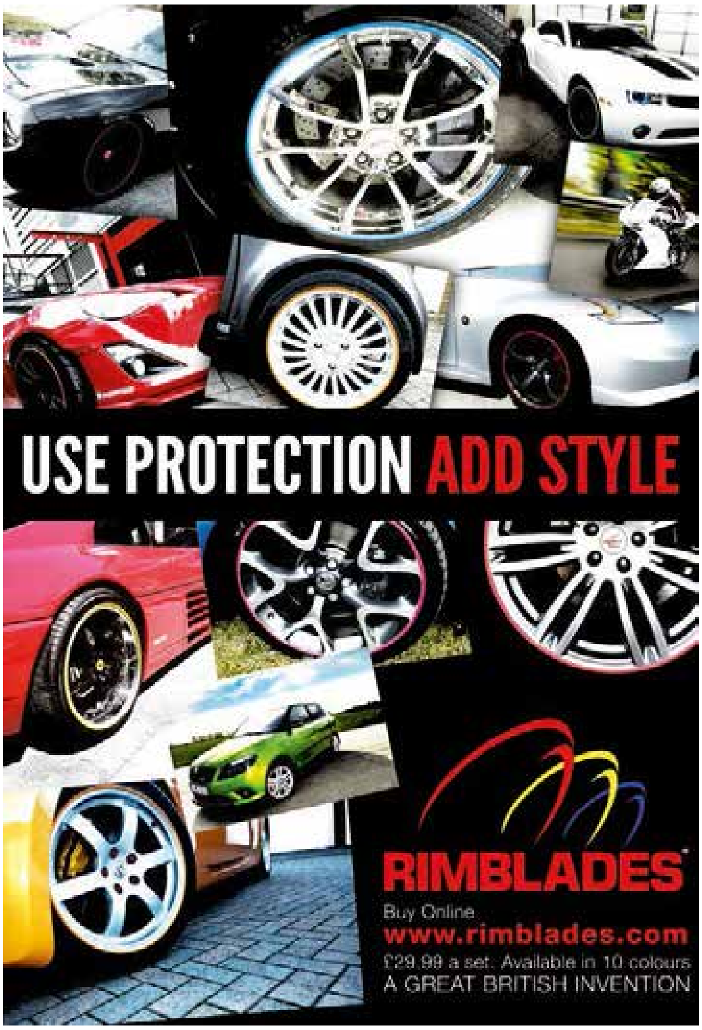
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Fuel cells
The last drop

Holley's new patent-pending HydraMat is designed to deliver the last droplet of fuel in a tank or fuel cell through the introduction of two rather clever principles: fluid wicking and surface tension.

The term surface tension refers to sealing the tiny pores of the HydraMat media with fuel in the same way water clings to the fine mesh of a screen door. This has the rewarding effect of accumulating and sequestering fuel in the reservoir, delaying any vapour intrusion until the fuel supply is exhausted. Wicking is capillary action, which promotes liquid flow in narrow spaces and small diameter tubes.

Capillary action is impressive because the flow is unassisted; it even defies gravity. As a result it invests the HydraMat with the ability to draw fuel from any area that is in contact with it.

Designed to operate in stock fuel tanks or racing cells, HydraMat's shapes and sizes vary from a single section to cross sections and from square- to rectangular-shaped mats. Holley also claims it is highly effective under hard cornering, acceleration and braking.

www.holley.com

Pit equipment
Scaling up

Intercomp Racing has launched its new SW656 iRaceWeigh Scale System.

The system features four wireless billet scale pads plus the newly updated iRaceWeigh Module; a scale system that is said to be a convenient way for scaling your car using a smartphone or tablet. It is claimed to be the first app to control, view, and record live scale data, with fully integrated RFX Wireless Weighing Technology. It also provides complete, secure control over scales and set-up data.

The app to drive the system is available for free on iTunes and Google Play, and can be downloaded to as many devices as desired.

As new updates become available, the app can be updated from the device, keeping racers armed with the most up-to-date features and functionality. The system includes four 15in x 15in x 2.5in (381 x 381 x 64mm) Wireless RFX Billet Scale Pads, an updated iRaceWeigh Module, batteries for the pads, and two year warranty.

www.intercompracing.com

Electronics
Throttle control for lead foots

This new electronic throttle control (ETC) module allows an electronic throttle body to be used with FAST EFI systems.

The FAST Electronic Throttle Control Module enables the use of any FAST EFI system with late model GM LS crate and transplant engines equipped with electronic throttle bodies.

The ETC Module takes readings from a GM LS-type pedal assembly and opens or closes the electronic throttle body in response. This creates a drive-by-wire system and eliminates the need for problematic throttle cables and linkages.

The module also features optional, user-selectable throttle response curves for more or less throttle-blade opening based on a given position. This affects how aggressively the engine responds to movement of the driver's foot. The FAST Electronic Throttle Control Module is plug-and-play with all FAST EFI systems, select OEM GM pedals and throttle bodies, and the FAST 102mm Electronic Throttle Body.

www.fuelairspark.com

Components
Cool to be a race fan

C&R Racing/PWR has added the 16in fan ring it uses in NASCAR, as well as the SPAL high performance fan, to its new line of commercially available radiators.

The fan ring is water jetted out of .100 aluminium and is bolted directly to the radiator, making for a stronger part, says C&R.

With this arrangement there is no chance for the fan to move around on the radiator. The fan is also sealed to the core which increases the cooling capability.

The new unit comes pre-assembled with the SPAL curved blade puller fan and SPAL 40 amp relay. A C&R Racing developed inlet can also be included.

www.crracing.com

Electronics
The Wire: undercover

Ron Francis Wiring has launched a clever new form of protection for wiring looms.

Its new braided fabric heat shrink wire covering looks and feels like cloth but is actually a heat shrink.

It is available in three sizes and is sold in 10ft or 50ft lengths, allowing customisation for a variety of needs, including tight bundles or multiple pathways.

It is easy to cut and size, even in situations where wires need to exit in various locations, and can handle temperatures up to 260degrees F.

www.ronfrancis.com

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Rise of the machines

Plans for the FIA GT World Cup appear to be coming together, with the venue, timetable and outline of grid requirements now set out by the FIA (see news). Manufacturers expected to take part in the event include Audi, Bentley and Porsche, which is starting to rebuild its endurance customer racing programme, but the closing date for entries has been extended to September as certain key aspects still need to be finalised and the manufacturers are not committing until they have more information.

All concerned are waiting for a decision on, for example, tyre supply, and whose balance of performance will be used for the sprint races around the street circuit. Series promoter Stephane Ratel has worked successfully with the AAMC in 2014 to provide the balancing figures, but this is an FIA-organised event, and it has its own BoP figures. Even Porsche, which at Spa confirmed its intention to go to the World Cup (which clashes with the final round of the WEC in Bahrain, and so excludes its Manthey Racing team from the event) with an old car, was expecting BoP figures before it commits although senior management confirmed the intention to do so.

With the number of GT3 cars falling in Europe perhaps the time for GT4 has arrived

XPB

Bentley may line up on the grid at Macau for the FIA GT World Cup in November this year, where it is expected to join six other manufacturers

However, the World Cup is aimed at manufacturers, with seven expected to enter three cars each. The GT3 concept was, and still nominally is, a customer racing category, with private teams buying cars from the manufacturers and flying the flags in such series as the Blancpain Endurance and Sprint series in Europe, the Pirelli World Challenge in the US, and national championships around the world, including the Asian and Australian series.

Manufacturer interest increased dramatically and now, at races such as the Spa and the Nurburgring 24 hour races, involvement from the factory is pretty clear and is actively encouraged. The introduction of the FIA GT World Cup might be a step too far for customer teams and now is a good time to expand the range of GT4 as a customer programme.

Ratel agrees, confirming that he is spending more time developing the category and says that now is the time to think about integrating GT4 as a support on the Blancpain Sprint and Endurance series programmes. 'I don't completely understand why throughout Europe there are [fewer] GT3 cars running,' says Ratel. 'The number of GT3 cars racing in Europe was growing and now it is dropping it a bit. Maybe with the coming of the new cars we will see it coming up again, but the fact is that many national championships are suffering, Europe is still not in a rosy situation, so I see GT4 as a perfect second category.

'The UK is a perfect example. We went from a series which was 80 per cent GT3 and 20 per cent GT4 into 50-50, and we are working hard to get large manufacturers to build GT4 cars and we are in a good way. And we are preserving the small constructor, which was something that was never part of GT3, or rapidly driven out of GT3. I like it, and I think it is cool. What I like about GT4 is that it is friendly, a perfect second category for national championship and a smaller market such as Sweden. We will provide the regulations and we have a franchise series that is very close to us, and we wish to integrate more in terms of meetings, with the Blancpain Endurance and Sprint so that they race with us.'

The new GT3 cars are rolling out around Europe over the next 24 months. Audi's R8 LMS has been raced by the factory in 2015, while BMW will introduce its M6 to customers in 2016, replacing the Z4. Porsche will also debut its new 991, with an all-new direct injection engine at the Daytona 24 hours in January, while Aston Martin will also prepare the Vantage replacement for 2017. Ferrari's 488 will begin testing mid-2015. Most of the cars, bar the Ferrari, are no more expensive that the old ones, and are more competitive, but with tyre manufacturers targeting a war at the Nurburgring, with car manufacturers expected to compete at Spa, the Nurburgring and at the GT World Cup, with competition in the US increasing and GT3 cars being integrated into the Tudor United Sports Car series racing on the same tracks as the Pirelli World Challenge, and with the number of GT3 cars falling in Europe, perhaps the time for GT4 has arrived.

ANDREW COTTON Editor