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DAYTONA PROTOTYPE INTERNATIONAL

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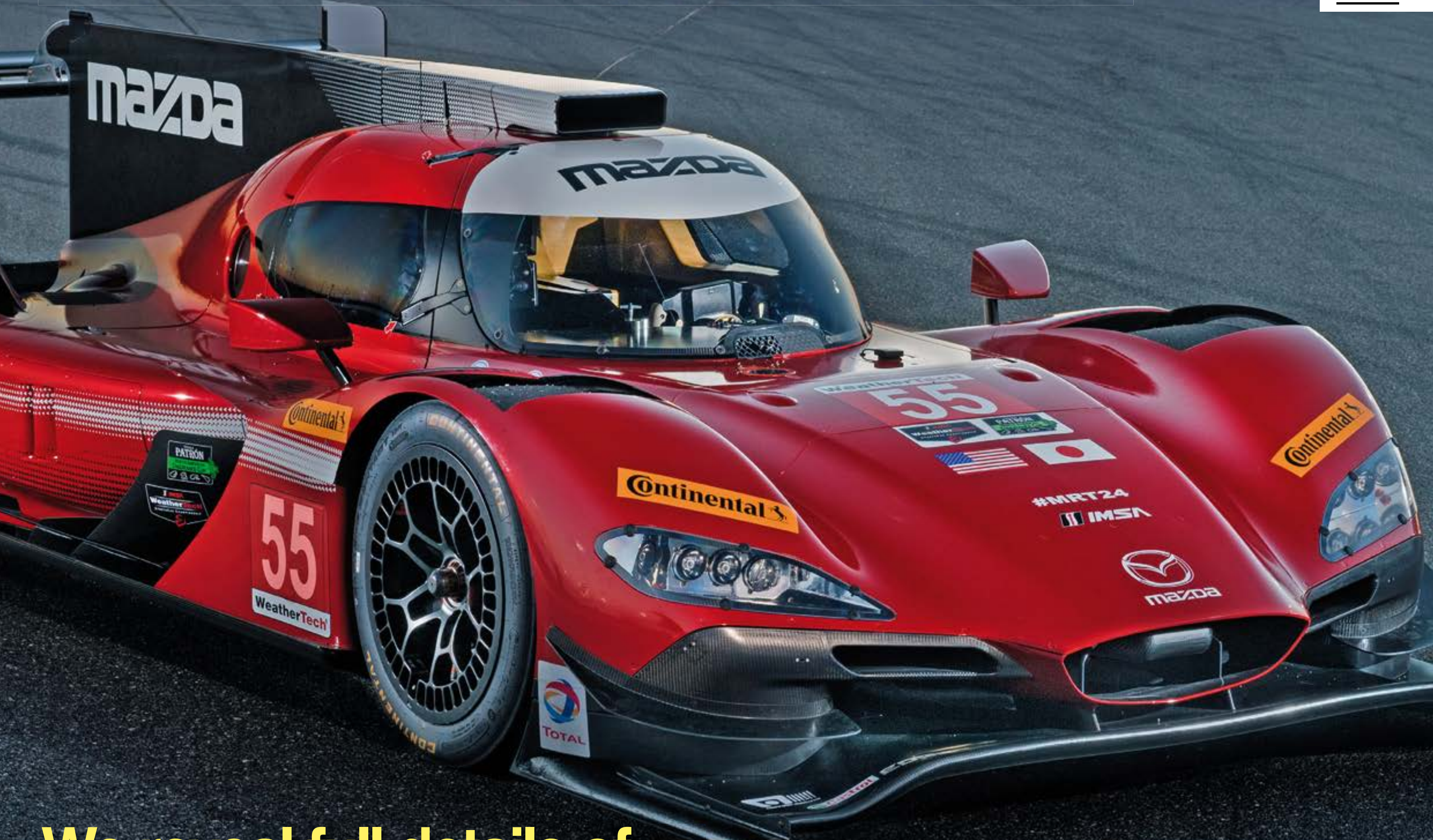

We reveal full details of Mazda's stunning DPi as new prototype era dawns

Porsche GTE
First mid-engine 911 since 1998 takes to the track

Front wing aero study
How to make sure your end plates are working effectively

Street race sim
Bespoke Formula E package examined

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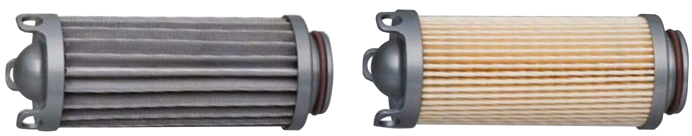

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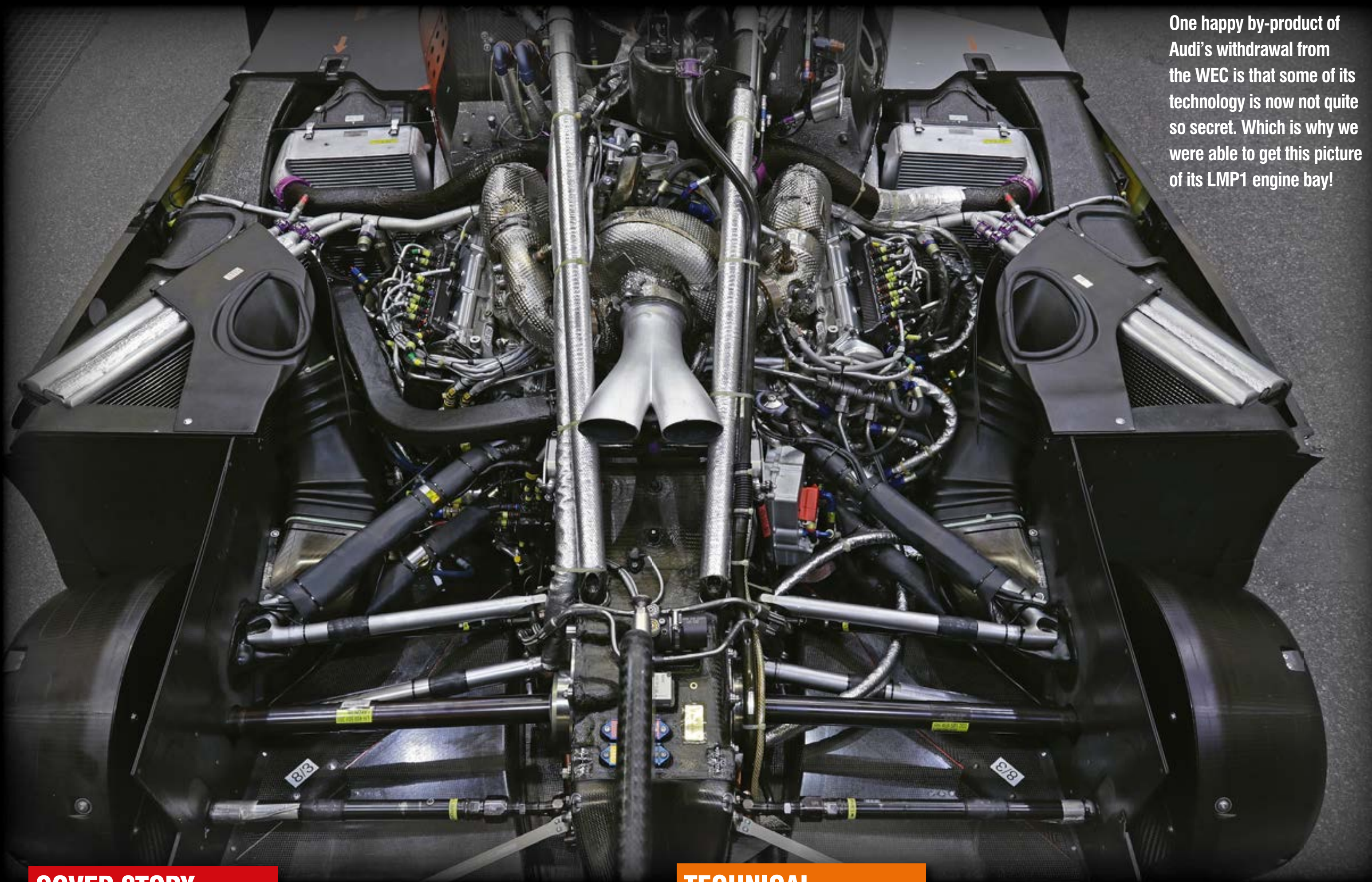

One happy by-product of Audi's withdrawal from the WEC is that some of its technology is now not quite so secret. Which is why we were able to get this picture of its LMP1 engine bay!

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It's all in the mind

To thrive in engineering you really need to be a particular sort of person

A well-known cliche is that someone who has a hammer will see all problems as nails. It is also known as the law of the instrument, Maslow's hammer (or gavel), or the golden hammer.

The upside of this is that presumably it will be spot on in solving any nail problems. But engineering is about extracting the most efficient way of doing something from what you know, with the equipment you have, within the time you are allotted and the budget you are given.

Being an engineer seems to bring out the critic in you about anything you use or even see, as you always think of a better way to do it. The habit of looking at things that surround you and figuring out how it was done, why it was done, and what were the probable constraints it was designed around, is an interesting exercise at all times.

The downside is what the French call *Déformation professionnelle*, meaning a tendency to look at things from the point of view of one's own profession rather than from a broader perspective. It is often translated as 'professional deformation' or 'job conditioning,' though French *déformation* can also be translated as 'distortion.' The implication is that professional training, and its related socialisation, often result in a distortion of the way one views the world.

Head case

So let us examine what else makes up the engineering mind-set, starting with curiosity, by examining the case of an engineer sentenced to death by guillotine. When the device malfunctions, he studies it, then calls out: 'It's easy! I see the problem!' Which demonstrates an almost pathological curiosity, and the need to improve what he sees, the engine that drives him.

Most people suppress their natural curiosity by not affording the time to wonder about things. Engineers indulge their curiosity, nurture it, and hone it with precision. Curiosity also drives their passion to make things better. The engineers will be passionate people who seek elegant solutions. This unfortunately can bring the case explicated in the saying: 'Normal people believe that if it isn't broke, don't fix it. Engineers believe that if it isn't broke, it doesn't have enough features yet.'

Knowing when to stop is the summit of the art. There is beauty in something that actually enhances someone's life. Finding that perfect balance of people, processes, and technology is why they come to work. One of the tools to do it is through capability in pattern recognition. We all recognize patterns; it's the way we all learn. It also allows us to see faces, animals or castles in clouds.

Engineers perceive patterns differently and perhaps more deeply, being driven to play with alternatives in the way things work, taking components and putting them together to make a greater whole. The ultimate goal is to create something that is so simple and effective that it becomes invisible because it works so well.

Another trait is a healthy dose of scepticism, that disrespect for the status quo, even if the solution ends up being thoroughly boxed and labelled 'standard', it has to work better. Let nothing deter you from examining the problem from an element of re-orientation. The uses of a fresh perspective. Something that is a paradigm of design and has been for a long time can be through being an irreducible condensation of a machine responding to a need (think bicycle) that does not fundamentally change over decades, or something that can be examined from different perspectives to see if knowledge, tooling or demand has progressed from what seemed cast in stone previously.

XPB

Radical solutions like the six-wheel Tyrrell P34 are rare in modern motor racing but an engineer still needs to look at all the possibilities

Talk the talk

You also have to be accomplished in working in a team and being able to communicate, engineering not being a solo occupation because it needs to bring together a plethora of practices and knowledge few people can master completely. The synergy of being able to bounce ideas with your peers and refine concepts is a collective gift. Being additionally able to explain to management or prospective sponsors and investors a new concept or design without getting bogged down in jargon goes a long way in making projects feasible.

As always, realism must be mixed into the cake. You will never have unlimited resources, time and knowledge, in fact those are always limited, including the third – don't kid yourself.

When I left University I thought I knew pretty much everything. Today I am at least aware of how much I don't know. It is not the things you don't know which are important; it's the things you don't know you don't know.

Genius pool

The pool of knowledge and information out there is the fastest growing corpus ever assembled by humanity, and the cross-fertilization brings serendipitous amalgams that break through into new frontiers. As always, it's the borders between the disciplines that bring new ideas, and not the deep hinterlands of accepted practice. Be at least interested in other disciplines. If you are curious, that element will take care of itself.

The take away from the increasing understanding that no one operates in a vacuum must guide design, being able to see the logical consequences of your design decisions, as the clear goal of improving performance, must be tempered by the downstream costs being accurately judged.

It is no use to have a design breakthrough that is not sustainable for a variety of reasons; one in racing being majorly upsetting the status quo – think double chassis Lotus 88 or Brabham BT46B fan-car

The bulk of good engineers are notoriously bad at general management of businesses. Understanding the behaviour patterns and strategies used by the engineer show that the mind-set, although useful for the solution of the problem situations that generally arise in the engineering fields, is often counterproductive, and can have serious inadequacies, in handling ill-structured management problems.

The basic feature of all ill-structured problems is that they network across many and diverse knowledge bases. So new and different world views should be introduced into the training of future generations of engineers, for with the increased networking of society, not just management but also technological problem situations, will move more and more towards the ill-structured end of the spectrum.

The engineers will be passionate people who seek elegant solutions

Changing gear

Why the new technical regulations are unlikely to disturb the status quo in F1

Here we go again. When the current power units were announced for Formula 1 in 2014, drivers were predicting that the levels of torque and power would make the cars hugely difficult to control beasts. So much so, it transpired, that a 17 year-old kid, albeit vastly talented, could step directly from a single season in Formula 3 into a grand prix car and immediately challenge some of the best in the business, as Max Verstappen did.

This time around there has been much to-do about how the chassis changes for 2017 will 'destroy' the drivers physically. F1 people have short memories; it's not so long ago that g-forces of the order anticipated from the new breed of cars were the norm, and the men behind the wheel coped well enough. Drivers are all Schumacher-fit now, with power-steering as standard; apart from having to increase the strength of their neck muscles, they will soon be up to the job.

Of more interest is just how radical the changes really are – 'the biggest since the introduction of flat floors' (1983), according to some – and to what degree they might shake up the status quo. The anxiety from technical chiefs who have made such comments illustrates the almost-OCD approach towards the merest detail of F1 design made necessary under the present dead hand of technical bureaucracy. Great performance steps have become almost impossible, and designers have become so used to just constant iteration of an established concept that, in some cases, the idea of a major change has them running scared. Instead, of course, they should relish the opportunity.

Changing vroom

Nonetheless, the established odds say that it will be business as usual, with the top three re-exerting their superiority. Resources are, after all, resources, and Mercedes, Red Bull and Ferrari have more than the others. But they also have to be well-managed and the order in which these teams may eventually align is not a given. After all, just a few years back Red Bull seemed invincible, just as Mercedes are perceived now. However, the possibility of another team coming up with a cunning and advantageous interpretation of the regulations, as Brawn did in 2009 with the double-diffuser (wasn't that fun?), may lurk worryingly in the back of the mind of many, but in reality with so much simulation available the chance of this is slim. With testing shortly to commence the die is cast anyway concerning the car concepts, and the result of these new regulations is about to be revealed. No doubt getting on top of the Pirelli tyre characteristics will remain a major key to competitiveness.

Waking Woking

But what of McLaren-Honda, which also should be up there? Although failure to adapt a car to take part in the initial big-tyre testing indicates financial resources not being quite what they were, they are still considerable, with Honda filling in the gaps where essential. Honda will get there, despite an amazingly-naive first approach to producing an F1 hybrid power unit. The question is: will McLaren step up as well? This season must be a make-or-break year for the famed outfit and its relationship with Honda. Fatuous statements about winning races last year if they had had Mercedes PUs fool nobody. Until the monolithic structure that developed under Ron Dennis (part hubris and part an attempt to retain one man's dominance) is taken down and rebuilt incorporating some creative humility, success remains doubtful. Especially so with enough Machiavellian political manoeuvring going on to make even Ferrari look calm and relaxed! The appointment of Zak Brown, whatever his title, looks to be aimed primarily at getting much-needed sponsor cash on board – nothing in his CV really indicates otherwise. Well and good, but firing the highly capable Jost Capito when his feet were hardly under the table can surely be only because of perception that he was the now-ousted Ron's man. So far, neither new 'grounded' management blood nor a more inspirational design leader have been brought in to drastically shake up McLaren's direction, which is what is needed.

Looking a little further into the future, such personnel movements could have as much, or more, effect longer term as the technical changes. Although without an immediate effect, one should not underestimate the significant loss to Mercedes of Paddy Lowe, who carried on where Ross Brawn left off regarding meticulous technical overview. Much will depend on who replaces him, more so I believe than the driver who replaces Nico Rosberg. Despite their recent dominance, the Silver Arrows are as open to defeat as any leading player when put under pressure, or when a key building block in the organisation slips. Both Wolff and Lauda have demonstrated basic errors in their driver handling – you don't (1) jump to conclusions when something goes wrong, (2) make your comments public, or (3) threaten punishment which you can't apply. With its technical advantage to date, these guys have had it relatively easy, although doubtless they would scoff at this suggestion. And really so has Lewis Hamilton, with only his team-mate to beat, no matter how hard Rosberg made this.

XPB

New wider tyres, pictured in testing, are among a raft of changes this year. Getting the new rubber to work well will be a key aim for the teams

Lowe profile

Lowe's departure to Williams bears scrutiny. Unless he was severely unhappy within Mercedes' structure, even a desire to become an F1 team principal would surely not encourage him moving to a team not best-placed to win races and championships. The Grove team's resources and consequent driver line-up are not going to achieve this in 2017, or beyond. But if a manufacturer comes on board bringing technical and financial clout, this could become dramatically different, and there has been a sense of preparatory clearing of the decks within the team. Can one imagine a Williams-Honda scenario (remember that?), maybe from 2018? Short of prising Red Bull away from its Renault engine commitments, what would make a better proposition for the Japanese giant, if McLaren Racing continues to disappoint?

The established odds say that it will be business as usual in Formula 1 this season, with the top three teams re-exerting their superiority

Daytona **peach**

Mazda's new RT24-P is just what IMSA intended from its new DPi rules – a fine-looking manufacturer-branded prototype that should be cheap to run. *Racecar* went to Daytona to take a closer look

By ANDREW COTTON

Mazda's long history in endurance racing has taken its next step with the introduction of a 2-litre turbocharged engine and stylised bodykit on a Riley Multimatic chassis – which is basically a complicated way of saying that it has debuted its new Daytona Prototype International, the RT24-P.

The 2017 Daytona Prototypes are the first of a new breed of US sports racing cars, with stylised bodywork fitted onto the new LMP2 chassis. They are also fitted with engines from a manufacturer. Cadillac, Mazda and Nissan let their production car designers loose on the bodywork styling, knowing that the kits would be balanced in the wind tunnel, so outright performance was of less importance (see page 20). The results are quite spectacular.

It's a novel way of going racing, and it also gives the manufacturers a chance to get involved in the prototype design on an unprecedented level. Mazda was one of the first to commit to the new regulations, a decision from the board that gave the team significant advantages , for while it was the last to have its bodykit validated in the wind tunnel shortly before Christmas, this was by design, and it was the first to put its name down on the list of choices for the homologation process.

Roar power

There were still final decisions to be made during the 'Roar Before the 24' test at the beginning of January, with different exhaust layouts evident on the two Mazda prototypes, but most of it was locked in during the final tests in December. 'We had a lot of success with the periscope exhaust,' says team president Sylvain Tremblay. 'And when we come back here for the race, the cars will have the periscope exhaust. Because Daytona is such a survival race it's bad to have pipes on the edge of the car right next to the turbo and any damage here would cost us, so it is safer to have it tucked inside the car.'

Tremblay's SpeedSource team has worked with Mazda since 1990, in GT racing and in prototypes, including the RX8 programme, the diesel in the GX class of the Continental Challenge and the diesel prototype that ran in 2014 and 2015.

'A lot of engineering went into that particular package but it only lasted one year but we carried [it] over to prototypes,' says Tremblay. 'The power requirements shifted so we went from 450hp to 600hp, so that's really challenging but it was a worthwhile experiment for us. It eventually finished up in Gen 7 road cars, with the steel piston

Already the DPi cars have shown performance that is approaching LMP1 speeds of six years ago

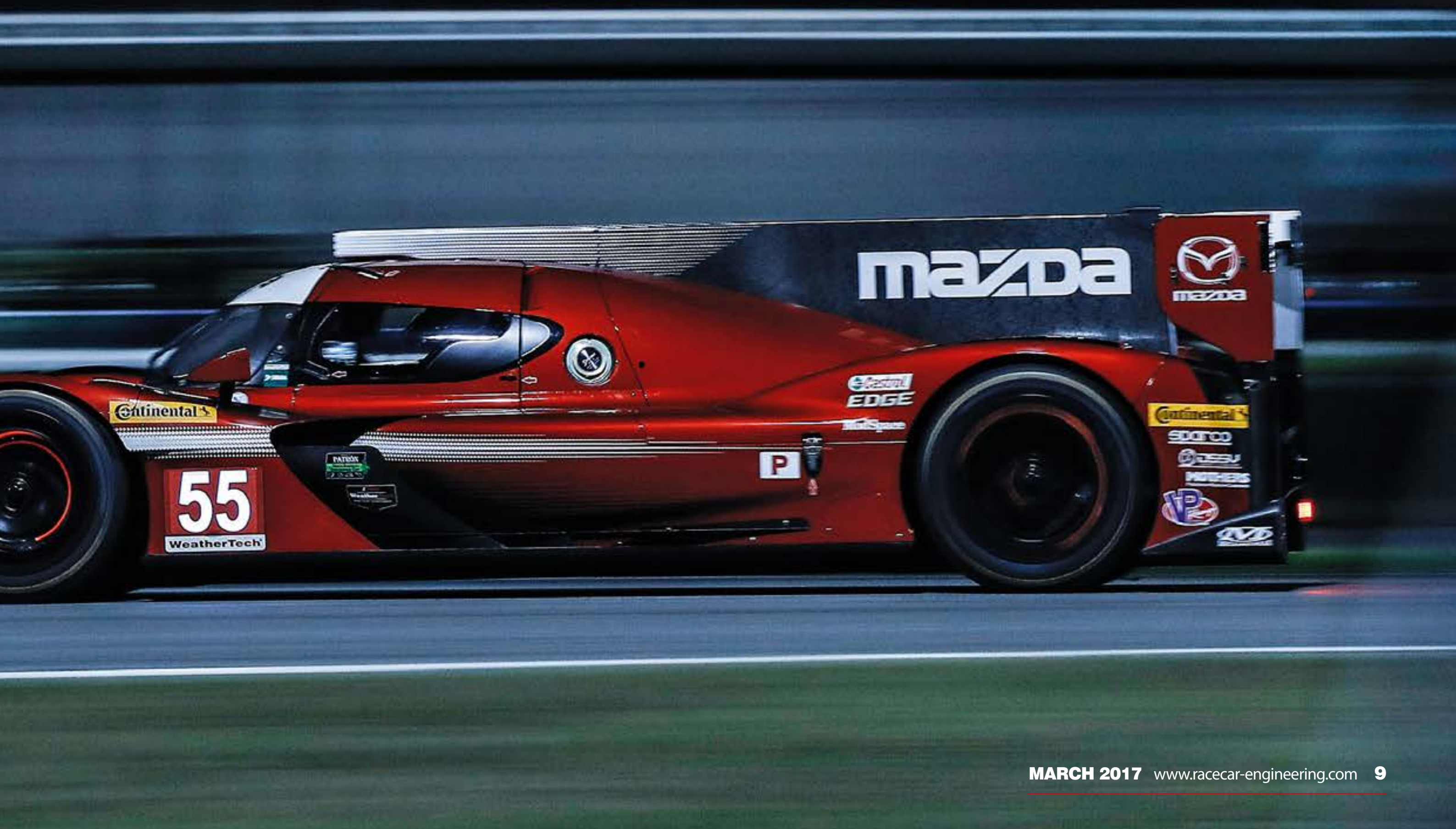
technology programme basically helping Mazda to make better road cars.'

Mazda was already on board with Multimatic and wanted it to produce a chassis for the LMP2 class, but Multimatic's Larry Holt did not think that there was enough money to be made with the whole concept. However, he realised that Bill Riley wanted to do a DPi programme, and so eventually the two linked up, allowing Mazda to get into the IMSA United Sports Car Championship.

'We studied DPi for 40 days before the go-ahead was given,' says Tremblay. 'Mazda wanted to know if they could really develop the car, or just put their name on the engine cover? Can we have styling cues and run Mazda hardware? All of those questions were asked, not only by us, but also by Mazda. Once we had some design goals and knew what Mazda wanted to achieve we had a look at

TECH SPEC

Mazda RT24-P DPi
Class: Prototype made to Daytona Prototype international (DPi) rules and regulations for IMSA WeatherTech Sportscar Championship
Chassis: Riley Mk 30, developed by Riley Technologies and Multimatic Motorsports
Weight: 930kg (2050lbs) without driver or fuel
Length: 4750mm (15.41ft)
Width: 1900mm (6.23ft)
Wheel base: 2950mm (9.67ft)
Top Speed: Approximately 200mph
Brakes: Brembo/Hitco carbon discs
Suspension: Independent double A-arms
Dampers: Dynamic DSSV
Transmission: Xtrac 6-speed sequential with paddle shifters
Tyres: Continental Extreme Contact Front: 320/680/R18 Rear: 325/710/R18
Wheels: Motegi Technomesh / Forged aluminium
Fuel: IMSA E20
Fuel Capacity: 75 litres (19.8 gallons)
Engine: Mazda MZ-2.0T; 1998cc; Bore x Stroke: 90mm x 78 Horsepower: 600bhp. Max revs: 8500rpm
Camshafts: Dual Overhead
Valves: Four per cylinder
ECU: LIFE Racing
Turbo/Intercooler: Garrett Motorsports, air-to-air intercooler
Fuel Injectors/Pump: Bosch Motorsport
Fuel Rail: AER



The new DPi regulations have allowed the manufacturers to get more involved with the design and styling of the racecars, something which Mazda has embraced wholeheartedly

‘We spent a lot of time and resource in the tunnel and in CFD to have a finished product that was tunable and raceable’

the relationship that we had with all four LMP2 constructors. Obviously we had a 20-year-plus relationship with Larry and with Multimatic and we had a long and very successful relationship with Bill Riley. At some point they were going to compete for one of the [four] slots but when they merged we felt it was probably our best bet to go with them. Obviously, all the other constructors are established and very well known but they weren’t North American based and they weren’t really tailored for what we were doing here as DPi. You felt that these guys would be the most focused for our RT24-P with Mazda hardware, with the styling targets that we wanted, so to be able to use the talents of Multimatic and Mark Handford [Multimatic’s head of aero] and all of the aero technology that is available to us, it was an easy choice.’

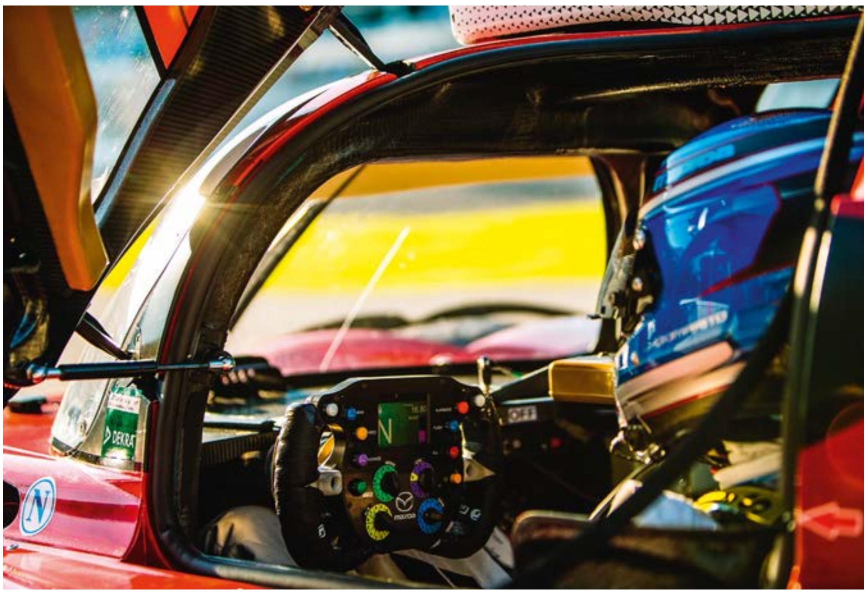
The team was the last of all to have its aero kit validated in the wind tunnel, as was mentioned above, and it used that extra time to finesse the design. However, both Multimatic and Riley admit that they were late with various components, too.

Bit stop

‘One of the issues is the stack up,’ said Tremblay. ‘Really a DPi is a WEC car with bits stuck on. So until the WEC car was done we couldn’t finalise the DPi, so even though we have certain components of the car that will be well designed and well engineered and well tuned, we had to wait until the WEC stuff was done.

‘We were supposed to run in September but didn’t get on track until November. That was frustrating but it was all part of it. We spent a lot of time in the tunnel and we had some pretty lofty targets from Mazda. They really wanted to have this car different from everything else. They did not want to have a WEC car with bits bolted on, which you have seen the other manufacturers do. It is within the rules but it is not within the spirit of what Mazda wanted to do with this programme. They wanted to be unmistakable, and that if you looked at that car, it was a Mazda. It is. That balance between design styling and performance has been difficult and required a lot of work. We spent a lot of time and resource to make it work in the tunnel to get it right in CFD to have a finished product that was tunable and raceable and we achieved all of those goals.’

The family resemblance to Mazda’s MX-5 is unmistakable – which is just what the car maker wanted from its DPi project



RT24-P has a bespoke steering wheel and related electronics while it also uses Life Racing’s ECU software

Collaborative effort

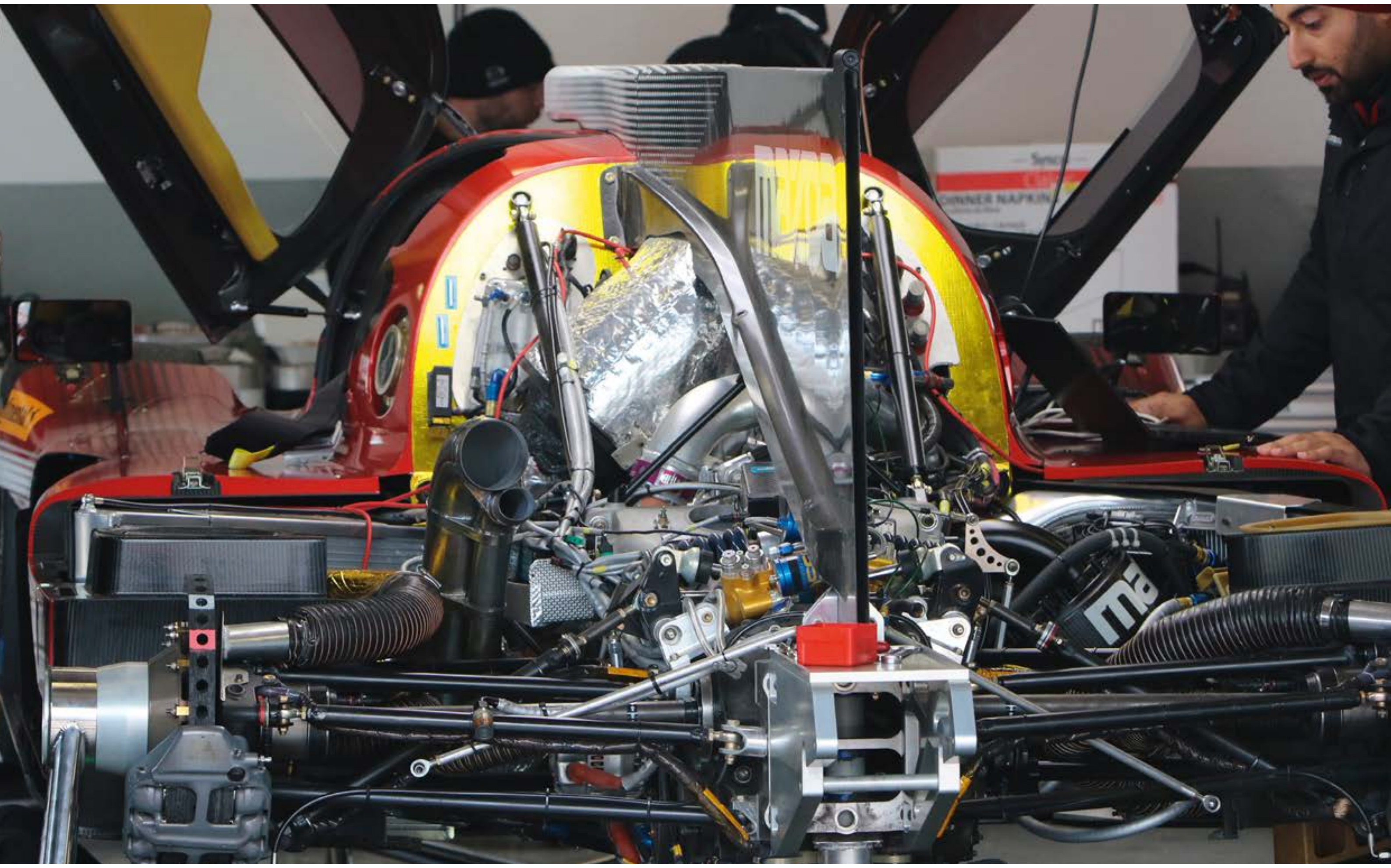
Early problems with the running of the car included the cooling of the gearbox, and at the Roar test they also had a suspension failure. However, with the two cars run by the SpeedSource team and a third run by the Visit Florida Racing team, development of parts is a collaborative effort. While SpeedSource is the only one to run the Mazda engine (Visit Florida runs a Gibson) both teams use the same chassis.

‘We are all working together on safety and reliability to really beat all the other competitors and that takes a lot of trust and confidence in partners Multimatic and Riley,’ says Tremblay. ‘There are going to be challenges, everyone is having challenges, especially with the new package, and we all wish we had an extra year.’

While many of the teams struggled in the early days with the Cosworth electronics package that is standard in the WEC, Mazda took the decision to develop its own package. IMSA has its own data logging system from Bosch, but the teams are able to develop their systems to work over the top of the Bosch. Mazda’s solution is to use Life Racing software and Motec hardware as its electronics package, Tremblay maintaining that this will help put the team in charge of its own destiny.

‘We have a specific Mazda technical package and we didn’t want to adapt hardware and so we committed to a very expensive and very difficult path of making our own [steering] wheel,’ says Tremblay. ‘Our own steering wheels, our own controls, and our electronics, which was a huge task. I know that some of our competitors are having hardware issues and that is really causing some issues. For us we are

IMSA's ruling ensures that the engine has to be mounted in the same place as the Gibson is in the LMP2 cars



Suspension is independent double-A arm with Dynamic dampers. Gearbox is Xtrac 6-speed sequential. Gearbox cooling problems and suspension failure were rare testing issues

not having no issues, but all of the hardware is performing as it should. We control all of the design and build in-house and all of that technology is kept within the Mazda group. We are currently using Life Racing [electronics] which is the preferred software for our engine and that is what we have developed since 2006. We have a wealth of knowledge on that particular package as a group.'

The path to a set of regulations has had a few bumps along the way, not least in the decision to allow the DPi teams freedom to develop their electronics package. However, the manufacturers were clear that to have a system that catered for a 6.2-litre production-based engine (Cadillac), a bespoke normally aspirated race engine (Gibson) and a 2-litre turbo developed by AER (Mazda), would be a tall order. Mazda's solution allowed it autonomous control over the electronics package, which it could design to work with the Bosch, a factor that the manufacturer considers could be to its advantage in the longer term.

'The IMSA logger is huge because it has its own power box, its own sensors, its own electronics and it is a standalone system. IMSA has all of that on top of all of our sensors,' says Tremblay. 'For things like our traction control and direct injection with our turbo engine, we didn't have to start over.'

The engine

The Mazda engine's weight is 'favourably comparable' to that of the Gibson, with the turbochargers and intercoolers taken into account. The team was not able to take full advantage of the packaging, however, as IMSA's ruling ensures that the engine has to be mounted in the same place as the Gibson and cannot be moved lower in the chassis.

However, with the weight of the engine spread across the chassis, rather than centred in one place as is the Gibson, it should have a small advantage in weight distribution. The engine is lightweight and has a high compression ratio, and is also a known quantity after many years in prototype racing.

It is no secret that this engine has its basis in one of Mazda's previous engines, and has even raced before in the back of a Dyson in 2013 in GDI trim, so the engineers are confident of reliability. However, that was air restricted as per the regulations, while this version of the engine has its boost carefully regulated to closer mimic the characteristics of the Gibson normally aspirated powerplant. It's a subtle change, but one that could be significant.

'From a balancing standpoint, we are about where they [Gibson] are,' says Tremblay. 'Our CG is probably a little bit higher, they have a V8, but we have been able to work around the packaging and cooling requirements. There is some ballast due to the weight of the engine, probably more than some, but less than others. When you look at the way that you manage the airbox, the intercooler, the crossover pipes, the boost boxes, oil control and how not to smoke on pit stops, then we are about even with the Gibson. The Gibson is a proper race engine, it is well packaged and it is a known entity, for the most part because it is an off-shoot of another manufacturer engine.'

Home to boost

One area where the turbo engine could be at a disadvantage is in the way that the power is delivered. The turbo engine has its boost carefully monitored by IMSA, with 16 points on

'That balance between the design styling and the performance has been quite difficult and it has required a lot of work'

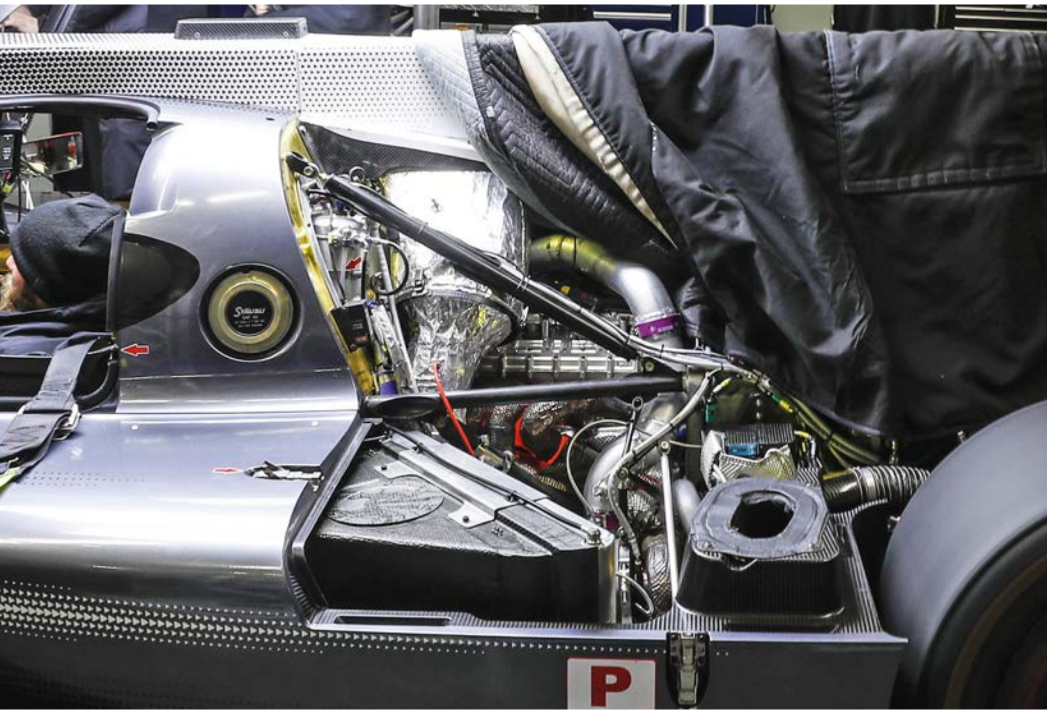
the boost curve that are placed in the rev range bespoke to each turbo engine. These points are monitored during the race, and fed live back to the organising team. If it sees a discrepancy it can penalise the car during a session, including the race. There is allowance for an over boost – five times in a stint, or a session – but that compares badly with the normally aspirated engine, which does not feed its data back live. That data is analysed after the race and, while the NA engine can over-rev a set number of times, during a race it cannot be penalised.

'For me, the advantage with a turbocharged car is that we have grown the team with that technology and we understand it well,' says Tremblay. 'The component of knowledge, a notebook of stuff, has some worth in motorsports. Is it a distinct advantage or disadvantage? I like to think that every package will have its high and low points. There will be some tracks where we are better off. If they do in-race compensation we will lose even more of our advantage. The way the rules are written, I don't think that having one architecture will be an advantage or disadvantage, but the knowledge base could be. We have a pretty good knowledge base, and we are comfortable.'

Aero meets styling

Clearly, carrying a turbo means that there is an aero cost and so the team spent a lot of time working in CFD in the early days, trying to get to the optimum package. It also allowed time for Mazda's designers to work with Handford to design in the styling cues of the car. 'The designers sketched the car, and then went to the UK to spend time with Multimatic,' says Mazda USA's director of motorsports, John Doonan. '[They] spent 10 days there, working morning until night and having our car engineers understand the impact of surface change to aero for example, and [we had to] have the team at Multimatic understand what artistry needed to be in there. We were scared to death – it was like throwing in a grenade and shutting the door. To have our aerodynamicists and designers come here [Daytona] and see the fruits of their labour, there is a unity now that could some day help the learning on road cars. It is like a dream come true to have that process take place. It is exactly what happened. The designers are so excited to see this car run. In LA, when we unveiled it, they were tearing up because they don't often get this chance.'

This meant that the team had a clear identity for its kit, and privately even those close to the European-specification car have admitted that the Mazda version looks better, a fact that is not lost on Tremblay. 'The WEC car became known as the Lego car, because everything that went on it looked like it was done in Lego,' he says. 'Design hated that, although there are aero advantages. From a design standpoint, changing one design surface from this to that makes a huge difference, and extending a line has a low aero cost, but it was important to design. But we knew that the styling thing would cost us downforce or drag.'



IMSA rules say Mazda 2-litre turbo unit has to sit in same position as the Gibson V8 powerplant that is spec engine in LMP2

Despite the need for Mazda styling cues there are some neat aerodynamic touches such as the remote rear wing mounts

Balancing act

Another grenade that was thrown into the mix was the fact that, although the bodykits would be balanced through aero testing at Windshear and with scale models, it transpired that there was a limit to the amount of help that could be given to each kit. The original plan was for the DPis to be balanced against the European car, but teams understood that IMSA was only able to slow down the fastest cars; those that were slower would have to help themselves. With production car stylists involved in the creation of the design, and knowing that they were going to lose efficiency, that set a whole new target.

'We didn't want to be great or soft anywhere,' said Tremblay. 'If you were outside the box they couldn't help you. It made the pressure even greater on the designers and on the aero folks to make sure we got it right from the beginning. It was a tough phone call for us. Hitting the target that Ben Wood and IMSA had given us was a clear milestone. If anything it rallied the troops; this is what we have to hit.

'The aero and styling compromises were back and forth,' Tremblay continues. 'But we


89.1
109.1
5.552
188.0
4
1:26.029
1:49.400
-0.002

Periscope exhaust has been chosen over the side exhaust (see below). Mazda had to wait until the LMP2 version of Riley-Multimatic was finalised before detail design could start

The new DPi regulations aim to give manufacturers the opportunity to race in sports prototypes for as little a $5m a season

came out with a beautiful racecar and it is right where we wanted it to be.'

By IMSA's calculation, a manufacturer should be able to purchase a car, and enjoy a four-year stability programme for around $20m, an average of $5m per year. That allows the manufacturer to not only style the bodywork, and run with a ready-sorted, ACO-specification chassis, but also go for some of the big wins in endurance racing, including the Daytona 24 Hours, the Sebring 12 Hours, the Petit Le Mans and the Six Hours of Watkins Glen.

Lure of Le Mans

For Mazda, this is a golden opportunity. 'IMSA has given us this platform and that's a historic moment in motorsport,' says Doonan. 'I hope that other sanctioning bodies around the world see the opportunity for people to compete at a relatively cost effective basis because it can be done, we believe. This is a North American focus, but I hope that our brand can go back to Le Mans, that would be a personal and professional dream, but it has to be the right place and right time. We are racers. Do we want to go to Le Mans and compete? Absolutely, but it is not possible right now. Let's live within the box, and focus on the North American programme, win races and championships and maybe it will come around. We will allow the skill set of IMSA and the skill set of the ACO to do their jobs.'

That last was in reference to the sudden and dramatic u-turn performed by the ACO in allowing the DPis to race at Le Mans. The LMP2 minimum weight was actually raised to help the US cars be able to come to Le Mans, and with the packages balanced against the Europeans, it made sense for them to race in France.

Le Mans lock-out

However, in June, 2016, there was a change, and the American teams would now only be allowed to race at Le Mans in European specification. There are options for teams in the US to run a Gibson engine and European bodywork, but not for manufacturers.

'Initially we all had that in our minds, but I think it wasn't a throw our hands up in the air moment when we found out that it wasn't going to be possible,' says Doonan. 'We focussed on North America, and it would be cool to go to Le Mans, but when it wasn't possible, we still had North America. Neither of us were beating our heads on the wall about this.'

Cost creep

Even so, the North American programme is comparatively inexpensive for a manufacturer, and that means it is attractive. But more manufacturer involvement will mean that there will be a pressure on the costs, but Doonan is not overly concerned about this.

'IMSA has that as one of their top priorities, so I think they are very religious about that,' he says. 'From our standpoint we have done a lot with a little, so we are going to be the first to stand up if there is a cost creep in this rules package. IMSA has more logging than they ever had, and I am not as worried about cost creep as I have been in years past.'

Tremblay adds: 'GT3 has been spoken about for 10 years, and although the costs have increased, so has the value. The wisdom of IMSA, and what we are trying to do for North America will keep it sustainable. Cost creep is a fact of motorsport, but the way that the rules are written, in four years there will be an evolution and it will be sustainable for years to come.'

With the Daytona event just the start of a four-year programme, natural evolution will see the lap times drop. Already the DPI cars have shown performance that is approaching LMP1 speeds of six years ago, and racing being the way it is that should improve over the lifetime of the car. For Mazda, right now the DPi is its main racing programme in the US, and it couldn't be happier with where it's at.

One area where the car's turbocharged engine could be at a disadvantage is in the way that the power is delivered

Two's company

When a couple of North America's top motorsport concerns got together to build an LMP2 car expectations were high – and the Riley-Multimatic Mk 30 that is the result does not disappoint

By ANDREW COTTON

Riley and Multimatic scooped the rights to produce a new rules LMP2 for this year (pictured), joining the three European companies also selected

When the tender for LMP2 2017 was put out, there was a clear message from IMSA – one of the four chassis manufacturers would be from North America. It was perhaps no surprise that the tender went to two of the most established and respected companies in North America, Bill Riley's eponymous concern and Larry Holt's Multimatic company, although how they came together was more haphazard than might have been expected.

'It all started when they started talking about a new car,' says Riley. 'I was going to the meetings, as did Multimatic, and we had worked with them on the Viper programme. We didn't want to go up against Multimatic, and I don't think that they wanted to go up against us, and we were both busy with our other projects, but we realised that this could work.'

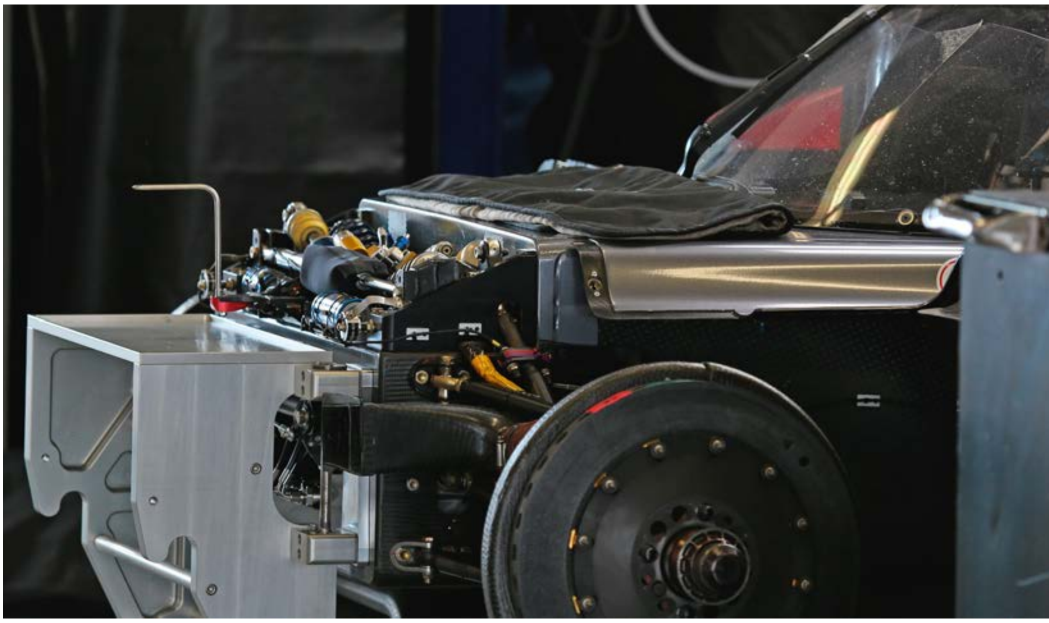
Multimatic already had the approach from Mazda (see page 8), but it was not interested in doing a DPi car due to the financial commitment that would need to be made. 'Mazda really wanted us to do it, but to do it we needed a base LMP2 car, and I wasn't super-interested as I can categorically tell you that it is not a profitable business! So there was no way I could have done it,' says Holt.

'So when Mazda said they wanted me to do this, I said I don't really want to do an LMP2 car. Bill was chomping at the bit to do an LMP2 car, even though he didn't have all the investment required to do that, so I said to Bill, do you really want to bid against each other? I am not that interested, but I need the car to do the Mazda programme. I said "do you want to fight or do you want to co-operate?" I am not good at partnerships, but in the end we said yeah, let's do it, let's go in together. Together, no other North American outfit would get a look in.'

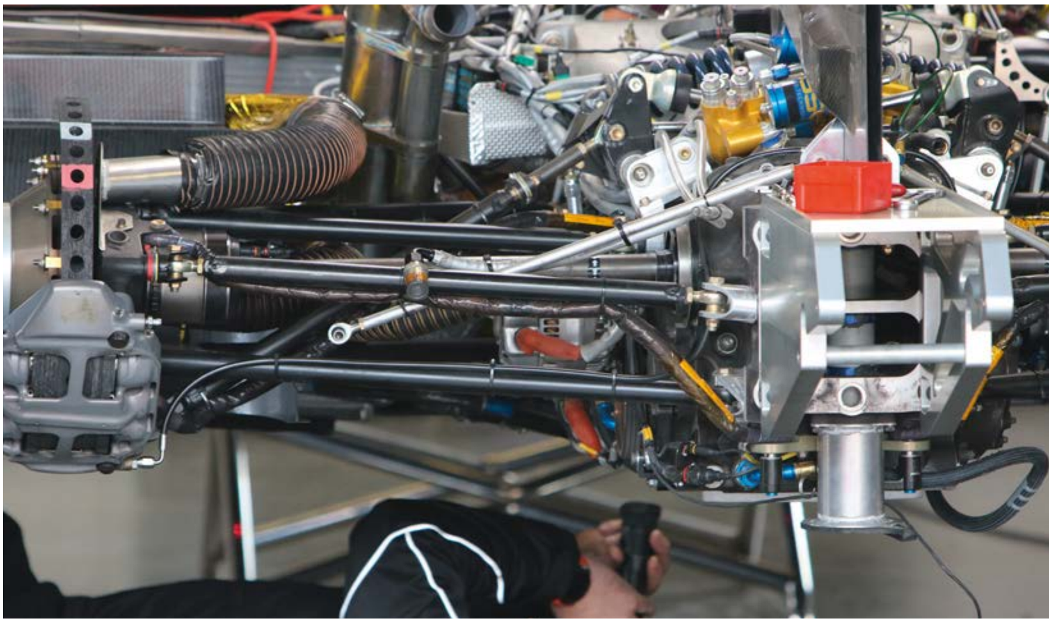
Multi-talented

Multimatic took on the chassis, carbon work, the highly sensitive underfloor, while its aero designer, Mark Handford, got to work on the body. 'We were late because there was a huge cooperation with Mazda in Japan and California,' said Holt. 'That always takes longer, dealing with

‘I’m not good at partnerships but in the end we said yes, let’s do it, let’s go in together’



Large crush zone in front of the driver’s feet helped make this a long racecar. It also features third element front suspension



Transmission is by Xtrac. Car was designed to pack Mazda turbo (for DPi only) or Gibson’s spec V8 LMP2 power units

an OEM design house and its styling guys, so we were a bit late coming to the party, and Bill was a bit late for his stuff.’

Before the car was ready, however, there was a lot of work undertaken in the wind tunnel. Riley doesn’t know how many runs were done, as Multimatic designed the wind tunnel model while Riley built it, and serviced it. ‘The group ran the tests, and we had a 45 per cent model and I know that I had to service the wheel bearings several times,’ Riley says.

‘We spent a lot of time in the wind tunnel and on the drawing board. When the little issues get out of the way, we will see the benefits, but on the Riley side we thought that the car would be best if it spends more time in the wind tunnel before it gets released, and we pushed that too far,’ Riley adds.

As Mazda was the first to commit to the DPi, offering an advantage in planning (see page 8), it was also the first installation for the car, with the Gibson following afterwards. ‘You have to do so much at the same time, and then finish one of them off,’ confirms Riley. ‘We finished the Mazda off first. We always knew that we would do a 4-cylinder turbo. We also looked at a twin turbo engine at the same time, a V6 or a V8. With the DPi they do give you some leeway on the cooling systems so we don’t have to design a lot.

‘The wheelbase is fixed by regulation, and it is more for safety, so there is a large crush zone in front of the drivers feet on the tub, before the nose cone, the tub is long, then 300mm for the B pillar, and then the FIA and ACO had a set dimension from the rear face of the tub to the centreline of the output shaft of the gearbox. That set the car as a long car, so you don’t have to think about it. I don’t know if we would have done a car quite this long, but it’s not bad.’

At Windshear in December the car ran at full size in the wind tunnel, in WEC and in IMSA DPi trim, in order to balance the cars effectively. That is primarily for the US market, however, as currently there are no European customers for the car (at the time of writing, that is). That, however, could change, with a good result in the opening races of the IMSA series at Daytona in January and Sebring in March.

There was no baseline data, no track data, nothing on which to base the Balance of Performance, and IMSA's season starts in January while the WEC begins in April

Aero balance

Allowing the DPi manufacturers to design their own bodywork styling cues meant that the racecars then had to be performance balanced. Here's how IMSA did it

By **ANDREW COTTON**

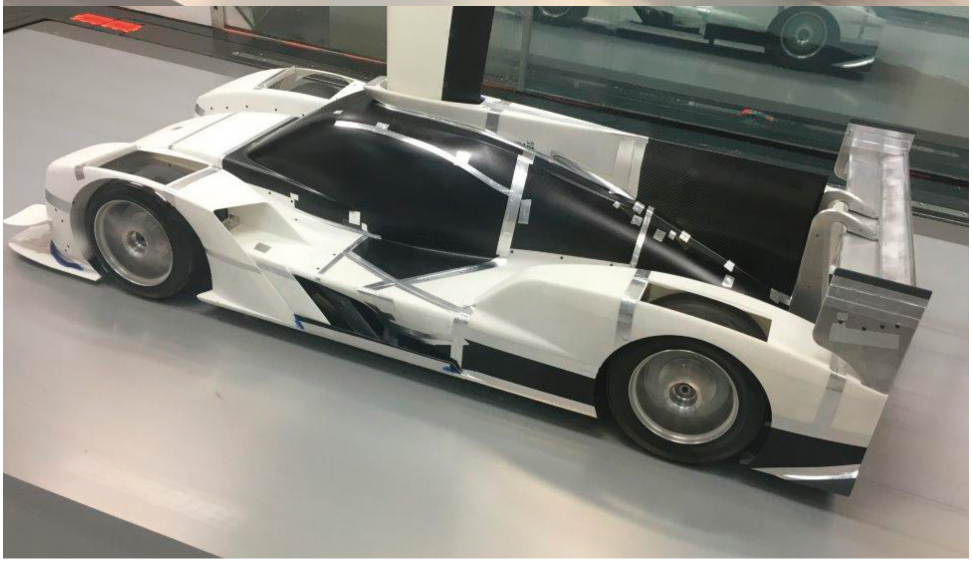
There are vast differences between the LMP2-specification cars and their DPi equivalents, in which the manufacturers' design teams were involved. Here the Ligier chassis is bodied as a Nissan DPi

When the new regulations for LMP2 were announced, there was an immediate problem identified by the ACO. While the category was, for them in Europe, the WEC and the Le Mans privateer class, in the US it was the main category and IMSA already had interest from several manufacturers, including Mazda and GM. So, would manufacturers allow their cars to be raced by privateers, or would they want to have professional drivers, and an input into the design and running of the car?

In the end, it was agreed that this would be the global prototype category as originally envisaged but, while the European cars would run with the Gibson engine and European-designed bodywork from Ligier, ORECA, Dallara and from the US partnership of Riley-Multimatic, in the IMSA series manufacturers would be able to supply their engines and design the aero to go with those engines. They would be allowed to incorporate styling cues that give their racecars their own brand identity, which would add value to their programme.

There are several issues with this, and it has taken the best part of two years of planning to address them. The first is that the manufacturer-styled aero, designed to provide styling cues rather than as a dedicated performance tool, could lack the efficiency of the European-spec bodywork. The second is that the weight of the engines is completely different for each manufacturer, as are the characteristics of power delivery. A third potential problem surrounds the layout of the engines. A small capacity turbocharged engine can spread the weight across the chassis – although it pays for this through an aero disadvantage due to more cooling – compared to a normally aspirated engine that sits centrally in the car.

The final piece of the jigsaw was that the LMP2 chassis and aero kits would make their



Top: IMSA built its own LMP2 spec wind tunnel model to use as a baseline and then created DPi bodywork that fitted onto it
Above: LMP2 spec bodywork was high downforce only; IMSA did not need the extra headache of a low-drag Le Mans kit

The Rebellion ORECA LMP2 car demonstrates the purely performance-driven philosophy behind the LMP2 aero packages

debut in 2017. There was no baseline data, no track data, nothing on which to base the BoP. To make that matter even worse, the European season starts in April, but IMSA needed all of its information in time for its season opener at Daytona at the end of January, and the BoP process to have actually been done by the beginning of the year. 'As our relationship continues to grow with the FIA and the ACO, over the last two years, they have definitely worked to come closer to our time-line and recognised that our season starts three months ahead of theirs,' says Geoff Carter, senior director, technical regulations and compliance. 'Them inspecting cars at the end of November and beginning of December, that is a definite move. We have appreciated that. They have come much closer to our time-line than they have in the past, and that is really a by-product of our relationship growing.'

The fifth LMP2

The first stage of IMSA's process involved putting together a group, which is headed by the highly experienced British aerodynamicist Ben Wood and his team, to set out the parameters of the balancing act, and then creating a scale model for testing the various components of the aero kits. However, Wood did not start either with the design of the DPi kits or those from the manufacturers in Europe. Instead, he designed his own car, against which the DPi cars would be balanced.

'We had a 40 per cent scale model and that was derived from an earlier LMP2 model, but it is unrecognisable [from its original form],' says Wood. 'We used the wheels, two rear suspension legs and the front spine boxes. Every other bit of it is new. We had to make sure it was a decent evaluation base between LMP2 and DPi cars, and it was. We evaluated the LMP2 cars as well, not globally because you can imagine that we have to be fairly selective in how we carry out the wind tunnel programme. You cannot build every car in its entirety in detail because it is prohibitively expensive, so we got practical information in a practical way.

'Essentially we designed an LMP2 2017 car that was independent from the other constructor cars, and then the DPi cars were evaluated against that. [We had to] make sure that our version, the 'IMSA WEC' shall we call it, was giving the same characteristics, and same overall numbers and stability, more or less, as the FIA LMP2 constructor cars.'

Having established a solid baseline, the work could then begin on both the DPi cars, and the European-spec cars that could also race in the IMSA WeatherTech Sports Car Championship. They were limited to their 'sprint' package, in line with the previous LMP2 cars that raced against the Daytona Prototypes from 2014 to

'We used one model package to test everything. It was very flexible'

2016 as their Le Mans bodykits were both not necessary for the IMSA series and they also added another layer of complication for the aero balancing team.

'The LMP2 cars were going to be what they were, so the majority of the work we had to do was on the DPi packages, and understand them because of their variances,' says IMSA's senior director of Racing Operations, Mark Raffauf. 'The other thing that I think was unique was that we used one model package to test everything that we needed to test. It was very flexible, to be changed from one car to the other.

'The three DPis have been model scaled and most of the P2s have been model scaled. We did tactical parts of all P2s as part of our practical process. Every full-size DPi and LMP2 car has been to the wind tunnel, per eligibility for IMSA competition, and there is no exception.'

Information exchange

That process started in August, but information from the various constructors and manufacturers came in from late summer to as late as December of 2016, giving the teams something of a challenge to prepare the racecars for the Daytona 24 hours at the end of January. The final full-scale test at Windshear was at the end of December.

'For the DPi cars we wanted to be sure that we understood the impact of the branding and styling of their top body surfaces, so their wheel pods, sidepods and engine cover and styling cues, and evaluate those against the LMP2 bodywork which is developed without styling in mind,' Wood says. 'We had a better conversation with the manufacturers about the impact of the aerodynamic loads of each of their branding strategies because that was core to the DPi mission, which was that the OEMs demonstrate a high level prototype class car that has their branding cues on it. These LMP2 cars have extremely high levels of performance anyway, so it is easy to upset their overall aerodynamic strategy even by changing small things, which might seem inconsequential. Some of them might have upset some of the balance of the car and lift over drag, and some were obviously much more wide-ranging, so we gave the DPi constructors more freedom to design their bodywork, and then evaluated that in a model scale test at the Williams wind tunnel.

Brand on the run

'[Having evaluated the IMSA LMP2 design], we could get into a dialogue with the DPi manufacturers about the strengths and weaknesses of their strategy; whether the branding was killing the performance too much, or there was too much on the performance side,' Wood adds.

'The branding and styling are quite subjective, so it is fair to say that the IMSA technical committee would be involved in the evaluations of branding, so that

Top: Dallara Cadillac with subtle design elements; in line with new DPi regulations and the US firm's marketing ambitions
Above: Dallara P2 is a more purposeful package. Note airbox design on roof, and headlight design as clear differences

Top: Ligier Nissan sports a hint of GTR. With different engines and bodykits balancing the DPis has been a delicate business
Above: WEC Ligier. Note the different cooling solutions at the rear; bodywork between the front and rear axle, and the nose

Top: Mazda DPi. Much of the aero work was over-body as most of the underfloor design has been homologated by the FIA
Above: The Riley-Multimatic teams worked together to solve early reliability gremlins despite the different engine solutions

Mazda was the first manufacturer to commit to the new DPi regulations, giving it first choice in dates for compulsory tests

was a collective. Then we would go through the iterative process of working with the manufacturer to establish the best balance of styling and performance.'

Breathing space

Clearly there would be major differences between the whole racecar packages, not only the aero but also the weight distribution and power, but IMSA had to be careful not to be too invasive, leaving room for the teams to prepare their racecars.

'We gave more aerodynamic centre of pressure leeway in terms of being able to achieve good figures at different aero balances of the cars that would have had significantly different weight distribution due to the engine, but we tried to couple weight distribution with aero balance, and the combined effect, and we are getting towards quite complex relationships in terms of how you set your car up,' says Wood. 'It is something that the DPi constructors and manufacturers need to build into their cars. They would have known their weight distribution and we have given them enough aerodynamic leeway to have a window of adjustment to go along with the weight distribution adjustment.

'Obviously there are certain things that are almost certainly going to be a penalty such as a more rearward weight distribution,' Wood adds. 'It is going to vary track to track and it can have less of an impact at Daytona than a track later in the year, but there is more scope for them to adjust and we haven't done any pinpointing for each team as to how they should tackle that.'

Scaling up

There were three scale model tests with the various kits before the full size kits started to go into the Windshear tunnel. Then there were two full-scale tests, one at the end of November and one at the end of December, in which all the kits were tested and validated.

'By the time we took the cars to Windshear tunnel in North Carolina and got the model sign offs, we knew the issues that we would face in terms of trying to collectively bring the DPis together as a group, and then try to bring that group to the performance point of the LMP2s,' says Wood. 'We knew that we had some margin that we could adjust – aero related and top speed related with the engine power – but the engines have their own sub-set of what you can and cannot do. We tried to bring the aero together as best we could with what we had been presented in model scale and full scale process. At the beginning of the process there was a normal differential and by the end of the process that differential was a lot smaller and minimised.'

The main focus of the aero work was over-body aero, as the underfloor aero was FIA

'The exhaust effect on a car's aerodynamics is dominant at low speed'

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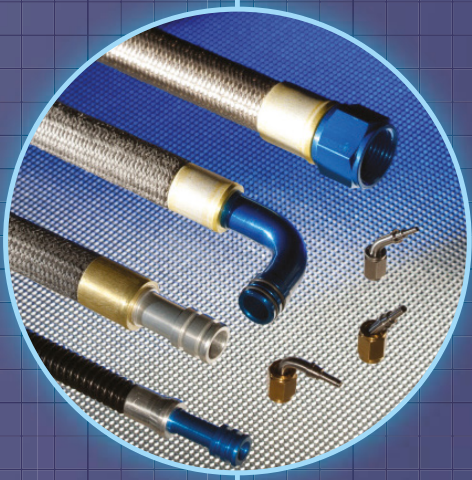

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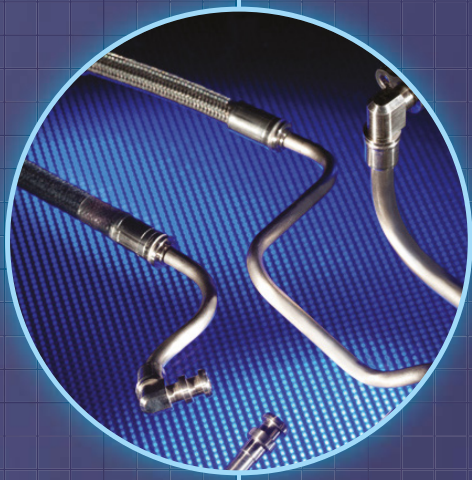

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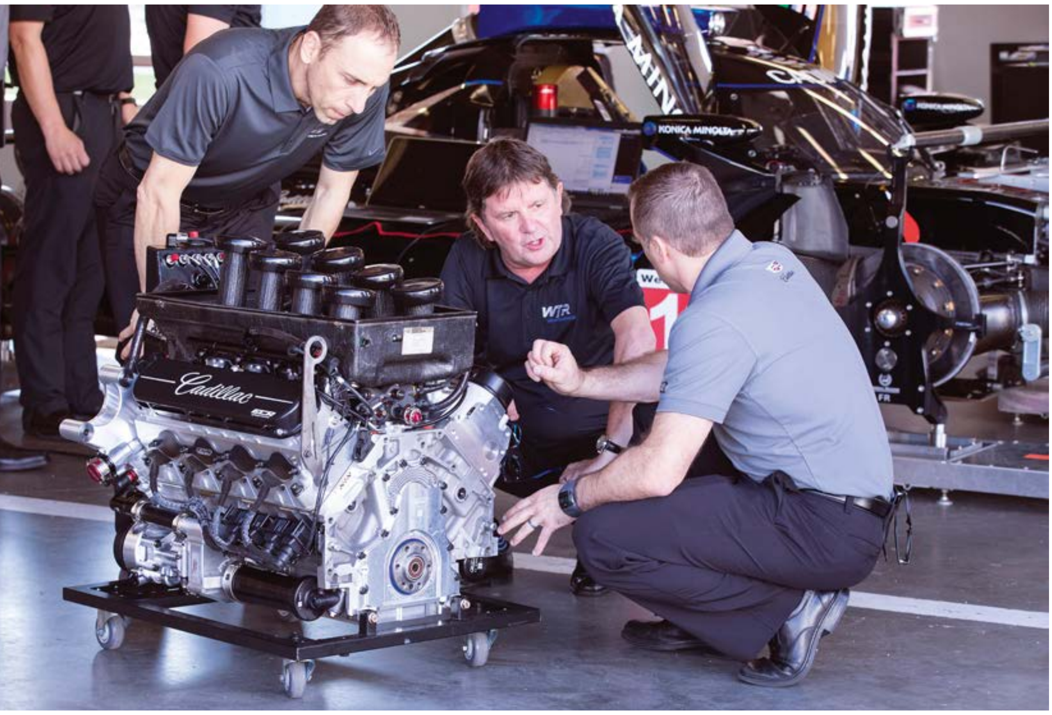
The main focus of the aerodynamic work on the DPi racecars was over-body aero, as the underfloor aero was FIA homologated



Wayne Taylor (centre) and Max Angelelli (left) with Cadillac engine. DPi's manufacturer power units complicate the process

The DPi Cadillac has its bodykit put through the full scale aero tests in the impressive Windshear facility in North Carolina

homologated. In fact, the entire car fits to FIA homologation standards, but in DPi there are some allowances to change the performance.

'On all the DPis, all the parts are FIA designed compliant to FIA LMP2 regulations, they just had more options,' says Wood. 'So they had packers to fit in to the front splitters to reduce the front downforce levels. If you imagine a Le Mans pack for an LMP2 car, you could do that for your higher speed circuits. Obviously we only allow the LMP2 cars to race in sprint configuration, so one of the differences you could point to is that the DPis could modify by means of packers and fillers and different dive plane arrangements to get to different downforce levels to scrub downforce off for Daytona speeds, while the LMP2s were not going to be capable of doing the same adjustments, so that was a non-straight L/D improvement that we could give to the DPis to help their level of adjustability that we managed to give them.'

Pipe dreams

There were still differences between cars, even from the same manufacturer; as detailed in the Mazda feature in this issue (page 8), where the two cars ran with different exhaust layouts. At the race, neither the LMP2 cars nor the DPi cars were finally homologated; the FIA had pushed to examine the European cars in what is expected to be their final configuration before rubber stamping the design before Christmas, while IMSA will deliberately wait until after the 24-hours to rubber stamp the DPi designs. This, says IMSA, is nothing new – they do the same with the GT LM and GT3 cars.

Experience counts

However, with such details as a side-exit exhaust or a periscope as seen on the Mazdas, IMSA's engineers had to rely on previous experience rather than test each individual component. 'The exhaust effect on aero is dominant at low speed, or manifests itself at low speed more than at high speed,' says Wood. 'The exhaust position, we found from our studies in the past, in terms of its effect on top speed, is not a huge amount. It is something that we can use experience to base a decision, but for IMSA to go through the modelling process in full scale or model scale was difficult. When you get to that level of investment to analyse that kind of item, we tend to go back to the Roar [before the 24 test] data to see if anyone has an advantage under traction, or where you might expect an exhaust generated downforce advantage

IMSA hopes to have a more proactive than reactive approach to BoP

[illegible]

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There is also the complication that some of the cars will work better on some tracks than others

Many have called on Porsche to ditch the 911 in favour of the Cayman for GTE, but the company considers this model its standard-bearer

Don't look back in anger

Porsche's new 911 RSR harks back to the 1998 Le Mans winner with its mid-engine layout – but that's just one of many innovations featured in this all-new GTE challenger

ANDREW COTTON

Porsche goes in to 2017 with a new car concept and an all-new chassis. It hopes to claw back ground lost to rivals Ford and Ferrari last season with its new 911 RSR

Porsche's latest Le Mans GTE car has finally stepped on to a similar platform to its rivals, with a rear to mid-engine layout that allows not only better weight distribution, but also better aero, which in turn allows it to exploit fully the new regulations. It is the first time since 1998 that Porsche has entered a mid-engine 911 – the last one was driven to overall victory that year at Le Mans by Allan McNish, Laurent Aiello and Stephane Ortelli, which was, incidentally, the last overall win at Le Mans for the Mezger engine.

Going up against the turbocharged Ford and Ferrari that were built to the new regulations and debuted in 2016, the old Porsche struggled, even with the waivers that allowed it to run different wings, front splitter in the US, and different size rear tyres to cope with the engine that was slung out beyond the rear axle.

The old cars were adapted as best they could be in 2016, and while the Aston Martin, which was also an older car, actually won in Europe, Porsche was off the pace everywhere and the team grew despondent. Not only was the car not up to scratch, but in 2016 Porsche also withdrew the Manthey squad from GTE in the World Endurance Championship, and instead entrusted the running of the car (after a little political persuasion to actually field a factory car) to the Dempsey Proton team.

In the US, the relationship with Core Racing will continue this year, and Porsche is back to full strength with Olaf Manthey's team running cars in Europe. The cars are completely new, featuring a new engine, new chassis, and new safety initiatives, that include moving the driver closer to the centre of the car, fixing the seat and allowing the pedals to move instead, and improving side impact protection.

Flat-six

Normally, a description of a racecar does not start with the engine, but in this case it is the launch pad for the entire car concept. The 4-litre water-cooled 6-cylinder normally aspirated boxer engine produces around 500bhp, and is developed from the GT3 unit that was introduced in 2016 (see *RCE* V26N3), but switching it with the gearbox to make a pseudo mid-engine layout (the company is officially unable to call it 'mid-engine') has opened up some great areas for development.

There are many who, for years, have called on Porsche to ditch the 911 in favour of the Cayman, but the company considers the model its standard-bearer and this was therefore an easy choice for Porsche – though the Cayman has been developed to race in GT4. With two- and four-wheel-drive available in the production car, turbo and normally aspirated engines too, the team argues that switching around the engine and gearbox is simply another derivative, and that the car is still 100 per cent a 911.

'The official wording is that the engine seat is now in front of the rear axle,' says Marco Ujhasi, head of GT Works Support. In fact, the exact location of the lightweight engine remains a closely guarded secret, and even those who have poked their heads into the car haven't found it, but Ujhasi adds: 'The position of the engine and the gearbox are rotated, because the engine has been behind the rear axle so far, so it is a rear-mid-engine, but we do not like the term. We have chosen the optimal position. In our diction, it is rather a mid-motor vehicle. We had no choice because of the output side, because you have to position the gearing so that you can get the shafts where they must go.'

Within the rules, the position of the drive and the orientation of the drive is optional, so there is no waiver needed for the switch. As to whether or not the chassis has actually changed for this, Porsche is a little cagey, but Ujhasi says: 'The effort was pleasingly low, otherwise

TECH SPEC

Porsche 911 RSR LM-GTE

Body: Weight-optimised chassis in combined aluminium steel design; removable roof hatch for cockpit access; lifting bushes integrated in the roof.

Weight: 1243kg.

Dimensions: Length 4557mm (without splitter, rear wing, diffuser). Width: 2042mm at the front axle 2048mm at the rear axle. Wheelbase: 2516mm.

Engine: Water-cooled 6-cylinder boxer, 4-litre; stroke 81.5mm, bore 102mm; approximately 510bhp (375kW) depending on restrictor; four-valve technology; direct fuel injection; dry sump lubrication; single mass flywheel; power output limitation via restrictor; electronic throttle. Positioned in front of the rear axle.

Transmission: 6-speed sequential constant-mesh gearbox; two-shaft longitudinal layout with bevel gear; shifting via electronic shift actuator; magnesium gearbox casing; multi-disc self-locking differential with visco unit; clutch, three disc carbon.

Suspension: Front axle – double wishbone front axle; four-way vibration damper; twin coil spring set-up (main and helper spring); anti-roll bars, adjustable by blade positions; electro-hydraulic power steering. Rear axle – integrated rear axle subframe with double wishbone axle; four-way vibration damper; twin coil spring set-up (main and helper spring); anti-roll bars, adjustable by blade positions; electro-hydraulic power steering; tripod drive shafts.

Brakes: Two independent brake circuits for front and rear axle, adjustable via balance bar. Front axle – one-piece aluminium six-piston racing calipers with quick coupling; internally ventilated steel brake discs, 390mm diameter. Rear axle – one-piece aluminium four-piston racing calipers with quick coupling; internally ventilated steel brake discs, 355mm diameter; race brake pads; optimised brake cooling ducts.

Wheels/Tyres: Front axle – one-piece forged light alloy wheels, 12.5Jx18 offset 25 with centre-lock nut; Michelin slick 30/68-18. Rear axle – one-piece forged light alloy wheels, 13Jx18 offset 37 with centre-lock nut; Michelin slick 31/71-18.

Electronics: Cosworth central logger unit; CFRP multi-functional steering wheel with integrated display; shift paddles and quick release; controlled alternator in connection with Life Po4 battery.

The engine position (not shown) is the main talking point with the 911 RSR – its normally aspirated unit is now located in front of the rear axle, leaving more space at the rear the car

it would not have happened.' Moving the engine ahead of the rear axle did not produce the cooling problems that might have been expected, either. 'It was a positive surprise,' Ujhasi says. 'We had no issues with cooling. Simulation from the thermodynamic standpoint is not easy, but there were no issues with a burning car, or anything like that. The heat rejection was surprisingly manageable. Where heat is you need air, not just to bring it in, but to release it, and if you have good ideas then it works easily, and that was a surprise.'

Normal aspirations

Porsche chose a normally aspirated engine ahead of a turbo due to reasons of weight, packaging and simplicity. 'The turbocharger would definitely have been a weight disadvantage, which would have eaten large pieces of the advantage of the new engine positioning again,' Ujhasi says.

'Politically, we believe that it is possible to balance turbos and normally aspirated engines, no matter which technical approach you take,' Ujhasi adds, referring to the Balance of Performance process that was such a topic in 2016. 'The engine itself is partly neutralised by the regulations [with better weight distribution and packaging], and the normally aspirated engine fits the GT3 road car.'

Porsche chose a normally aspirated powerplant ahead of a turbo due to reasons of weight, packaging and simplicity

The simple weight benefit of running an NA engine compared to a turbo is around 15kg for the engine, and 40kg with all the peripherals taken into account, according to Porsche. That all helps with getting off the line, and with cornering, as well as tyre wear over a stint, as ballast can be placed around the car rather than lumped in a single component.

Ujhasi continues: 'The engine is very close to the GT3 R engine, so the latest member of the family. It is direct injection, but nothing sophisticated, but adapted to the regulations. DI is definitely important. Following the philosophy that we have always followed, that is at Porsche the best overall car concept, the NA was the best way because it was an advantage of weight. Packaging is simpler and complexity is reduced. The overall concept is always more important than a single decision. And we trust in the sanctioning body that it is equal for normally aspirated and turbo engines.'

With the engine moved forwards, a substantial rear diffuser is now on the car and the underfloor aero has been extensively developed. This not only improves downforce, but also gives the team a little more breathing space around the tyre wear. 'The under flow aero is extremely important in order to achieve downforce with as little air resistance as possible, but in a GT car, the flow under the car is much less stable than over it,' says Ujhasi, who cites the Ford as the best in the class for the combination of airflow both over and under the car. 'Ford has LMP2-like design with the air over the body, which is then very efficient and that is their strength. Flow over the car is in principle much more stable; that helps in multi-class racing and in traffic, but the rear diffuser helps the flow over the rear wing, and helps with the entire balance of the car, starting from the front.

'Because at the front it is limited due to the form of the cars, in principle, the rear diffuser absorbs the air, so the negative pressure arises at the front,' says Ujhasi. 'That is its primary function, besides downforce at the rear.'

The rear wing itself is mounted under the supports to clean the airflow beneath it. 'The underside of the blade at the tail wing is clearly more sensitive [than the top] for flow, because at the bottom the air must follow the tail wing geometry. So-called interfering contours, such as the support, are undesirable on the underside; this is not a question of the output level but rather a larger adjustment range because of a lower stall inclination,' Ujhasi says.

Boxing weight

The gearbox is a completely new development, but the goal is not ultimate performance; rather reliability. A 24 hour race can be lost on the performance of the gearbox, but never won by it, reckons Porsche. The weight of the gearbox has actually gone up. Porsche has moved away from pneumatic or hydraulic options in favour of electronic shifting, so an electro-mechanical system, which reduces shifting times. 'This significantly reduces the interference from the gearbox,' says Ujhasi. 'It also helps the drivers to stay within the optimum speed range [of the engine].' The team has also switched to a magnesium housing, for weight reasons.

The 911 still has the inherent problem of where to put the fuel tank. Over the 40-year

The driver can see what class of car is coming, how fast it is approaching, and which side it will pass on, even if there is heavy rain or a thick fog

racing history of the 911 the tank has been located all over the car but now resides in the front, and strangely is even further forwards than in the outgoing model. The team concentrated on having the three heaviest components of the car as low down as possible; the engine, the driver and the fuel tank. With the fuel tank at the front, it will still have the same old issue of changing weight distribution as the fuel load lightens, but Porsche considered this to be a price that was worth paying.

'The tank is still in front as in the past, so the balance shift between full and empty exists, which is also relatively massive,' says Ujhasi. '[In fact], the balance shift is even a bigger deal now because the tank is even more on the front axle, so we must live with that.'

Chassis developments

As with the engine, the decisions based around the all-new chassis come from an unusual source. Factory driver Richard Lietz had an accident at VIR (Virginia International Raceway) in 2015, which left the Austrian with a broken arm after a double impact that the Porsche team analysed in great detail. The first impact was with the crash barrier, the second when Jan Magnussen's Corvette slid off on the same corner and then hit the Porsche on the left side. The accident led to an overhaul of the chassis design and the safety features within the car.

'[We aimed] to give the driver as much survival space as possible, it is also important that the energy input into the driver must be low,' Ujhasi explains. 'That means much deformation as possible, and thereafter absolute protection in case of survival. There are two aspects; the cage is integrated, so that it is absolutely unyielding. At the same time we have moved the driver as far as possible towards the centre axis, about 50mm more than before, so that there is 50mm more deformation, where energy can be dissipated. We have developed conceptually with the safety, and the seat is now screwed tightly to the floor. That means that it can reduce the energy, but is also a stiff survival space for drivers.'

The RSR packs two independent brake circuits for the front and rear axles, both adjustable via balance bar (front brake assembly shown). Front has six-piston racing calipers and internally ventilated steel discs, four-piston calipers at the rear

The rear brake assembly and suspension. The latter has changed to a double wishbone layout – the 2016 Porsche was multi-link. Suspension features four-way vibration dampers and twin coil spring set-up, comprising main and helper spring

Meshy business

There was also an exchange of information between Porsche and Corvette, which has for years run a mesh filled box in the side that reduces the possibility of a component, such as a piece of suspension, coming into the cockpit. The resultant improvements to side impact protection, which also includes a strong, production car doorsill, means – the team claims – the car would pass the FIA's A-pillar pressure test without the roll cage installed.

The fixing of the seat to the floor also means that the driver can be accessed easier through the hatch cut into the roof of the car, a new safety addition to the GTE regulations in 2016, while the weight of the driver is in the same place for each driving stint, too. 'So, no more longitudinal adjustment, more fixing, and it's safer, the driver always sits in the same place, which is also important because of the ridges in the roof,' says Ujhasi with a smile, noting that by getting rid of the seat runners the car has also shaved 7kg from its base weight.

The pedals are spring-loaded and can be adjusted with a lever, much as the seat used to be. The only disadvantage as far as Ujhasi is concerned is that the uncoupling of the seat belt could be slightly slower, as before a driver could loosen the belts by adjusting the seat.

There was a further exchange of information among the GTE teams with regards to the Bosch-developed radar system that helps drivers identify a faster car coming from behind. Through either solely visual cues, or a sound in the drivers' ear piece, the driver can see what class of car is coming, how fast it is approaching, and which side it will pass, even if there is heavy rain or thick fog. The system has proven to be

'The under floor aero is extremely important in order to achieve the required downforce with as little air resistance as possible'

popular in multi-class racing, particularly at the Nurburgring 24 hours where drivers traditionally struggle with rearward visibility.

The suspension has changed to a double wishbone layout – the 2016 model had a multi-link layout. 'The regulations say that you either stay with the concept used on the road car or you do double wishbone, so we decided to do double wishbone front and rear,' says Ujhasi. 'There are some advantages and disadvantages, but it is easier to do the set up work with the double wishbone than the multilink, in that it is easier to handle.'

On balance

Porsche's 911 has been known as the 'waiver car' for a variety of reasons. In order to get it into the performance window of its competitors, it has been allowed to make significant changes, such as running with a longer splitter in the US, and a wider rear tyre around the world to compensate for the higher weight beyond the rear axle. In 2016, uniquely it was also allowed to run with a 2015 tyre from Michelin. However, at the end of October last year, Porsche brought its new car to Michelin's test in Road Atlanta and was able for the first time to select its preferred tyres from the range offered to all the other competitors racing in the class.

The RSR's rear wing is mounted under the supports to clean up the airflow passing underneath it. Under the chassis Porsche has also been able to include a substantial diffuser, thanks to the positioning of the powerplant further forward in the racecar

The all-new chassis is bristling with safety features which include improvements to side impact protection. Driver has also been moved as close to the centreline of the car as possible (50mm further than before) while the seat is now fixed in place

Charged up

While the organisers battle to balance turbocharged engines as used by Ferrari and Ford, and normally aspirated engines used by Porsche and Aston Martin, Porsche believes that some of the gamesmanship from 2016 will be addressed and that the BoP will not favour one concept or the other.

'The regulators have the *desire* to balance cleanly against the turbo engines by taking the line curve as a basis for the load pressure classification of the turbos,' explains Ujhasi. There is still a potential that the NA engine will be at a disadvantage in traffic compared to the torquey turbos, and much of GT racing occurs in traffic, but the BoP has taken steps to address that by manipulating the torque curve of both.

What about the BoP problems that came to a head after Le Mans last year, when the performance of Ford and Ferrari was such a topic in the lead up to the race, and at the race itself where the Ford came into its element?

'The risk always exists, but they have learned a lot in the 2016 season with Ford and Ferrari, as far as monitoring is concerned,' Ujhasi says. 'The definition of reference curves is the verification of compliance, one over the other. The theoretical idea is there; [from] 2016 we can see which gaps exist in monitoring under real conditions, and if we fill these gaps we can have a good competition in 2017. The greatest learning and focus is on the turbocharging air temperatures and the environmental pressure, which is well known to everyone.

'Ford heated the charge air temperature before Le Mans, afterwards they cooled it, which was an enormous delta, with significant performance differences,' Ujhasi adds. 'Therefore, charge air temperature as an additional monitoring parameter is integrated into the scrutineering data logger for 2017.'

Before the start of the season Porsche embarked on an extensive 35,000km test programme. It remains to be seen whether or not the new weapon from Weissach can, indeed, take the challenge to Ford and Ferrari. But ahead of the Daytona 24 hours, Porsche was quietly confident.

Sowing the Cee'ds

Kia might not be well-known for its motorsport exploits but with its new Cee'd touring car it hopes to take the fight to Audi, Honda and Volkswagen in the burgeoning TCR category

By LEIGH O'GORMAN

Initially planned as a potential one-make series car, a project with the Austrian and European arms of Korean car maker Kia, the Cee'd will now join the ranks of TCR this season. Rather than Kia running the Cee'd itself, STARD – the advanced research and development wing of Stohl Group – has decided to play a key role in running the car.

According to Michael Sakowicz, CEO of STARD: 'With the recent possibility around TCR [its growth], we came back to this idea to do something with the Kia brand in motorsport, based on the production car.'

From what was to be at one-time a one-make series car, the Cee'd received critical development to bring it in line with the expected level of competition in the TCR. 'We had a look at TCR and our Cee'd project idea and we said that we want to do something that would be new to TCR – new by means of not simply upgrading a cup [one-make] car, or not producing something that is so strongly [focused] on low cost, but rather trying to fit the best possible technology and the most individual technology within the cost-cap of €130,000,' says Sakowicz.

While admitting that there is no pressing urge to produce huge numbers of the Cee'd TCR, Sakowicz says that STARD's focus is to concentrate on a reasonable number of

top projects, while also supplying close and personal technical support. He adds: 'The customers that are in contact with us or have purchased cars are pretty convinced that we have hit that spot quite well.'

Hi-tech approach

The development of the TCR was based on analysis of the technical regulations. Applying its systems of simulation and predictive development for CFD simulation, STARD analysed multi-body simulation of the suspension, and system analysis of body and suspension and how they should work together. 'We also had a close look at the tyres, especially on the international series, for what is important to have a good functioning suspension. This also includes an entire package on CAD, so the car has been completely developed on computer and every single part has been designed in CAD,' Sakowicz says.'

The engine was developed on the dyno with STARD's own electronic system – it is a dealer for MoTeC – allowing the entire electronic system package to be developed in-house.

Weight's a factor in TCR and STARD reduced it from the bodyshell by removing the Cee'd's unused access ports, a factor that took the weight down significantly, before designing a roll cage, which focused on the optimal ratio between weight and stiffness. Sakowicz says: 'The focus [was] a little bit more toward the weight side, which in our point of view is the more important.' The stiffness of the cage was calculated by using FEA analysis.

Sakowicz says that aero development concentrated more on drag reduction and efficiency, rather than creating a huge aero package. 'We focused on having a good drag coefficient and good cooling package for the intercooler and the water radiator, which is particularly difficult as OEM components have to be sourced and used in all TCR cars.'

Optima primed

Under the bonnet, the Cee'd utilises a base engine from the Kia Optima, as there is no 2-litre version of the Cee'd on the market at this time. 'It is a particularly good engine,' notes Sakowicz, adding: 'We have had extraordinarily good results in terms of the power delivery, power curve and especially the reliability. We are very confident on the power level where we have already focused on the 2017 regulation, which allows 350bhp, rather than 330bhp – we [are going in a] very good way with that system.'

The turbo engine is mounted transversely in the front in keeping with the original base-car position. But the regulations did allow modifications to the oil sump to adapt it to circuit racing use. '[This] means proper baffled sump plates are installed to ensure there is no oil surge, even in high speed banked corners. In testing, it has proven to function very efficiently, so that is a big difference in the lubrication system from the OEM engine.

'TCR is based pretty much on the OEM stock engines and that is one of the winning concepts here, because the cost is pretty low, the reliability is good and the power ratio chosen for the series is quite well suited to the 2-litre turbocharged engines,' Sakowicz adds.

While proud of the engine package, Sakowicz also believes that the MoTeC electronic system could be one of the strongest in the international TCR field. 'We have huge experience with that,' he says. 'It has many applications for OEM projects for works engines and being a MoTeC distributor, that suits us quite well. We're very happy with the engine.'

STARD has applied a slightly different approach to transmission selection, by allowing the option of two separate gearbox units. 'We have chosen Xtrac as one option,' Sakowicz says. 'We have a very good cooperation with that company in other projects. We believe that Xtrac is the market leader in transmissions and we wanted to offer customers the best in transmissions, that is unique in TCR – nobody else is offering an Xtrac package, so I think that is something quite good.

'On the other hand, we have the 3Mo gearbox, which, I can say after testing, is a fantastic product. It is definitely [cheaper] than the Xtrac. Based on this we do expect some more maintenance and more service on the 3Mo package, but on the other hand it is a very good choice for customers who don't want to spend every extra euro they might have in their budget [on a gearbox].'

The shifting system, as required by the regulations, is an electro-mechanical one for

TECH SPEC

Kia Cee'd TCR

Body: Reinforced and lightened steel bodyshell; carbon fibre aero bodykit; 25CrMo4 FIA homologated safety cell

Engine: Kia Theta II 2-litre turbo 4-cylinder engine mounted transversely; four valves per cylinder; direct injection. Power: 350bhp at 6400rpm. Torque: 440Nm at 1970-4720rpm. Bore x stroke: 86mm x 86mm. Wet sump with baffle kit; Motec M142 engine management

Transmission: 6-Speed racing paddle shift gearbox (Xtrac or 3Mo, customer choice); electromagnetic gearshift actuator; paddle shift Integrated into Motec M142 ECU; downshift throttle blip.
Multi-disc limited slip differential

Suspension: Front – MBS-optimised McPherson KW Suspension Dampers; CNC machined aluminium hub carrier; 2-way adjustable damper' adjustable ride height; adjustable stabiliser bar.
Rear – MBS-optimised multi-link suspension; KW Suspension Dampers; CNC machined aluminium hub carrier adapter; 2-way adjustable damper; adjustable ride height; adjustable stabiliser bar

Wheels: OZ Racing STARD 18x10in WTCC spec

Brakes: Position adjustable Tilton pedal box with balancer bar.
Front brake – AP Racing 6 piston Radical 5000R aluminium belled discs 378 x 36mm. Rear brake AP Racing 2 piston aluminium belled discs 280 x 9.65mm

Dimensions: Length: 4651mm. Width: 1950mm.
Height: 1430mm. Wheelbase: 2672mm

Weight : 1145kg (dry)

Fuel tank: ATL Ft3 100L FIA safety fuel tank

'The car has been completely developed on computer and every single part has been designed in CAD'

Aero development focused more on drag reduction and efficiency rather than the package of aero add-ons allowed in TCR

both gearboxes, so even with two different gearbox packages, the shifting actuation principle remains the same. Both gearboxes are 6-speed and are paddle-shift operated.

Multi disc diff

The differential is a multi-disc limited slip item with ramps for coast and drive with different settings. Adjustments can be pre-loaded, removing the need to move the differential cassette to adjust the preload. 'It's pretty good, because in racing conditions during free practice, you can save a lot of time changing the differential set-up, and not lose time by needing to take it out,' Sakowicz says.

The Cee'd is operated by an M142 direct injection ready MoTeC ECU, which includes a paddle shift system. Sakowicz is delighted with this package as – unlike systems in other TCR machines, he says – the M142 offers synchronicity between the engine operation and the shifting system that is integrated into the ECU. As well as this, the Cee'd also contains a MoTeC C127 seven-inch coloured dashboard, with a powerful data logger as standard.

'We have a driver interface, which is integrated into the steering wheel with movable steering wheel hubs, so there is a lot of possibility for the driver to interact with the electronic system by means of interactive feedback through the display with pop-up messages for the setting for the speed limiter for different races; virtual safety car, for example.

'We have unique adjustment possibility of the driver display, because we found in the past that you never find the perfect position for the display, so that every driver sees it – whether they're tall or not so tall. Therefore we can mount it in various conditions to make sure that it is clear in the cut-out of the steering wheel and that everyone can see that,' Sakowicz says.

The dashboard also has an intelligent warning system, which warns the driver in case of any dangerous or potentially dangerous situations, with various LEDs. The integrated shift lights are mounted on the dashboard, just below the sight line of the driver.

'The customers that have purchased cars are pretty convinced that we have hit the spot quite well'

Solid state

The power box, also from MoTeC, has a solid-state relay, negating the need for mechanical fuses or relays. 'If it shuts down, it can be diagnosed and restarted. All those systems communicate with each other, so we have one comprehensive logging file, which includes all the vital diagnostic performance information of the engine, the chassis and everything else.'

As per the regulations, the Cee'd TCR uses the same suspension concept as the road car. At the front it runs with MacPherson dampers with triangle arms on the bottom, while on the rear there is a multi-link suspension.

Following much testing, STARD chose KW Suspensions from Germany to provide the materials. 'In addition to supplying a fantastic product by itself, [KW Suspensions] was incredibly supportive during the development process with dyno testing, on-track testing and supporting us with our simulation work with our MBS models, which we used for the suspension optimisation. We are really happy about the cooperation of KW and that is why we have chosen to work with them.'

The Cee'd makes use of adjustable stabiliser bars on the front and rear, with different thicknesses. The racecar also uses unique hub carriers for the left and right side rather than having one that fits both sides. Sakowicz says that, 'this was done mainly to optimise the weight and stiffness to the maximum level possible.' The triangle arms were constructed with 15CDV6 aerospace steel, as used in the WTCC and World Rally, and they include machined housings for uniball bearings.

Brake time

The Cee'd uses AP Racing's 5000R Radical calipers – similar brakes to other TCR entrants. But it differs on the rear of the car, where it has: 'underslung calipers, which means they are lying on the bottom, resulting in a lower centre of gravity. Also, we have aluminium bells on the rear, so that means we have lower weight on the unsprung half and lower weight on the rotational inner shaft.'

Naturally, STARD has created a comprehensive support programme to work alongside the customer teams. 'In addition to our usual technician support with engineers on site … we also supply the possibility for specific technician training in-house,' says Sakowicz. 'That includes mechanic training, which [entails] joining the build of their individual cars and receiving special introduction and information on the car, on the build-up and the servicing.'

As part of the package, STARD also offers cloud-based on-track lap time simulation via an Austrian partner, AVL Racing. 'They cooperate with us on the so-called 'sim-book', which is a cloud-based simulation tool. We have worked out with them all the various possibilities of settings for this car in the cloud, ready for download. This means the customers on the race track can immediately, for the given race circuit, try different settings and see the results, rather than having to wait until the computer calculates it.'

While not divulging detailed information regarding the simulator, Sakowicz did confirm that it utilises the same physical set-up as the Cee'd touring car with the seats, pedal box and steering position used. 'It's not just a simulator with a computer and game steering, but a proper built-up chassis on multi-post movable hydraulic struts, which completely copies the real TCR cockpits, especially the steering and brakes, their feeling and forces.'

For Sakowicz, the objective of the Kia Cee'd TCR programme is clear. 'Our expectations are to be competitive from the start; to have a number of high profile projects in the most interesting TCR series in the world, and to show that Kia-based racecars, and therefore Kia technology, is absolutely on a world top-level in terms of performance and technology.'

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Fun size

The Dome Cheetah is small in stature but promises to be big on thrills. It's also been created by one of Japan's most respected racecar constructors …

By SAM COLLINS

Go to a Formula Student event anywhere in the world and you will likely see groups of nervous students who have to present a business pitch to a panel of industry experts. The aim of this exercise is to show a serious business case for the production and sale of an FSAE rules style car for the amateur weekend racer. It's always been something a theoretical exercise as, aside from a very small number of American autocross cars, no company has ever seriously built and marketed such a product.

Until now, that is. Dome, the Japanese constructor best known for its Le Mans Prototypes, has created what it calls 'Micro Formula' racers, and the first of this new class of competition car is the Dome Cheetah.

'Our President, Takahashi-san [Takuya Takahashi] likes these small competition cars; he bought a Legends racecar in the USA and really liked that concept,' explains Takuya Nakamura, chief designer at Dome. 'Then he met with Manabu 'Max' Orido, who is well-known in Japan not just as a racing driver but as a drifter, and the idea was formed.'

Pleasure Dome

The design concept for the Cheetah was almost exactly that of the Formula Student business presentation: a low cost car designed for amateur drivers to have fun in, and this approach led to some design trade-offs. 'It was all about creating a low cost easy to maintain car and that meant that we could not use a composite chassis,' Nakamura says. 'The cost of a composite chassis was just unrealistic for this project even with high volumes. A car like this has to be cheap and even with our Uova [a low cost coreless monocoque] technique we could not make the car affordable if we used a composite chassis. Some of the bodywork is composite of course, the side panel for example.'

Wild cat

The size of the Cheetah is very similar to that of a Formula Student car, but a quick look at the type of tubing used and the weight of the car (around 320kg) shows that its construction is rather more robust than most of the cars seen dodging cones at Silverstone.

'For Formula SAE there are quite a few restrictions but this car was completely free of them so while it looks similar and the concept is similar, this one has things that SAE cars cannot have, but also it can do things that Formula Student cars cannot do,' Nakamura says.

'Formula SAE is about cars running against the clock on specially designed courses, so they are not built to the same safety standards as this car,' Nakamura adds. 'This car is able to race wheel to wheel on a full track as it meets the proper safety standards, so you will see that the driver's feet are behind the centre line of the front axle. But the small size carries over, it

The Cheetah is a low cost car designed for amateur drivers to have fun in

The Cheetah features double wishbone front suspension; front uprights are from the Dome F4 car. It also uses AVO dampers. The robust spaceframe is made from tubular steel and the little racecar weighs in at 320kg

It packs a Honda 650cc engine at present, which gives around 80bhp, but Dome says it should be possible to fit a larger unit

makes it fun to drive and really user-friendly. You can just wheel this into the back of a van, you do not even need a trailer.'

In an attempt to keep design costs down, the Dome engineers raided their not insubstantial storeroom to see what could be adapted for use on the new car, and a number of mounting points and other small machined components have carried over from the Dome F110 FIA F4 car, including the entire front upright. At the rear, however, the uprights are bespoke due to the slightly unusual demand of the first Cheetah customer, Orido himself.

'The rear upright had to be bespoke as we had to mount the standard motorcycle components [and had] to accommodate a handbrake. That also means that we had to use a standard production rear brake caliper. Orido-san was a key driving force behind this car, he is a bit of a drifting expert, so he insisted that we fit the car with a handbrake, for him it was such an important thing. But I think he has seen an opportunity in the market, the car is designed so that drivers can learn drift driving using the three foot pedals and the handbrake, as well as learning slide control training in the best way. The car is meant to be fun and easy to drive, maybe all of the staff at Dome will get to drive it, that is the aim,' Nakamura says.

Cat's cradle

The first Cheetahs produced have been fitted with a water-cooled Honda RC86E motorcycle engine mated to a 6-speed transmission. The engine gives about 80bhp in standard trim, but Nakamura makes it clear there is more to come. 'We chose that because it is compact, readily available, and we can carry over much of the electronic system. But the chassis is easily adaptable to other engines, bigger ones too,' he says, in such a way as to suggest that a more powerful version is already in development.

It is noticeable that there is very little bodywork on the Cheetah; just side panels, a very basic nose and front section, and most of the chassis and mechanical parts are exposed. However, this was deliberate, according to the car's creators. 'We wanted to keep it simple, not just for cost but for when customers come we can offer them upgrades, or maybe they can develop their own bodies,' Nakamura says. 'We will develop better bodies but we have designed the car in a way that it has a large degree of freedom, so owners can modify or tune the chassis and develop their own bodies, that way they can enjoy designing their own Cheetah as well as driving it.'

Cheetahs prosper

The final part of the puzzle with the Cheetah is where many students fall down in the business presentation at Formula Student events – the price. Dome has yet to finalise the exact retail price, but it will certainly be less than many strong Formula Student teams spend on building their cars each year. 'The final price is not known. Some of the volumes and exact part specification is not known, and in the UK where some parts come from the currency is a little strange at the moment,' Nakamura says. 'But the price will be very cheap, there is already quite a lot of interest from customers. We have seen a lot of interest from kart tracks wanting something new to offer its customers as well as full size circuits looking for a new type of track car. It is something different.

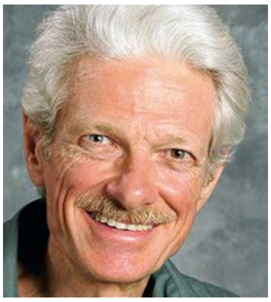
'There is more to come from this project too, things we have not yet announced, but this Cheetah project is not just about providing and selling a chassis,' Nakamura adds. 'We are planning to propose [new ways] to create fun – races, trials, driving lessons, or rental driving, available with cooperation with amusement facilities. We are also planning to introduce some new ways of having fun.'

With the Cheetah now commercially available, and when its versatility and low cost is proven, it could make some questions for students a lot easier to answer – but it will also make some design choices made by many a lot harder to justify.

TECH SPEC

Dome Cheetah
Class: Micro Formula
Chassis: Tubular steel
Power unit: Honda RC83E, Water-cooled; 4-stroke; DOHC; 4-valve; 4-cylinder; 648cc.Max power: 83PS at 9500rpm. Maximum torque: 6.4kg/f at 8000rpm.
Transmission: constant-mesh 6-speed return (without reverse), wet multi-plate clutch coil spring.
Fuel capacity: 15 litres.
Steering: Rack and pinion (without assist).
Suspension: front/rear – double wishbone; AVO dampers
Tyre size: front 185/55R15; rear 185/55R15
Brakes type: Hydraulic single disc front and rear
Dimensions: length: 2600mm; width:1200mm; height:1100mm; wheelbase: 1800mm. Minimum clearance: over 40mm
Weight: less than 320kg (empty).

'You can just wheel this into the back of a van, you do not need a trailer'



Cheap and rig-less kinematics testing

The practicalities of testing K&C in your own workshop

QUESTION

Do you have experience with suspension compliance and the home made measurement of it? Is it possible in workshop conditions?

I think it might be good for a quick estimate of data, or for finding some potential problems.

For example: the car stays on the ground and you laterally pull up to the tyre and then measure wheel alignment deviation, perhaps?

THE CONSULTANT

I think probably low-cost compliance testing would be difficult (though Ricardo Divila might disagree, see page 74, *Ed*). At least, it would be hard to do accurately. Compliance testing involves holding the car in place very rigidly, and then applying large forces at the contact patches. These forces have to be precisely measured, and the fairly small deflections that result must also be precisely measured. This demands a large, robust, and complex mechanism. In fact, compliance testing is actually the expensive part of K&C (kinematics and compliance) testing.

Finger-licking K&C

Low-cost kinematics testing, on the other hand, could have possibilities. It should be possible to devise something a bit like a bump-steer gauge that would measure lateral and longitudinal displacement at the contact patch as the wheel is displaced vertically by measured increments, and also measure angular motion of the wheel in front and side view (camber change, and wheel rotation or caster change).

This would then tell us front and side view swing arm length. Swing arm length would be 180/π, or 57.3, divided by angular displacement in degrees per unit of vertical displacement. For example, if we measure one degree of camber change per inch of vertical travel, we know the front view swing arm is 57.3 inches long (measured horizontally). If we measure half a degree per inch, the front view swing arm length is 114.6 inches.

We would also know jacking coefficients, or force line slopes. The force line is perpendicular to the contact patch motion path. The force line rises (or drops) the same amount per inch of horizontal run as the contact patch moves horizontally per inch of vertical motion. For example, if the contact patch moves a tenth of an inch horizontally per inch of vertical motion, the force line has a slope of one in ten, and the system generates one pound of jacking force for each 10 pounds of ground plane force.

Rig for victory

If we know the slope of the force line and the horizontal length of the swing arm, we know the height of the force line at that distance from the contact patch centre. That gives us the coordinates of the front view or side view instant centre. This can then be used as a check on results obtained by other means, or even a substitute for results obtained by other means.

By itself, even a good K&C rig can only tell us how much compliance we're getting at each wheel. In most cases, what we would really like to know is not only how much compliance we have overall, but also where it is occurring. For that, we need to instrument the racecar with sensitive displacement pots, digital indicators, and/or proximity sensors at locations where we suspect deflection is likely to occur.

In some cases we can improvise simple mechanical deflection recorders using clay or tie wraps on sliders that will record maximum displacement at a particular location. We can also do this and simply run the car.

The advantage of testing on a K&C rig is that we can more accurately repeat the loading conditions, and we are somewhat better able to observe the racecar visually.

But if we just want to know what's deflecting so that we can stiffen it up, instrumenting the car and driving it will often give us enough information for that.

A kinematics and compliance rig is a very expensive piece of kit but there are some lower cost alternatives

It should be possible to devise something, a bit like a bump-steer gauge, that would measure lateral and longitudinal displacement at the contact patch

How to get a stable aero platform

Does separating springing and damping for ride and role help with aero performance?

QUESTION

I have been planning for a high downforce set-up on a fast sports racer. My aero guy stresses the importance of a stable platform. We have too much dive and roll right now.

We're considering a set-up using a heave spring (like a typical third spring) and a roll bar (damped) only. The third spring (not really a third spring in this case) has zero roll resistance as typical. My expectation is that the car could be stiff in roll and heave, but allow good compliance on one wheel bump (like running over kerbs). I am thinking about this on the front only. What are your thoughts on this?

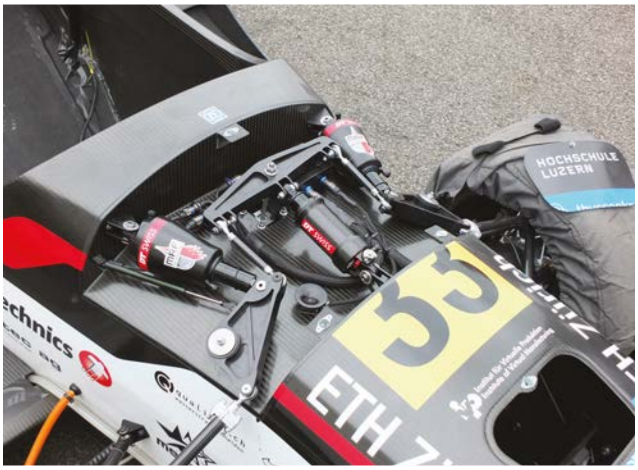
THE CONSULTANT

There seems to be a lot of interest in this idea lately. I plan to write a feature article for this magazine soon about three systems that use separate springs and dampers for synchronous and oppositional wheel motion. One of these is from Porsche, another from Audi, and the third from a consulting client of mine in Sweden. There have also been a number of Formula SAE/Formula Student cars sporting such systems recently.

First, a bit about terminology. It appears that Porsche and Audi and some FSAE teams are using the term *heave* to denote synchronous motion of a front or rear wheel pair. I have been interested in interconnective suspension systems for over three decades and I use the term to denote synchronous motion of all four wheels of a car. This comes from the nomenclature that Lotus used for the four possible modes of a four-wheel system when they were developing control strategies for their fully active suspension systems in the 1970s. I use the term *ride* to denote synchronous motion of a front or rear wheel pair. Heave, then, is synchronous ride at the front and rear, and pitch is oppositional ride at the front and rear. Roll is oppositional motion of right and left wheels, either at one end or both ends synchronously. And finally, warp is roll at both ends oppositionally, or the synchronous motion of diagonally opposite wheel pairs in opposite directions.

Anyway, do we get anything from having separate springing and damping for synchronous and oppositional motion of a front or rear wheel pair? Maybe we do. Just in terms of springing, if everything is linear, it doesn't matter. That is, suppose we have a simple independent suspension with no anti-roll bar and a constant 100lb/in wheel rate. If instead of that we have a system with a ride or heave spring that gives a 100 pound per inch per wheel force change in synchronous motion only, and a roll spring that gives a 100 pound per inch per wheel force change in oppositional motion only, is there any difference between these two systems in any situation? No, there isn't. The tyre loads are the same either way in all situations.

The best way to exploit this is to keep the wheel rate in the roll mode fairly constant



Third element suspension systems, as used on this Formula Student project, feature a heave spring to support the aerodynamic loads acting on the car

Roll with it

If we add an anti-roll bar to the conventional suspension that resists only oppositional motion with a force of 100 pounds per inch per wheel, and we compare that to a separately sprung system with a 100 pound per inch per wheel ride spring and a 200 pound per inch per wheel roll spring, is there then any difference? Again, no.

However, with separate springing and damping of the two modes, we can have different damping characteristics and different rising rate characteristics for the two modes, and we can more easily tailor these separately. The best way to exploit this possibility is to keep the wheel rate in the roll mode fairly constant, while providing a pronounced rising-rate effect in the ride springing, much as we typically do with a third spring system. Additionally, we may wish to have more low-speed damping in roll at the rear than at the front. With separate damping for the roll mode, we can do that without affecting damping for synchronous wheel motion.

We have so far considered only the possibilities of separating the ride and roll springing when there is no front/rear interconnection. But where things really get really interesting is when we begin to consider the possibilities of interconnecting the front and rear.

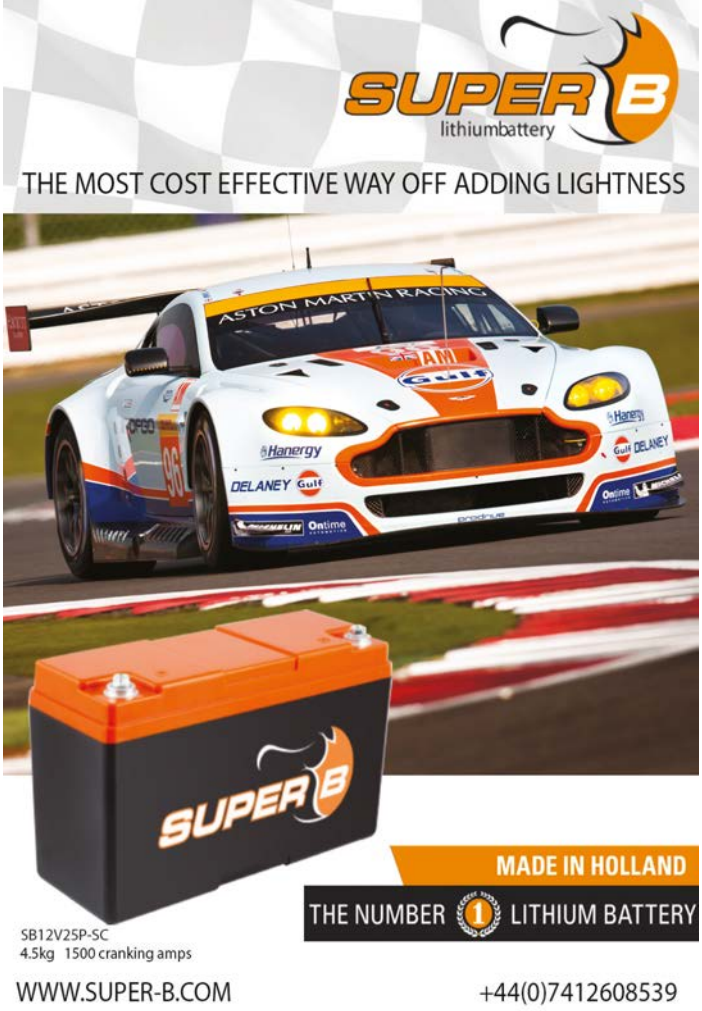
Connectivity

Any spring device that interconnects two wheels – an anti-roll bar, a Z bar, a third spring – resists two of the four modes. Anti-roll bars resist roll and warp. Third springs resist heave and pitch. But if we interconnect interconnective springs, we can resist a single mode. If we hydraulically interconnect anti-roll springs, we can make them resist roll and not warp – or, if desired, warp and not roll. If we interconnect heave or ride springs, we can make them resist pitch and not heave, or resist heave and not pitch. If we interconnect interconnective dampers, we can put accumulators in the lines and make the system resist two modes but with different rates.

But, returning to the original question, having dedicated springs for ride and roll only at the front does offer some possibilities. However, to really get a serious pay-off for riding kerbs we should consider having such systems at both ends of the car and interconnecting the roll dampers to create a system that is soft in warp.

CONTACT

Mark Ortiz Automotive is a chassis consultancy service primarily serving oval track and road racers. Here Mark answers your chassis set-up and handling queries. If you have a question for him, get in touch.
E: markortizauto@windstream.net
T: +1 704-933-8876
A: Mark Ortiz
155 Wankel Drive, Kannapolis
NC 28083-8200, USA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BMW endurance racer aero study

A potent 1 Series BMW gets the MIRA wind tunnel treatment

The Saxon Motorsport-prepared BMW 1 Series racer that's the subject of this study is being used in a race tyre development project by Singapore headquartered Giti Tires. The company has European R&D facilities at Hannover, Germany, and also on the MIRA UK site, a stone's throw from the full-scale wind tunnel used by *Racecar Engineering* for our Aerobytes features.

When Giti Tires decided to dip its toe in motorsport's waters the challenge of the Nurburgring 24 Hours proved irresistible, but first it had to go through the permit qualification process to be allowed to compete with its intended V10 petrol engine. This involved running for three races with a 2-litre engine, with approximately 250bhp, rather than the 500bhp V10 engine now installed.

Half the horsepower focussed minds on drag, and part of the reason for conducting this wind tunnel test was to see how drag changed at different downforce levels. The Giti Tires/Saxon Motorsport team is also targeting other Endurance categories, including Dutch Supercars and Britcar, which have different rules for wing overhang and splitter length, so these and many other parameters were examined in a session that was very well-executed by the Saxon Motorsport team.

The baseline

As always, curiosity was high as the car was set up for its first wind tunnel run. On-track impressions implied it was short of front end downforce but, beyond that, information was sparse. **Table 1** shows the first run data compared with what transpired to be the best set-up found on the day from 'configuration 19' (of 26 configurations achieved by the team in the four-hour session). Differences are given as Δ (delta) values in counts, where one count is a coefficient change of 0.001.

Looking first at the baseline numbers we see that the car had moderate drag, and total downforce was significantly greater than, say, a BTCC car. For comparison, the baseline –CL value of the BTCC Subaru Levorg featured in our September 2016 issue (V26N9) was 0.200, and the cars' frontal areas were quite close so the –CL comparisons are reasonably valid. However, the Levorg was closer to being balanced than the BMW was on its first run, and the front downforce gains that achieved the improved better balance saw the BMW downforce significantly higher than the BTCC levels of downforce.

Another downforce comparison could be made with the Ferrari F430 Scuderia GT3 we tested in 2010, which baselined with a well-balanced 42.4 per cent front, a –CL value of 0.821 and –L/D of 1.58. So the BMW fell roughly halfway between a BTCC car and a GT3 car on total, reasonably well-balanced, downforce.

The initial ~26 per cent front value on the BMW vindicated the on-track impression of a shortage of front downforce, and given that the car's static weight distribution was around 53 per cent front, the need for more front downforce was a priority. We shall analyse where the front end gains came from shortly, but one of the interesting things about adding front downforce by the usual methods is that drag is rarely much affected. The Δ per cent values in **Table 1's** bottom row illustrate this point, with total downforce increasing by 43.5 per cent but drag increased by only 3.0 per cent. At 100mph this would amount to a difference of just 1.7bhp in drag horsepower for a much better balanced car. The story is rather different when adding rear downforce via wing adjustments, but we'll come back to that in next month's issue.

Forward movements

One of the simplest ways of adding front downforce to a car with a splitter is to add vertical fences to the ends and seal them to

Table 1: The baseline data compared with the optimised data from later in the wind tunnel session

	CD	-CL	-CLf	-CLr	%front	-L/D
Baseline	0.469	0.345	0.089	0.256	25.69%	0.735
Optimised	0.483	0.495	0.224	0.272	45.15%	1.026
Δ, counts	+14	+150	+135	+16	+19.46%*	+291
Δ, percent	+3.0%	+43.5%	+151.7%	+6.25%	-	+39.6%

*Absolute rather than relative difference in percentage front

The Giti Tires development mule – a Saxon Motorsport-prepared BMW 1 Series endurance racer

The small splitter end fences achieved good forwards balance shift

Table 2: The effect of splitter end fences

	ΔCD	Δ-CL	Δ-CLf	Δ-CLr	Δ%front*	Δ-L/D
Small fences	+11	+16	+23	-7	+4.68%	+16
Large fences	+34	+9	+27	-17	+6.24%	-33

*Absolute rather than relative difference in percentage front

Table 3: The effect of taping up front end gaps

	ΔCD	Δ-CL	Δ-CLf	Δ-CLr	Δ%front*	Δ-L/D
After taping	-5	+8	+22	-13	+4.71%	+24

*Absolute rather than relative difference in percentage front

The large splitter end fences were not as successful as the smaller examples when tested

That old Aerobytes favourite, race tape, once again proved its aerodynamic value

Extending the splitter worked well, effectively adding over 100 counts of front downforce

Table 4: The effects of extending the splitter

	ΔCD	Δ-CL	Δ-CLf	Δ-CLr	Δ%front*	Δ-L/D
Longer splitter	-30	+65	+77	-11	+10.92%*	+189

*Absolute rather than relative difference in percentage front

The BMW fell roughly halfway between a BTCC car and a GT3 car on total, reasonably well-balanced, downforce

the front wheel arches. Two sizes of fence had been prepared for that purpose, small and large, and the data are shown in **Table 2** as delta values in counts relative to the session's previous configuration (not the baseline).

Both sizes of fence achieved useful forwards balance shifts but very different overall effects. The small fences were not exactly 'efficient', with a total downforce to drag contribution ratio of 16/11 (1.45), but they did achieve three-quarters of the forwards balance shift for a third of the drag increase of the large fences; less than half the rear downforce reduction; and increased, rather than decreased, the –L/D value. Development would focus at the smaller end of the fence spectrum, then.

Usually an afterthought, taping up gaps at the front end was carried out early in this session. In this case, gaps around the cooling ducting, headlight housings and the gap between the rear of the bonnet and base of the windscreen were taped up, with the results in **Table 3**. A further very useful forwards balance shift was achieved with this cheapest of modifications, with 22 counts more front downforce for five counts less drag.

The 13 count rear downforce reduction was larger than expected, and may have stemmed from increased mass flow over the roof generating more lift there.

Splitter extension

Later in the session the large splitter end fences were removed and a 100mm extension was added to the splitter, this in response to the longer splitter allowed in some of the categories the car competes in.

Table 4 illustrates the changes compared to the nearest equivalent configuration, which included the tall splitter fences.

Adding the splitter extension had a potent effect, producing the results of the 'optimised' run shown in **Table 1**, that is, with balance at over 45 per cent front. **Table 2** showed that the large splitter fences added 34 counts of drag, so their removal here largely accounts for the drag reduction. The fences also added 27 counts of front downforce, so the splitter extension effectively added over 100 counts of front downforce to get a net front end gain of 77 counts. Splitters are our friends.

Next month we'll see that drag is much more affected by some mods at the rear.

Thanks to Martin Gibson at Giti Tires Europe and Nick Barrow, Jon Taylor and all of the team at Saxon Motorsport.

CONTACT

Simon McBeath offers aerodynamic advisory services under his own brand of SM Aerotechniques – www.sm-aerotechniques.co.uk.
In these pages he uses data from MIRA to discuss common aerodynamic issues faced by racecar engineers

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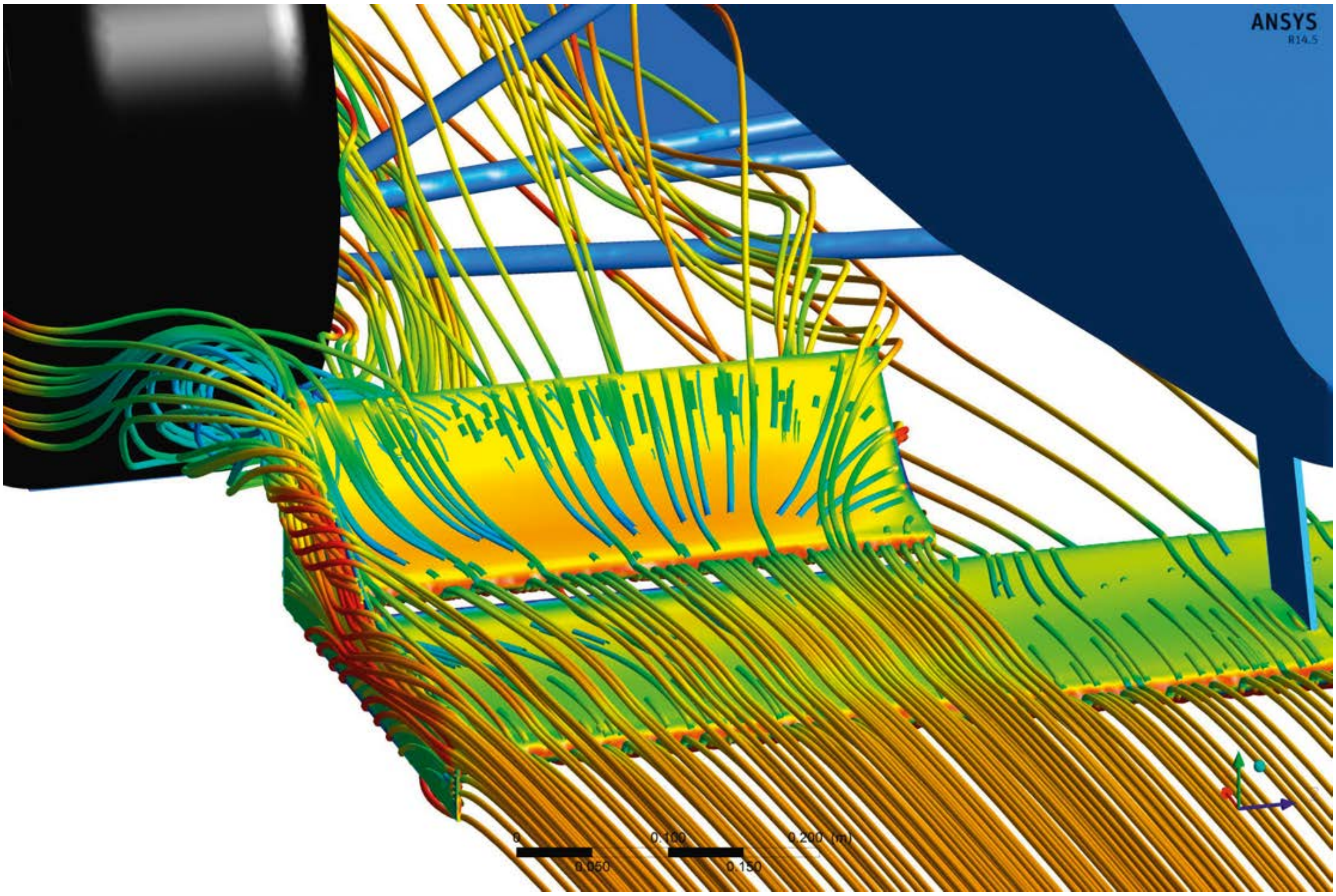
A HORIBA COMPANY MIRA

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

The **end game**

Front wing end plates on high end single seaters are intricate and complex but much can be learned by examining the flows around some simpler devices

By SIMON McBEATH



The complexity of front wings and their end plates on Formula 1 cars is pretty bewildering, and certainly beyond the capability of those of us operating from our humble home workshops to manufacture, let alone design in the first instance.

Furthermore, the design solutions we see in the top echelons are specific to the prevailing technical regulations and are not necessarily generally applicable to other categories. And it is also readily apparent from the wide variation in designs that there is no single definitive solution for a front wing end plate, although there may be some generic aspects we can learn from. So, with the benefit of ANSYS CFD-Flo and our oft-seen basic single seater CAD model, this feature will look at some of the basics of front wing end plates to visualise what they do, and to see what the extent of their effects might be.

The CAD model used for this feature (**CAD 1**) may be familiar to regular readers, and was last used in a rear wing study in our November 2016 (V26N11) issue. More relevantly, we ran a feature on Front Wing Fundamentals in our April 2014 (V24N4) issue. In that we examined the basics of single- and dual-element front wing deployment in isolation and on our single seater model, covering the topics of ground clearance, span, flap span, the wing's fore/aft position and a brief look at the effects of alternative end plate configurations. This feature then is a follow up to that project.

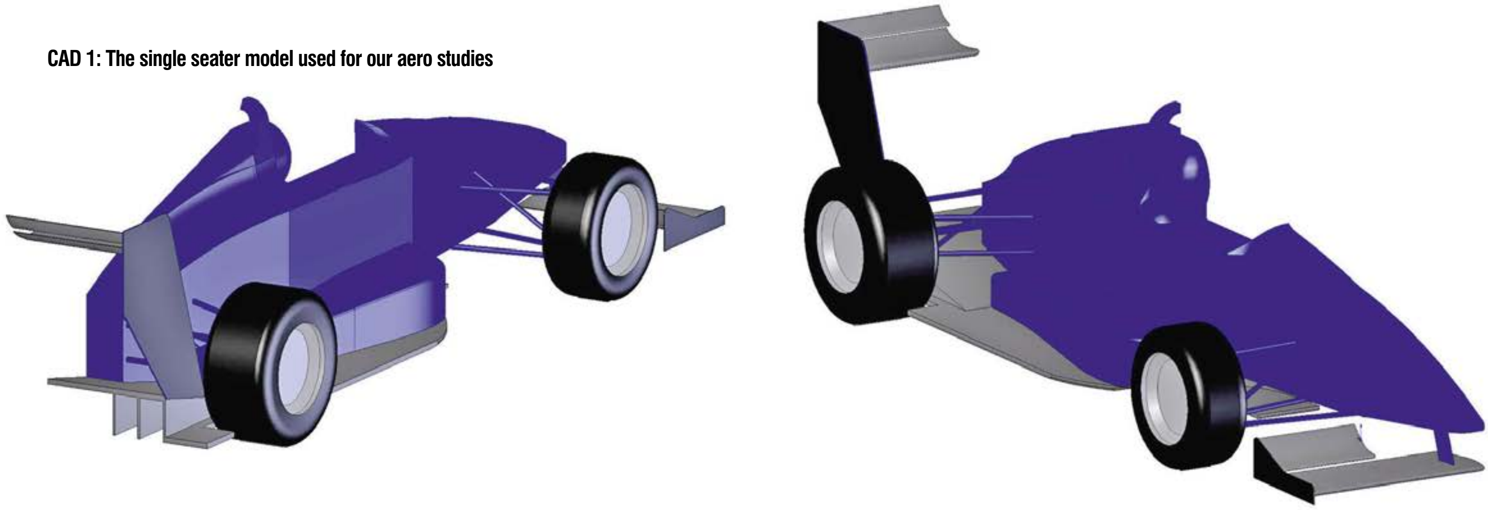
The model used as our current basis is just as it was in the November 2016 rear wing study, and that differed principally from the one used in our original front wing feature in 2014 by having a nominally 1-metre span dual-element rear wing rather than the 2014 model's UK hillclimb specification 1.4-metre span rear wing, although the maximum height of 900mm above the ground plane was retained. There were other differences too, and the current model featured a flat underside between the front and rear wheels, a V-divider and tea tray splitter in the forward underbody, and a simple rear diffuser with its transition from the flat floor in line with the front of the rear wheels, and ground clearance was set at 40mm. Thus, the model respected the typical regulations found in many series.

CFD runs were done as usual at 100mph air and ground speeds, with rotating wheels. Meshing included refinements on the wings and wheels to improve the simulation of flow separations on those components. The k-epsilon turbulence model was used, and simulations were run until forces on key components were deemed to be steady.

Span filter

Our 2014 front wing feature showed how, rather unsurprisingly, front downforce increased with increased front wing span on our single seater

CAD 1: The single seater model used for our aero studies



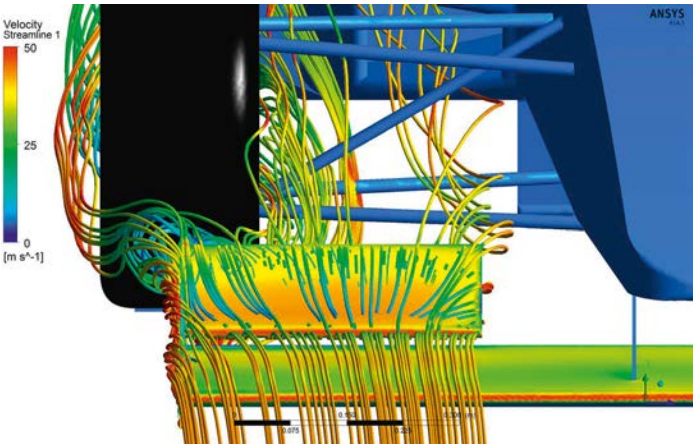


Figure 1: This shows streamlines (coloured by velocity) projected upwind and downwind from the end plate and flap of our baseline 1400mm span dual element front wing

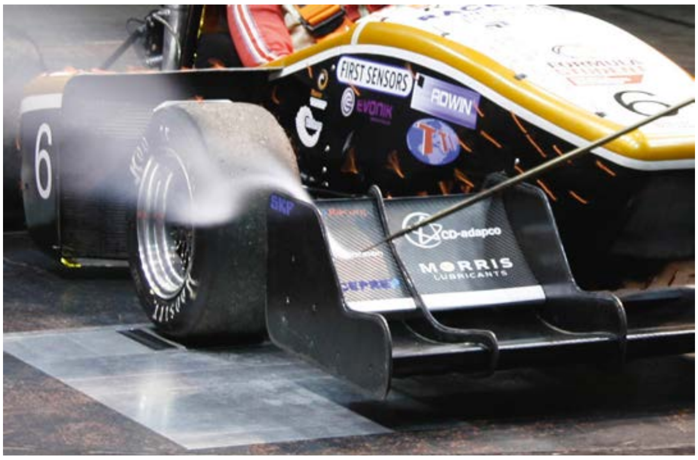


Photo 1: Here the smoke plume shows upper tip vortex passing outboard of the front wheel on the Hertfordshire Formula Student car in the MIRA wind tunnel back in 2013

Photo 2: Lower tip vortex passes under the end plate and inboard of the front wheel

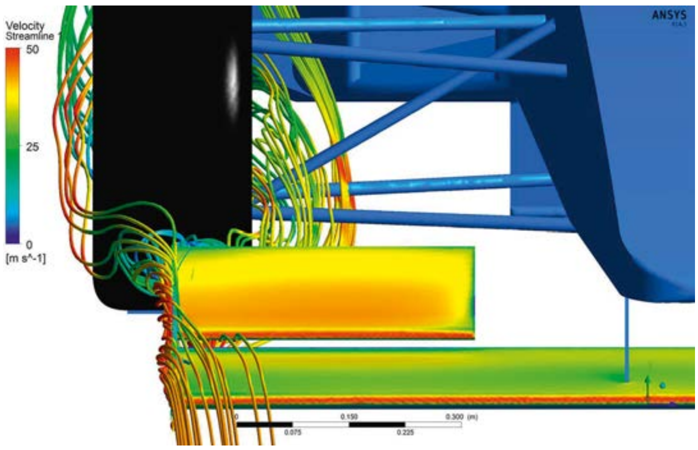


Figure 2: Streamlines from the end plate only show the split around the front wheel

model, and that the aerodynamic balance shifted forwards as a result. For this first exercise three different spans were again evaluated: 1615mm equated to the maximum width of the car (analogous to the full width 1800mm span front wing on F1 cars from 2009-13); 1400mm effectively terminated the front wing in front of the centre of the front wheels; and 1200mm terminated the front wing in line with the inside edge of the front wheels. In each case the inboard end of the front wing flap was kept at the same location (actually on a plane 297mm from the car's centreline, at 'y=297mm' using international convention (or z=297mm using the McBeath convention), and the flap's span was then set to terminate level with the relevant main element's outer end before a simple end plate was then attached.

The principal objective here was to examine the flows from the front wing and the end plate to see how they encountered and passed around the front wheels. Looking first then at **Figure 1**, this shows streamlines (coloured by velocity) projected upwind and downwind from the end plate and the front flap of the 1400mm span wing. Outboard, air from the top of the end plate, which formed the upper tip vortex, passed outside the front wheel, while air from the bottom of the end plate, which formed the lower tip vortex, passed inside the front wheel.

These same phenomena can be seen in **Photos 1** and **2** on the front wing of the University of Hertfordshire's Formula Student car in the MIRA wind tunnel in 2013, and have been evident on some (but not all) of the other single seaters we have tested in the wind tunnel for our Aerobytes series. Further inboard, the vortex at the inner end of the flap (the 'Y297' vortex in our case) is also very evident. **Figures 2** and **3** respectively show the streamlines from the end plate and from the flap in isolation. The keen eyed reader will have spotted something going on under the outboard section of the flap, and **Figure 4** from an alternative angle reveals all. The outer end of the flap had actually stalled, which seemed to be associated with the downwash of

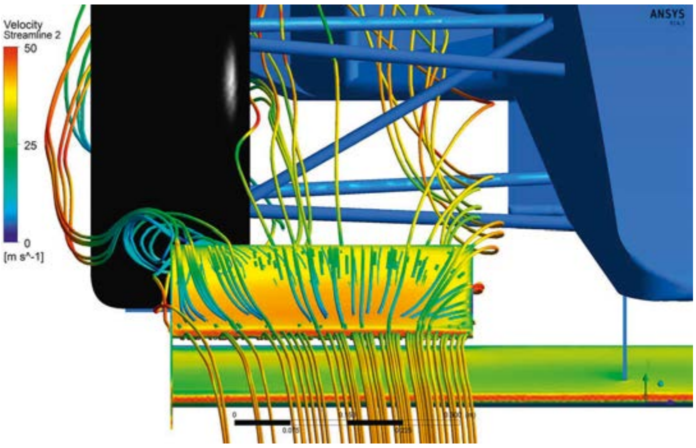


Figure 3: Streamlines from the flap shown in isolation reveal more detail, including the 'Y297' vortex at the inboard end of the flap

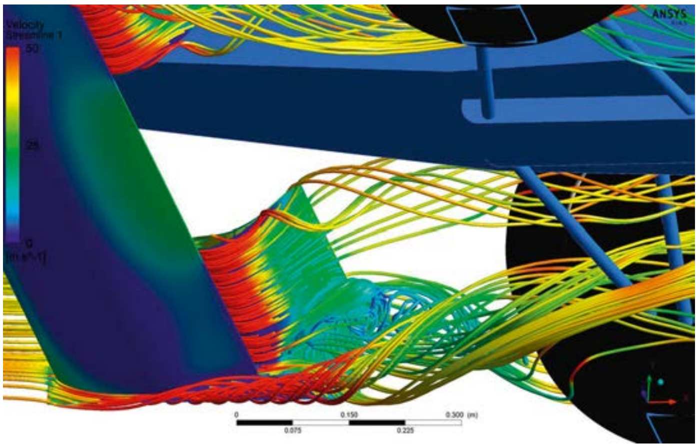


Figure 4: Viewed from underneath, stall at the outer end of the flap was visible. This seemed to be associated with the downwash of the outer side of the lower tip vortex

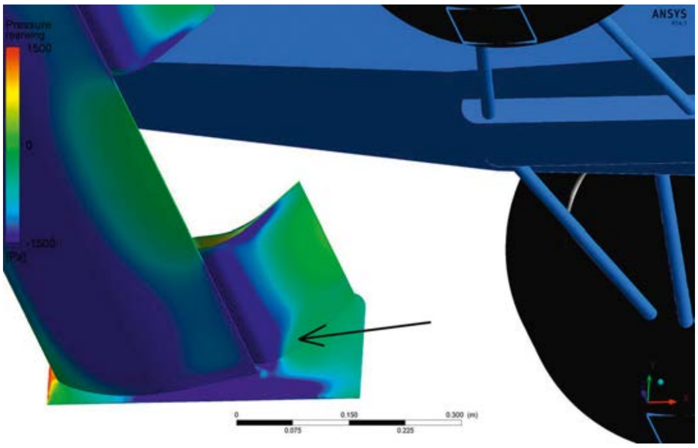


Figure 5: With the streamlines turned off the 'dent' in the flap's low pressure region which was caused by the stall, arrowed in the image above, was visible

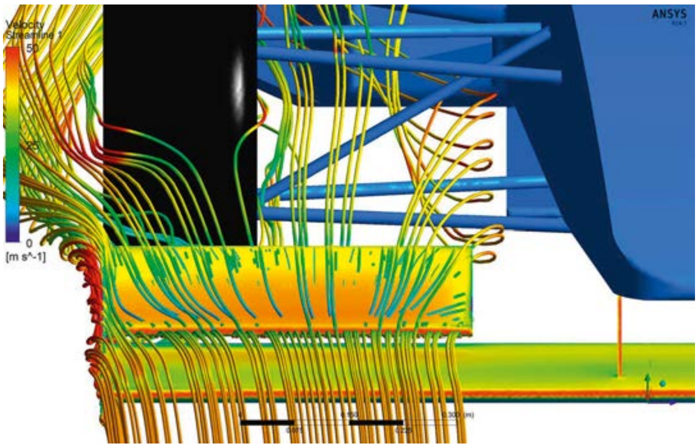


Figure 6: The full width front wing (this was 1615mm rather than the 1400mm span shown in Figure 1) caused far more of the flow to pass outboard of the front wheel

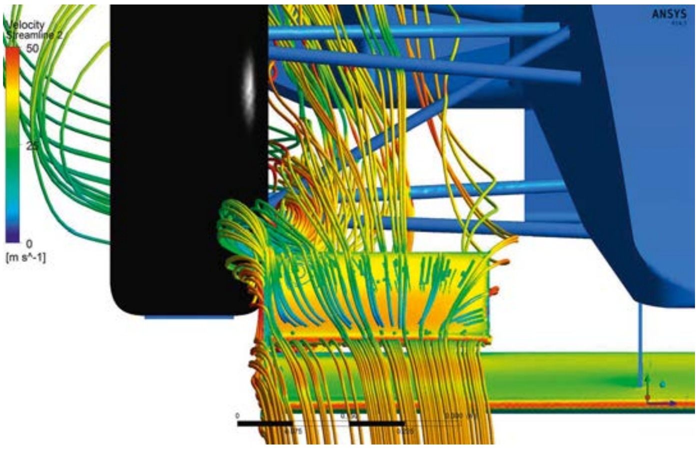


Figure 7: The narrowest span wing sent all its streamlines inboard of the front wheel

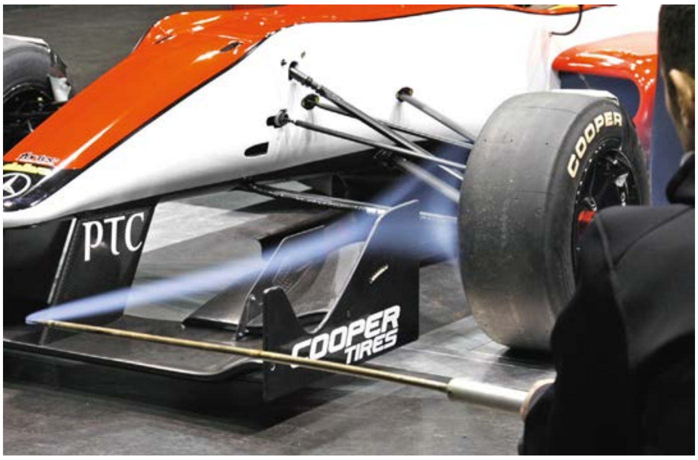


Photo 3: Dallara F312's front wing terminates in line with the inside of the front wheels

the outer side of the lower tip vortex, no doubt coupled with the fact that this is an area of adverse (rising) pressure gradient on the flap where stall is prone to occur if triggered by a suitable mechanism. The effect on the flap's surface pressure distribution can be seen in **Figure 5**, where the stall shortened the blue low pressure region (arrowed). We will return to that phenomenon shortly.

Moving on to **Figure 6**, it's clear that when the front wing span was increased to full car width, or 1615mm here, more streamlines passed around the outside of the wheel than with the 1400mm span wing in **Figure 1**. This reflected the situation in F1 when full-width front wings were brought in for 2009. Conversely, after changing the front wing span to 1200mm all the streamlines passed inside the front wheel, as **Figure 7** demonstrates.

Photo 3 shows the smoke plume on the upper tip of the Dallara F312 we tested in 2012, and the flow goes inside the front wheel from this wing that also terminates more or less in line with the inside of the wheels.

One thing that did *not* change with span was the outboard stalling of the flap, so that would appear to have been non-span dependent, on this model and with this wing configuration at any rate.

What effects did these span changes have on the aerodynamic data from our model? **Table 1** summarises the basic parameters.

The changes to the drag coefficient don't at first sight appear to fit an easily explained pattern, so we'll return to that shortly. The gains in overall downforce (-CL) were in the anticipated direction but were non-linear, with the bigger jump in –CL from 1200mm to 1400mm span. Likewise the jumps in %front and –L/D were larger at the first span increase.

It's interesting to look at plots of the relative drag and downforce contributions from the major


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Table 1: The basic aerodynamic data versus front wing span on our single seater model

	Cd	-CL	%front	-L/D
1200mm	0.799	1.726	21.8%	2.161
1400mm	0.763	2.040	37.6%	2.673
1615mm	0.807	2.288	48.3%	2.837

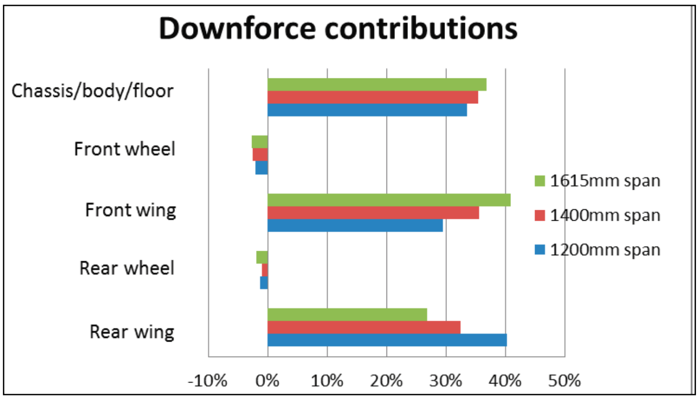

Chart 2: Downforce contribution comparisons with different front wing spans

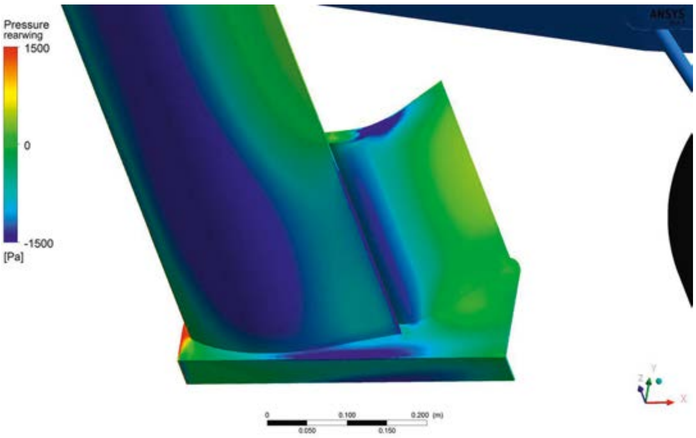
Figure 9: The flap stall was still in evidence with the footplate, but low pressure could be seen under the footplate too. This generated more downforce for front wing assembly

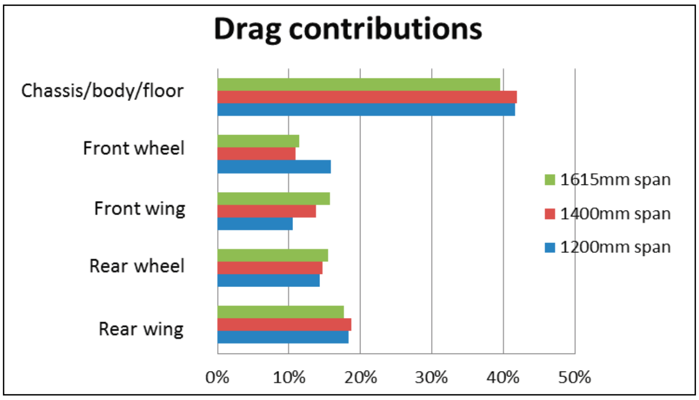

Chart 1: This shows drag contribution comparisons with different front wing spans

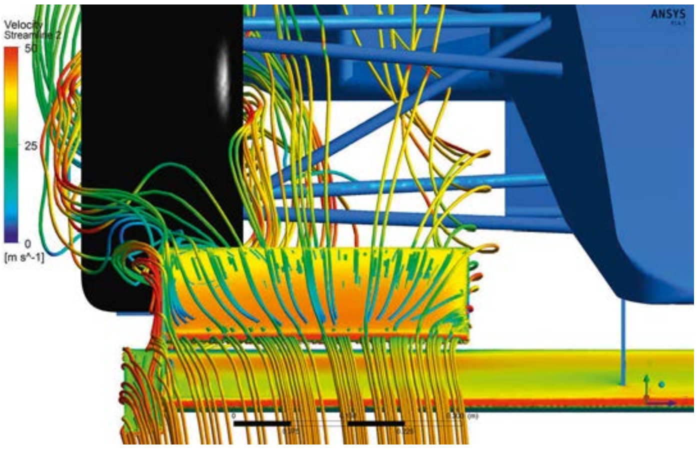
Figure 8: The footplate was modified and exploited the front wing's lower tip vortex

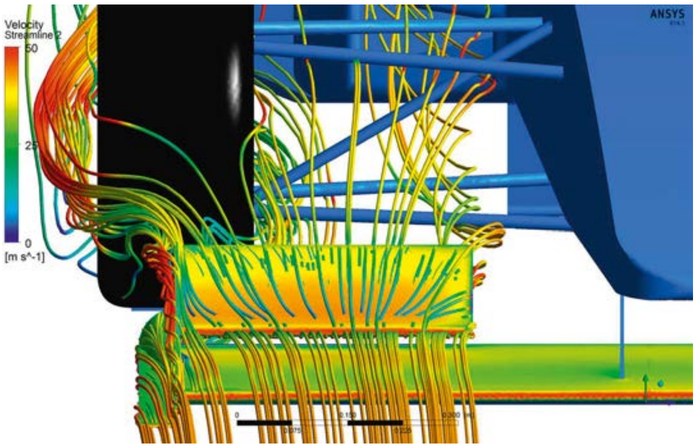
Figure 10: With the 50mm wide vortex entraining end plate (VEEP) fitted the streamlines were seen to be more organised around the outside of the wheel

component groups on the model, and **Charts 1** and **2** illustrate the proportionate changes. In **Chart 1** we see that the front wing's drag contributions seemed to follow what might be expected from the incremental span increases. The contributions of the chassis/body/floor, however, did not respond linearly. Nor did the contributions from the front wheel change linearly, although the narrowest front wing saw the largest front wheel drag and clearly the two are inter-related.

Chart 2 also reveals some interesting responses in downforce contributions. The front wing's contribution stepped up with each front wing span increase, while the rear wing's contributions stepped down in unison. But notice how the chassis/body/floor contribution also increased with each front wing span increase. Was this related to the visual phenomena we saw earlier, with the wider wings directing more airflow outboard of the wheel? And another interesting detail was how front wheel lift also increased with increasing front wing span, presumably the result of more air being directed over the wheel/tyre and so generating more lift. Invaluable though wind tunnel testing is, it's only by using CFD that individual components can be examined to gain these sorts of insights.

Footplates and VEEPs

One of the simplest modifications that can be made to a front end plate is to add a horizontal footplate to the outside of its bottom edge, so a 50mm footplate was attached to the 1400mm span front wing, making overall span 1500mm now, to gauge its effect on the data and the flows. **Figure 8** shows that the overall flows were visibly little changed compared to those shown in **Figure 1**, with the obvious exception of the footplate re-directing the flows that turned under the end plate. **Figure 9** shows that there was now low pressure on the underside of the footplate, the influence of the lower tip vortex and the reduced pressure therein, and this generated more downforce for the front wing assembly. However, there was still evidence in **Figure 9** of stall on the outer flap, although the 'dent' in the low pressure here was smaller than in **Figure 5**. Streamlines confirmed stall was still present.

Slightly more difficult to manufacture in reality but often seen on single seater front wings (and sometimes on the end of sports racing and saloon/sedan splitters) is what has been called the 'VEEP', or 'vortex entraining end plate'. This incorporates a quarter cone or similarly shaped 'quasi-diffuser' section in the rear, lower corner of the end plate, which is often integrated with a footplate.

So a 50mm wide VEEP replaced the end plate with the 50mm footplate on our model and the flows and data were examined. **Figure 10** shows that the flows from the front wing were broadly similar to those with the footplate except that the streamlines that passed outside of the front wheel appear slightly better


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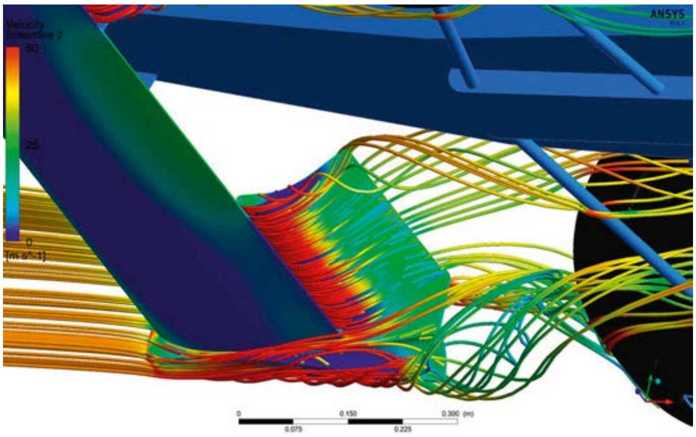

Figure 11: With VEEP the flow was more organised, which eliminated outer flap stall

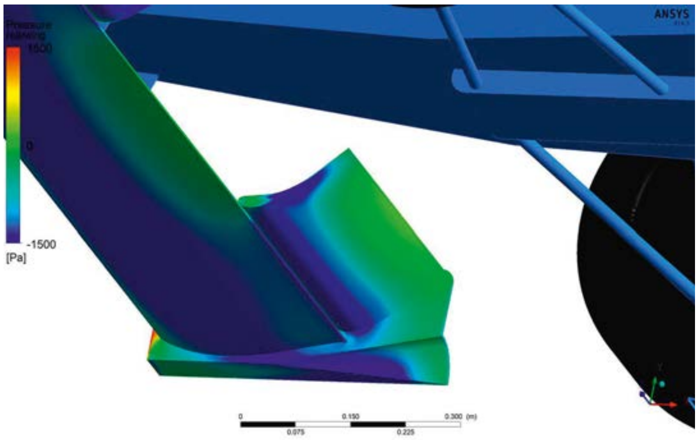

Figure 12: This shows that the flap's low pressure region was fully developed with the VEEP, which also developed low pressures on its downward facing surfaces

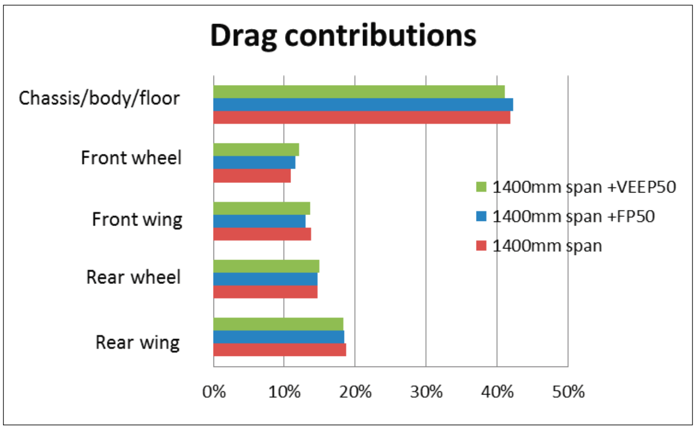

Chart 3: This shows the drag contribution comparisons with footplates and VEEPS

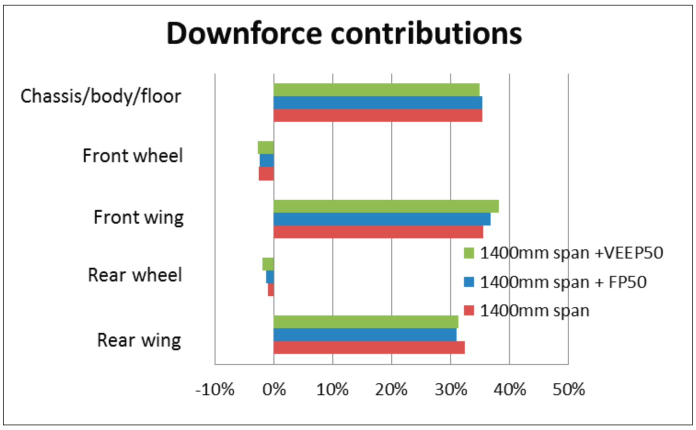

Chart 4: This shows downforce contribution comparisons with footplates and VEEPS

Table 2: The effects of footplates and VEEPs

	Cd	-CL	%front	-L/D
1400mm baseline	0.763	2.040	37.6%	2.673
1400mm + FP50	0.774	2.088	40.6%	2.699
1400mm + VEEP50	0.778	2.066	41.8%	2.657

Table 3: The downforce on the front wing components (as a percentage of the car total)

	End plate	Flap	Main element	Total
1400mm baseline	0.0%	8.2%	27.4%	35.6%
1400mm + FP50	1.6%	7.7%	27.6%	36.9%
1400mm + VEEP50	2.0%	8.0%	28.3%	38.3%

Table 4: The effects of taller front end plates

	Cd	-CL	%front	-L/D
1400mm +VEEP	0.778	2.066	41.8%	2.657
Horiz. EP top	0.782	2.068	42.1%	2.643
100mm taller EP	0.772	1.931	40.8%	2.501

organised in this view. Furthermore, as **Figure 11** shows, the flows under the wing were also better organised, with no sign of the previous outer flap stall. And by turning off the streamlines, **Figure 12** shows that the low pressure region on the flap was now fully formed, and the lower tip vortex was exerting its low pressure on more of the downward facing surfaces of the VEEP. It would appear that the vortex has been given space to provide its low pressure benefits without its downwash stalling the outer flap. Shape refinements could, no doubt, optimise matters further.

Table 2 compares the data of the 50mm footplate and 50mm VEEP options with the baseline 1400mm span front wing. **Charts 3** and **4** illustrate the component group relative contributions to drag and downforce. Best overall downforce and efficiency (-L/D) came from the footplate, but the VEEP produced a bigger forwards balance shift by virtue of greater enhancement of the front wing's function.

Chart 3 shows incremental increases in front wheel drag which were sufficient to outweigh the drag changes on the other components, even in the case of the VEEP50 model where the chassis/body/floor drag reduced relative to the baseline model. **Chart 4** shows that the predominant change in the downforce distribution was to front wing downforce, and clearly the wing with the VEEP was the most potent of these three options in this regard.

It's also interesting to examine the downforce contributions of the individual front wing components in these three cases, as **Table 3** illustrates. Both the modified end plates generated extra downforce but the VEEP was the more effective of the two. The flap clearly lost downforce in both modified cases, but lost less with the VEEP. And the main element gained downforce with both modified end plates, but again the one with the VEEP was the more effective.

Short and sweet

Front end plate height is sometimes restricted by technical regulations, and sometimes not. Two simple variants on the baseline end plate were tried; the first saw the top edge set horizontal at the original height of the rear corner of the baseline variant; the second simply added 100mm in height right across the top of the baseline variant, so it had the same shaped top edge but 100mm higher. The effects on the basic aerodynamic parameters are shown in **Table 4**, compared to what was now the new baseline wing with the VEEP50.

Straightening the top edge of the end plate so that it was horizontal appeared to have negligible effect on the overall aerodynamic numbers. However, adding 100mm to the original end plate height clearly had a pronounced negative effect, with overall downforce decreasing by 6.5 per cent. Looking at **Figure 13** the streamlines from the end plate with the horizontal top edge look little different to those in **figure 10.** However, **figure 14** shows that the streamlines from the wing with the 100mm taller end plate were different

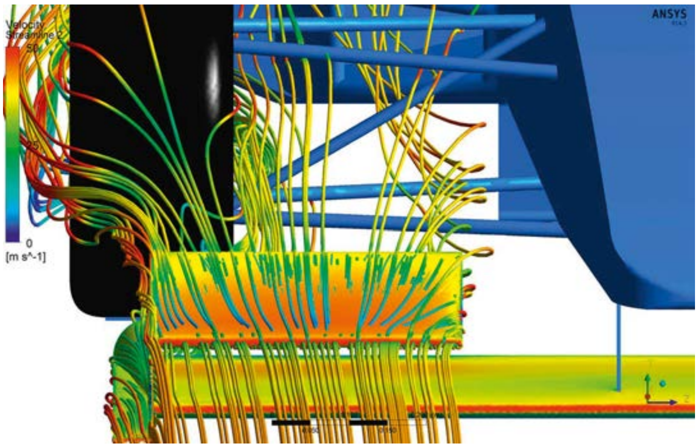

Figure 13: Streamlines from the horizontal top edged end plate were actually very similar indeed to the original with the VEEP, as is shown in Figure 10

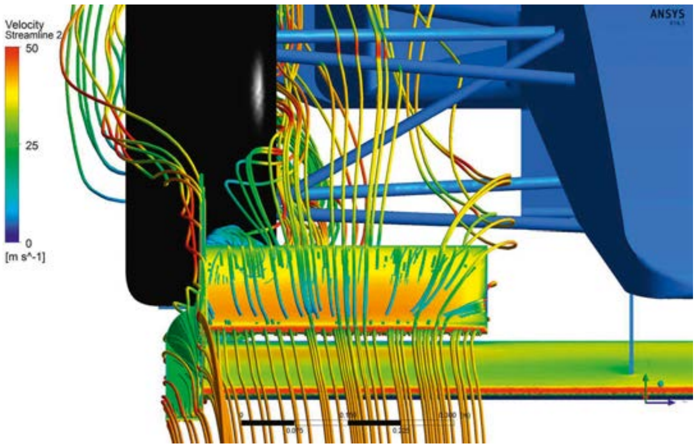

Figure 14: However, the 100mm taller end plate altered the streamline paths significantly, with fewer streamlines from the flap passing outside the wheel

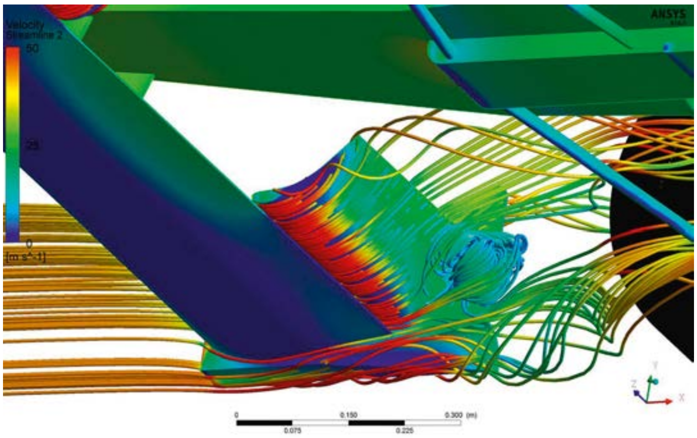

Figure 15: The 100mm taller end plate also caused the return of the outer flap stall that we encountered earlier in this study, even with the VEEP in place

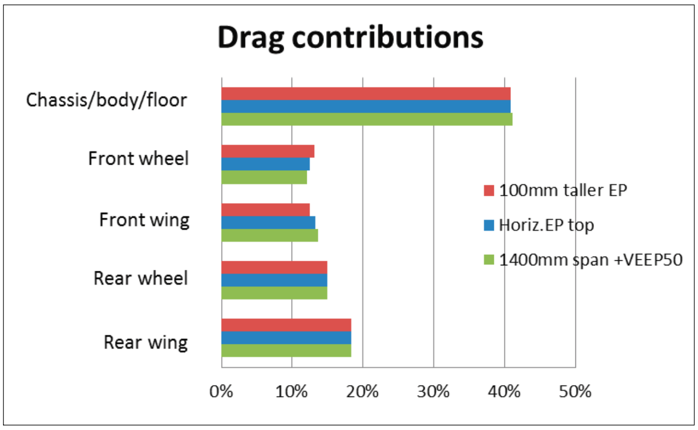

Chart 5: Drag contribution comparisons using the different height front end plates

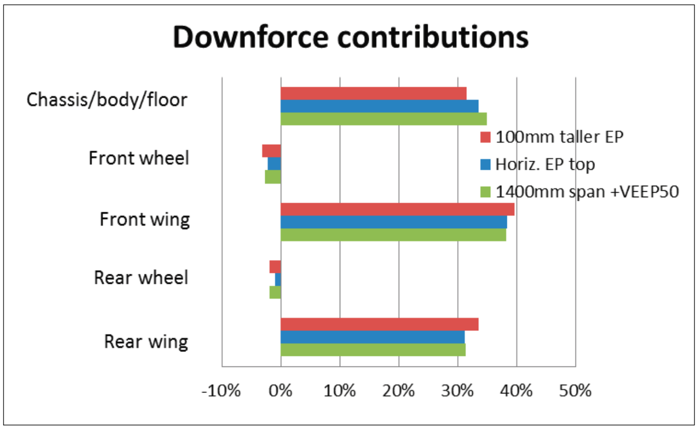

Chart 6: Downforce contribution comparisons with different height front end plates

Table 5: The effect of FWFLUPS

	Cd	-CL	%front	-L/D
1400mm +VEEP	0.778	2.066	41.8%	2.657
+FWFLUPS	0.776	2.225	43.5%	2.866

around the end of the flap, with less streamlines from the flap passing outside the wheel. And once again there were signs of the flow under the flap having been adversely modified, confirmed by **Figure 15** which shows the return of stall on the outer flap. So in this instance it looks like the original short end plate was the best choice.

Chart 5 shows that the drag contributions were pretty similar across most component groups except the front wing and the front wheel, which saw what were obviously related and diametrically opposite trends with the changes to end plate height. **Chart 6** meanwhile shows how chassis/body/floor downforce was the main cause of the overall drop in downforce, actually falling in absolute terms by over 15 per cent. The front wing in the 100mm taller end plate case lost three per cent downforce in absolute terms, although its contribution relative to the reduced total downforce on this variant did increase slightly. Much the same applied to the rear wing, which produced similar downforce in each case. So changing the end plate height had a more pronounced effect on downstream components than it did on the front wing itself.

FWFLUPS

Front wing flip ups (FWFLUPS) are another oft-seen attachment on the outside face of front wing end plates, so a 50mm wide flip up was modelled and trialled, with the results shown in **Table 5**. A 7.7 per cent increase in downforce for virtually no change in drag seemed like a very useful gain. The forwards shift in balance clearly implied the gains came from the front end, but the component group contribution plots once again showed that the obvious assumptions didn't tell the full story.

Chart 7 shows that once again there was a trade-off between the drag of the front wing and the front wheels which, combined with minimal changes elsewhere, saw a negligible change in overall drag. **Chart 8** shows that the major source of increased downforce as the result of fitting the FWFLUP was not the front wing but the chassis/body/floor, which in absolute terms produced a 15.1% increase in downforce. The plot shows that the relative contribution of the front wing dropped (by 1%) but in absolute terms the front wing actually generated 5.0% more downforce, of which more than half came from the flip up itself. **Figure 16** suggests there may have been more streamlines passing outboard of the front wheel with the flip up in place, and this again strengthens the notion that directing air outboard of the front wheel enhanced underbody downforce while, as we saw in the previous section, directing more air inboard of the wheel had the opposite effect.

FWFLEPS

A device used on the previous generation Dallara F308 Formula 3


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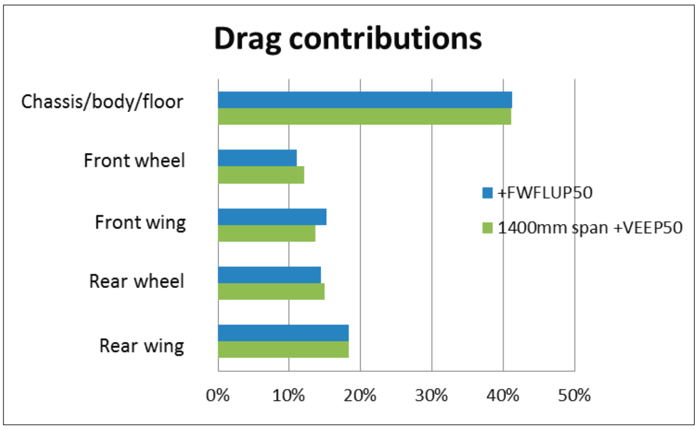

Chart 7: This shows drag contribution comparisons with the front wing flip ups fitted

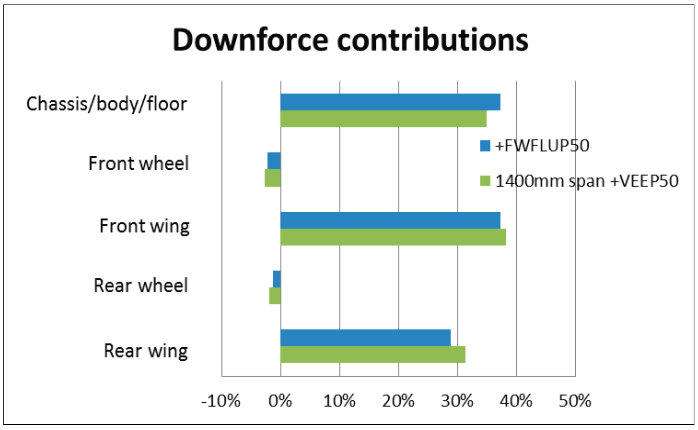

Chart 8: The downforce contribution comparisons with the front wing flip ups fitted

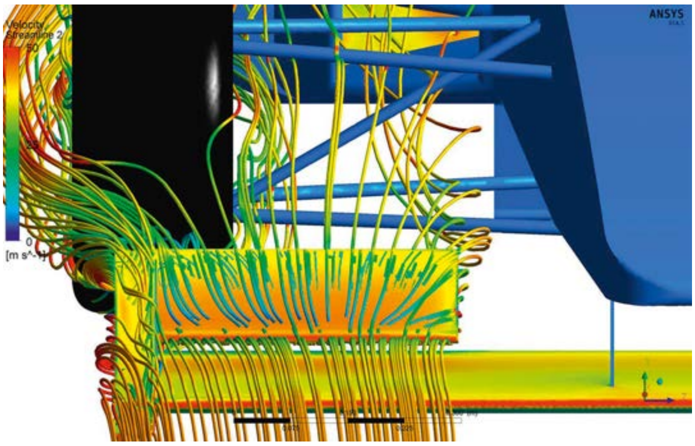

Figure 16: More streamlines passed outboard of front wheel with the front wing flip ups

Photo 4: The inboard front flap end plate on the Dallara F308 Formula 3 car

Table 6: The effects of FWFLEPs

	Cd	-CL	%front	-L/D
1400mm +VEEP	0.778	2.066	41.8%	2.657
+FWFLEPS	0.781	2.142	42.7%	2.742

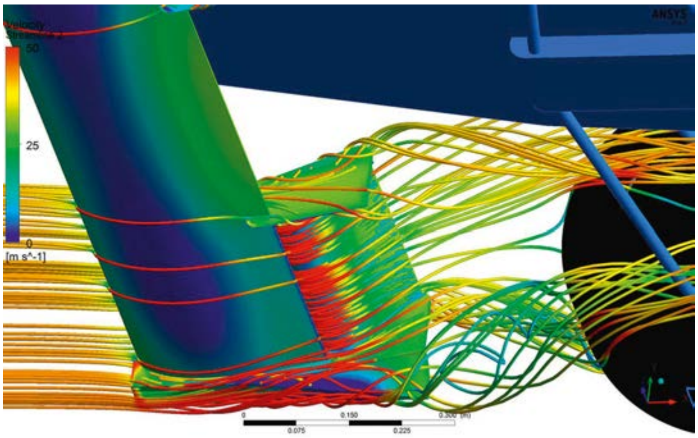

Figure 17: The inboard flap end plate modified the Y297 vortex and increased flap and main element downforce with just a small increase in drag and a modest balance shift

car that ran up to 2011, was a small end plate on the inboard end of the flap, the front wing flap end plate or FWFLEP, as seen in **Photo 4**. A similar device was affixed to the inboard end of our flap to gauge the effect, and the data are shown in **Table 6**. The result was a 3.7 per cent gain in total downforce with a very small increase in drag and a modest forwards shift in balance. Again the obvious assumption was that the front wing's performance was enhanced, and indeed this was so, with a 3.3 per cent increase in absolute terms, just over a quarter of which came from the front flap, but the majority came from the main element (see **Figure 17**).

However, the chassis-body/floor downforce contribution also increased by 3.6 per cent in absolute terms and this, combined with small reductions in wheel lift, meant that the forwards balance shift was relatively small. It also meant that the relative contributions of the major component groups changed very little overall. Once more, what we might have seen in a wind tunnel where just overall forces are measured would not have told the whole story; CFD provides a wider view.

Summary

We have seen that increasing the front wing span made the obvious differences to front downforce and also determined much that happened downwind, perhaps most importantly by influencing chassis/body/floor downforce. Footplates and VEEPs exploited the lower wing tip vortex to add front wing downforce, and VEEPs eradicated outer flap stall. End plate height may have a practical maximum height, above which the performance of downwind components and that of the wing itself were adversely affected. Front wing flip ups enhanced downforce for no drag increase and appeared to enhance chassis/body/floor downforce as well as front wing downforce. And front flap inboard end plates also enhanced downforce for minimal drag increase, improving chassis/body/floor and front wing downforce almost equally.

But it should be noted that the CFD being used here was not high-fidelity; the model is basic and the CFD mesh was relatively coarse. But it would be interesting to see if these general responses could be picked up in the wind tunnel, should the opportunity arise.

Clearly, all of the items looked at in this feature would bear more detailed study, and the devices examined are but a sample of the range of possible modifications. Which leaves us with plenty of scope for further exploration in future articles, then.

Many thanks to ANSYS UK for software provision.

We have seen that end plates may have a practical maximum height


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Sim cities

High-end simulation package rFpro is now being put to work to model the distinct and challenging street race environments of Formula E. *Racecar* investigates

By LEIGH O'GORMAN

Part of the DNA of Formula E is the use of city centre street circuits such as this one in Hong Kong. But this brings its own challenges when it comes to producing engineering-led track sim packages

Back in 2007 rFpro was launched as an offshoot to the game rFactor. It is described as an environment simulation program that is physically accurate as well as visually and aurally realistic, and it has now emerged as one of the motorsport industry's go-to sim packages, in what is an ever-more competitive market.

Intriguingly, rFpro's story starts at the very highest level of motorsport, as its technical director Chris Hoyle explains: 'We started as a project within a Formula 1 team, on October 23 2007, when I was introduced to the head of R&D at one of the higher budget F1 teams. We spent most of that day planning out the architecture for what would be their simulator. They had a very good vehicle model, a mathematical model of their car, but they had nothing else, so we came up with a plan to create an interface between their model and the computer game rFactor.

'That went quite well, but the following year, they were one of the teams that left Formula 1,' Hoyle adds. 'And so I was faced with the choice of "that was an interesting diversion for the year" or "shall we see if anyone else is interested?" We started talking to the other F1 teams and a couple of other people and by March of 2009 we had three Formula 1 teams. Then, within a few months, we were a going concern with four customers, and it grew from there.'

Having also worked with teams from A1GP, WEC, NASCAR, the WeatherTech SportsCar Championship and Super GT, rFpro's customer base has also expanded to include OEMs, but it is its tie-up with several Formula E teams that is particularly interesting. 'Since Formula E started, we've been watching with great interest,' Hoyle says. 'But along with a lot of people we didn't know if it was going to last more than the first season and so it was only this year [2016] that we decided to commit to the series and make

‘Once you get to the level that we are aiming at, the driver is a component of the simulator’

the investment to build all of the tracks, because that is a huge investment for us.’

The costs of surveying and building a temporary street or park circuit are indeed very high, but the number of major manufacturers who have committed to the series have soothed any long term worries that Hoyle may have had. ‘What we didn’t want to do was make a relatively large investment and then discover that the series was going to be wound up,’ he explains. ‘We’ve been marketing this and talking to all of the teams and we now have four customers, so given that we only started a few months ago, we are reasonably happy with the progress and we now hope to pick up a few more teams over the course of 2017.’

Rather than treat it as a ‘driver trainer’, Hoyle sees rFpro as a engineering development project – a direction that restricts rFpro to high budget teams and manufacturers, but also makes it an enticing project for Formula E. ‘If all you want to do is train drivers, there are dozens of people offering seat time,’ Hoyle says. ‘Generally speaking, once you get to the level that we are aiming at, the driver is a component of the simulator. The simulator is predominantly for the engineering benefit.’ At the same time, Hoyle jokes that if a race driver still actually requires training at this top level then ‘you’ve brought the wrong race driver’.

rFpro runs a mathematical model of the car – that typically runs at 1kHz – ensuring that in every millisecond, every moving component is being recalculated and run inside an environment called vTAG, which is a virtual model equivalent of the McLaren ECU that is in the real life Formula E racecars.

A fully surveyed circuit gives rFpro a basis that allows teams to accurately simulate the control systems, which Hoyle says, ‘allows them to exercise all of the control systems that they are developing to run the car and the

Top: **The rFpro package was originally developed for Formula 1 using the rFactor racing game as a basis. Pictured here is the rFpro digital model for Monaco**
Above: **Chris Hoyle, technical director at rFpro, says he wanted to make sure Formula E was a success before committing to costly mapping of the circuits**

powertrain and to test the whole car with the human driver in simulation.' He adds that 'it is quite early on in its development curve and so no one can remotely say that it is starting to plateau in terms of its development.'

Understanding the powertrain within the environment is one of rFpro's biggest selling points. In Formula 1, simulating an environment for the powertrain may be relatively low on the list of priorities and far behind aerodynamics, but for Formula E teams, creating an exacting environment for the powertrain is of vital importance. 'One of the nice things about what we can do is we can allow them to test in a very realistic copy of the circuits they'll be racing on. You don't want to be running out of juice 100 metres before the finish line,' Hoyle says.

Whereas a basic offline lap simulation creates a path in space, which more or less follows the fastest line through the corners, what can be missed is everything that is affected by the human driver in the car. Hoyle explains further: 'The human driver won't necessarily follow what is the theoretical fastest line. We see that in Formula 1 at places like Monaco, where they leave Casino Square and shoot down the hill, you will always see the cars jink over to the right hand side, because if they stay on the logical left-hand side of the road, there is a huge great bump which upsets and destabilises the car.' With Formula E predominantly racing on street circuits, drivers are occasionally required to find a faster line which isn't necessarily the racing line, where more stability and better traction is available. 'We are able to test that in simulation, where you have every square centimetre of the road surface modelled accurately, every bump, roughness and disturbance from a manhole cover or zebra crossing or whatever is in simulation [and] you get those effects coming through to your car.

'When you are trying to extract every last joule of energy out of a very finite battery pack, you want to be running your simulation the way the real car will be running on the track and we have already seen last season that there can be a reasonable variance there,' Hoyle says.

rFpro surveys a circuit by creating a kinetic scan with kit mounted on a truck – also referred to as a dynamic scan – whereby one single contiguous scan is created by driving slowly around the track. For this, Hoyle rarely requires a large team and on occasion is able to manage a project solo, as he reveals. 'For most circuits where there is somewhere secure to leave the base station, we can do the scan with just one person. For some circuits, where we are not offered a secure location, we will need a second person just to babysit the hardware.'

Hoyle continues: 'Getting the kit on to the roof of the truck, calibrating it and running the scan are all one-man jobs. The only exception to this is when we are in areas where the satellite constellations conspire to produce poor coverage, for example, Singapore, and there we will have a second person monitoring the trajectory data continuously to make the most of the positioning information.'

Space notes

To execute this, Hoyle's team uses a truck with a GPS positioning system, which listens to the GPS and well as the BeiDou satellite (Chinese navigation system) and GLONASS (Global Navigation Satellite System) in order to triangulate points on the survey map. 'We've got three or four constellations, so there's a reasonable chance that in any point in time there's going to be a good number of satellites above the horizon, but there are places on the planet where that is not always the case.'

The information obtained is closely coupled with an INU (Inertial Navigation System),

'We will have all of the roadside buildings and scenery captured, so that when we build the model all of the drivers' sightlines will be accurate'


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Top: Donington has been a test venue for FE from the start; the detail of circuit's furniture is very impressive
Above: rFpro is concerned with the interaction of the tyre contact patch with every single piece of the circuit

running not just in parallel, but coupled through the GPS solution. 'The reason we need that is first of all we need to take the motion of the truck out of the data – the truck will bouncing over the surface, just like any other car – but also we need to keep the positioning signal honest beneath GPS shadows. For example, bridges, tunnels or very heavily built-up areas where you are surrounded by large office buildings, and it is the INU that keeps the position signal honest through that patchy coverage.'

The team also uses at least one high frequency, very accurate, phased-based scanner that captures the road surface to a very high degree of accuracy with a very dense point cloud, but as Hoyle points out: 'The compromise that you pay for this is the range is relatively short, so we will also have at least one 'time-of-flight' scanner.'

The time-of-flight scanner is a lower frequency, less accurate scanner, but it is one that is capable of capturing all of the roadside furniture from the kerb outwards.

'We will have all of the roadside buildings and scenery captured, which means when we build the model, all of the drivers' sightlines will be accurate. If a driver gets used to a sign or something in their peripheral vision as a braking point, it will be accurately placed – there won't be any guesswork there.'

The bigger picture

Hoyle and his team also captures video of the layout, using six cameras that can go through 360 degrees, creating a visual overlap and complete circular coverage. The cameras take a geo-reference image every 0.7 of a second, creating an extremely accurate point cloud for the entire circuit and up to 100 metres either side of the road.

This allows for three dimensional reconstruction, modelling and engineering of the road surface to be formulated, allowing for the creation of the end digital model.

There are challenges in terms of venue environment, however, and Hoyle says that at the western end of the Mexico circuit there are numerous metal grandstands, which create sizeable GPS shadows. In situations where satellites sit at a relatively low altitude, the existence of grandstands can make it difficult to create an optimum survey of elements within that shadow. Hoyle says: 'There will typically be very few satellites above, the satellites you see are going to be a little bit above the horizon, but we still have to cope with that same issue.'

Data management

Data processing has also raised issues over time. As surveying technologies develop in potency and with a huge number of gigabytes of raw data being collected during every survey, managing that information forced Hoyle and his rFpro team to quite literally work outside of the box. 'To give you an idea, typically the interval between points in the cloud across the road surface might be 3mm,' Hoyle says. 'If you do the maths and go all the way around a circuit that's around 1.5 to 2km for at least two scanners, plus everything that is calculated for the 3D reconstruction, you've got large amounts of data and out the end of that pops an engineering surface, which will be everything that's driveable, everything that a tyre could touch and on the side of that goes all of the scenery.' Two years ago, rFpro moved all of its data processing capabilities onto AWS (Amazon Web Services), allowing the team to rent additional servers for that data when each project is brought in. This has taken a huge

'The driver won't necessarily follow what is the theoretical fastest line'

‘We handle the envelope, the intersection of the tyre with the road’

load off of Hoyle’s back. ‘Otherwise we would have a great big dirty data centre and we would be responsible for the reliability and the air conditioning and the maintenance and so on.’

Scanning of a circuit layout in Formula E is a rather speedy process, due in part to the short nature of the circuits (generally 1.5 to 2km in length), but also due to constrictions of scanning a public road. It often means circuits are scanned at unseemly hours in order to get the job done. If all goes well, a schedule allows approximately two hours to scan the layout and calibrate the information.

‘On a closed circuit, we can get away with driving at a crawl, but on public roads we can choose to scan at 2am, for example, but there still might be constraints that mean we need drive a little bit faster, so you just do the maths,’ Hoyle says. ‘We typically want to drive as slowly as possible, but it depends whether it’s on public roads or a closed circuit.’

There are other barriers that need to be dealt with, too, as Hoyle discovered recently when the Berlin layout was being scouted. Under German law, the rFpro team was not allowed to photograph number plates of cars that may have inevitably fallen into shot. It was a situation that created an additional headache, but not an unsolvable one. ‘There was a whole heap of processing that needed to be done, so that we’re not capturing that information,’ he says.

Surface tension

One of the areas that rFpro does not analyse is the active surface condition of a road. The temporary street and park circuits that are used in Formula E are, by their very nature, covered in layers of dirt, grease, grime and other elements, and there are very good reasons as to why rFpro has not moved into this specific area. ‘We are not experts on tyres or tyre modelling. We don’t offer the macro road surface scanning; we have customers that are doing this, but it is not an area of expertise that we have,’ Hoyle says.

He adds that vehicle modelling is also not an aspect that rFpro is involved in and that organisations who operate in that arena tend to use products such as Dymola, Simpack and Simulink, amongst others. ‘We handle what’s called the envelope, the intersection of the tyre with the road, so a thousand times per second, we’ll calculate the exact contact patch for all four tyres, but that’s where we stop.’

There is also a practical reason as to why analysis of road surface conditions may not be useful; as surface evolution may potentially render gathered information out-of-date come the end of the opening practice session.

Wages of sim

Hoyle is more than aware that he operates in an industry that can be fickle and unpredictable. The loss of three big manufacturer teams from Formula 1 (Honda, Toyota and BMW) nearly a decade ago was indicative of that and the very recent withdrawal of Audi and Volkswagen from the WEC and WRC respectively shows that winds can still change rapidly. Yet Hoyle is not pessimistic. If anything, the experience the company has had in the past has actually led rFpro to diversify, and find new business. ‘Motorsport is lumpy,’ says Hoyle. ‘We were there in 2008 when three big manufacturer-backed teams pulled out of Formula 1 and this year one third of the major LMP1 teams pulled out of the WEC with Audi disappearing. In 2012 we decided to diversify into road car manufacturers, because we either had to remain a small organisation operating solely within the motorsport niche or we had to grow and market ourselves into vehicle dynamics and applications within road cars.’

This remains a big justification for rFpro to grow rather than remain a high-risk small organisation that relies on significant investment that can take two or three years to amortise through sales.

‘We only do driving simulators and we are focused solely on simulating for engineering developments, so we don’t sell the small seat time simulators that you see, and we don’t sell the massive, giant £100m simulators that are used for managing interface and ergonomics and all the things like that,’ says Hoyle. ‘We have a very clear focus and we invest and continually invest in our R&D, so that the product has grown significantly over the years and I think as long as we keep investing in the product so that we offer more, then we should remain successful.’

Top: Some of the raw data captured in Paris. Realistic surroundings are an important aspect of the package
Above: One of the big selling points of rFpro to Formula E teams is its focus on the powertrain environment

Nailing compliance

Checking wheel compliance need not mean spending a fortune on hiring K&C rig time – you just need access to some quite basic equipment, perhaps a nail gun, and a little engineering savvy

By RICARDO DIVILA

Claude Shannon, the famed mathematician, once said: 'Information is the resolution of uncertainty'. So what do you do when your new design is not behaving as you thought it would, or more pertinently, should?

You did all the geometry, you ran your simulation, you stressed out all the components, you managed to get your centre of gravity where you wanted it to be, you may even have evolved a stunning L/D. But when you fit your driver in it you have the usual turbine like high pitched whine (that a driver will often emit) berating its handling characteristics. Assuming you are a better man than me, and have got all your parameters and design targets right, that in itself does not mean the car as built is behaving like the little gem you have on the screen (falling in love with your design is totally natural behaviour and should not worry you unduly).

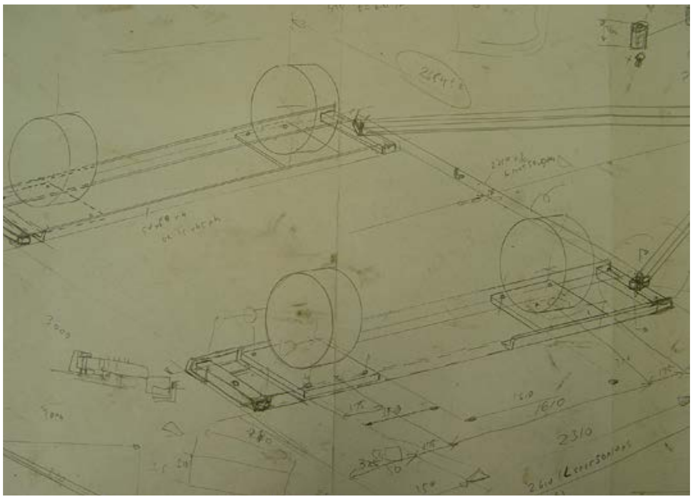
One will venture to say that no racing car that ever physically existed did not have flaws in it, and the most common is that the essential control of the contact patch is not correct.

Any material deforms and the laws of physics and material characteristics will determine by how much. So you have to make sure your suspension pickups, wishbones, hubs, and bearing packs are stiff enough to maintain your wheels in the right attitude (their camber and toe). That will give the best grip and, most importantly, it will mean you have the least deflection during transients.

A good tool to measure this is a kinematics and compliance rig, colloquially known as a K&C rig, where after positioning the car on the platforms the body is restrained and longitudinal or lateral loads are applied, and the wheels are monitored with gauges to measure deflections in toe, camber and caster.

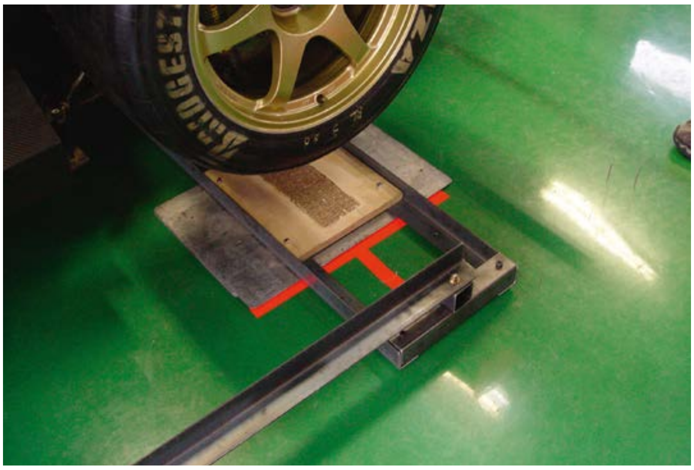
These tend to be major pieces of equipment and can measure either static or dynamic

You don't need to splash out on hiring an expensive K&C rig to test your compliance

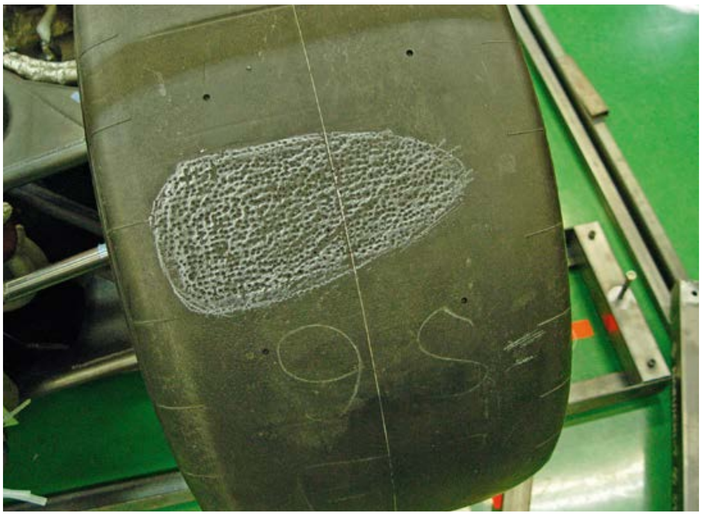


The first step is to measure your track and wheelbase and sketch out your frame simply

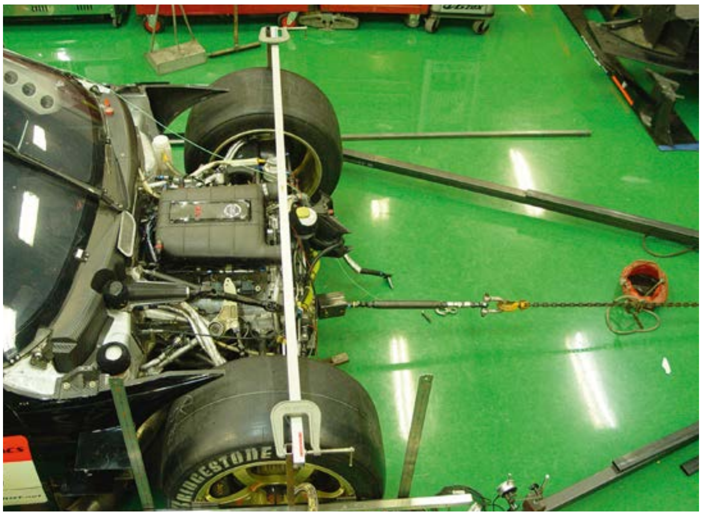
The best way to measure the deflections is by using a pulley system to move the car



Forces can then be measured on a studded patch; this is where those nails come in

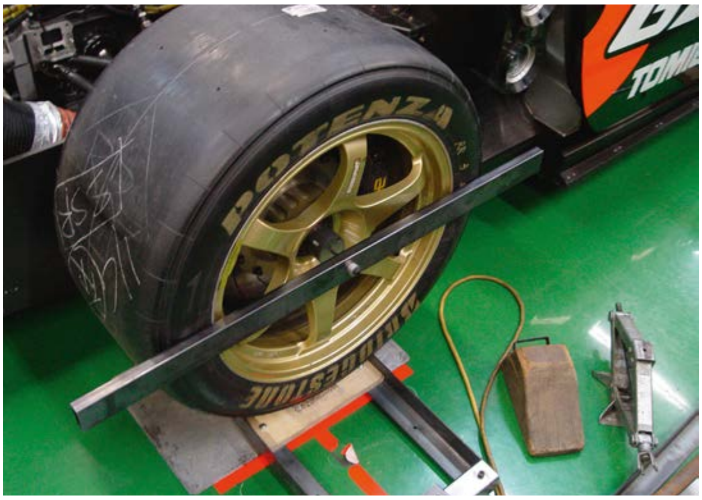


The contact patch with nail imprint – it's important that the nails protrude by 3mm max

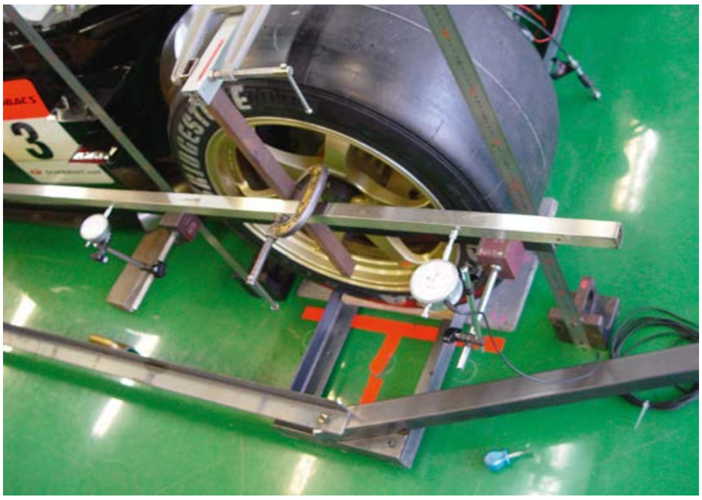


The pads are bolted to the L-section profiles and the racecar is hooked up to the pulley

This shows the individual axle frames that are a vital part of the test rig equipment



To measure the deflections you need to use a beam mounted on the wheel with clamps



You will also need to fabricate a sturdy steel frame to hold the dial gauges in place

Here the L-shaped measuring bars can be seen in relation to the rest of the racecar

loading deflections by applying known force inputs to the suspension and measuring the position changes at the wheel centre. A static measuring one is known also as a Suspension Parameter Measurement Machine (SPMM).

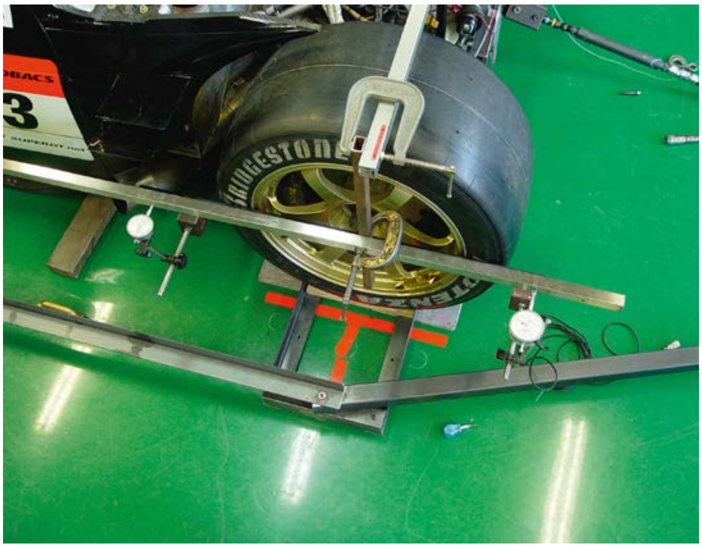
Kinematics tests measure wheel attitude changes that occur due to position changes, such as roll and ride height, with zero horizontal forces. Compliance tests measure wheel attitude changes due to horizontal force inputs.

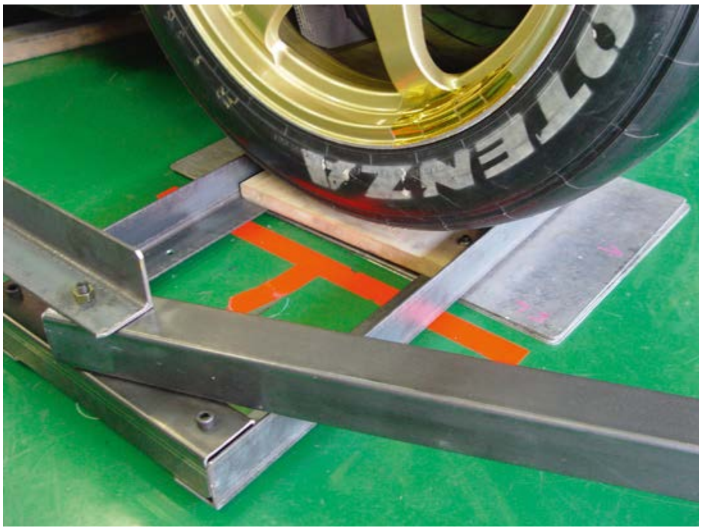
These dedicated rigs impose six directions of motion or force on each wheel of the test vehicle and precisely measure the resulting wheel displacements. Values from this test will give the deflections and geometry changes in longitudinal torsion (warp), vertical bending and lateral bending. Great equipment and pertinent results, but unfortunately you could find yourself without access to one either because of where you are, or because you do not have the finance to pay for a test.

What to do? Well, following on from last month's (*RE* V27N2) low budget torsion rig, you can at least check your compliances with a

There's no racing car that ever existed that did not have flaws in it


This complicated looking arrangement is the toe, caster and camber bars and the dials


Here's another view of the set-up from above: note the hi-tech G-clamp to keep it secure


The pulley is mounted on to a horizontal gantry, which is then bolted to the nail pads


The car also needs to be restrained; here the brakes are kept on with a car jack and pole

self-built rig, again on a small budget. Required items will be L-section mild steel bars, some plywood, a couple of bags of nails, a handful of bolts, a ratchet pulley, at least a pair of common or garden variety dial gauges, and a system to measure the load you are applying.

Systems I have made use of in the past were either a suitable calibrated strain gauged pull rod or a rented pull dynamometer (in my case a this was a Dillon AP 5in 5k 3000lb/f). Also renting a roofing nail gun, or borrowing one from your friendly local carpenter, can make the job a lot easier, for reasons that will become very clear as we go through the process.

The process

The first thing you need to do is measure your track and wheelbase, and sketch out your frame simply. To measure the deflections, you are trying to simulate loads coming in through the contact patch as you corner, brake or accelerate. The best way to do this is to pull the car mechanically through a pulley and let it react through a set of studded pads. This is where the plywood, nails and nail gun come in.

Mark out the plywood with a grid of 5x5mm and drive the nails through the plywood leaving the tips protruding approximately 3mm past the surface, this will give you a surface that can load the tyres without damaging them, although they will have some dimpling. This also shows the loaded contact patch you have at the track.

Grid positions

A closer grid will increase your load capacity, but this means a lot more nails and consequently a lot more hammering work (or nail gun work). Also, though this depends largely on the quality of your plywood, it can make the wood split.

Some experimenting will bring you to an optimum spacing depending on your material. Be prepared to have around 400 nails per pad, and you will need four pads, which are then bolted to the L-section profiles, giving a frame where the wheels will rest.

To measure the deflections use a beam mounted on the wheel with clamps.

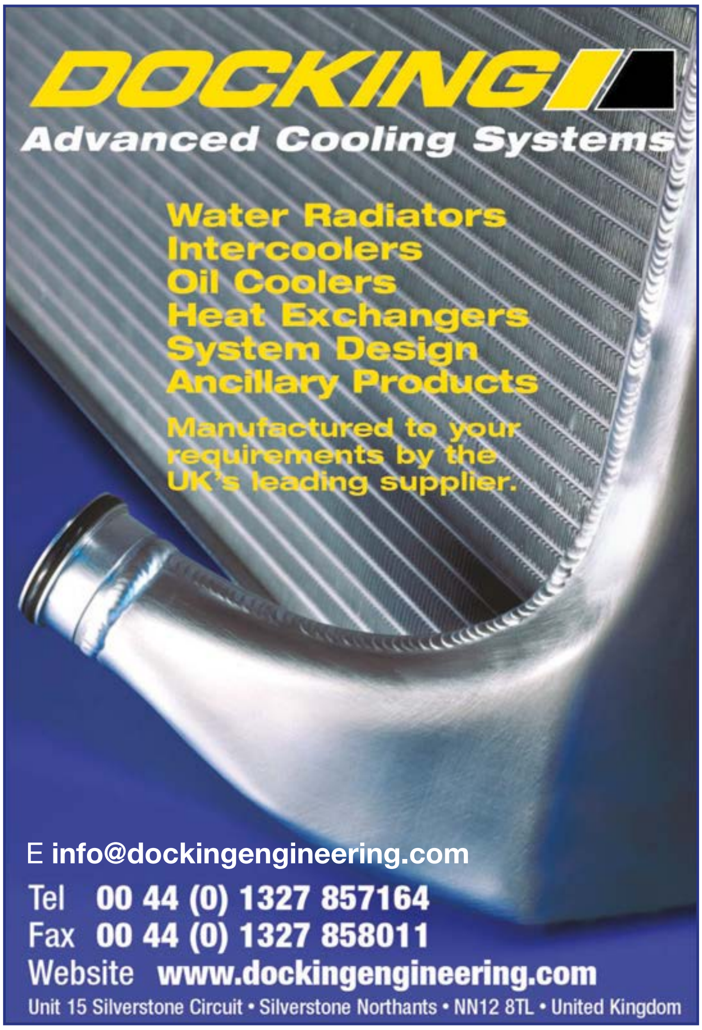
The vehicle will have to be restrained and common practice is to use a jack which is applying a load to the brake pedal.

The pulley is mounted on a horizontal gantry, which is then bolted to the pads. The same bolts can be used to interconnect the pads with another pair of L-profile bars.

Loading your ratchet pulley in increments and recording the dial gauge values enables you to build-up a table of loading and unloading. Running the procedure several times allows you to see the dispersion in values, and to establish your trend lines.

The load you can apply will depend on the car weight, so ballasting the car increases the range of values you measure. As the frame

Because of weight transfer the front axle is the one we will be most concerned about when checking toe stiffness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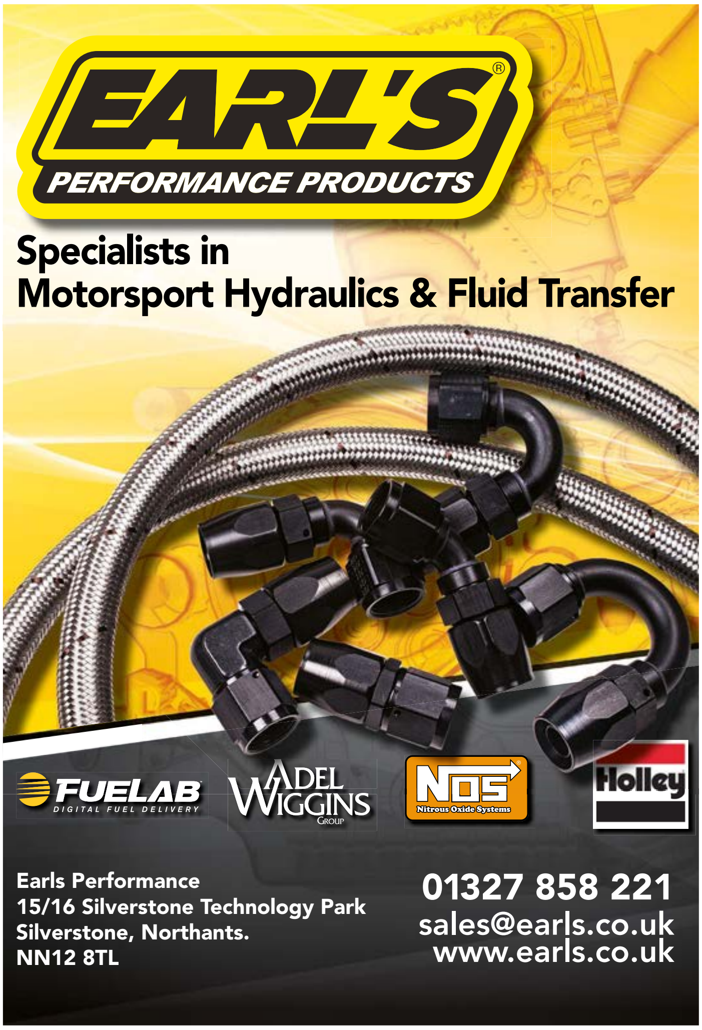
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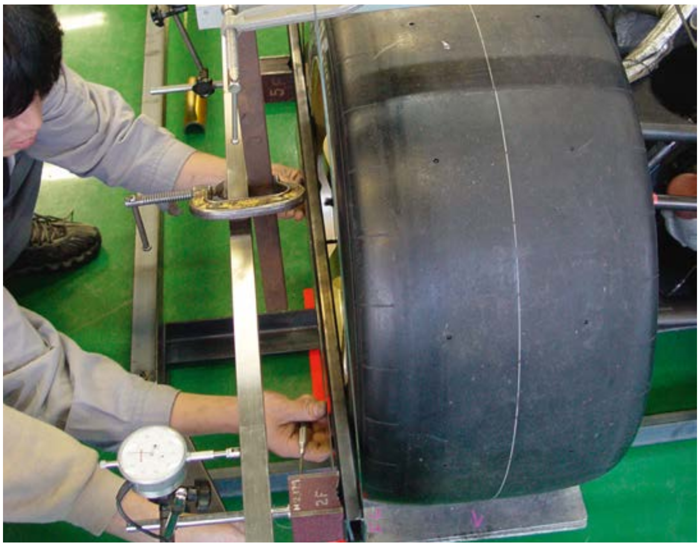


Load ratchet pulley in increments and record gauge values and compile a table of results

As the testing frame is actually pulling against itself it will not need to be restrained

is pulling against itself, it will not need to be restrained, but it will certainly need to be stiff enough to take the loads.

Having the car restrained on all four wheels with the two frames interlinked, will reduce your individual longitudinal wheel loads as they will be distributed on all four wheels, and this can make separating them difficult as individual deflections on each corner will tend to transmit the load to the stiffest corner.

Measuring them fully connected will give an overall deflection, and then blanking the front or rear brake lines will load just the axle on a single pad, probably doubling your force range. Then, by overlaying these forces over the four-wheel results, this will also separate out which of the axles reacts more.

Because of weight transfer the front axle is the one we will be most concerned about when checking toe stiffness, because it will be doing most of the work under braking.

Compliance tests measure the wheel attitude changes due to horizontal force inputs

Rigged results

Mounting the rig reversed makes traction induced toe change easy to measure (on a single pad again) but you will have to be careful when measuring braking forces on the rear (single pad again), and you need to ensure the front wheels have brakes disconnected. This is probably the most difficult value to obtain.

You will probably have to load the car with ballast as we will only have the front weight of the car to give you your *Fz*, the nail pads can usually take *Fx=Fz* before it starts slipping off. Lateral loading can also measure your camber deflections, the same comments as above being valid again. By mounting your dial gauges appropriately you can separate hub and bearing deflections from wishbone and pickup deflections, also rim deflection.

Caster, steering rack and rack mounts can be measured under braking, rear suspension under braking and acceleration – again depending on the pull force direction.

Camber values are obtained simply by mounting the pulley gantry at 90 degrees to the longitudinal tests, and again, you should measure the four-wheel loading, then have a non-studded pad on the inboard or outboard side of the car, or more simply fit a pair of blanking plates over the nail pad, greased so it does not constrain the corner. This again increases the load available for deflection and separates individual corners.

Using the rig in eight easy steps

The ratchet chain pulley system is effective and much cheaper than hiring time on a K&C rig

The ratchet chain pulley is used to input lateral and longitudinal loads into chassis via tyre contact patch.

1. Four studded pads are fixed on frame to provide grip.

2. Pads are studded for maximum grip, and made out of marine plywood, with approximately 400 nails per pad.

3. Attachment points are made for the chassis, in this case a bar is bolted to the front bulkhead for brake tests.

4. For toe and caster stiffness, the same bar is used at the rear for acceleration tests.

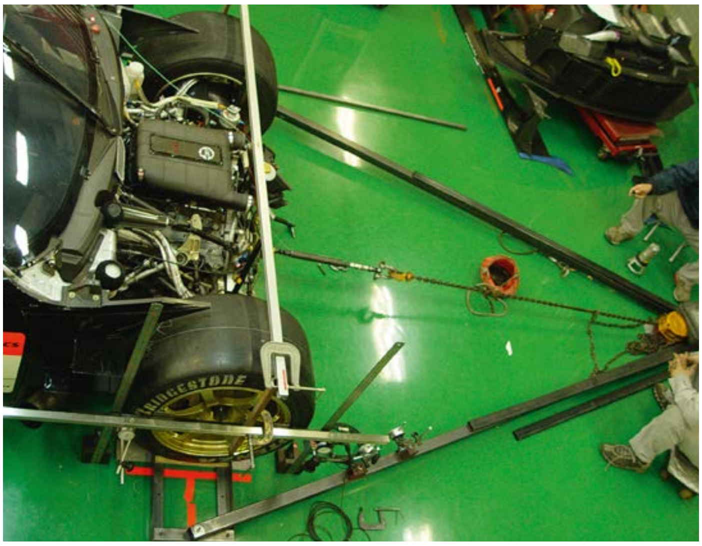
5. For side load, a pulley attachment is fitted to side of rig, and loads applied to plate bolted to floor of car (camber stiffness).

6. Bars attached to chassis give a reference for dial gauges attached to the wheels.

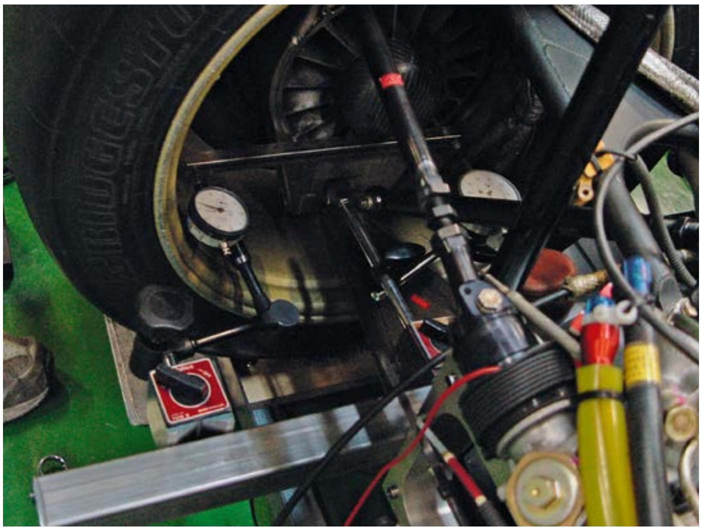
7. Ensure holder bar for dials is fixed to rim, not the sidewall of the tyre. Loads are measured with a sensor, in this case a standard car push rod, capacity of plus/minus 2000kgs. Initial braking test did not have forces high enough for accurate measurement.

8. As the kpi intersection point with ground is in middle of contact patch, the torque applied to wheel was very low, as pull force measured must be divided by four, for each wheel (approximately). Braking only one axle improves accuracy.

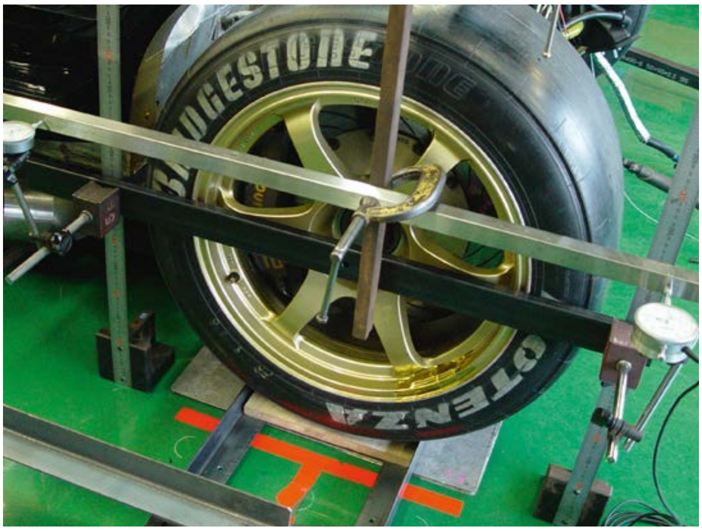
Car restrained on all four wheels with the two frames interlinked will reduce wheel loads



A view from above of the toe rig assembly. The car may need to be loaded with ballast



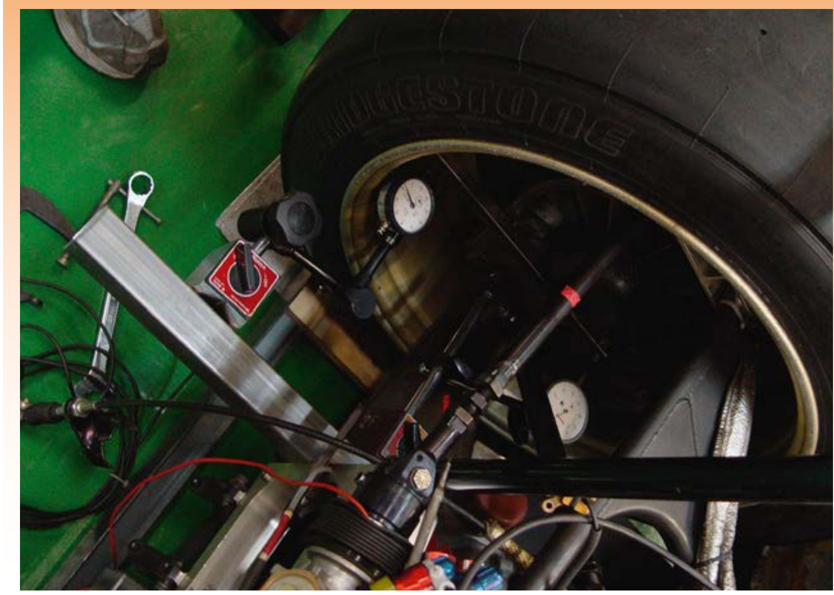
The caster, the rack and rack mounts can be measured under braking and acceleration



This shows the caster measurement process with the rulers fixed on to the wheel bar

With any testing, values recorded will only be as good as the care you take

Procedure for toe test in eight easy steps



Toe is tested with the car mounted on the toe and side pull rig with the pulley used to supply the forces

1. The car is mounted on Toe and side pull rig.
2. A strain gauged pull rod is mounted with pulley to give simulation of braking or acceleration forces.
3. For braking, total load checked with all four wheels on pads. Brake pedal locked.
4. For front or rear braking deflections, blank off hose so appropriate front or rear system is neutralised.
5. Load car with pulley.
6. Register the readings on dial gauges mounted on the wheel. Widest possible span best. Beam attached to wheel with clamps.
7. If you are feeling ambitious, you can apply combined loads by pulling simultaneously longitudinally and laterally, but for a given car weight it will reduce individual wheel deflections before you pull it off the rig. It is better to measure single direction forces then. After all, you are looking for individual problems.
8. As with any testing method, values recorded will be only as good as the care you take. So make sure you are not losing accuracy through rig deflection or dial gauge frame deflection.

The ragged edge

Sometimes a set-up arrived at by lap time simulation can result in a hard to drive racecar – which is why it makes sense to use the stability index

By DANNY NOWLAN

Lap time sims can occasionally arrive at a set-up that is difficult for the driver, but incorporating the stability index into the simulation can help. Pictured is an old DTM Opel with vicious turn-in oversteer

Why will lap time simulation sometimes favour an unstable response? Simply because at times that is where the grip is

One of the biggest criticisms that is often levelled at lap time simulation packages is that they can deduce set-ups that are simply undrivable. There is a key reason of why that is so and we will discuss this in some detail shortly.

Over the last couple of years I have discussed in depth a concept known as the stability index. Recently we have just incorporated this into ChassisSim and this should go a long way to incorporating driver feel into the lap time calculation. The purpose of this article is to discuss in depth where this comes from, and more importantly how to employ it.

Just to refresh your memory, the stability index has its origins in aircraft longitudinal dynamics and it measures the moment arm between the cg and the centre of the tyre forces. This situation is illustrated in **Figure 1**.

Stability index

The Neutral Point is the location of the sum of the lateral forces. With the stability index, what we're measuring is the moment arm between

One of the biggest advances in fighter aircraft design was when designers recognised the performance potential in making aircraft unstable

this and the cg. We then non-dimensionalise this by dividing it by the wheel base.

To kick this discussion off, this all started with a feature I wrote about the 'magic number' (*Racecar* V26N9, September 2016) and how to use it. In particular it can be traced to the analysis that is shown in **Table 1.**

To say these figures are fascinating is an understatement. As we can see, the peak lateral force occurs at a front lateral load transfer of 0.5. Not surprisingly the stability index is very marginal at -0.00291. What is interesting is when we go to a lateral load transfer factor of 0.6 we drop only 80N of force but the stability index drops to -0.072. This is a big change in handling. What is even more interesting, though, is the spread of forces is only about 1000N or about four per cent. However, we see large fluctuations of the stability index.

To fully appreciate this it would be wise to look at it graphically. To that end a plot of lateral load transfer against available force is shown in **Figure 2.** For effect I have put the maximum number of this plot at 25000N and the minimum at zero. Note the small variation. Plotting the stability index shows a completely different story – as is shown here in **Figure 3**.

A colleague of mine plotted this out and telephoned me straight away and said: 'You are on to something here and if you don't pursue this you are nuts.' I took his advice.

True grip

Before we get on to why the stability index is such a good measure of quantifying drivability changes we should discuss why lap time simulation will sometimes favour an unstable response. The simple answer is that at times this is where the grip is. I discussed this in detail in the magic number article when we discussed why the ideal lateral load transfer for a rear-wheel-drive car was 0.473. Also, to reiterate, before you all start hitting the rev limiter, just remember one of the biggest advances in fighter aircraft design was when aircraft designers

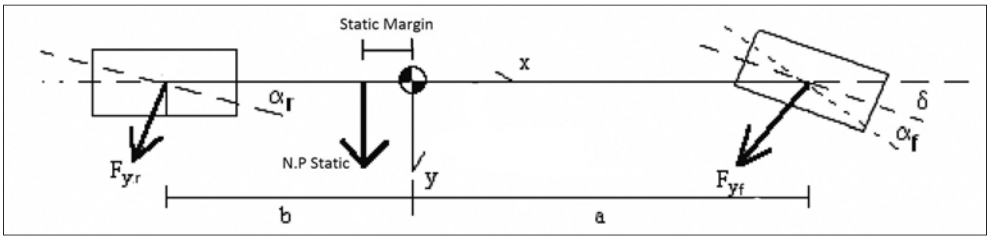


Figure 1: The stability index measures the moment arm between the cg and the centre of the tyre forces

Table 1: Results of lateral load transfer *vs* the stability index for an F3 car

Lateral load transfer	Total lateral force (N)	Projected front slip angle (deg)	Stability index
0.1	21952.64	4.24	0.162
0.2	22264.4	4.42	0.13
0.3	22479.4	4.6	0.09
0.4	22597.6	4.80	0.05
0.5	22619.05	5.01	-0.00291
0.6	22543	5.24	-0.072
0.7	22371	5.51	-0.166
0.8	22102.6	5.8	-0.303
0.9	21736.9	6.14	-0.524

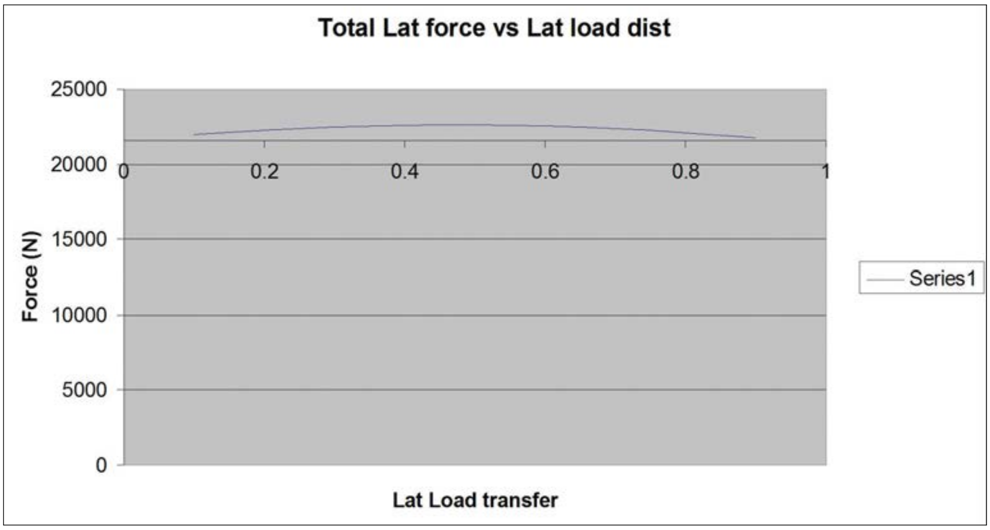


Figure 2: Total lateral force *vs* lateral load transfer distribution. For effect, max is 2500N while min is zero

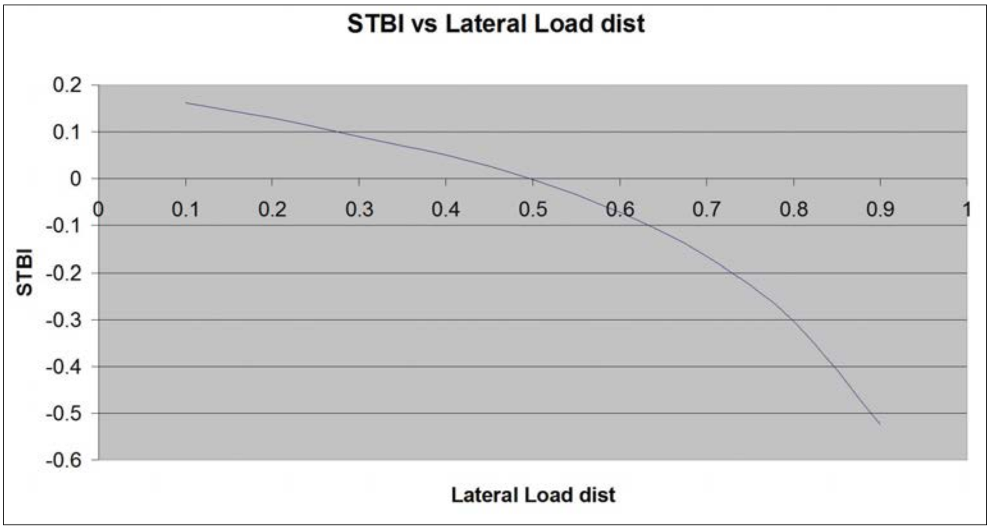


Figure 3: Plotting the stability Index *vs* the lateral load transfer distribution resulted in some very interesting findings

Table 2: Plot of normalised ChassisSim slip angle derivatives

Slip angle (deg)	Slip angle (rad)	FNORM	δC/dα
0	0	0	14.323
1	0.0175	0.25	13.925
2	0.0349	0.5	12.731
3	0.0524	0.69	10.742
4	0.0698	0.85	7.9567
5	0.0872	0.96	4.375
6	0.1047	1	0

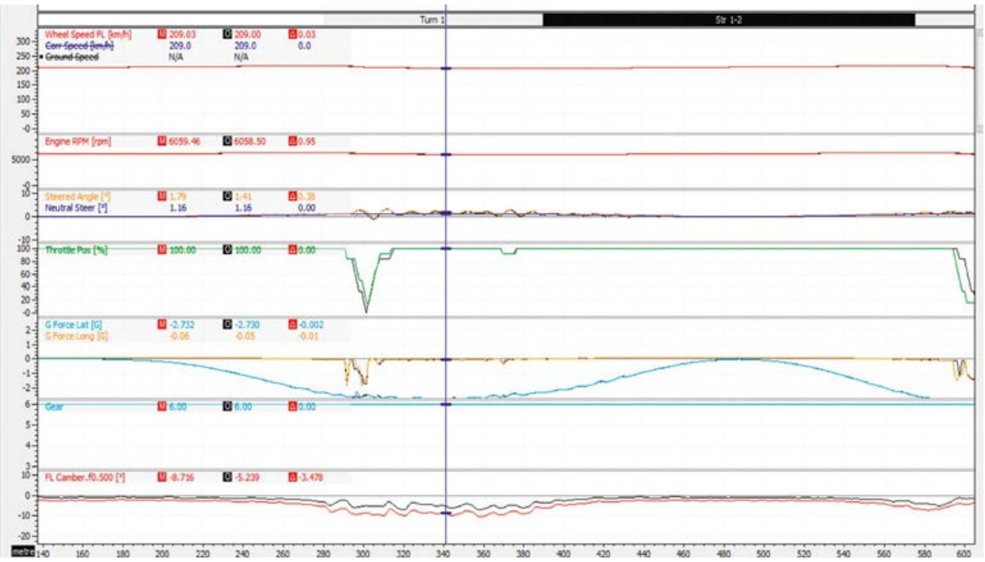
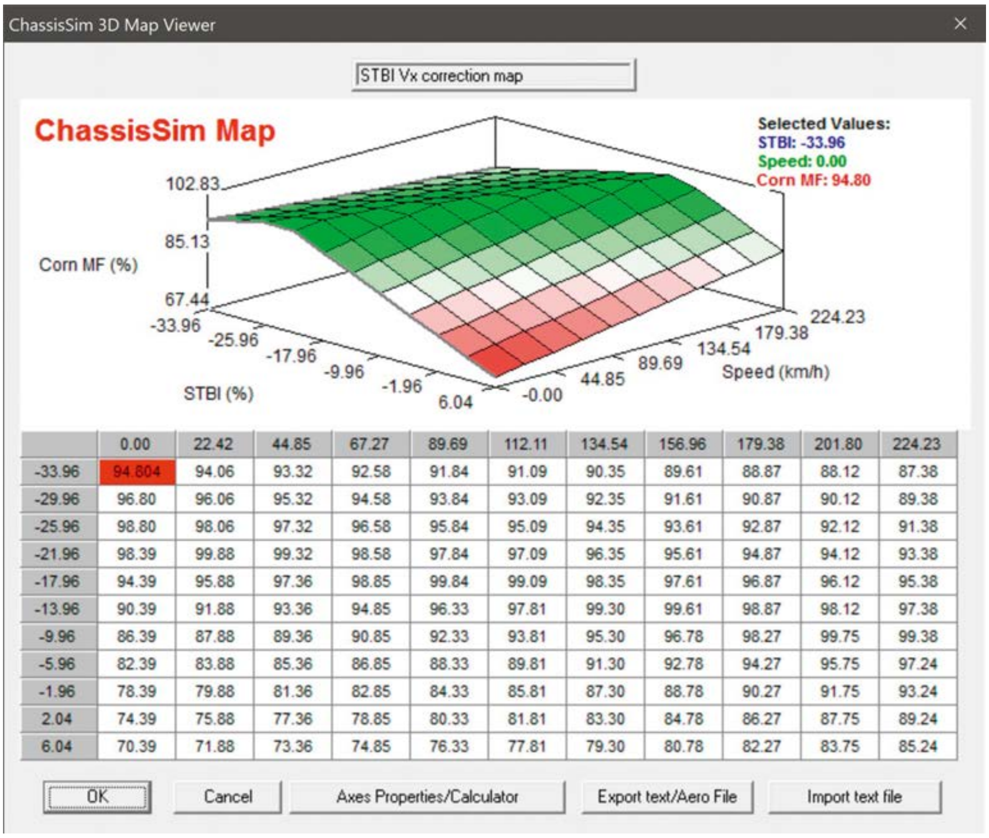


Figure 4: A plot of steer, neutral steer and stability index for a Formula 3 car with aero balance at stock and at five per cent



	0.00	22.42	44.85	67.27	89.69	112.11	134.54	156.96	179.38	201.80	224.23
-33.96	94.804	94.06	93.32	92.58	91.84	91.09	90.35	89.61	88.87	88.12	87.38
-29.96	96.80	96.06	95.32	94.58	93.84	93.09	92.35	91.61	90.87	90.12	89.38
-25.96	98.80	98.06	97.32	96.58	95.84	95.09	94.35	93.61	92.87	92.12	91.38
-21.96	98.39	99.88	99.32	98.58	97.84	97.09	96.35	95.61	94.87	94.12	93.38
-17.96	94.39	95.88	97.36	98.85	99.84	99.09	98.35	97.61	96.87	96.12	95.38
-13.96	90.39	91.88	93.36	94.85	96.33	97.81	99.30	99.61	98.87	98.12	97.38
-9.96	86.39	87.88	89.36	90.85	92.33	93.81	95.30	96.78	98.27	99.75	99.38
-5.96	82.39	83.88	85.36	86.85	88.33	89.81	91.30	92.78	94.27	95.75	97.24
-1.96	78.39	79.88	81.36	82.85	84.33	85.81	87.30	88.78	90.27	91.75	93.24
2.04	74.39	75.88	77.36	78.85	80.33	81.81	83.30	84.78	86.27	87.75	89.24
6.04	70.39	71.88	73.36	74.85	76.33	77.81	79.30	80.78	82.27	83.75	85.24

Figure 5: The corner multiplier map multiplies the final corner speed and is key to using stability index in lap time simulation

recognised the performance potential in making their aircraft unstable. This trend was kicked off by the F-16 and has come to full maturity in the extreme plus agility designs you see with the Russian Sukhoi Su-35S and Su-50 PAK-FA. They are unstable because that is where the performance is and it is no different to what we have seen with the magic number.

The next question that needs to be addressed is why the stability index is such a good measure of drivability. To answer this question let's compare the simulated results of a Formula 3 car with an aero balance at stock and with the aero balance of plus five per cent. This is illustrated in **Figure 4**.

Formula 3 study

If we take a look at the mid corner condition there isn't a lot of change in speed and the steering has reduced by 1.8 deg to 1.4 deg. However, where things really change is in the stability index, which is the bottom plot (ignore the *FL Camber* title). The stability index is shown as a percentage. The baseline has a stability index of -8.76 per cent and the change shows a stability index of -5.3 per cent. I should also add the reason this is filtered is due to how bumpy the circuit is. Also, anyone who has spent more than five minutes in Formula 3 will know that this is a change even a novice driver will feel.

Why this is such a clear measure of drivability change lies, as always, in the mathematics and the formula for the stability index is shown in **Equation 1**. However, things get interesting when we look at the numbers under the hood that drives it, by looking at the normalised ChassisSim slip curve we can see in **Table 2.**

The key reason we are getting such big variations in the stability index is the gradient of the normalised slip curve. As we get closer to maximum force you will see the normalised slip curve is dropping off quite markedly.

However, from a slip angle of four to six degrees the normalised force is only changing by 15 per cent. Given that these are the slip angles we will spend the most time at when the car is at peak *g*, cross-referencing the above

EQUATION 1

$$C_f = \frac{\partial C_f}{\partial \alpha_f}\Big|_{\alpha=\alpha_f} \cdot (F_{m1} + F_{m2})$$

$$C_r = \frac{\partial C_r}{\partial \alpha_r}\Big|_{\alpha=\alpha_r} \cdot (F_{m3} + F_{m4})$$

$$C_T = C_f + C_r$$

$$stbi \approx \frac{a \cdot C_f - b \cdot C_r}{C_T \cdot wb}$$

Here we have,

dCF/da(α_f) = Slope of normalised slip angle function for the front tyre

dCR/da(α_r) = Slope of normalised slip angle function for the rear tyre

Fm(L_1) = Traction circle radius for the left front (N)

Fm(L_2) = Traction circle radius for the right front (N)

Fm(L_3) = Traction circle radius for the left rear (N)

Fm(L_4) = Traction circle radius for the right rear (N)

Anyone who has spent more than five minutes in Formula 3 will know that this is a change that even the most novice of race drivers will feel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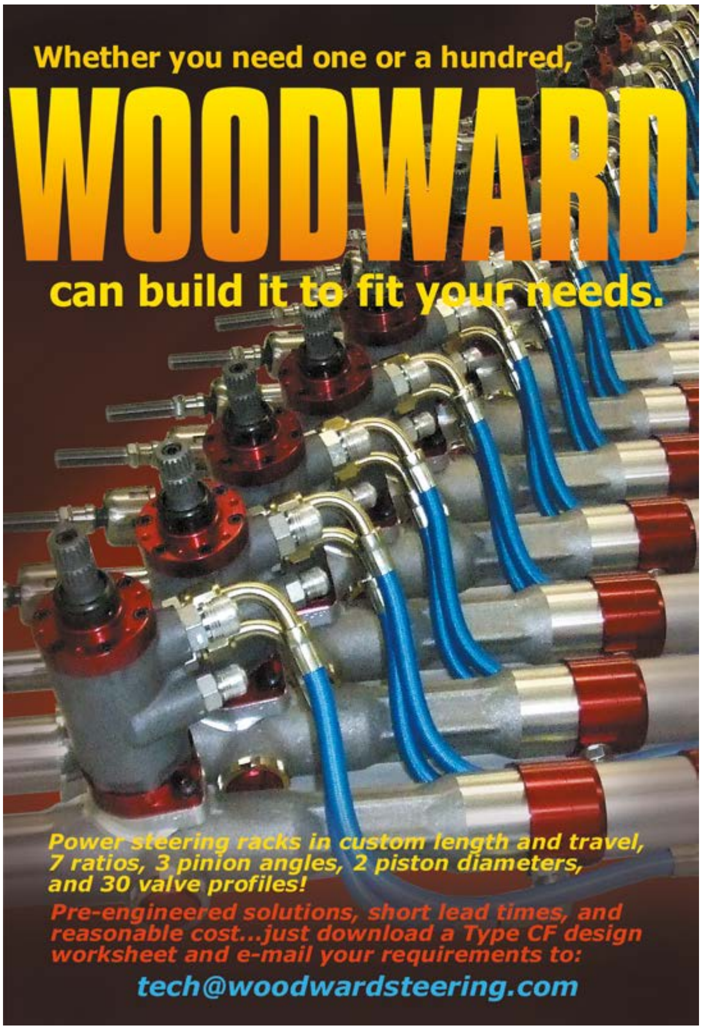
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with **Equation 1** shows why the stability index variation here is actually so large.

So the key question to be asked is; how do we role this out and implement it and use it in a lap time simulation package? **Figure 5** will go a long way to answering this question. What this map does is it multiplies the final corner speed by the look-up table. The reason that speed is in there is that racecar stability is strongly affected by the aerodynamics, so in order to get an accurate picture you also need to have speed as well as stability index in the picture. So, in this case, ChassisSim will calculate its mid corner and turn in speeds and will then modify these values by cross referencing the mid corner speeds to this map. The first point in this process is how do you actually define this map?

Map method

The key method to do this is to run a simulation on a set-up that your driver is comfortable with. However, more importantly it should be a set-up they feel comfortable pushing the car in. This will give you the stbi *vs* speed characteristic they feel comfortable in driving to. Then all you need to do is specify the map as the basis of this. This can be done manually or using the map generator. **Figure 6** shows an example of how to use it.

Here you simply use a slope of corner multiplication percentage *vs* stability index as a percentage. In this case the oversteer slope is *one* so if the car oversteers for every stability index increase of one per cent the corner speed will be penalised by one per cent. In the understeer case for every decrease of one per cent of stability index the corner index will drop by 0.5 per cent. These are default numbers but they can be increased or decreased depending on the skill and sensitivity level of the driver

To quantify all this we ran two tests at the Willowbank circuit in Queensland Australia. For this test we ran a live axle V8 Supercar and a twin shock Formula 3 car. The reason Willowbank was used is it's a notoriously bumpy circuit so consequently it formed the perfect torture test. The F3 results are presented in **Table 3**

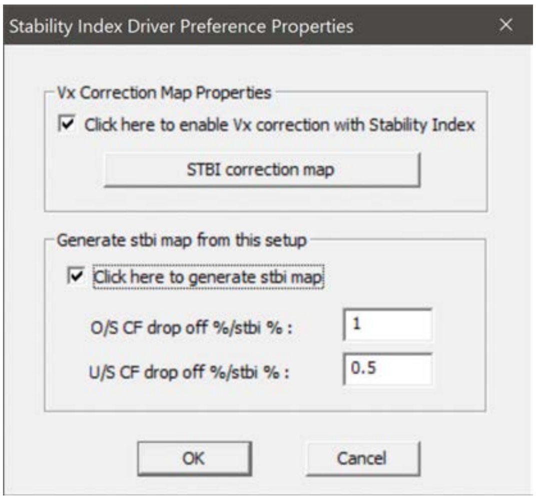

Figure 6: STBI map generator in ChassisSim. You should run a simulation with a set-up that your race driver is comfortable with

Aero effects

The F3 results are an interesting set of numbers. The smallest change here was the rear spring change of 900lbf/in. Since the rear bar rate is 1200N/mm it's not surprisingly there aren't big changes in the base corner speed so the effect here was minimal. The next change was halving the rear bar rate. On standard the delta was 0.305s while for the stability index change it was 0.32s. It's starting to make its presence felt but due to the fact the bar rates are still saturating the tyre spring rates, the effect wasn't large.

The aero changes are where things got interesting for the F3 car. When we reduced the aero balance by five per cent the delta in the standard lap time calculation was 0.44s. For the stability index calculation the delta was 0.538s, so this effect was starting to show. However, where things get interesting is the forward aero balance change. The delta for the standard lap time calculation was a gain of 0.12s. The stability index calculation was a loss of 0.218s. This is where the stability index correction is making its presence felt, because car stability as opposed to corner grip is now taking precedence in the corner speed calculation.

There is also a key reason for the lap time discrepancy between the standard and stability index correction. Given this is an Formula 3 car, stability index will be varying with speed. Here we used only a 10 by 10 matrix and had five corners to go off. If you increased the size of the map and you had more corners this discrepancy would be eliminated.

V8 Supercar

The V8 Supercar numbers were even more enlightening. These results are shown in **Table 4**. In this particular case the stability index correction now dominates the corner speed calculation. For the spring and bar changes the standard lap time calculation was in the order of 0.1s. With the stability index calculation it is now 0.3s.

The large rear roll centre was even more pronounced with a change from 0.284s to 0.86s. Again the differential between standard and the stability index correction comes down to a coarse correction map.

As can be seen the stability index correction has definitely made its presence felt. In the Formula 3 car it prevented what can all too often happen with lap time simulation that the more aero balance you apply the faster you get, where in reality you wind up with a car that is quick but undrivable. Also, in the V8 Supercar case it accentuated the characteristics that were already there. This in and of itself is quite significant. Where it didn't have an effect is where the chassis changes were too small to effect a change in the stability index. This does show that we aren't making something up here, and that is a good thing.

In closing, the stability index is a viable way of quantifying drivability changes and the results shown here show considerable promise. As can be seen in the Formula 3 example with the increased front aero change, while there was a small change in the steer angle there was a much bigger change in the stability index.

Also, as seen in both the Formula 3 car and the V8 Supercar examples studied here, the stability index correction methodology produces results that enhance and add to the base lap time calculation.

I have no doubt this will prove to be a valuable tool in figuring what set-ups work for both the racecar and the race driver.

Table 3: Stability index correction results for the Formula 3 car at Willowbank

Change	Standard	STBI correction
Baseline	61.96s	62.262s
Aero balance + 5%	61.84s	62.48s
Aero balance – 5%	62.4s	62.8s
Rear bar 600N/mm (Std bar 1200N/mm)	62.26s	62.58s
Rear spring 900lbf/in (Std spring 800lbf/in)	62.0s	62.3s

Table 4: Stability index correction results for the V8 Supercar at Willowbank

Change	Standard	STBI correction
Baseline	69.5s	69.69s
Rear spring 70N/mm (standard RSP 60N/mm)	69.584s	69.99s
Rear spring 50N/mm	69.464s	69.62s
Rear bar 25N/mm (standard rear bar 15N/mm)	69.564s	69.9s
Rear roll centre 300mm (Standard 230mm)	69.784s	70.55s

As seen with both F3 and V8, the stability index correction methodology produces results that enhance and add to the base lap time calculation


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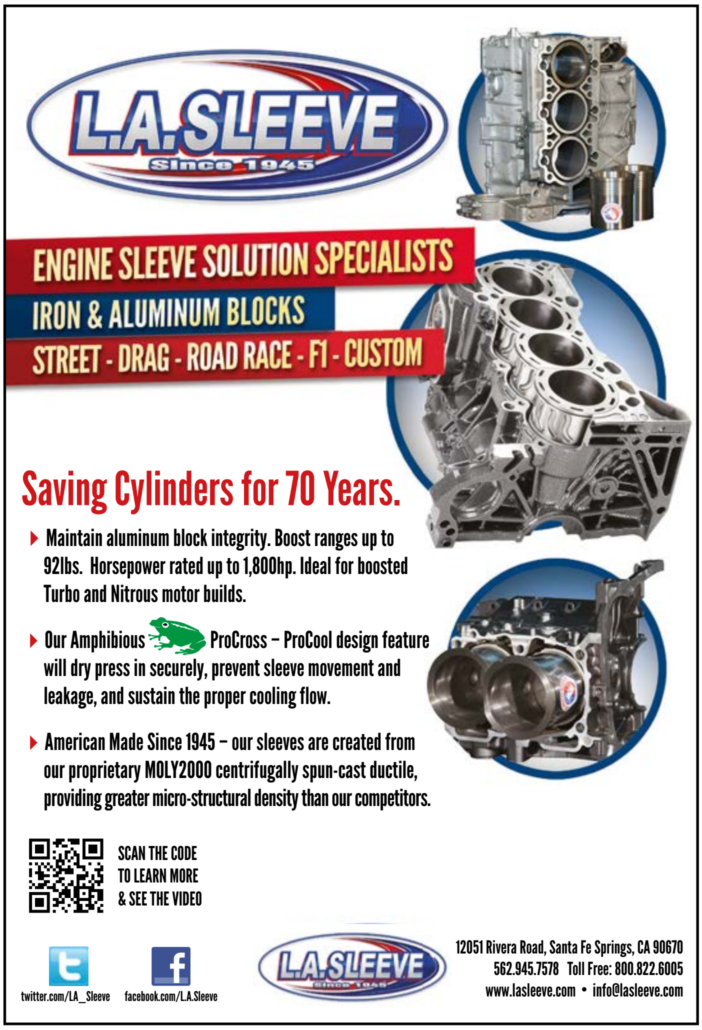
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The main event

For the motorsport industry there's only one place to be in mid-January – the Autosport show. But if you did happen to miss it here's a flavour of ASI 2017

By SAM COLLINS

Solihull in Birmingham, England, is not the most appealing place to visit in January in the depths of winter. Despite this, year after year the motorsport industry descends on the National Exhibition Centre – despite its over-officious staff and over-priced coffee. The reason is the annual Autosport International event, now the fourth and final stop on a round trip that takes in Cologne (PMW Expo in November) and Indianapolis (PRI, in December), having kicked off at the Advanced Engineering show, also at the NEC in November.

Some years ago the Autosport Show was the traditional place for companies to show off their new products, especially British racecar constructors. However, there were no significant new car launches at the show this year, something which has not happened before, if memory serves. There were still some firsts, though: the first public showing of a 2017 specification LMP2 car in the UK (the Ligier JSP217), and the first public showing of a 2017 World Rally Car in the UK (the M-Sport Ford Fiesta).

Delight in the detail

Beyond that though the real interest could be found only in smaller details. Radical cars showed off its new front bodywork package to go on its ever expanding range of sports prototypes, and a number of teams and organisations revealed 2017 plans.

Look hard enough and you can find some real gems at ASI – this old single seater packing a Ducati engine was up for sale

Most of the industry turned up in some capacity, many just to stroll around to see what was going on and to gossip with others who they had not seen since the start of the Christmas holidays. Many Formula 1 staff were noted strolling the aisles of the show in civvies, looking a bit lost and wondering what to do in the five weeks until the paddock re-assembles for pre-season testing in Barcelona.

The single biggest topic of conversation was the fate of the Manor

MIA Energy Efficient Motor Sport Conference: Sam Collins reacts to gaming debate

The Consumer Electronics Show in Las Vegas has become more popular for major motor manufacturers than the traditional car shows such as Los Angeles and Geneva, and that has alerted the motorsport industry to what may be a paradigm shift in the way consumers view automobiles and motor racing.

This was one of the main topics of discussion at the annual MIA Energy Efficient Motor Sport Conference, held at the NEC in Birmingham, just before the Autosport Show kicked off. While the five panels were made up exclusively of men aged over 45 wearing suits, the main topic of conversation was not the future of fuels in the sport, rather it was all about fan engagement and lessons to be learned from the rise of CES Las Vegas and the $1m dollar Formula E sim race which took place there.

One regularly repeated ambition of many 'forward thinking' organisations in motor racing is to create a stronger link with e-sports and gaming. The most regularly discussed target has been to create some way of allowing gamers at home to compete against the real cars on track in real time. During the event that bright idea was again, predictably, rolled out. On paper this is great, after all who would not want to take on Lewis Hamilton around Monaco in real time?

Game boys

This kind of interactivity between reality and the gaming world allows fans and gamers to interact with the sport in a way which was impossible pre-digital revolution. That is the reason why it has been proposed for Rallycross, GT racing, F1 and Formula E.

However, the harsh reality is that it is impossible, at least at the moment. The GPS used in the major championships is simply not precise enough, with only around 20cm of accuracy. It may not sound like much but if you are trying to race wheel to wheel through a corner, 20cm is a lot.

This is not a show stopper. Defence specification systems have a much higher degree of accuracy and these are becoming available commercially (at a high price, of course), but this will get sorted in time anyway.

But that's not the real issue. It may be that this is a flawed idea in the first place. A racing driver reacts to what is happening with the car at any given point, things which may not be immediately apparent; different engine modes is an obvious one, fuel loads and consumption, tyre degradation and component temperatures. Teams and manufacturers would need to be far more open than they are now for it to even start to work properly, otherwise the gamers have a huge advantage over the drivers on track.

Also, in reality, racing drivers respond to events in real time, but it would be impossible for them to react to a car that is not there in reality. Look at Max Verstappen in Suzuka. Lewis Hamilton would easily have passed him in the closing stages of the Japanese Grand Prix if Verstappen did not know that he was there. Think of Monza, if the gamer gets a tow off the car racing in reality and goes alongside, it is likely that the real driver will turn into the gamer as he is utterly unaware of the gamer's existence.

Without the other cars in the 'race' reacting to the gamer's car it then simply becomes a lap time competition. But the gamer does not face real factors like tyre wear, power unit wobbles or crosswinds, so in theory the gamer should always win.

With such interaction boiling down to a mere timing competition, then the technology for this is easily possible already, but there seems to be little interest – where is the real-time World Rally game, for example?

Paddle shift

So real drivers 'racing' in races as they happen in real time is never going to offer a realistic or satisfactory gaming experience. However, a conversation with *Racecar Engineering* founder Ian Bamsey got me thinking that a new technology means that there is another way to get gamers immersed in real motor racing, and it is one

Who would not want to take on Lewis Hamilton at Monaco in real time?

The crowds still flock to the NEC in January and it's still regarded as the start of the season in many respects. This year's ASI had its usual eclectic mix of cars on show

If you put this in the Tate Modern a man with a small beard would contemplate it for an hour. Even in this CAD-driven age there's still a degree of art in motorsport engineering

F1 team, which had just entered administration and at the time of writing faced an uncertain future.

But overall there was something of a feeling that the show was a bit flat, a sentiment voiced by many industry visitors. Perhaps it was something to do with the timing of the show, being the fourth in the series means that the engineering exhibitors had few things which had not already been seen at least once before, and with the start of both the F1 and World Endurance Championship seasons some weeks away, it was a bit early for cars from those championships to be seen. The year-round racing schedule doesn't help, either.

There was one curious but actually rather innovative feature in the event. At what was called the Williams F1 Experience fans were allowed to don fireproof overalls and go through a guided tour through the heritage of the Williams team. This tour cumulated with what can only be described as a modern dance interpretation of a 2016 F1 pit stop – this probably seemed rather less surreal if you had the tour guides earphones on.

It is clear, to this writer at least, that the show needs a refresh, but that is something that its organisers have promised will come in 2018, with new owners now taking control of ASI , and rumours of major changes were doing the rounds.

It seems clear that the industry will gather each January at ASI, in whatever format it takes, and wherever it is held.

which actually was first proposed many years ago, and one which has fascinating possibilities. At the Special Interest Group on Computer GRAPHics and Interactive Techniques (SIGGRAPH) conference in 1991 Loren Carpenter, one of the co-founders of Pixar Studios, ran an experiment. An auditorium full of a couple of hundred people played a giant game of Pong using coloured paddles.

Carpenter was looking into subconscious consensus, but in this context it is more relevant as an early example of collaborative gaming.

Collaborative gaming, or 'crowd play' has become a bit of a trend in recent years, with Amazon's Twitch leading the way, famously having over a million people collaboratively playing a Pokemon game in 2014.

Each individual taking part plays the game at the same time and all of the gamers' inputs are averaged, and that becomes the master input controlling the game. Now, it is not beyond the scope of existing technology to control a real car on a real track this way, indeed it should be relatively easy to do so, but what you would need to make that happen is a fully autonomous racing series, where the cars are controlled by computers, not by humans sat inside the actual vehicle. In other words, Roborace.

Game of drones

The nascent autonomous racing series is the perfect place for such a collaborative gaming approach and that could build up its exposure and fan base, a kind of humanity *vs* robots, *Westworld* meets F1, sort of thing.

But for those, like me, who prefer the more cerebral gaming experiences offered by strategy games such as *Football Manager* there is another opportunity for collaborative gaming, where gamers can take all the decisions for a real team ahead of a match. It may sound far fetched but in fact it has already been done. In 2008, a group of 27,000 online gamers took over Ebbsfleet United, a lower league English club, and essentially ran it collaboratively for a couple of seasons.

The same could be possible in racing with the recent launch of *Motorsport Manager*. This game allows players to take over a team and run it; pick the drivers, engineers and mechanics, and negotiate contracts, decide on tyre and pit strategy and react to real time situations in the race. It would work brilliantly in Super Formula, GP2 or even Indycar, and could capture fan interest.

It is capturing fan interest in the sport which seems to have captured the interest of the senior industry figures who roll out each year for the MIA conference. But almost none of those present had ever been involved in online gaming or e-sports, yet they spent most of the event discussing it. For the conference and indeed the sport to stay relevant it needs younger voices and wider participation, otherwise both will fade into obscurity.

There was much talk about gamer-interaction in racing at the MIA conference

Shutter speed

This year's show delivered its usual mix of high-end racing exotica and grassroots innovation – our snapper was on hand to capture the highlights

You couldn't go too far at this year's Autosport International show without bumping in to a Ginetta of some description – this particular version is a National Hot Rod oval racer

The show gave UK rally fans their first glimpse of the new-regulations Fiesta WRC. The M-Sport built and run Ford went on to win the Monte Carlo Rally just a week or so later

Jaguar's Formula E car was on show, sporting FE's new-for season three front aero package – JLR is one of many manufacturers attracted by the series' green ideals

Deputy editor Sam Collins spots a nifty tweak on the new Ligier LMP2 car's sidepod. This Oak-built racer is one of four new types of P2 that will be in the WEC this season

It's a Lotus Elise, but not as we know it. Underneath the curvaceous bodywork sits a Jade sports prototype. Fans of 1970s silhouette racers would appreciate this little car

This Lotus Evora FIA GT3 project is being built up by students at Staffordshire University – as always academic institutions were very well represented at the Birmingham show

PHOTOGRAPHY BY JEFF BLOXHAM

Radical used the Autosport show to debut a series of body mods across its range (pictured is the RX). It was also keen to speak about its plans for a new LMP1 car

One of the UK's best-known sports prototype makers, Juno, has now been bought by a Portuguese company – as ever, ASI witnessed a number of industry announcements

Pilbeam's new mother chassis was on display at the show and attracted the interest of deputy editor Collins. It will be featured in the next edition of ***Racecar Engineering***

Xtrac was one of many motorsport engineering companies to display its wares at the show – a rare chance to get up close and personal to the bits usually hidden in a car

Possibly the most-popular stand at the Autosport Engineering show during a very rare quiet period

Italian automotive engineering companies are very proud of their roots, and their customers

Business of the Year Award – for companies with sales above £5m a year – is given to Malcolm Wilson (right), boss of M-Sport, by Adrian Moore of award sponsor Xtrac

Business of the Year Award – for companies with sales under £5m – is presented to Simon Dowson of Delta Motorsport (right) by Chris Batty of award sponsor Lestercast

The Service to the Industry Award is presented to Stuart Pringle (right), the sporting director at Silverstone Circuits Ltd, by Jon Hourihan of award sponsor Goodridge

The MIA New Markets Award is presented to Simon Crompton (right), who is the managing director at Wirth Research, by Anthony Blackwell of 920 Engineering

Xtrac chairman Peter Digby (left) and managing director Adrian Moore (right) receive the prestigious MIA Export Achievement Award from Francisque Savinien of PRI

Ian Cluett (right) of Williams Advanced Engineering picks up the Technology and Innovation Award, which was presented by Iain Wight from award sponsor Ricardo

Luminaries from the motorsport business world gathered at Autosport International for the Motorsport Industry Association's annual Business Excellence Awards in January

The MIA Teamwork Award was presented to West Surrey Racing founder and team boss Dick Bennetts by Phil Ward of high end casting company Grainger and Worrall

INTERVIEW – John Manchester

Engine management

Gibson Technology's operations director tells us how the LMP2 spec engine deal is progressing and why the company's pulled the plug on manufacturing racecars

By MIKE BRESLIN

'The interest level and commitment level is way above our expectations and there are going to be a lot of P2 cars this year'

There have been a number of changes at Gibson Technology in recent times – the name change from Zytek just one of them. But amidst the evolution and flux that is an integral part of motorsport business there has been one notable constant, its operations director John Manchester, who is now in to his 30th year at the concern.

Manchester was there at the very beginning, in fact, when race engine builder Alan Smith Racing, where he was then employed, was approached by Zytek founder Bill Gibson in 1987 about building an F3 engine incorporating Zytek's engine management system (Zytek was born in 1981). One thing led to another and Gibson ended up buying the company, which became Zytek Engineering. To cut a very long story very short, this went on to supply F3000 with its engines for nine years, build a number of highly successful LMP cars, and excel in pretty much every mode of motorsport it turned its hand to. Then, in 2014, the original Zytek Automotive part of the company, which deals with vehicle technology and electric vehicle systems, was sold to German company Continental Engineering.

This left Zytek Engineering to concentrate on motorsport, but it also needed an independent identity. 'We decided to change the name to avoid any confusion,' Manchester says. But with 30 years of history behind the brand he admits this was no easy decision: 'It was a massive decision. We thought it might affect the brand, but we still felt it was the right choice and I have to say it has worked very, very well. There were no real issues. Everyone knows we are now Gibson Technology.'

To the power of two

There have been other changes lately, too, the biggest both to do with the new LMP2 regulations that come in to force this year. This has resulted in Gibson no longer being a chassis manufacturer, having decided not to tender for one of the four licences to build P2s in order to concentrate on winning the engine deal for the same category. This proved to be a wise move, but how much of a wrench was it for the company to turn its back on racecar manufacturing?

'It's sad because most people, when we show them around the factory, love seeing a racing car. I think from that point of view it got the company's name very well known, the fact that we were a chassis manufacturer. That really promoted our brand,' Manchester says. 'But the way the tendering process was written, it stipulated that you could not tender for both engine and chassis, so you were only ever going to get one. And essentially we are a powertrain business, so all of our experience and a lot of the set-up within the organisation is based upon manufacturing, designing and developing race engines. Whilst we did produce chassis it wasn't a huge part of the business, and as such the investment required to become a big chassis manufacturer would have been way above what we needed to do to continue with engines.'

While that decision might seem straightforward, there was still another crucial factor that needed to be addressed before it decided to compete for the engine deal. With the tight cost constraints to meet the engine tender – less than €1300 per running hour with track support having to be included in the price – could Gibson actually make the P2 engine pay?

'I still look at it now and think it's going to be tight!' Manchester jokes. 'It is very difficult. It's not a vast amount of money for this level. We've got a pure race engine here; it's over 600bhp, has cost a lot of money to develop and produce, and you have got to get a return on that investment, otherwise it's not viable, so we did the figures very carefully. We looked at ways where we could reduce costs without impacting on the reliability and performance and I guess it's made us look at the efficiency of the way we've done things, which has made us more efficient in terms of productivity. If we get enough teams out there, then we've also got a bigger investment in terms of having to make more engines, but hopefully we will have more cars running, so you start to get your payback probably in the second year; you should start to see a return, at least by the third year if everything goes to plan.'

Power trip

So far everything really does seem to be going to plan, with the new LMP2, fitted with the Gibson GK428 4.2-litre naturally aspirated V8, the hot ticket for 2017. 'The interest level and the commitment level is way above our expectations and there are going to be a lot of P2 cars this year,' Manchester says. 'We're absolutely flat out in terms of manufacture and build and we're having to produce another batch of 20 engines, on top of what we've already laid down, that's 40 altogether, and we're now

XPB

looking at producing another batch of engines after that as well. There are a lot of people very interested. I think they are encouraged by the stability of the regulations, at least the next four years, and also they've seen the performance levels of the cars that have tested so far – they will be doing around 330kmh at Le Mans. They will be very, very quick cars.'

One of the reasons Gibson believes it won the contract was its long experience with spec engines. Manchester says: 'We've done single make racing since 1996 in International Formula 3000, which we did for nine years. After that we got Euro F3000/Auto GP, A1 GP and Formula Renault 3.5 [it still supplies what's now called Formula V8 3.5]. We've got a huge amount of experience in supplying single make engines to race series. I think people know that we've done a reasonable job over the years. We've got a lot of very good systems in place, to be able to manage that; because a lot of it is down to engineering, making sure the product's reliable and performs well, but also the logistics of moving things around.'

Power curve

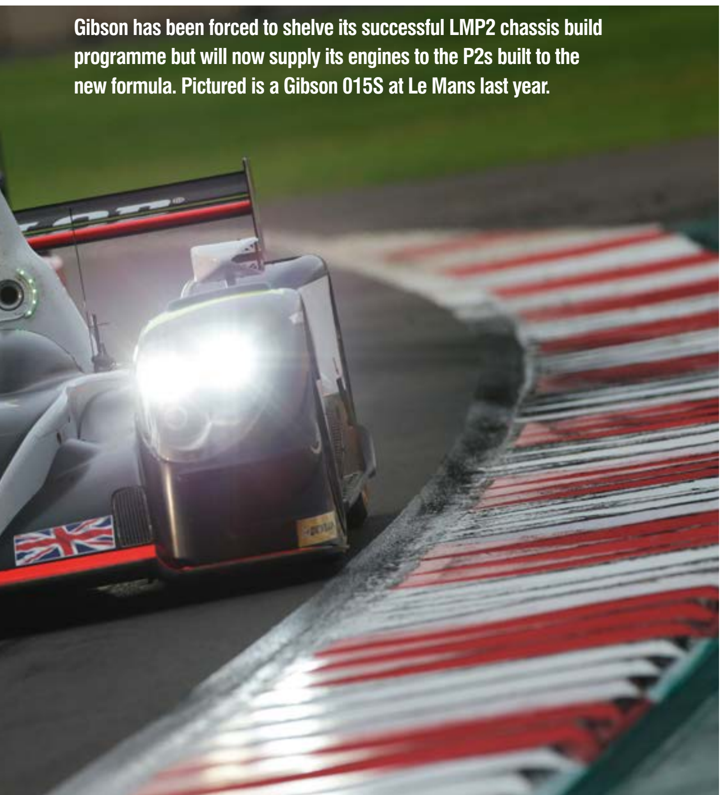
All that said, while the engine is a spec unit the new LMP2 is not quite a spec formula, and this has created some issues, Manchester admits. 'Every race series we've done for a single engine has always been for a single make chassis. So it's been challenging, with slightly different installations with different cars. But we've done a lot of testing with these cars now, so I think we've overcome each challenge as it's been presented, so it's been different and it's been a learning curve for us, but it's gone very well, all things considered.'

So well, in fact, that Gibson is now expanding its workforce and for the longer term is looking at the possibility of adding to its 27,000sq.ft facility in Repton, Derbyshire.

Meanwhile, the LMP2 engine now makes up the bulk of its work, but it also still has the Formula V8 supply deal and is also involved in a number of projects that it's not at liberty to speak about at present, some of these outside of motorsport.

Further down the road Manchester says it is looking at the possibility of hybrid systems work again, if the market is there for it, but what would be his dream project?

'I think that it would be great to design an engine for a specific car from the ground up,' Manchester says. 'That would really be quite an interesting challenge, but maybe outside of motor racing, something like a supercar perhaps. I think that would probably tick a lot of boxes.'



Gibson has been forced to shelve its successful LMP2 chassis build programme but will now supply its engines to the P2s built to the new formula. Pictured is a Gibson 015S at Le Mans last year.

RACE MOVES

XPB

Ciaron Pilbeam has left McLaren to take up the post of chief race engineer at Renault. Pilbeam has actually previously spent a year with the Enstone team, when it was known as Lotus, before he joined McLaren in February 2014. He has also worked at Red Bull, where we was race engineer for **Mark Webber**, and BAR.

Trent Owens is to be the crew chief on JTG Daugherty Racing's new No.37 Chevrolet, driven by **Chris Buescher**, in this year's Monster Energy NASCAR Cup Series (formerly the Sprint Cup). Owens was most recently crew chief for Aric Almirola in the Richard Petty Motorsports No. 43 Ford last season, before **Drew Blickensderfer** replaced him following a run of poor results.

Former Williams F1 test driver **Susie Wolff** has been made a Member of the British Empire (MBE) in the Queen's New Year Honours list for her services to women in sport. The honour is specifically for the Dare to be Different campaign she's spearheaded since her retirement from the cockpit at the end of 2015, an initiative that aims to increase female participation in all areas of motorsport.

Julia Schumacher has joined the Motorsport Industry Association (MIA) as director of business growth. She was previously with the Northamptonshire Enterprise Partnership, where she led the development of the successful Northamptonshire High Performance Technology Network. This was made up of over one thousand performance engineering businesses within the fields of motorsport, automotive, defence and aerospace.

Cole Hitchcock has returned to the Australian Supercars organisation to take up the role of general manager, corporate affairs. He previously held the post of general manager, communications, at Supercars for 12 years until August 2015, and since then he's been Corporate Affairs manager with Tourism and Events Queensland (TEQ), which is the main partner of the Gold Coast, Townsville and Ipswich Supercars races.

James Nicklin has joined Precision Technologies as finance director. He replaces **John Sandland**, who has now retired. Nicklin is a certified accountant and has several years' experience in international companies including Brightstar and JCB. He is also currently restoring a 1970s Lancia Stratos rally car.

Malcolm Boote has also joined Precision Technologies (see above) to assist with its 'change management'. Boote is a highly-experienced motorsport professional who has held senior roles at world-leading manufacturers such as TWR, Toyota Formula 1, and Williams Grand Prix Engineering.

Silverstone Technology Cluster, which has been formed to support the hi-tech activity within a one hour radius of Silverstone Circuit, has appointed **Pim van Baarsen** as its chief executive officer. Van Baarsen has previously worked with the Motorsport Industry Association, Xtrac and Haymarket Exhibitions. He also fills an on-going role as managing director for CMA Marketing, a company specialising in motorsport PR.

Rob White has been appointed to the role of operations director at the Renault Formula 1 team, transferring from Renault's Viry-Chatillon power unit facility to take up the position at the race team's Enstone base. White has been a mainstay at Renault for many years, and also has F1 experience with Cosworth.

Wally Dallenbach Jr, Tans Am champion in 1985 and 1986, is to return to the well-known US touring car series to work as its chief steward for the 2017 season, a post which will see him spearhead a restructured race control set-up.

Joining Dallenbach (see above) in Trans Am race control will be **Terry Dale**, as operating steward, who makes his return to the series having previously acted as chief steward from 2002 until 2003.

Ecclestone no longer F1 CEO; Brawn hired as MD

Bernie Ecclestone is no longer chief executive of Formula 1, its new owner Liberty Media has confirmed, while Ross Brawn is now F1's managing director.

Ecclestone has steered F1 for the past 40 years but he has now been replaced by Liberty stalwart Chase Carey, who will add the CEO title to his current job as chairman of Formula 1. Ecclestone has meanwhile been given an honorary role as 'chairman emeritus'.

Liberty Media has now also confirmed its acquisition of F1 has been completed.

Ecclestone said: 'I'm proud of the business that I built over the last 40 years and all that I have achieved with Formula 1. I would like to thank all of the promoters, teams, sponsors and television companies that I have worked with.'

Carey said: 'The sport is what it is today because of [Ecclestone] and the talented team of executives he has led, and he will always be part of the Formula 1 family.

'Bernie's role as chairman emeritus befits his tremendous contribution to the sport and I am grateful for his continued insight and guidance as we build F1 for long-term success and the enjoyment of all those involved,' Carey added.

Meanwhile, former Mercedes F1 boss Brawn has been named managing director, and will work alongside Carey and former ESPN executive vice president of sales and marketing Sean Bratches, who takes on the role of managing director, commercial operations.

Brawn, who has won 19 F1 world titles with Williams, Benetton, Ferrari and his own Brawn GP team, left Formula 1 at the end of 2013. He said of his new role: 'It's fantastic to be returning to the world of Formula 1.

'We have an almost unprecedented opportunity to work together with the teams and promoters for a better F1 for them and, most importantly, for the fans.'

Meanwhile, Greg Maffei, president and CEO of Liberty Media Corporation, has been appointed deputy chair of the board of F1.

XPB

XPB

Bernie Ecclestone (left) is no longer CEO of F1, while Ross Brawn has joined the management team as MD

Vasseur quits Renault F1 team

Frederic Vasseur has stepped down from his position as team principal at the Renault Formula 1 squad.

The Frenchman, who was hugely successful in sub-F1 single seaters with his ART Grand Prix outfit before joining the Enstone team at the start of last year, spent 2016 working with Renault F1 chief Cyril Abiteboul on a major restructuring and recruitment drive at Renault. He was then appointed team principal part way through the 2016 season.

It is thought that he has left the team due to differences of opinion with senior Renault management figures that are to do with the French manufacturer's future in F1.

In a statement, Renault said of Vasseur's departure: 'After a first season spent relaunching and rebuilding its Formula 1 team, Renault Sport Racing and Frederic Vasseur have agreed by mutual consent to part company, effective as of today. Both parties remain committed to maintaining the good working relationship they have enjoyed and expect this to take a new form some time in the future.

'The outlook of Renault's second season back in Formula 1, as well as the resources implemented to meet them, will be set out in detail at the presentation of the team's new racecar [due to be unveiled on February 21],' it added.

Renault also said that its Formula 1 team will now continue to be managed by Jerome Stoll, its president, and Cyril Abiteboul, managing director, and that it will not replace Vasseur.

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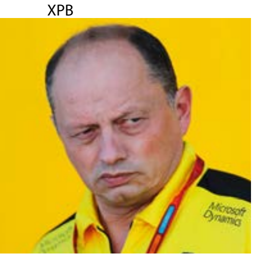

Frederic Vasseur is no longer the team principal at the Renault F1 operation

RACE MOVES – continued

XPB

It's been officially announced that **Dieter Gass** is to succeed **Wolfgang Ullrich** as head of motorsport at Audi. Gass, who has served under Ullrich for the last five years, will now steer the company's factory campaigns in Formula E and the DTM. Ullrich will remain with Audi in an advisory role until the end of 2017.

It's been widely reported that **Jost Capito** has lost his position as CEO of McLaren Racing after just four months in the job. Capito was appointed by McLaren's outgoing chairman and CEO **Ron Dennis**, but since Dennis was placed on gardening leave, pending the expiration of his current contract, Capito's position has been regarded as vulnerable.

UK manufacturer Ginetta has enlisted well-known racecar designer and former constructor **Adrian Reynard** to lead the aero development on its new-for-2018 LMP1 project. **Paolo Catone,** who previously designed the Le Mans winning Peugeot 908, will also be heavily involved in the Ginetta LMP1 design process.

Chris Stuckey is to now fill the race engineer role on the Preston Hire Racing Holden in the Supercars championship, taking over from **Jason Bush**, who has now quit the premier Australian motorsport series. Stuckey, who has been in Supercars for a decade, has spent the last two seasons at Lucas Dumbrell Motorsport and before that he worked at Dick Johnson Racing.

Toro Rosso planned to have its staff working 24 hours a day for seven days a week in the four-week run-up to the first Formula 1 test, scheduled for February 27, in an effort to have its 2017 car running on time. The Italian team took a similar approach last season, but this was because it secured its engine deal with Ferrari late in the day.

Long-time McLaren man **Ekrem Sami** has stepped down from the board of McLaren Technology Group, but he still remains a part of the Woking-based outfit's management team. Sami's place on the McLaren Technology Group board has been taken by **John Riches**, a partner at top London law firm, Withers.

Dean Antonelli is to join **John Medlen** and **Neal Strausbaugh** as a co-crew chief on the Don Schumacher Racing Chandler's Infinite Hero Foundation Dodge Charger R/T Funny Car in the NHRA drag racing series this season. Antonelli previously worked as general manager at John Force Racing for the past two seasons, an organisation he had been at for 12 years.

Well-known motorsport journalist and author **Brian Laban** has died at the age of 68. Laban, who was known for his work in sportscar racing and his enthusiasm for the Le Mans 24 Hours, wrote 40 books and contributed to many magazines and newspapers during a career that stretched back to 1973.

Jim Kaser, the first head of SCCA Pro racing, has died. Kaser oversaw the first SCCA professional racing series, the United States Road Racing Championship , and he was also instrumental in setting up the CanAm series. Kaser, who started his career in motorsport as a driver, is now due to be inducted into the SCCA Hall of Fame.

◆ 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**

Electronics
Charge of the light battery

RPS has launched a range of lithium based batteries for motorsport. It is claimed that they offer a weight saving of approximately 70 per cent over conventional batteries, have a smaller volume, faster charge time and a lower self-discharge than conventional products.

RPS says that its batteries can be fitted in any position, even inverted, and require no checking or topping up. They can also be placed in the boot or under the rear seat for better weight distribution across the racecar or to free up space in the engine compartment.

The batteries are available in 12v only with a nominal capacity of either 13.0Ah, 16.0Ah or 20.0Ah, with various mounting brackets.

www.rps-battery.co.uk

Instruments
Clock work

AEM's X-Series GPS Speedometer displays ground speed, course and altitude via an included 10Hz GPS receiver, the company tels us.

Users can integrate the X-Series GPS Speedometer into an Infinity ECU, Series 2 EMS or EMS-4 to add track mapping, and an included vehicle speed signal can be outputted to any existing speedometer to eliminate the need for a vehicle speed sensor. A 10Hz GPS receiver receives speed, heading and altitude data from multiple satellites at 10 samples per second providing excellent accuracy and reliability. The GPS receiver includes a magnet and adhesive bottom for exterior mounting on the vehicle.

The X-Series GPS Speedometer Gauge has a bright four-digit LED display that is 87 per cent larger than AEM's original digital gauges and provides better readability. A sweeping LED 'needle' lines the edge of the gauge face for quick reference, while a 33 per cent overall increase in the gauge face display makes it easier to see at a glance. X-Series Gauges come with a black bezel and faceplate, and an optional silver bezel on white faceplate accessory kit is available.

Despite the larger display, X-Series Gauges are contained in a standard two and 1/16th-inch (52mm) diameter housing for mounting in a standard gauge pod. Thanks to an advanced single board design, X-Series Gauges have an slim overall depth of under 0.825in, with a cup depth of only 0.2in. This shallow cup depth allows X-Series Digital Gauges to be mounted practically anywhere.

www.aemelectronics.com

Tyres
Getting the rubber on the track

Toyo Tire has launched the Proxes R888R, an evolution of its well known Proxes R888.

The Proxes R888R has a new tread design and an improved contact patch that puts more rubber on the surface of the track. This optimised contact patch improves braking as well as acceleration and cornering in dry conditions, we're told.

With a treadwear rating of 100 AA A, the Proxes R888R is available in a full range of sizes to fit 13in up to 20in diameter wheels with additional sizes to be released through the summer of 2017.

'The Proxes R888R represents an evolution of the Proxes R888 in its design, technology and performance,' says Marc Sanzenbacher, senior manager, Competition Performance Products Division, Toyo Tire USA Corp. 'It provides dramatically increased levels of performance for use in numerous NASA and SCCA classes, as well as Time Attack and high-performance driving schools – all while maintaining a great appearance for car customisers.'

The Proxes R888 remains in the company's competition line-up for racers who are faced with both wet and dry conditions on race weekends.

Toyotires.com

Pit equipment
Jack for all trades

B-G Racing has released a range of four quick-lift Jacks, each designed for a particular form of racing.

The four jacks in the range are called: Rally Car, Track Saloon Car, Long Formula and Small Formula.

All of the quick-lift Jacks feature a very low closed height and are designed to locate beneath the differential and front or rear chassis members, raising the car to a fixed height in one swift movement. All the jacks are produced from high-grade mild steel with a durable silver grey powder-coated finish for longevity. Design detail includes an extra-long, detachable, shaped handle for excellent leverage and nylon roller wheels to allow rapid manoeuvrability

Specific features of individual models can be found on the website.

www.bg-racing.co.uk.

Fluid transfer
Piping hot

Goodridge has introduced an all-new line of high-end performance hoses intended for the motorsport market.

The G-line Ultra range was unveiled at the Autosport International show. It features a new wire construction, which means that the Ultra range will come with the latest patented technology, a 316 stainless steel wire, helically wound into the external PTFE convolutions to provide superior vacuum and kink resistance in extreme applications. The addition of this wire has had a dramatic impact on the properties of the hose, we're told, and has increased the vacuum resistance from 130degC to 200degC in order to address the ever increasing vacuum demands required in today's dry sump racing engines.

All sizes of G-Line Ultra are usable at full vacuum up to 200degC (above this, the vacuum resistance should be reduced two per cent for every degree above 200degC in order for the hose's thermal efficiency to be maintained).

Goodridge offers G-Line Ultra with both a lightweight aramid fibre braid as well as a 316 stainless steel braid.

www.goodridge.co.uk

Composites
Gold medal material

Lentus Composites has been showing off its Cervelo track bike, that was used in the Rio Olympics.

Lentus designed the structure of the bike, specified all the materials and laminate design, designed and manufactured the tooling, produced the bikes, and carried out mechanical testing ahead of the delivery of seven frame variants to Rio.

The project showcased Lentus' capability, which is also applied to motorsport customers; including the delivery of chassis parts, aerodynamic parts and body panels. These capabilities are also offered to other advanced sectors.

Lentus has also showed its growing range of filament wound composite products and technologies. The drive-line products displayed at the Autosport Show included composite propshafts and flexible disc couplings, as well as the newly developed and tested composite half-shaft; a range of composite pressure vessels and hydraulic accumulators, and a selection of typical magnet retention sleeves; which are used in very high performance motors and generators.
lentuscomposites.co.uk

PRODUCT FOCUS: Walero racewear

Walero MD Fiona James tells us about its hi-tech racing underwear

'We launched in 2015. I started the company because I race, and I didn't like what I could find on the market.

'We use NASA developed technology, a phase change material [Outlast]. I found it when I was searching for equestrian products. I didn't like the comfort of the products that were then available.

'The company's named after my old Olympic horse. When I found Outlast for the equestrian product, I asked if we could have it in flame retardant material and they said yes. They obviously developed it because they go through extreme temperature changes in space. That was around 15 years ago.

'Most clothing is based around evaporation or wicking, but sitting in a car, evaporation is limited because you have overalls on and a seat that is surrounding most of you, you have a closed cockpit and not much air flow, so all of that can't happen very well in the car. But this actively regulates your temperature, and if you go above a certain point it takes the heat energy away from you, and if you cool down it gives it back to you. It has phase change material, tiny micro-capsules that are integrated into the yarn before the fabric is woven so it is kind of like paraffin, in that it starts liquid and goes solid. It will last for the life of the garment, it is not going to run out.

'The US military has used it and sweat reduction was around 30 per cent, which leads to better reaction times, because you are not dehydrated. This actively regulates your temperature at 37.5degC.

'Also, if you are doing an endurance race and you get out of the car at 2am you won't get a chill, and you don't need a cool suit either.

'We exceeded the FIA flame test by almost double, and are SFI approved for heat spread. We are comparable with the high-end Sparco, Stand 21 in terms of price, but you can wear this garment with everything. People are wearing it skiing, hunting, dog-walking and everything! We even had someone who is doing fit camp with it, for example so it is extremely versatile.
www.walero.uk

Turbochargers
Honey monster

Honeywell has launched the extremely impressive Honeywell Garrett GTX 5533R Gen II turbocharger, its most powerful turbo ever. The Gen II features new compressor wheel technology in a large frame turbo producing 1000 to 2500bhp.

The GTX5533R Gen II is designed for race classes with specific compressor inlet diameter rules, and for enthusiasts looking to make extreme horsepower. The GTX5533R is class legal in inlet restricted drag racing classes including NHRA Pro Mod, NMCA Drag Radial, and PDRA Pro Boost.

Furthermore, the GTX 5533R features Honeywell's Gen II forged CNC machined compressor wheel. Starting with a high strength, near net shape, forged blank, Honeywell CNC machines the blade profiles to make the thinnest blades possible without sacrificing strength. This, it claims, results in the strongest, lowest inertia, fastest spooling and most aerodynamically efficient compressor wheels that are currently on the market.

GTX Gen II compressor wheels are available in 85mm, 88mm, 91mm, 94mm, and 98mm inducer diameters to help you match the compressor to the desired power output or class rules.

The improved Gen II compressor wheel is housed in a revised high flow compressor housing with a fully machined inlet, V-band outlet, and integrated speed sensor and pressure signal ports. The integrated speed sensor port accepts Garrett's speed sensor kit.

Meanwhile, a fully-machined ported shroud features an improved ported design for surge resistance allowing air to bypass the compressor wheel when the engine's flow rate is lower than what the compressor wants to flow, reducing surge during these times. The compressor housing also has a new sleeker profile and features a lightweight billet aluminium backplate which is lighter than the previous steel version, we're told.

The GTX5533R uses Garrett patented dual ceramic ball bearing centre section. The dual ball bearings reduce friction resulting in much faster spool and they also require less oil than traditional journal bearings.
turbobygarrett.com

3D printing
Airwolf takes off

Airwolf 3D has launched a large new 3D printer called the Axiom 20.

It has a 20in Z-axis and boasts a large 12.5in x 12in x 20in build chamber.

Unlike any other desktop 3D printer in its market segment, the Axiom 20 has a fully enclosed build chamber, auto-leveling, direct drive dual extrusion with independently controlled hot ends, and the adept ability to print flawlessly in over 40 different materials, including high-temperature, industrial-grade polycarbonate and polypropylene, we're told.

'One of the biggest challenges with designing a high-performance 3D printer of this size was getting the Z-axis to work correctly over 20 inches of travel with 20 to 30lb sitting on it,' said Airwolf 3D co-founder and lead designer Erick Wolf. 'We redesigned the bed bracket system and switched from plastic and polycarbonate parts to all aluminium and steel components. Plus, the Z-axis now has a precision ball screw to provide high repeatability, zero backlash, and extreme precision.'

The Axiom 20 can print high-density parts with materials, such as PLA, PET, ABS, and polycarbonate.

Built to meet the rigorous demands of the automotive market and other manufacturing industries, the Axiom 20 is said to easily run for 30 to 40 hours at a time.
Airwolf3d.com

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PIT CREW

Editor
Andrew Cotton
@RacecarEd

Deputy editor
Sam Collins
@RacecarEngineer

News editor and chief sub editor
Mike Breslin

Design
Dave Oswald

Technical consultant
Peter Wright

Contributors
Mike Blanchet, Ricardo Divila, Simon McBeath, Danny Nowlan, Leigh O'Gorman, Mark Ortiz

Photography
Jeff Bloxham, James Moy, Leigh O'Gorman, Marshall Puett, Mark Raffauf

Deputy managing director
Steve Ross **Tel** +44 (0) 20 7349 3730
Email steve.ross@chelseamagazines.com

Head of business development
Tony Tobias **Tel** +44 (0) 20 7349 3700
Email tony.tobias@chelseamagazines.com

Advertisement Manager
Lauren Mills **Tel** +44 (0) 20 7349 3796
Email lauren.mills@chelseamagazines.com

Advertisement Executive
Mitchell Coulter **Tel** +44 (0) 20 7349 3700
Email mitchell.coulter@chelseamagazines.com

Marketing John Rumble
Tel +44 (0) 20 7349 3710
Email john.rumble@chelseamagazines.com

Publisher Simon Temlett

Managing director Paul Dobson

Editorial
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700

Advertising
Racecar Engineering, Chelsea Magazine Company, Jubilee House, 2 Jubilee Place, London, SW3 3TQ
Tel +44 (0) 20 7349 3700
Fax +44 (0) 20 7349 3701

Subscriptions
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A racing uncertainty

Motor racing has always been about change, progress and development, but right now it sits at a crossroads. After a conversation with the PR man of a major car company recently, it seems to me that the car makers have lost their clear direction, and have no idea how to get it back. For more than a century the target for them has switched between performance and economy, luxury, and sometimes the outrageous. Sometimes, though thankfully rarely, cars are built solely with practicality in mind. However, there has been a common theme running throughout the time-line of the horseless carriage, and that is that a car will run on a fossil-based fuel. Sure, you have the choice of petrol, and in recent times diesel. Manufacturers have even experimented with hydrogen, and in the last few years, electric.

However, says the PR guru, they are in the planning process for their next generation concept car, and they don't know what to build. Electric? That rather depends on government investment in infrastructure, or the development of batteries. If you do need to recharge your car on a long journey, and there are five cars in front of you, in a gasoline car there is capacity that you will be waiting for less than five minutes. If a charge-up is 30 minutes for an electric car, you may have to wait a bit longer.

At the MIA conference at the Autosport Show in January, Tesla had a couple of cars outside the NEC for interested parties to try. There was something disconcerting about jumping into a car and finding that there was 64 miles to empty. In a petrol or diesel, that would mean identifying a fuel station somewhere along the route, and how far into the journey means how much risk you take if there is a queue. Despite using regeneration, I failed miserably to get the mileage up by a single mile. Despite using techniques discussed with LMP1 drivers, such as braking lighter for longer, by the time we finished being lost trying to get back into the NEC, the mileage sat just above 50, and the salesman was, indeed, considering where he could charge the car. This was not a great advert for a machine that costs more than €100,000 although the overall experience was positive.

Reading Sam Collins' analysis of the MIA conference (page 86) and with the wholesale changes that are happening in Formula 1 this season, it seems that racing is similarly struggling. Do the cars need more or less grip, more or less downforce, be faster or closer in racing, use hybrid or electric, have a driver or not? Do manufacturers need to lead on how racing is shaped, or should it be more for the privateer that has, for so long, been what racing is about? No one has a single, definitive answer, but F1's new owners, Liberty Media, has to find one for its new acquisition, and quickly.

Having now effectively purchased F1, the first task for it is to find a clear direction that will strengthen its brand and deliver a return to its investors. Does that mean that there will be an Asian Pacific series, a US series and a European series? Will there be more races and, if so, where will they be? Is there a one-glove-fits-all format that F1 will adopt? What I mean by that is; will global audiences sit down to watch Formula 1 in the same way that the US audience has embraced NASCAR? Will the sponsorship opportunities really present themselves as Liberty hopes? Or the television revenues reflect what the English Premier League soccer currently enjoys?

If the drivers are the heroes, will that mean that technology will be parked?

One item that does come to mind when discussing football and motor racing is a discussion I had with James Weaver years ago. When he was racing in the US, the series built up the drivers as heroes and everyone benefited from it. Weaver, Butch Leitzinger, Andy Wallace and the like not only had a long and successful careers with Dyson Racing in the US, but they were also revered among the spectators. I wonder if that will be the way forward, and that technology will be parked. As mentioned months ago, the crowd in the grandstand doesn't care if a car has 8MJ or 10MJ of stored energy; that's for manufacturers to market. It now seems increasingly unlikely that Peugeot will, indeed, step into LMP1 in the near future. So if there is no third manufacturer in LMP1, will the future, indeed, be the Ginetta model of building six customer chassis, and selling to privateers?

There is no doubt that racing can improve technology that will find itself in production cars, but as one engineer who is no longer involved in motorsport put it: 'if a production car development team was given a racing budget, it would not choose to spend it in racing'.

Although IMSA seems to have struck a good balance between manufacturer and non-manufacturer racing for now, perhaps it's time to make a clear delineation between prototype racing in the real sense of the word, and motor racing. If the return on investment is not there for the manufacturers to make a simple choice and enter the WEC, (and it is simple, if expensive), then something is wrong.

ANDREW COTTON Editor

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