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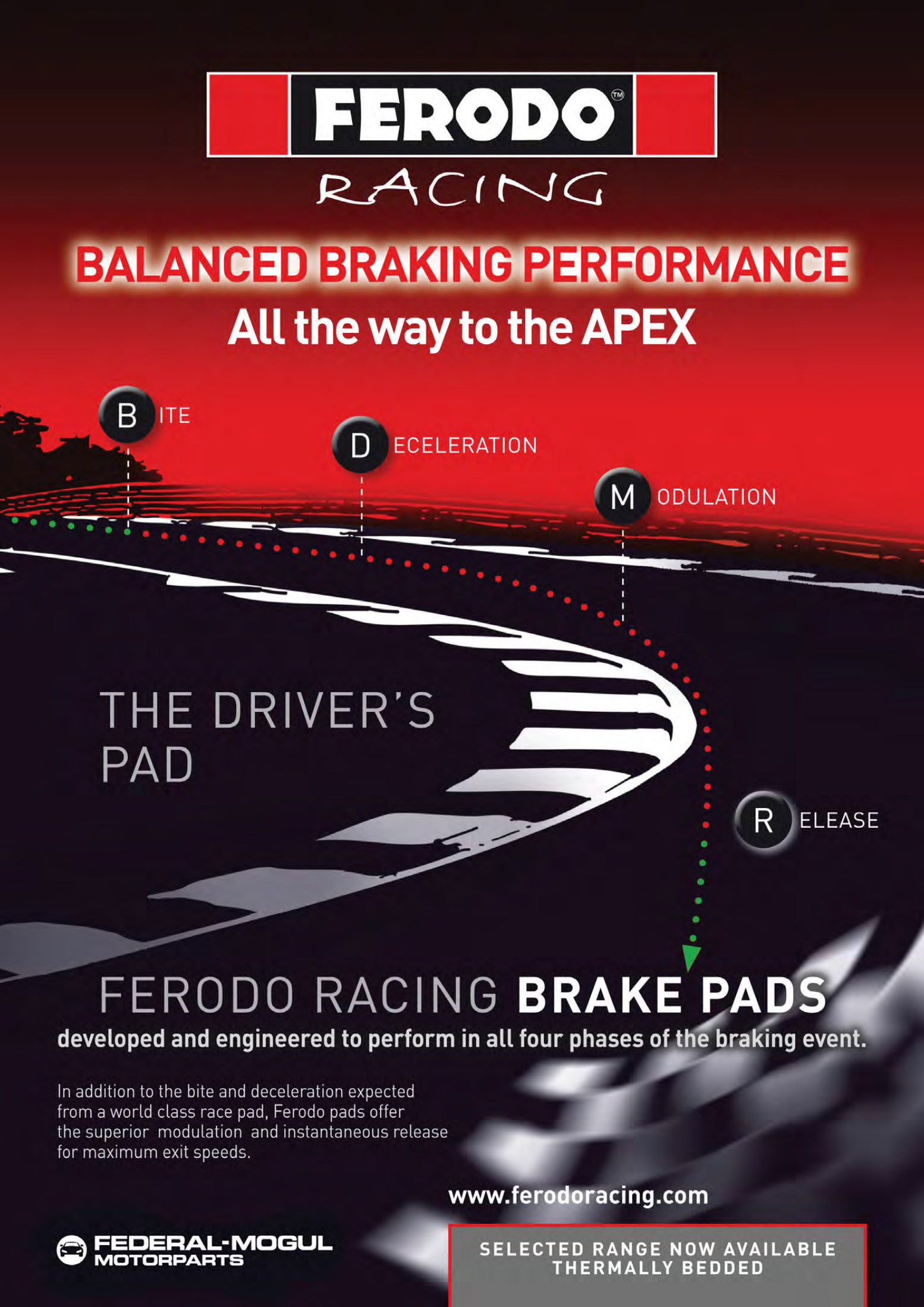
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F1 v WEC

Le Mans cars have the power, the looks and the technology that F1 dreams of. So is there room for a rival?

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"People talk of glory days, of more noise and 1,000 bhp. Chariot racing was also popular 2,000 years ago, but times change…"

DRIVING TECHNOLOGY INTO POLE POSITION
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Knee jerk reactions and no vision for the future

YET again we hear criticisms of the current Formula 1 engine from Bernie Ecclestone, the F1 commercial rights holder, telling another magazine that they have absolutely no relevance to road car engines. Thank goodness Andy Cowell, managing director of Mercedes-Benz High Performance Engines, has spoken up in their defence, saying that they are absolutely relevant and that "exactly the same" technology will soon be found in a production Mercedes-Benz. It may initially be a high-performance AMG version but the principle of downsizing the engine allied to bigger turbochargers and a hybrid system is absolutely the way the automotive industry is going. You can bet that lessons learnt in Formula 1 in terms of processes, materials and design will be passed on to the production car side. Not all will be relevant but for sure most of it will be.

As Cowell said in a BBC interview, the current Formula 1 engine has a thermal efficiency, by which all engines are measured, of more than 40%, which is even better than a road-going diesel engine, so for sure there are lessons to be learnt here as well. As he said in the interview "In the road car world we don't need the amount of power we have in F1, so the power level will be smaller but the schematic of the power unit will be exactly the same."

Will this response be enough to silence the critics who seem to crave noise, which after all is wasted energy, for the sake of it? I do understand that this is part of the show and to some people is a vital element, and I have to admit I'm one who loves listening to an engine at full throttle, but you do have to weigh that against the responsibility the sport should be portraying.

It also seems absurd to me that there is talk of bringing back refuelling during a race. It was banned a few years ago for safety reasons, and that hasn't really changed, while the message that a hybrid engine needs to be refuelled during a race makes a nonsense of any sort of energy efficiency that Formula 1 is trying to portray, added to which, the added cost in terms of money and energy in transporting extra fuel and refuelling rigs around the world is a nonsense in my view.

So why are such suggestions being put forward and seriously being considered? I think there are several factors at play. One is the apparent panic among some that Formula 1 is failing, that the audience, particularly the television viewership, is going away and so we are getting knee jerk reactions. It is also reinforcing any prejudices.

A much bigger threat to Formula 1 and its popularity in my view is the seeming agenda of forcing the smaller teams to become customer ones, to make it completely uneconomic for them to participate in Formula 1 due to the bizarre way the prize money is distributed so that if they want to remain in it, then they have to become a B team. That to me is the road to ruin. The whole point of Formula 1 is that it is a constructors' series, that teams have to make their own car to participate. There may be a case for a sharing of some of the components, as we have written about an issue of two ago, but to forego your own manufacturing capacity and buy in your own car, as if you were a GP2 or IndyCar team, cannot be the way to go.

If you follow this train of thought to its logical conclusion, you will ultimately end up with a single make series as one manufacturer begins to dominate. Imagine you were a team owner of one of the minor teams in Formula 1 and the only way you could continue was to buy a chassis/engine combination, who would you be talking to? I suspect it would be Mercedes, so we could have a case of six or eight Mercedes F1 cars on the grid, against a couple of Ferraris, Williams, Red Bulls and McLarens. Then if these Mercedes dominate a race, it could mean the other teams chasing for the crumbs on the table, which has a direct impact on sponsorship opportunities and prize money. Perhaps Red Bull will go away, perhaps Williams may be forced into becoming a customer team, who knows. It's a gloomy prognosis that really must be avoided at all cost. The trouble is, the way the sport is run at the moment, the only thing that counts is money, not fairness or really a vision for the future.

We are in perilous times and I just hope that sense prevails. RT

William Kimberley
EDITOR

Refuelling on the radar as Strategy Group plots F1 future

By Matt Youson

BIGGIN HILL, UK. Proposals put forward by the Formula 1 Strategy Group could lead to a dramatic change of direction for the top tier sport. In its short history, it has garnered something of a reputation as a blunt instrument. Rarely do its meetings pass without stimulating comment. Its proposals tend to be bold, verging on the adventurous. It excites the passions – in the anodyne world of corporate governance, a very rare thing indeed – which is why the Strategy Group's Biggin Hill meeting, held in between the Spanish and Monaco Grands Prix in mid May was expected to produce fireworks. Few, however, would have expected it to attack the status quo with a flamethrower.

The upshot of the meeting was a series of measures that, if enacted, will see a tectonic shift in the sport. There's a proposal to free-up tyre choice for 2016 and, beyond that, a range of big-ticket items for 2017. Visually and aurally the cars will be more aggressive – but the real changes go beyond aesthetics: there's a proposal to decrease benchmark lap times by five to six seconds through aerodynamic regulation changes, increased mechanical grip and lighter cars.

The basic powertrain package survives but refuelling is to be reintroduced and engines will rev higher. History suggests the regulations as delivered will be watered down – but even diluted, this is a significant change in direction.

If adopted, it would also reverse much of the work done by the Overtaking Working Group, that comprised Paddy Lowe, Pat Symonds and Rory Byrne with input from other senior engineers, between 2007 and 2009 that led to a reduction in the size of the diffuser, a smaller rear wing and the deployment of the DRS adjustable rear wing.

The re-introduction of refuelling during a race would also send mixed signals about the energy efficient powertrain message that Formula 1 is trying to project with its hybrid power units, both in terms of energy efficiency and in transporting fuel and refuelling rigs to 20 races around the world.

The question remains as to whether technical change is really required. There is a counter argument that F1's current woes – perceived and empirical – have little to do with racing and a great deal to do with business. The racing, it can be argued, has not been lacking in appeal.

The latter point was one made by some of F1's most senior engineers in a spirited discussion a few days before the Strategy Group met. Speaking at the FIA's Spanish Grand Prix technical press conference, a

Tee/LAT

ABOVE Refuelling returns in 2017 as part of a package to improve the F1 show

Coates/LAT

ABOVE All the talk is of changing the F1 regulations for 2017, but is the sport itself so bad that it requires a major rethink? Many think not and that it's actually pretty good

representative panel argued for and against change. While not impervious to the global issues, the focus was more geared towards on-track action. It presented a slightly different take on the continuity-versus-change argument that has been going on around the sport in recent months.

Asked what would be on a hypothetical wish list for a mooted 2017 regulation revamp, the case for change – albeit limited change – was made eloquently by Jonathan Neale, McLaren COO and acting CEO. "I think that the sport needs to rethink a number of areas," he said. "It would be foolish to mess around with the immense amount of good work that has been done on the power units. Some minor adjustments maybe, but it's a much more efficient package. It's got some great technology, it's still maturing in the sport and the price can come down if it's left to mature because we're not putting in the same R&D costs – so I would leave that alone.

"However, I would look for… we've spoken about a step-change in aerodynamics, to make sure that these cars are difficult to drive and maintain that performance gap to the junior series. It's important that Formula 1 remains an out-and-out race. We can still have the efficiency, we can still have many other attributes of the sport but I think it should just be a flat-out race."

A counter-point offered by Lotus technical director Nick Chester suggested, far from improving the appeal of F1, reordering the technical landscape has the potential to degrade it. "There's a lot of talk about the rule changes for 2017 but I think people forget at the moment the racing's actually quite good," he said.

"There are some very good battles up and down the whole grid and as the cars' performance is improving a lot – I think we're seeing a two-second improvement from last year – do we really need a huge change of regulation? A huge change is going to open up the grid again; there'll be bigger differences between teams. Obviously it's going to add a lot of cost, so I think we shouldn't forget the show's actually not bad at the moment."

MAINTAINING THE STATUS QUO

That view was echoed by Rob Smedley, Williams' head of vehicle performance. "I think we should leave it alone – we should perhaps think about [not] tampering with it rather than thinking we're going to create a new set of rules and that's going to fix everything," he argued. "Every time you create a new set of rules, you'll usually find the people with the biggest resource or with the cleverest thinking, or the people who stopped working on the current generation of Formula 1 cars, come out with quite a big gap.

"When we talk about 'these boring races', that's what we're referring to isn't it – a team dominating at the front? However, a team dominates when we have radical rule changes. I think we have to seriously think about not changing anything. Nick was quite right in what he said: the racing is very good.

"It's got to be the racing spectacle that we put at the forefront. By having a radical rule change you're not guaranteed to increase the racing spectacle – but what you are guaranteed to do is increase costs."

One impression that can be drawn from the Strategy Group meeting is that the majority of its members believe that F1 isn't currently quick enough. This was partially borne out at the Circuit de Catalunya, arguably F1's benchmark track. There was little to choose between GP2 practice times and those recorded in F1's Friday afternoon practice session. ART's Stoffel Vandoorne set a time of 1:30.171 – ignoring the eccentric data-point of Manor-Marussia, that was four-tenths of a second behind Force India's Sergio Pérez (1:29.707) and only three seconds off fastest man Lewis Hamilton (1:26.852).

Paddy Lowe, Mercedes' executive director (technical) cautions against reading too much into this, arguing that natural development will see the gap widen. "Formula 1 is in an early phase of a major regulation era: this is the second year of a set of regulations, so generally performance will increase until the next reset is required," he says. "I think we've got a period now where we will stretch out relative to some of those other formulae. For 2017 it may be that we need to give it a bit of a nudge and that's what's being talked about. Perhaps some more aerodynamic performance could be added – but historically we have always reduced aerodynamic performance step-by-step. I can't recall us ever increasing it."

The next few months will decide what F1 looks like in 2017. Quite how closely the views of the Strategy Group and the senior engineers align is a matter of considerable interest. RT

PA Images

BELOW One of the three lurid accidents that took place during the Indy 500 qualifying. Fortunately no driver was injured but questions have been asked about the new aero kits

Practice flips force aero changes to IndyCars

Andrew Charman

INDIANAPOLIS, IN: The IndyCar Series has been forced into making major technical changes to its cars, hours before qualifying took place for its Blue Riband event the Indianapolis 500 on 24 May.

The urgent action followed three dramatic crashes during practice sessions, when after spinning backwards, cars took off and flipped over, fortunately without injury to their drivers. As a result the qualifying procedure, a major part of the Indianapolis 500, was heavily shortened to allow time for teams to modify their cars.

This season is the first that the engine manufacturers supplying the series, Chevrolet and Honda, have been permitted to design bespoke aerodynamic kits, to rules mandated by IndyCar, for the Dallara cars running their engines. Two distinct kits have been designed and approved for road/street courses and speedways, and the Indianapolis meeting is the first to use the speedway kits, which as our panel shows, include a great many adjustable options.

The trouble started on Wednesday 13 May when the Chevrolet-powered Penske Dallara of Helio Castroneves, fastest in practice the previous day, lost control on the first flying lap of the Wednesday session. The car spun backwards and then took off, rolling over before landing quite softly on its rollhoop and pitching back onto its wheels.

"I got loose and suddenly I was flying," Castroneves said afterwards. "The accident was most impressive, my crew guys gave me a 10, but I'm just glad I landed softly and didn't hit anything hard."

Team boss Roger Penske immediately sounded a note of caution, admitting surprise that the car had taken off. "It's our first run with this aero package and it's pretty hard to simulate what might happen," he told local media.

Tension increased on Thursday afternoon when Josef Newgarden's Dallara-Chevrolet snapped sideways on its first flying lap, slid backwards along the wall and then flipped backwards onto its roll hoop in similar fashion to Castroneves. Speculation as to the cause focused on the long side pods that both cars were using (see panel). However, having consulted with Chevrolet, IndyCar officials permitted teams to continue using the long pods.

With qualifying rained off on Saturday, teams were preparing to qualify on Sunday morning when the Chevrolet-powered car of Ed Carpenter crashed in an almost identical manner to those of Newgarden and Castroneves. At the time Carpentier was running in full qualifying trim, with added turbo boost pressure of around 40-50bhp, and had just recorded a lap of 231mph when his ▶

The Superspeedway kits

The Superspeedway aero kits produced by Chevrolet and Honda differ in several areas from the road-course versions.

- The front wings and endplates are individual designs whereas the road course car uses a specification front wing supplied by car manufacturer Dallara.
- The front wing itself must use a single, central adjuster but both manufacturers have methods of adjusting the endplates. While Chevrolet's are adjustable during a pit stop, changing the Honda version requires loosening bolts, but the latter can build in adjustability by adding wickers to the top and trailing edge of the plate for extra downforce.
- A number of sidepod options have been tried particularly by Chevrolet, including the standard two-part sidepod and a longer low-drag version that extends between the rear wheels and has a number of rear vents that can be covered or uncovered as required.
- While Honda's side pods have been to one basic design, they have included a number of vents and panels to block off sections of the air inlets.
- Chevrolet decided on one rear wheel pod, while Honda's includes a great deal of adjustability with bolt-on panels with apertures of varying sizes at the back of the pod to change the rear airflow.
- Teams have been experimenting with a number of wickers mounted on the rear underfloor diffuser.
- Chevrolet designed a single rear wing element, with a mandatory camera mounting in the left endplate, while Honda has used both single element and three-element rear wings, the extra aerofoils bolted to the outside of the central element. All three are adjustable and mounting wickers on them has also been experimented with.

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ABOVE & BELOW The difference between the Chevrolet standard package (above) and the low-drag speedway package (below) is obvious from these two pictures of Will Power's car during practice

car spun backwards and took off.

The session was red flagged while series officials convened urgent meetings with teams. Eventually it was decreed that cars must qualify in the same specification they would race in, effectively forcing teams to drop the low-drag aero options, and with turbo boost pressure reverting to the lower, race setting.

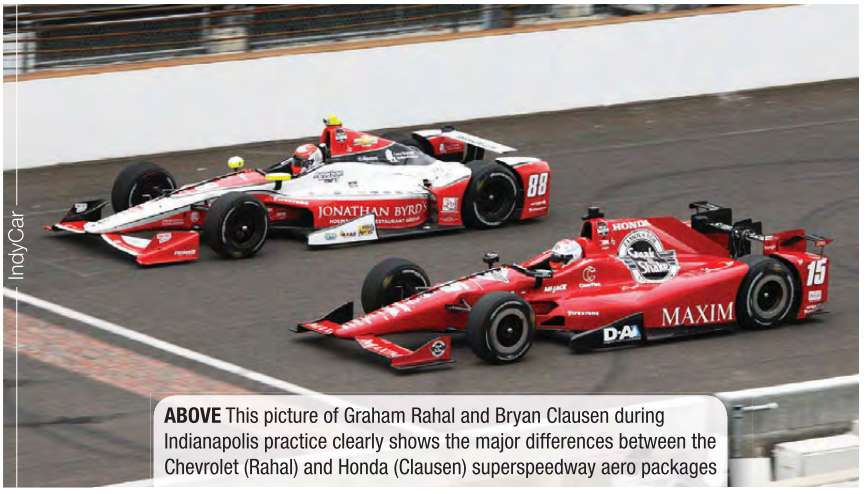
All cars were required to follow this rule, including those of Honda which had not been involved in any of the accidents, while Chevrolet teams were also required to remove aerodynamic panels inside the rear wheel pods of their cars.

The changes sparked criticism along the pitlane with an unnamed former champion quoted by one media source as describing the moves as "Amateur hour". He added that not enough pre-race testing had been carried out on the kits and changes were being made with no idea of the likely consequences.

In a press conference IndyCar technical head Derrick Walker described the rule changes. "We've mandated that what you start qualifying with, you must race, so that rule alone will cause the manufacturers to select certain components that are biased towards the race," he said. He added that such a choice would increase downforce on the cars, which was the aim. "We're adding more downforce and we're reducing the engine power."

He also pointed out that the three accidents might not be connected. "They all started in different ways – we had one that had a tyre pressure issue; we had another one that had an aero balance issue – the car was set probably a little too far one way and it caused a spin; and there's the one we had today, which was just an accident."

IndyCar confirmed that further regulation changes were unlikely before the Indianapolis 500 itself, but that further testing to determine what if any inherent aerodynamic issue is present would take place before the series goes to the high-speed ovals of Texas, Fontana and Pocono. RT



ABOVE This picture of Graham Rahal and Bryan Clausen during Indianapolis practice clearly shows the major differences between the Chevrolet (Rahal) and Honda (Clausen) superspeedway aero packages

FIA to source global motorsport accident data

PARIS, France: The FIA has announced that it is to begin sourcing data and information from hundreds of racing accidents around the world, using the information gathered to guide the future of motorsport safety. The FIA World Accident Database (WADB) will be used by the FIA and its National Sporting Authorities (ASNs) to log data from accidents. This will include vehicle and procedural information, as well as medical and other repercussions.

Jean Todt, president of the FIA, believes that the new process will help provide the best possible information for the engineering of safety solutions in motor sport. "The database will be the next key step in the development of safety improvements," he said. "A significant number of the major safety improvements made throughout motorsport have been predicated by fatal or serious accidents.

"It is difficult to talk about a particular occurrence or a change in safety procedures and technology from a hypothetical point of view. It is an easier task to develop procedures and technology based on actual data.

"Currently, we have accident data recorders in 25 championships around the world, which provide real car data – the introduction of the FIA World Accident Database will open up an opportunity for the world of motorsport to provide detailed information on any serious accidents that occur. This obviously creates greater opportunity for us to access data and use it to develop our safety regulations."

The WADB will be populated by the 139 ASNs around the world, all of which will have access to the web-based resource. They will then add data from fatal and serious accidents that may occur during events across the various disciplines, including circuit racing, rallying, rallycross, off-road, and hill climb. This data will include measurements such as acceleration and speed, descriptions of accidents, as well as the repercussions, especially medical. RT

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BTCC head refutes engine power claim

SWINDON, UK: British Touring Car Championship head Alan Gow has firmly refuted accusations that the TOCA-specification engine built by Swindon Race Engineering is more powerful than team-developed rivals. Rob Collard told *Race Tech* at Donington Park (issue 175) that the location of the ballast that his rear-wheel drive West Surrey Racing BMW 1 Series was forced to carry this season was hurting its straight-line speed against TOCA engine equipped cars.

Then in the second race of the following meeting around the high-speed track of Thruxton on 10 May, Collard forced his way to the front early on and then had a race-long battle with the TOCA engine powered Volkswagen CC of Jason Plato. The BMW was unable to pass the Volkswagen which duly won the race, and afterwards Collard told the website Touring Car Times that his car was losing out in engine pace.

"Speed wise I just can't keep up with these TOCA engines on the straight, they're so fast. They just pull away – we've made steps forward this weekend from Donington with our engine performance but there's nothing left in the tank, we can't do any more. It's physically at the best where we can get it and you're fighting a race you really can't win at the moment."


JakobEbrey/BTCC

BELOW Touching distance: Rob Collard's BMW shadowed the Volkswagen CC of Jason Plato at Thruxton but was unable to pass

Gow, however, described Collard's comments as "very different from reality". He argued that studying data collected at the circuit showed that the BMW was losing out to the Volkswagen by less than 1mph.

"The fastest Volkswagen is an average of 0.66mph faster than the quickest BMW through all three sectors over the entire lap – I really don't know of anyone that would look at those numbers and not feel that perhaps the perception given is very different from reality," he said. RT

Ecoboost BTCC engine debuts in Motorbase Ford test

WROTHAM, UK: British Touring Car Championship team Motorbase Performance has tested its Ford Focus cars with a newly developed 2.0-litre Ford EcoBoost engine. The team, which has been sidelined from the BTCC this season by sponsorship issues but hopes to return for the Snetterton races on 9 August, ran at Brands Hatch on 15 May with both of its Focus cars and both drivers, Mat Jackson and James Cole, in attendance.

The new turbocharged unit is built to the BTCC's NGTC specification regulations by long-time Ford engine specialist Mountune, alongside the Motorbase team's other technical partners Pro Alloy, SamcoSport, Milltek and Speciality Fasteners.

Team principal David Bartrum described the test as fruitful. "Mat and James worked through some set up work and engine work that we had planned which went extremely well. We also covered both qualifying and race run simulations with both cars and were very satisfied with the results."

The Brands Hatch test day also saw Onyx Motorsport running the Ford Focus car that it has built to the regulations of the new-for-2015 TCR International Series. The cars made a brief and unfortunate debut in the series at the opening round in Sepang, Malaysia, when they were hit by overheating issues.

Onyx principal Mike Earle commented that the car had run well. "The engine that our partner Mountune has produced is particularly impressive, very strong. We had a couple of things to sort out during the day as you would expect with a brand new car, but looking at the data and the feedback, it is very encouraging at this stage."

After the Brands Hatch test the car was delivered to Proteam Racing that was set to run it in the TCR International Series from the round at Monza Italy on 24 May. RT

BMW reveals new GT3 for 2016

NURBURGRING, Germany: BMW has revealed the M6 GT3 that is set to replace the Z4 GT3 at the end of this season. Weighing less than 1,300 kg, the new car is powered by a 4.4-litre V8 engine with M TwinPower Turbo technology, which is also used in the BMW M6 Coupé and has only been slightly modified for its outings on the racetrack. The high-tech powertrain with dry sump lubrication generates 500 hp and impressively high torque.

The transaxle drive concept, 6-speed sequential racing transmission and chassis, which was optimised in the BMW wind tunnel, ensure that BMW Motorsport will compete with a genuine racer in 2016. The reliability, efficiency and ease of maintenance of the BMW M6 GT3 have also been optimised for its outings at endurance races. The longer wheelbase significantly improves the car's handling compared to the current BMW Z4 GT3.

BMW Motorsport has developed and produced the FIA-approved safety cell in accordance with the very latest safety standards. The car also boasts numerous other features, including the roof hatch specified in the regulations, through which the driver's helmet can be removed if necessary, as well as the safety seat, which was also developed by BMW Motorsport and is bolted firmly into the chassis. RT

ABOVE BMW has revealed its new GT3 challenger based on the M6 Coupé

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International Business Days

LE MANS, France: As has become part of the tradition of Le Mans, the 8th International Business Days event will be held at the Technoparc, which is adjacent to the circuit, on Wednesday/Thursday, 10/11 June in the run up to the race.

The format follows the now familiar pattern with a welcome at the Complexe C'élégo in the Technoparc, signing in with a selection of the local gastronomy at 12 noon on the Wednesday. After a welcome by the organisers there is a private guided tour of the paddock with visits to AF Corse, Rebellion Racing and ProSpeed Competition. Time has also been allocated for those who might want to visit the 24 Hour Village museum while there is also a private visit to the Dunlop Motorsport and Michelin tyre workshops.

The evening comprises a gourmet dinner at the famous L'Auberge de Mulsanne followed by the opportunity to view qualifying from a private location on the Mulsanne straight close to the restaurant.

The following day is devoted to the one-to-one pre-arranged meetings following a welcome by Nicolas Landy from Le Mans Développement and Jean-Jacques Foignet, CEO of Sarthe Développement.

Companies that have signed up to participate include Danisi Engineering as the event patron, 3A, AA Modelleria, Böhm & Wiedemann, BrightLoop, Michelini Automotive, Pyrmeral Systems, Spartacus 3D, Stäubli Faverges, KA Sensors, Malinex, SELVA and Hinduja Tech from India. Richard De Cabrol will also be participating in the event on behalf of Grand Prix ESSEC, the association for promoting the economic interests of motorsport.

Teams that have agreed to participate include AF Corse, Rebellion Racing, Courage Classic, ProSpeed Competition, Peugeot Sport, Citroën Racing and Toyota Motosport GmbH.

For further information, visit www.ibdlemans.com or email contact@ibdlemans.com RT

IN BRIEF

FOLLOWING a meeting of the so-called 'Class One' steering committee comprising representatives from the Japanese GTA, IMSA and ITR eV, DTM's umbrella organisation, agreement has been reached that the universal powertrain for the new international series that commences in late 2017 will be turbocharged four-cylinder engines producing around 600 bhp. At the same time the aero specs have been defined meaning that the cars will look similar to those competing in the current DTM and GTA championships.

THE NASCAR Sprint Cup Series appears to be backing away from introducing technical changes for a second successive season in 2016. A raft of major changes mandated for this season saw power levels reduced by around 125 bhp and downforce cut by 30 per cent, with a strong suggestion that the downforce levels could be further reduced in 2016. Team owners are thought to be unhappy at bearing the costs of significant technical changes two seasons in succession. NASCAR competition chief Steve O'Donnell said that the goal is still to finalise the 2016 rules by 1 August, two months ahead of the release date achieved last year.

NASCAR has changed the rules regarding rear end differential assemblies. At events except at the gear-punishing Martinsville Speedway, road courses, the Daytona 500, the Sprint Showdown and the NASCAR Sprint All-Star race, teams will only be allowed to use one assembly, instead of changing gears at will as has previously been the case. The rule is thought to be a means of preventing teams using gear ratios specifically for qualifying.

NASCAR has made it mandatory for all crew working on pit lane to wear flame-retardant balaclavas, underwear, socks and gloves following two fires in recent weeks while cars were being refuelled. Previously only the fueller had to wear a protective balaclava.

AS *Race Tech* went to press the Hendrick Motorsports NASCAR Sprint Cup team of six-time champion Jimmie Johnson was warned by officials about making unapproved body panel adjustments following a crew member allegedly modifying the side skirt of Johnson's car during the non-points Sprint All-Star race on 16 May. As reported in *Race Tech* 173, the practice of deliberately pulling out the skirt during a pit stop to improve the car's performance was outlawed for the 2015 season.

NASCAR Sprint Cup team Richard Childress Racing has lost its final appeal against penalties levied against it for manipulating tyres, as reported last month in *Race Tech*. The No 31 Ryan Newman team's crew chief, tyre technician and race engineer have now begun six-race suspensions as originally penalised, and the team has had 50 points in the drivers' and owners' championships removed.

FIVE NASCAR Sprint Cup teams have received written warnings in recent weeks after their cars failed pre-qualifying inspection more than once. Teams that receive two written warnings could face a number of penalties, including practice times being disallowed. It is widely believed that many teams use the inspection process to gauge how far they can push the rulebook, and early in the season the inspection process took so long that some teams were missing qualifying.

SUBARU will be the latest manufacturer to be seen in top-level Touring Car racing with the news that Italian team Top Run plans to build and develop a Subaru WRX STi to the technical specifications of the TCR International Series.

ADVANCED Engine Research (AER) has been working alongside Rebellion Racing to prepare the team's new ORECA LMP1 cars. The two cars, powered by the Essex firm's P60 engine, will make their racing debut at Le Mans this month. RT

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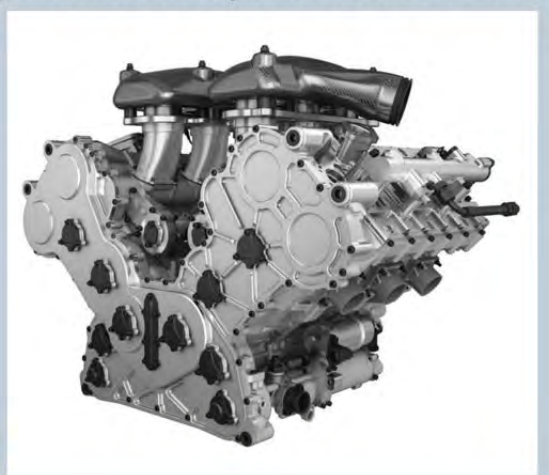

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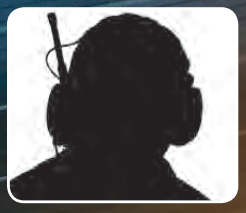


One category boasts innovative 1,000 bhp cars, close racing and is a magnet for manufacturers. *The other is Formula 1!* Our **Expert Witness**, a knowledgeable insider, assesses the growing rivalry between the WEC and F1

THE racing community – staff, suppliers, supporters, people who rely on and love the category – is justifiably concerned that F1 has completely lost its way at the moment.

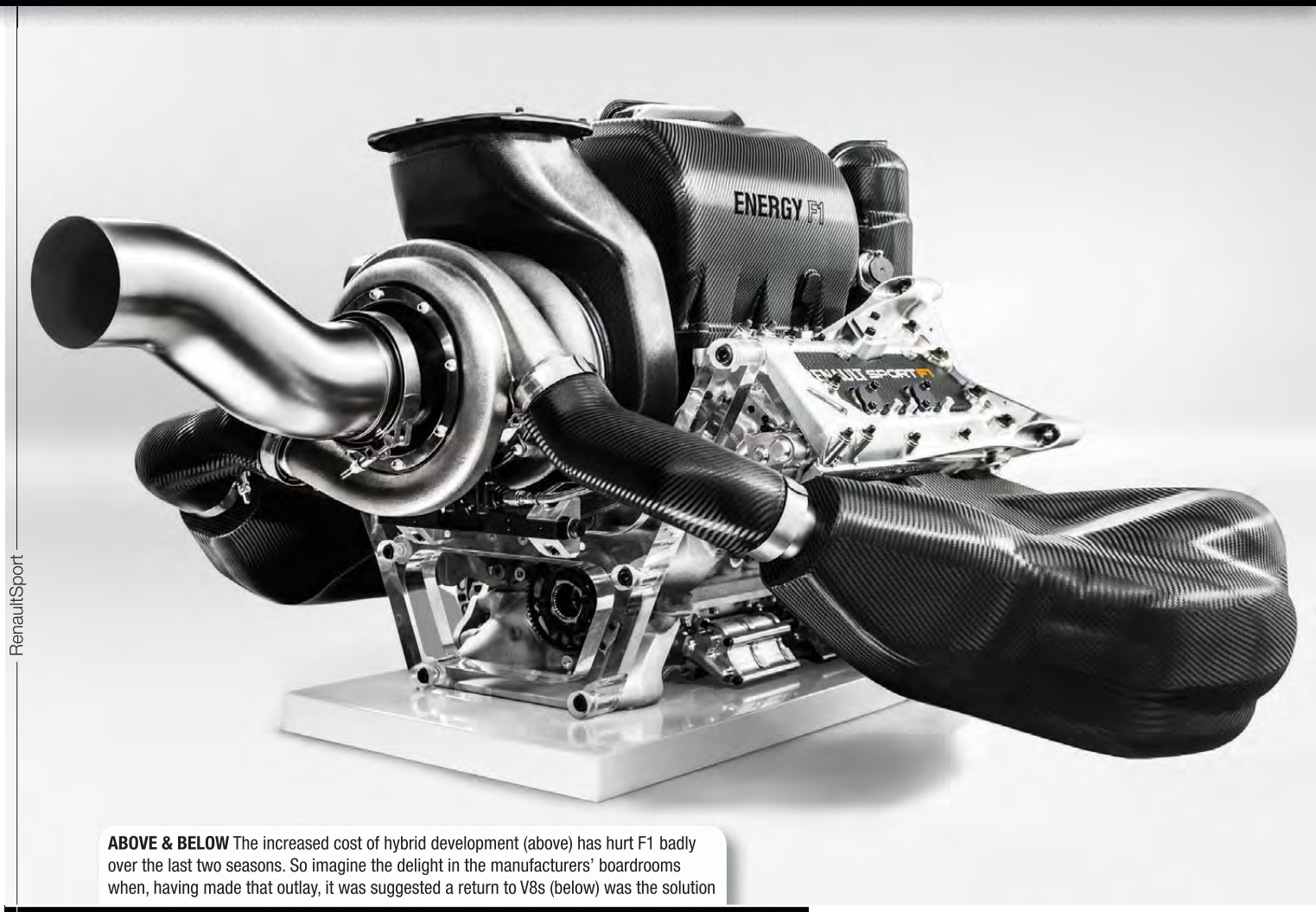
All the signs are there: increasing cost for reduction in value is not a successful business model anywhere in the world. The rules that should provide the stability of framework and direction are being tinkered with to little effect in some areas, and flip flopping between fundamentals that are the most expensive to adapt to in others.

Why is there an inability to get the formula right? Is anything actually changing to improve the situation? Or, as with a normal meritocracy, is there an alternative solution out there that is doing a better job of fulfilling the brief that could, given the right circumstances, provide a more effective platform?

Today's debate, then, is can the World Endurance Championship (WEC) rival F1? Are they naturally converging and haven't we seen this all before… and not learnt from it? ▶

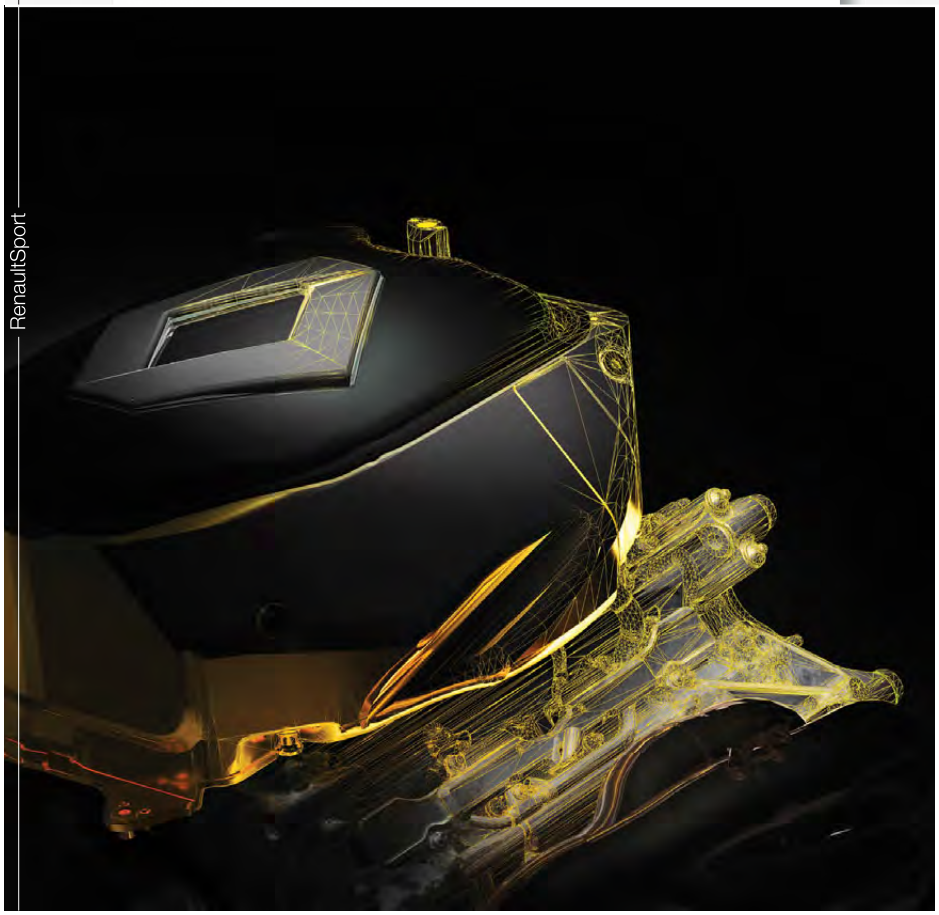
> *"People talk of glory days, of more noise and 1,000 bhp. Chariot racing was also popular 2,000 years ago, but times change…"*

ABOVE & RIGHT Add WEC to F1 and you end up with Red Bull's X1 on the grid at the Monaco GP! Offering the best of both worlds, the X1 was a genuine engineering exercise conducted by Adrian Newey for Sony that resulted in the ultimate virtual racer



RenaultSport

ABOVE & BELOW The increased cost of hybrid development (above) has hurt F1 badly over the last two seasons. So imagine the delight in the manufacturers' boardrooms when, having made that outlay, it was suggested a return to V8s (below) was the solution



RenaultSport

NOSTALGIA

One of the most striking differences between the two is that one category is looking to the future. The other, preoccupied by the quest for 1,000 bhp, appears to be forever casting envious glances back over its shoulder to the past.

There is a strong temptation, as we and the F1 motorsport demographic begin to grey out, to fondly remember the good old days. When the cars were noisy, had fat tyres, slid around, had much too much power, were difficult to control. The drivers in those days really risked their lives every single time they got in the car. Yes, but hang on a minute, haven't we moved on a bit from there in terms of technology, safety, alignment to today's technology and requirements? Chariot racing was also popular 2,000 years ago, but times change…

So, surely a modern pinnacle category should be avant garde, up to date, pushing the boundaries of the coming trends of the automotive industry to attract manufacturers, suppliers and blue chip technical partners. Shouldn't it? ▶

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30th Nov - 1st Dec 2015

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"This will change our sport for the better"
Ben Bowlby, Director of Motorsport Innovation, Nissan

ABOVE Top row, from left to right: Dr Sam Akehurst, BEng(Hons) CEng, Reader in Advanced Powertrain Systems, Powertrain & Vehicle Research Centre, Luca Marmorini, engineering consultant, Ulrich Baretzky, head of engine technology, Audi Sport, William Kimberley, Race Tech editor, John Iley, technical director, Caterham F1, Steve Eriksen, COO, Honda Performance Development, James Key, technical director, Scuderia Toro Rosso, Kirsty Andrew, sales director, Cosworth, David Lapwirth, technical director, Prodrive, Sergio Rinland, managing director, Astauto and Blake Fuller, president, Braille Battery.
Bottom row , left to right: Gilles Simon, engineering consultant, Arnaud Martin, director powertrain, RML Group, Dominic Harlow, Dominic Harlow Consulting, Dialma Zinelli, head of aero, Dallara Automobili, Bernard Niclot, FIA technical director, Soheila Kimberley, Race Tech publishing director, Andy Cowell, managing director of Mercedes AMG High Performance Powertrains, Roger Griffiths, Andretti Autosport's director of motorsports, Willem Toet, head of aerodynamics, Sauber F1 and Russ O'Blenes, senior manager performance & racing engines, GM Powertrain Advanced Engines

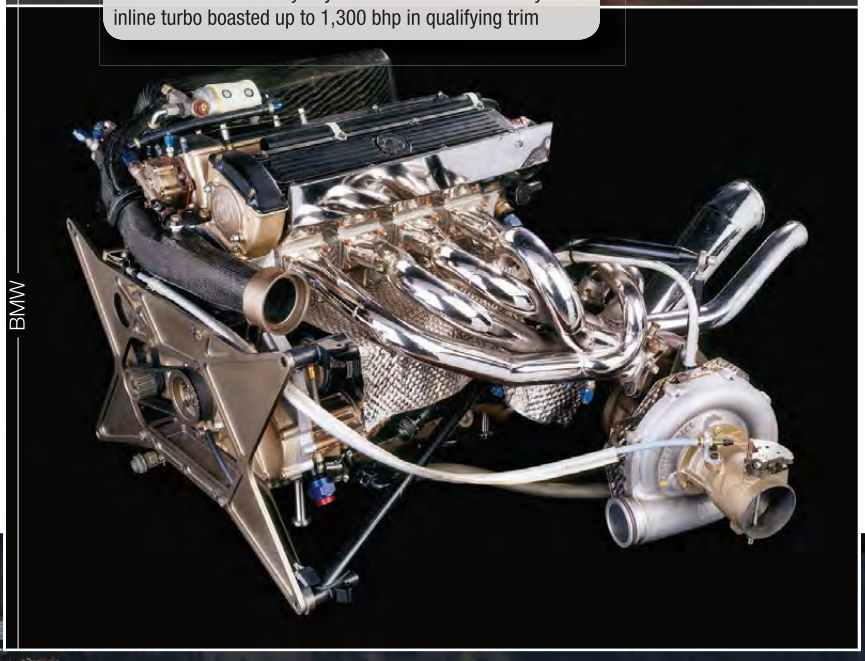
HYBRID HURT

It may or may not surprise you to know that I am hugely in favour of the principle to go to hybrid, energy recovery, reduced capacity turbo in F1. It has been a contributory factor in the increased cost that has hurt F1 badly in the last two seasons, but was directionally correct.

However this area of the package, due to its processes, number of components, lead times and incredibly complicated R&D, is the most expensive part of the car architecture by far. So why change it and keep changing it if it costs so much? Why not have a correctly aligned format to industry that is robust, transferable across categories, reliable and offers manufacturers the appeal or benefits to want to participate?

Instead F1 was changing capacity, aspiration and number of cylinders until 2006 when V angle, cylinder number (8), bore, stroke, valve number and 2.4-litre normally aspirated engines were required. This format was 'frozen' (2007) until 2013 with a couple of maximum rpm drops to 19,000 (2007) and 18,000 (2009) to reduce development cost further. In 2009 KERS (Kinetic Energy Recovery Systems) were first permitted, but only adopted by two teams ▶

LAT


BMW

ABOVE & BELOW Glory days: Brabham's M12/13 4-cylinder inline turbo boasted up to 1,300 bhp in qualifying trim

Adrenal Media/WEC

ABOVE While F1 hankers after 1,000 bhp cars, the WEC already races them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LAT

ABOVE We've been here before: sportscar racing caught the F1 paddock's attention in the early nineties when Jaguar's XJR-14, effectively a two-seater F1 car, took full advantage of the rulebook. Its drivers rated it the best car they had ever driven, including their F1 mounts!

(Ferrari and McLaren), not used by anyone in 2010 by agreement and then reintroduced by the majority of teams in 2011.

During this seven-year freeze there was engine stability and continuity and even some equalisation opportunity to make the engines more comparable. However there became some insistence to go for a smaller capacity turbo energy recovery. The subsequent results were ironic, given that a manufacturer threatened to withdraw unless this format was adopted.

> *"How many road cars have a V6 1.6-litre turbo?"*

Here then was the opportunity to go reduced capacity inline 4-cylinder turbo, the 'world engine', transferable across multi categories, industry relevant, increasing unit quantity, manufacturer footprint and motorsport involvement, further reducing cost. No. V6 1.6-litre. How many road cars have a V6 1.6-litre turbo? Exactly.

Ah yes, that nostalgia again. It "wouldn't be a Formula 1 high-performance car without a V angle" or "it would not be structural". ▶

LAT

ABOVE From right to left, Peugeot, Jaguar and Mercedes racing in the 1991 endurance series. All three were lured into F1. Where would their allegiance be if they had that choice today?

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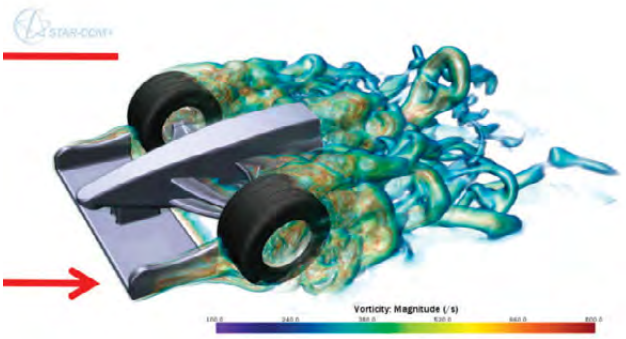
Remind me of the first car to win the F1 World Championship with a 1.5-litre turbo? Brabham-BMW, 4-cylinder, inline turbo, 1983 – road car engine-derived and up to 1,300 bhp in qualifying trim. It is interesting how selective memory can be.

The new hybrids, we are told, are "too quiet", "not hard enough to drive", "have too little horsepower", "we need 1,000 hp", "let's bring back the V8s". I'm sorry? Firstly, didn't we just change KERS-no KERS-KERS-2.4-litre V8s-1.6-litre turbo hybrid? Isn't this the most expensive part of the car? Is F1 not in a financial problem? Oh and by the way, if you harvest energy from the exhaust, one form of that energy is noise, so quieter cars are a direct result; the turbos were also quieter in the eighties, remember? How many people complained about it then?

Meanwhile, WEC competitors were given the choice of what fuel, engine and hybrid configuration they would run within a series of parameters, namely absolute fuel consumption per lap combined with an amount of recoverable hybrid energy. This approach of focusing on energy, amount in-amount out, allows the manufacturers and the technology the chance to create the most relevant options for both performance and brand. As an endurance category efficiency and less time in the pit lane is highly important, coupled to absolute pace. The racing so far has been excellent, with the diversity of choice creating very close competition.

Here we come to our first convergence point, although it does not sound like it. That BMW engine from '83 with up to 1,300 bhp perhaps would only do a couple of laps in qualifying before it would be changed, after less than 10 miles. Both WEC, despite its long distance format, and F1 have dropped the number of engines permitted now per season to five and four respectively, so this has definitely improved the number of units required per team, per season. Imagine if this were not the case...



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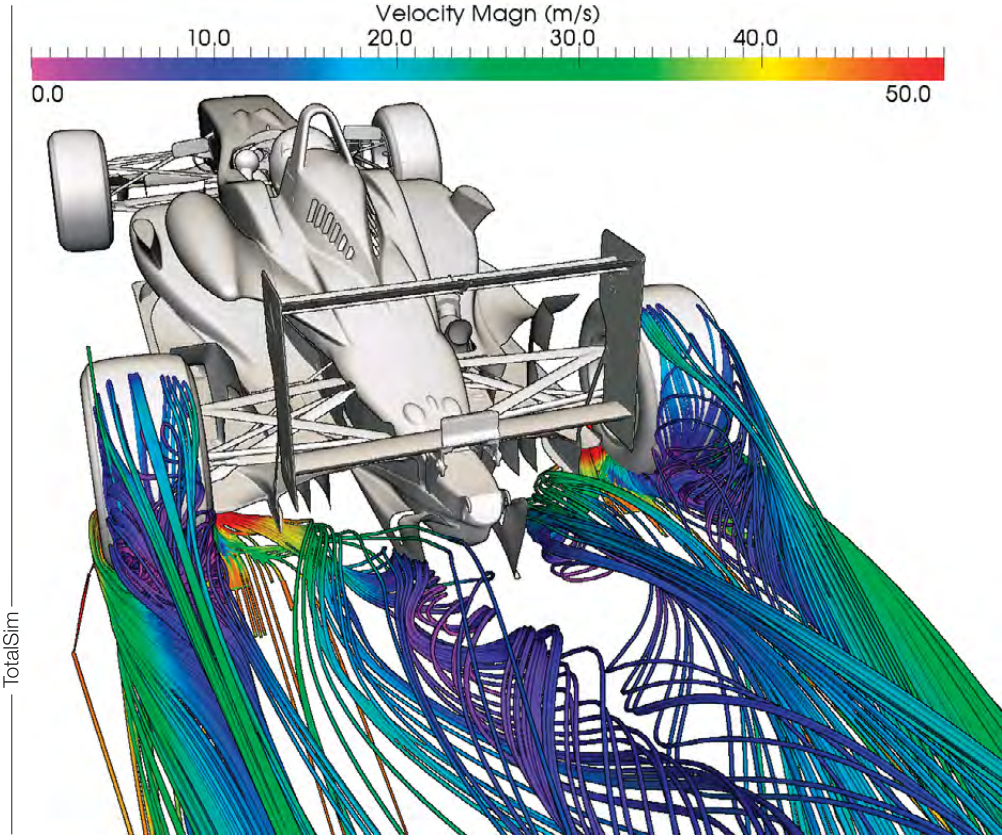

TotalSim

LEFT & BELOW
CFD illustrations of the aerodynamic disturbance created by exposed wheels

> *"Exposed wheels and tyres are an aerodynamic disaster, not only for car performance but also for the following car"*

CAR LAYOUT

Well, you would have to say the F1 layout is 'traditional': open wheel, open cockpit, single-seated, 13-inch rims so high profile tyres. If technical freedom was permitted, how many of those criteria would you keep? Secondly if you were looking at alignment to the motor industry, how many parallels do you see here? So referring back to the technical freedom offered to WEC on powertrain, if you could choose what an F1 car should be and why, what are the answers that present themselves? Both Red Bull with the X1 and the latest Ferrari concept rendering have been proposing suggestions.

If we look at the performance, you would never have exposed wheels and tyres. They are an aerodynamic disaster, not only for the car's performance, but also for the following car. The wake structure off a rotating cylinder is unstable and time dependant, so why would you have four large ones exposed? Couple that to how much drag they generate and how applicable that is to road car development.

Open cockpit? Okay, yes occasionally, depending on time of year and climate, it is nice to drive a convertible car on the road, but is it efficient, structurally, aerodynamically? Safe? I understand the concerns in F1 of visibility and quick extraction in case of fire, but cannot believe there is not the technology to overcome these obstacles. There have been two severe incidents in recent times: I feel Massa would not have been injured in a ▶

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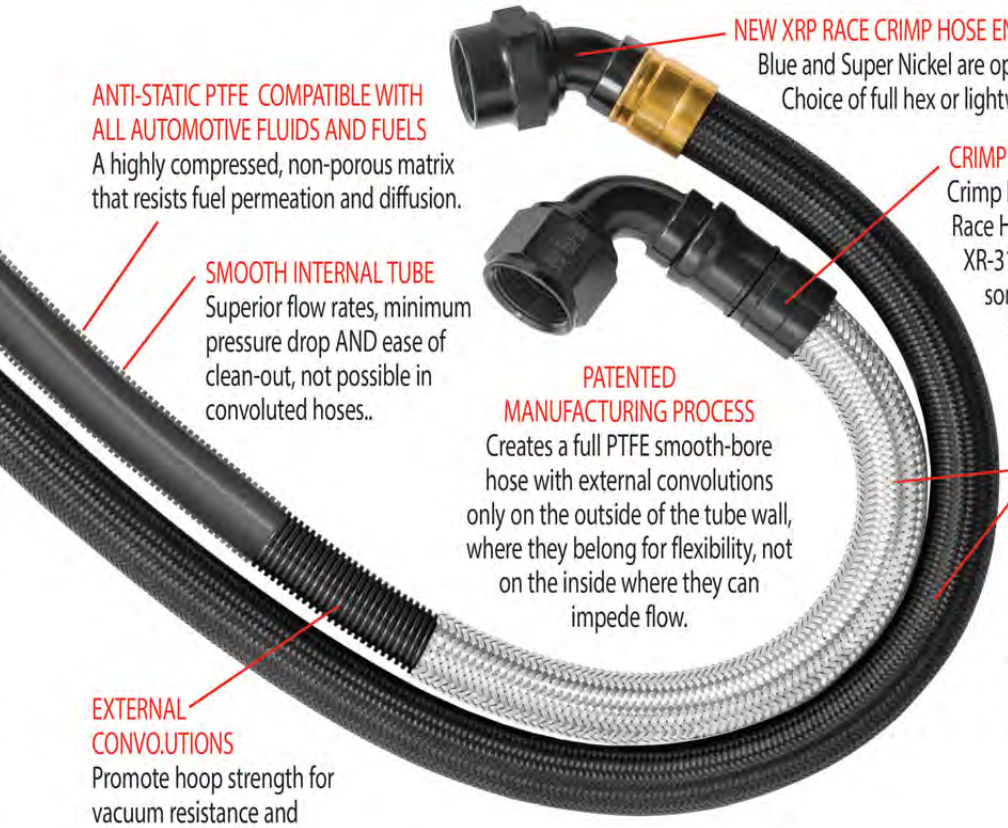

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THE XTREME IN RACECAR PLUMBING

Chris Jones/IndyCar

FIA/Formula E

ABOVE & BELOW IndyCar and Formula E, both rivals for the single-seater audience, are entering a period of aerodynamic and powertrain freedom respectively. Each has adopted covers and fairings around the wheels

closed cockpit car in Hungary; unfortunately, due to circumstances, the outcome of the Bianchi accident in Suzuka would have been very similar even with a canopy.

As for tyres and wheels, if they are covered up the influence and tradition is much reduced, also the aerodynamic reliance on having exactly modelled tyres for the development tools. Low profile tyres have become commonplace on the road, not just for performance but because wheels with elaborate spoke patterns and design look so much better than black rubber. The name of a road car with 13-inch rims? Erm… perhaps a late original Mini?

Lastly, the floor or diffuser of the car, the single most efficient and – when executed correctly – stability-enhancing device for the car in isolation or when running in a wake. Increasingly utilised on road cars despite their much higher ride height envelope, but largely reduced and emasculated from a current F1 car because of its performance potential and previous loophole exploitation. If controlled it can provide both close racing and plenty of performance at a budget. Have a look at the size of a GP2 diffuser the next time you get the chance – it will help explain their relative pace to an F1 car.

So, a closed cockpit, two-seater, covered wheel, low profile-tyred, diffuser-controlled, innovative hybrid-powertrained car would be a sensible way forward. Well that would be a current LMP1 WEC car.

RIVAL CATEGORY

This then is potentially a problem: a rival category to F1 in terms of technical solution, as it was all the way back in the early 1990s. Back then, with tobacco advertising under increasing threat of being blocked, the source of future F1 revenue was a concern. A 3.5-litre version of Group C (WEC in 1990) was formed that just happened to coincide with the same engine rules of F1 at that time.

Mercedes, Toyota and Peugeot developed specific engines for the class, but it was the Ford HB-engined Jaguar XJR-14 that really caught the eye. A no-compromise Ross Brawn-managed TWR programme, despite less power and a considerably higher minimum weight limit than an F1 car, its times in qualifying would still have made the cut for F1 grids at the same circuit.

The manner of the demise of Group C still pains many sportscar racing fans, not to mention providing a feast for ▶

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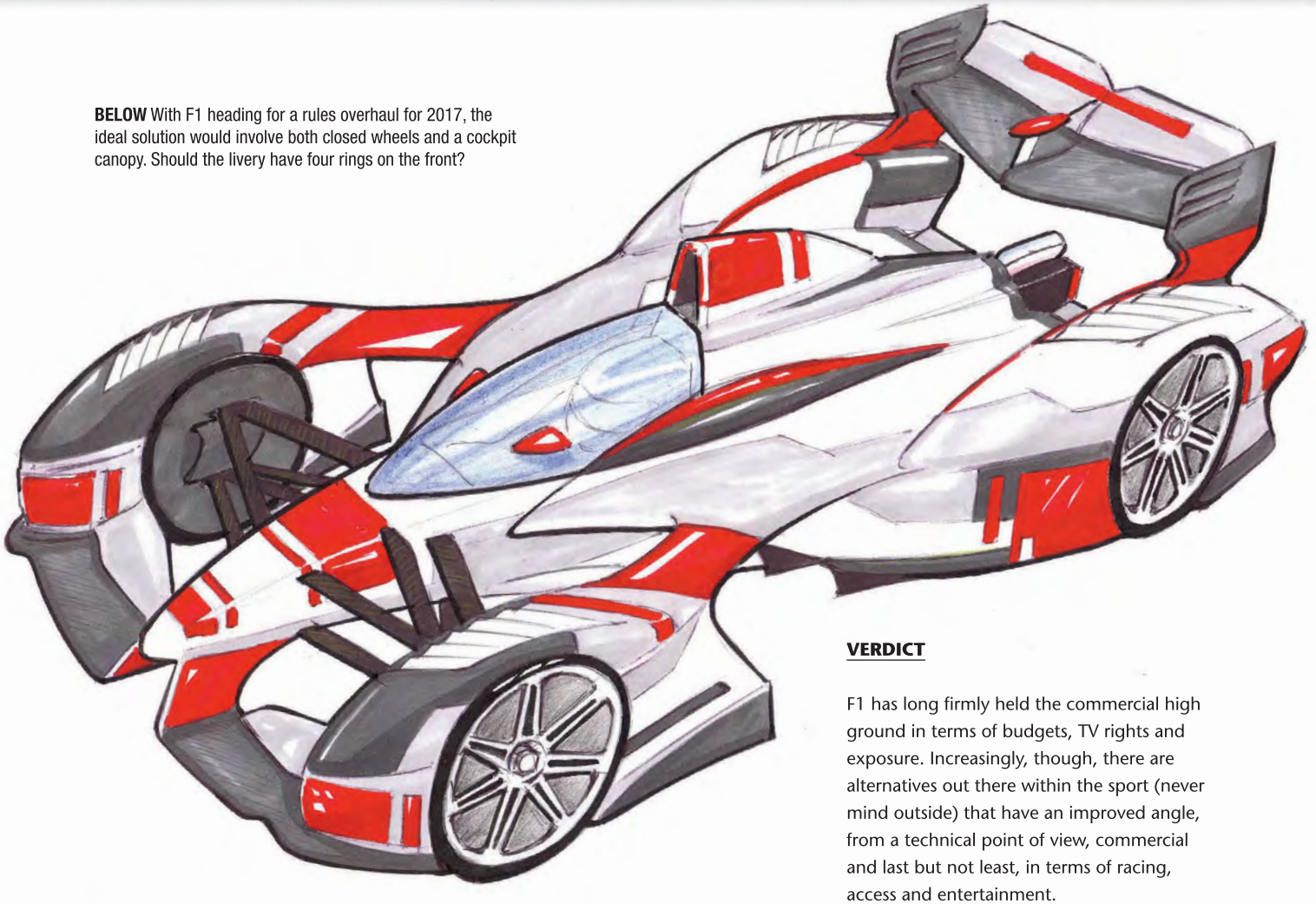

BELOW With F1 heading for a rules overhaul for 2017, the ideal solution would involve both closed wheels and a cockpit canopy. Should the livery have four rings on the front?

> *"It would worry me if a motorsport engineer was asked which category he would rather be working on and his first answer was not F1"*

conspiracy theorists. Spiralling costs and regulation change – sound familiar? – meant the end for the format in sportscar racing, but if you had already gone to the time, money and effort of producing an F1-compatible engine, there was always another series to migrate to…

IndyCar is another old rival which flew too close to the sun. It and Formula E are both options in the similar to F1 format space, and both are in an interesting area of development to pose an alternative option for the motorsport spectator. They are entering a period of aerodynamic and powertrain freedom respectively in the coming months. Both have chosen to adopt covers and fairings around the wheels as a design direction.

Back at its peak in 1993 when Nigel Mansell moved from F1 to ChampCar (IndyCar), the American series was a genuine single-seater threat to F1. Multi manufacturers, international drivers and a calendar that started to spread around the globe outside the US to Australia, Brazil, Germany and even the UK (Rockingham), there was real potential. A bitter disagreement around the Indianapolis 500 and the alternative IRL series ultimately meant two championships into one space would not work and the momentum was lost. I hope, some 20 years on, it is returning?

Formula E is still in its first season, but the amount of publicity, social media and the model of taking the quiet, non CO2/CO, non-particulate cars to the fans in urban areas, rather than requiring them to travel in numbers independently to a track, is certainly an interesting one. I wait with optimism to see if powertrain and battery technology gets enhanced as a direct outcome from the series.

VERDICT

F1 has long firmly held the commercial high ground in terms of budgets, TV rights and exposure. Increasingly, though, there are alternatives out there within the sport (never mind outside) that have an improved angle, from a technical point of view, commercial and last but not least, in terms of racing, access and entertainment.

If there is the substantial rule change in F1 coming up, mooted for perhaps 2017, this is perhaps *the* chance to get F1 back on track. With good, sustainable, decisions it's the opportunity for a healthy and premium category featuring lower costs, closer competition, more teams and better racing.

People ask me whether the WEC could really emerge as a rival to F1. I'd say that for engineers, it already is. It would be a worry to me if a motorsport engineer was asked today which category he would rather be working on in the future and his first answer was not F1. Right now, it feels like WEC is the much more interesting and applicable format and therefore, nostalgia apart, the most likely response.

If engineers think like that, put yourself for a moment in the shoes of a major car manufacturer. You have to choose a series, to promote and develop your product. Which one would you choose, and why? Right now that has to be the key question, doesn't it? With speculation regarding Audi and Red Bull's fundamental future decisions, where two major players decide to commit to or not will be the test of who is getting the formula right. RT

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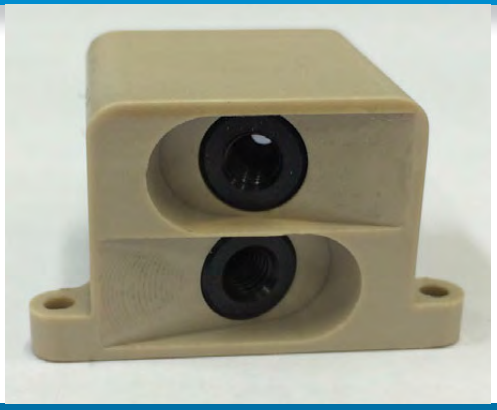

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No racecar divides engineering opinion quite like Nissan's GT-R LM NISMO. So having quizzed the car's creator, Ben Bowlby, is **Craig Scarborough** a convert?

IT'S a machine that turns the conventions of racecar design on their head.

Bearing a layout akin to Nissan's famed 'Godzilla' GT-R road car, the Nissan GT-R LM NISMO P1 is a Le Mans special that sports a front-mounted twin turbo V6 engine with front-wheel drive. It will eventually run RWD ERS to provide a four-wheel drive set up.

When sitting down with the spectacular car's designer, Ben Bowlby, in London just a month before the action at La Sarthe starts, Race Tech was able to find out the reasons behind the odd concept and what was needed to make it work.

Starting off, was there ever the option of Nissan going conventional in its Le Mans challenge? "There was a certain strategy at Nissan that said that they were only going to do a project like an LMP1 attack, if it was done with an innovative project," Bowlby explains. With innovation in mind,

Hate it?

Gimmick
Crazy
Stupid
Ugly
Naive

All photos: Nissan

ABOVE Confronted by rules penned around conventional rear-wheel drive, rear-engined cars, Ben Bowlby (left) designed Nissan's GT-R LM P1 car to attack from the opposite direction

Bowlby was the obvious choice for the role following the DeltaWing and ZEOD projects. "They needed someone willing to be wild enough," he admits, "and I thought it was a fantastic opportunity."

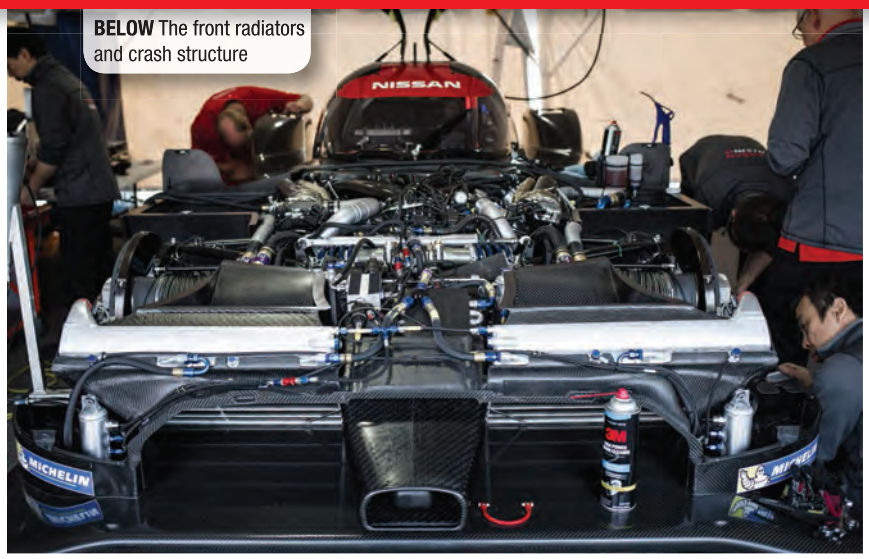
Bowlby's suitability for this car fascinates me. His preference to take alternative directions has roots in a general interest in car design, often citing other designs (especially the humble Mini) and even aircraft as sources of inspiration. But his being dyslexic also plays a role. "Churchill was too," he recounts. "It makes you ready to fight in a way that's unlike anybody else, because you know if you are going to compete with somebody on their terms, you are probably not going to beat them. But if you are prepared to attack it from another direction, then you've got a chance to get one over on them."

With a Le Mans assault the competition is fierce and conventional "Going into Le Mans, with Audi in particular, there isn't a strategy or a layout they haven't investigated because they've spent what accumulates to billions over the years. So why do you think you can take them on?" he asks. "On paper you are a smaller team, you've less money, you've got less experience; why would you be in with a chance?"

So the innovation central to both Nissan and Bowlby becomes the focus. "It's better to do it by being innovative and bold, so we'll hit them where they're weakest," he suggests.

So in planning the new car, Bowlby went unconventional and had an idea bubbling up in his head. "I've been keeping an eye on the LMP1 rules for decades," he concedes. "It was like, 'You know what? There *is* a way.'"

Thus the roots of the front-engined, front- ▶



BELOW The front radiators and crash structure

wheel drive design came about directly as a result of the conventional rear-engined, rear-wheel drive cars and the rules that have formed around them. According to Bowlby, "When you look at the regs, the regs are always published for the incumbents, so whatever people are doing, the rules get written to squeeze that or prevent such and such.

"Typically rear-engined, rear-wheel drive cars need rear downforce. If you want to hurt them, you put the wings in a tiny box; you make the diffuser a mandated height and geometry. Basically if you draw all the rules of the rear of the car, that's all the downforce you're going to usefully get. So essentially I know Audi's and our diffusers are, within a fraction of a degree, at the same angle. Width, height and the rest of it, are all the same."

Thus with regulations aimed at hitting rear downforce, the potential remains in the front end aero of the car. Bowlby outlines his thinking: "The front of the car is super-free. So I said, 'Hang on, I think there's a lot more you can get from the front'. It won't be simple, but I thought there was huge efficiency at the front of the car, so with a bit of investigation you could really do something exceptional and you think, 'How far do we go?'"

With the aim to go for a front end focused car, the option for a front engine was obviously not the only solution. "Like Porsche, we could do a really small, light engine and shove everything forwards," he points out. "But a) it's very difficult to see it's very different from Porsche and b) it's not really an innovation: we already did a small, light engine with the ZEOD."

So to meet the front bias and innovation required, Bowlby thought: "Let's go the opposite way and we'll turn the whole concept on its head: put the engine ahead of the driver and get the weight distribution far forward. As soon as you move the weight distribution forward, you realise you have to drive the heavy end of the car. Not like the pickup truck effect, where you have a heavy front then nothing at the back and end up just spinning the wheels."

SPIRIT OF GODZILLA

Thus the concept of the front engine set up was born. The marketing parallel was not lost on Bowlby. "It was such a beautiful match for the GT-R road car, front-engined, 4WD and a total beast in itself as a road car," he acknowledges. "We were taking that concept and essentially turning it into a modern LMP1."

So, I ask, how far forward is the weight bias? "It's way ahead of 50-50," he replies with ▶

BELOW The aero concept revolves around large through-ducts, running from the splitter to the rear of the car

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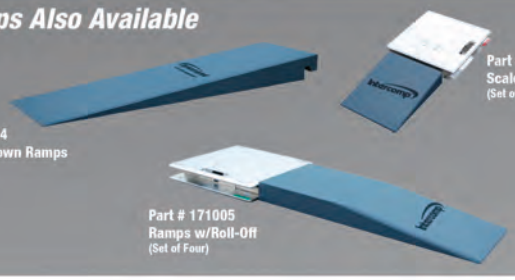

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a smile. "I mean let's say it's about 65%." The front weight bias and driven front axle also bring advantages in varying conditions, Bowlby suggests optimistically: "As Le Mans throws up so many curve balls, you don't know what the weather's going to do. It's incredible: you get heat, rain and intermediate conditions. There are certain layouts that are beneficial in certain circumstances, so we are doing rain dances every day!"

This is clearly a key vehicle dynamics trait that Bowlby wants to make the most of. "How good is a front-wheel drive car in the snow?" he asks. "The worst thing in the world is a front-engine, rear-wheel drive. Basically road cars are front-wheel drive because they are just not very good at laying down the power or having high rear end stability. In our case, if we say our weight distribution is 65% forwards, then with weight transfer we get let's say 5%."

When this analogy is pointed at the rear-engine, RWD cars, Bowlby sees they are penalised: "They might be less than 50% on the rear axle and with the weight transfer that might give them 55 percent. We've got 5% more vertical load to get traction; down the straight we can be 10-15% more vertical load. Running in wet conditions we have a tremendous advantage."

With the layout theorised, Bowlby admits he's no good at sketching. He concedes some doodles were done on napkins, but simulation work was the first proofing of the concept.

Bowlby pondered different shapes: "We thought of a ChampCar with turning vanes at the front, or a much more traditional wing on a splitter, then manage the aero exiting sideways to the back. Knowing the goal of a Le Mans special is to have low drag, it has a very high LD ratio, with as much downforce as we can make, but it would beat everybody on drag; we have to beat the fastest."

His experience as a one-man racecar constructor and racer underlines his aero goals. "My philosophy, having raced myself, was that I was as fast as Lewis Hamilton on the straight because it was just a question of holding the pedal down!" he laughs. "If you can give drivers a straight line speed advantage, particularly at tracks like Le Mans, you put them in a place where they overtake in a much safer, lower risk way.

"I've seen this in my own racing car against big, heavy cars that are super-fast on the straight. There's nothing worse. I was fast around the corners, but if you dive-bomb them on the corners it's very risky and then they just overtake you on the next straight! I'm three seconds a lap faster and they screwed you on the straights."

So with the LMP1 car his philosophy was clear: "If you've got the slowest racecar in the corners, then maybe the same lap time as you're faster on the straight, you've got everything covered. You can hang back in the corners and then you pass on the straights. No-one's holding you up. It's magic. You can move very quickly through the field."

UNCONVENTIONAL

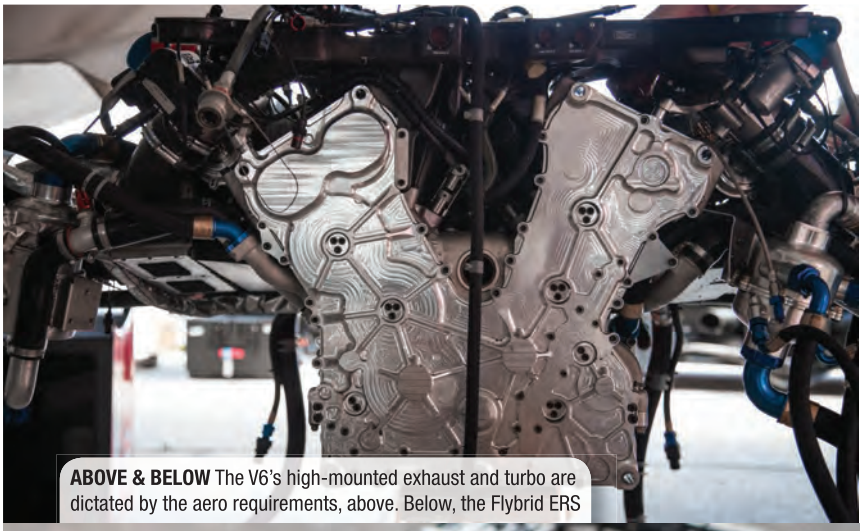
Thus the car's layout is an unconventional one. From front to rear, it starts with the front crash structure, then the differential and gearbox that also mounts the front suspension. The engine sits between this and the monocoque, the driver ahead of the fuel tank and inside an integral carbon roll structure.

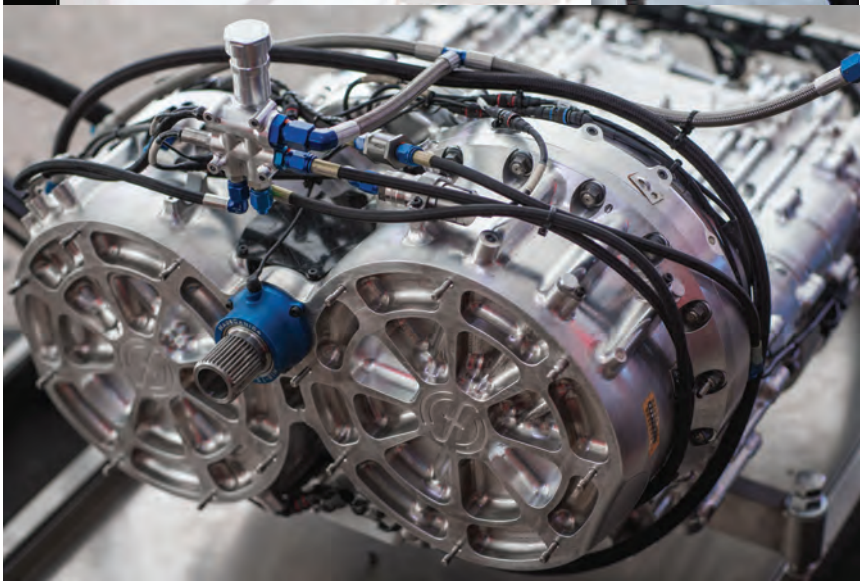
Behind, the tub extends past the rear axle line with a beam structure emerging laterally to provide the rear suspension pick up points. If you view the car stripped of bodywork, it looks like a conventional rear-engine car parked the wrong way.

Of course given the freedom in the front splitter area and the mandatory cross sections for the monocoque, now moved further down the car, the area around the splitter is opened up. Thus with a narrow engine and front crash structure, the expansion of the front diffuser area can be much larger.

Not wanting to vent the splitter wake outboard of the car, the splitter extends to form two huge tunnels along the car's sidepods, termed by Bowlby as 'through-ducts'. These exit above the mandatorily-sized diffuser and the flow structure inside the car is key to producing front downforce, not at the rear, as required by the weight bias and tyre sizing.

As outlined by the designer: "The splitter's undersurface becomes the top of the through-duct, then the floor starts 400 mm back from the front axle. So you've got this metre ahead ▶





ABOVE & BELOW The V6's high-mounted exhaust and turbo are dictated by the aero requirements, above. Below, the Flybrid ERS

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of the front wheels, a diffuser 1.8m wide that goes between the front wheels. Basically what's lovely is that you use the base pressure at the back of the car to suck the air from the splitter."

With the splitter flow passing internally through the car there is really only the exhaust and cooling ducts perforating the outer bodywork, as well as the regulatory wheel arch openings. In fact the front arches feature no additional venting; the wheel sits within an inner arch and the airflow and brake dust exit through the arch opening along the flanks of the car and partly through the regulatory top opening.

With the outer arches themselves being the fashionable tall shape, the front end is a bluff, rounded design. Most airflow not entering the central radiator inlet passes instead around the sides of the nose and then attaches to the flanks after the front wheel arch.

Proof that the flow structures are working was made evident by Bowlby showing me pictures of the car after a long stint in the wet Kentucky test. Long continuous smears of brake dust were acting like flow viz paint and remained attached to the car's flanks with little sign of separation.

The top deck of the bonnet remains surprisingly low considering the presence of an engine beneath. This low height carries to the back of the car, the wheel arches projecting upwards to accentuate the low, flat lines.

Being front-wheel drive, the rear wheels do not need to be sized as large as the fronts, so just 16" x 9" rims are adopted. This allows the rear wheel arches to be smaller, critical for a closed wheel body, as the rear arches sit in "virgin" air according to Bowlby. Thus drag can be usefully reduced by not obstructing the flow as much.

WINGLESS

With the cockpit canopy, rear fin and wing all being sized to the regulations, little scope for innovation remains there. However, there have been rumours of a rear wingless set up for Le Mans. Bowlby refutes this, suggesting the wing is there both for high speed and braking balance, as well as to tune the car's aero balance. But he did admit the wing run will only be a single element.

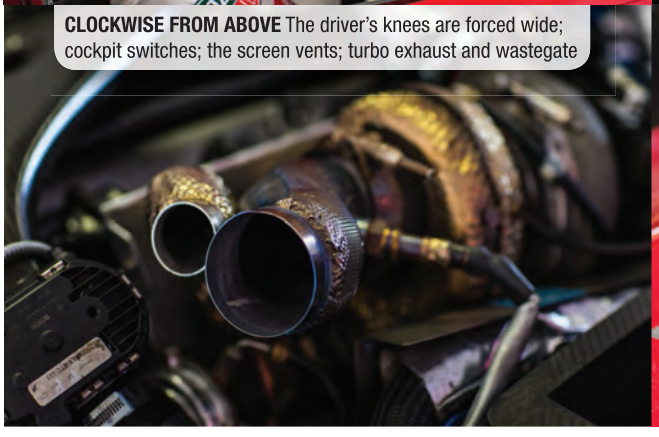
At the pre-Le Mans event a show car made to the same dimensions was available to sit in. Having never sat in a contemporary LMP1 car, but in representative recent F1 cars, I found the seating position is perhaps more cramped than expected. Access into the cockpit is aided by the wide, flat-topped sidepod, but the front bulkhead to seatback bulkhead distance was surprisingly short considering the length of the car. The need to bring the driver's head down forces the legs to bend into the available space.

Without the high dash bulkhead of an F1 car, the driver's legs are forced wide, with knees akimbo either side of the steering wheel. I'm told by the drivers that this isn't unusual for an LMP1 car and ex-F1 pilot Max Chilton reported it felt similar to an F1 car.

No air con is used but the polycarbonate screen has cut-outs to provide cooling and heat conducted through the front bulkhead is surprisingly not an issue. Thus nearly 10 kg is saved from not having an air con unit in the car.

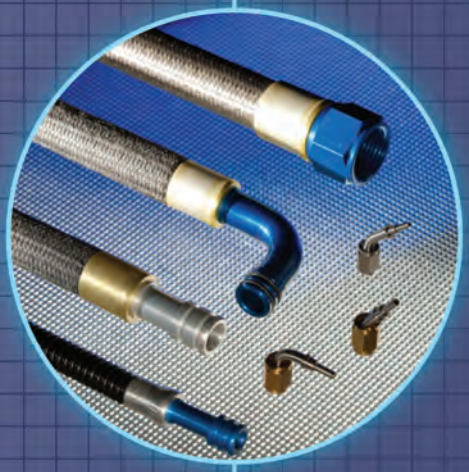
The power unit is characterised by an equally fierce drive for efficiency. "We wanted an engine that was thermally efficient," says Bowlby. "We worked very closely with the Super GT guys. Theirs is a two-litre four; ours is a three-litre six. We shared a lot of combustion technology, direct injection, and twin turbos."

Working with Nissan's other race engine departments was critical to getting an LMP1 engine up and running quickly. "We didn't have to go through a single-cylinder test engine; in fact, we used a (Super GT) four, that we lopped a cylinder off to make a three," he reports. "It's no secret a lot of the work was done in Europe and it was a brilliant collaboration of clever people putting in lots of bits of information. It also led to a very efficient development cycle as we were able to go from ▶



CLOCKWISE FROM ABOVE The driver's knees are forced wide; cockpit switches; the screen vents; turbo exhaust and wastegate

INTELLIGENCE CONNECTED



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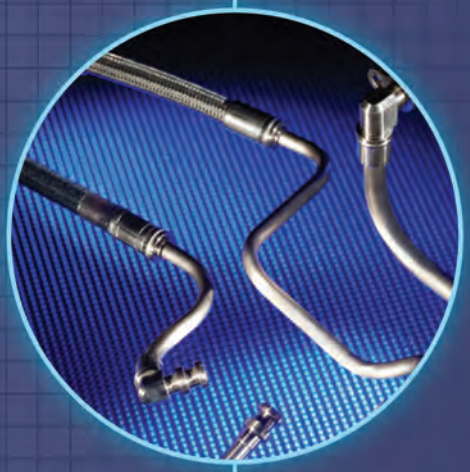

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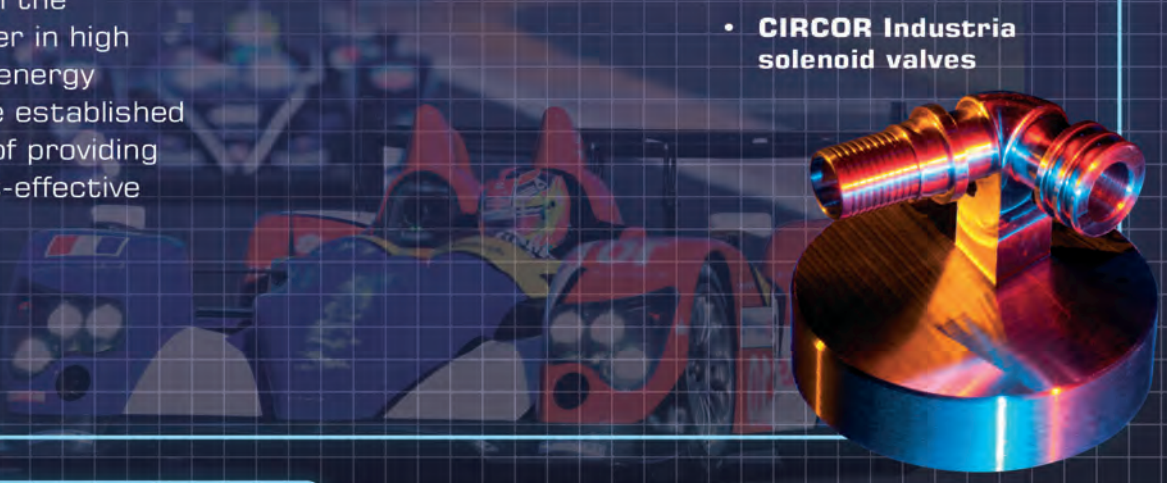

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Technical Specifications

Configuration
- Front engine; front-wheel drive

Engine
- Nissan VRX 30A NISMO: 3 litres, 60-degree, V6, direct-injection, gasoline twin-turbo, Flybrid ERS flywheel

Transmission
- Xtrac 5-speed + reverse sequential gearbox with pneumatic paddleshift system. Epicyclic final drive reduction with hydraulic limited slip differential
- Tilton 3-plate carbon clutch assembly

Chassis
- Weight: 870 kg. Right-hand driving position
- 68-litre capacity FT3 fuel tank featuring electric lift and feed pumps
- ERS housed ahead and beneath driver's feet in self-contained module

Bodywork
- Carbon composite body panels
- Polycarbonate windscreen with hard coating
- CFD and full-scale wind tunnel-developed ultra high efficiency bodywork geometry, adjustable rear wing

Suspension
- Öhlins multi-adjustable front dampers and Penske multi-adjustable rear dampers, hydraulic rear anti-roll bar system

Brakes
- 6-piston front (AP) and 4-piston rear (PFC) calipers. Driver-adjustable brake bias

Wheels
- BBS centre-lock, magnesium forged 18" x 13" front and 16" x 9" rear

Tyres
- Michelin 31/71-18 front, 20/71-16 rear radials

Electrical
- Cosworth engine control unit featuring: engine control, gearbox control, driver-adjustable traction control, anti-lag system control, lift-and-coast fuel conservation, drive-by-wire throttle control and ERS deployment strategy control

Fuel/lubricants
- Motul

Interior
- Willans seatbelts
- Lifeline lightweight extinguisher system

Data/display system
- Cosworth Electronics with NISMO steering wheel-mounted LCD

Dimensions
- Length: 4.645m, Width: 1.9m, Height: 1.03m

the 3-cylinder complete combustion system then double it up, so in a very short time we were in a position to have the engine."

With the base engine developed, packaging the ancillaries was tricky due to the front end aero concept. To maximise the front splitter, there are two through-ducts running from the splitter through to the rear of the car. These flank the motor and force the ancillaries to be mounted high and rearwards.

"Because of the shape we had a sort of keel that goes around the V of the engine, so the pumps were all moved to the back of the engine," continues Bowlby. "The whole thing is a bespoke unit but the aero forced a lot of the layout of the engine. There's no space at the front; I really feel bad for the engine guys."

The V6 engine mounts the water and oil pumps at the back of the motor, while very short exhausts feed up through the wastegate junctions to the high-mounted twin turbos. The compressor is fed by long forward-facing tubular inlets and blows into a Mezzo water-cooled charge air cooler. The exhausts for both the turbine and wastegate are incredibly short and exit periscope-style through the bodywork. Although off to the side, they are certainly visible to the driver as the flash on the overrun at night!

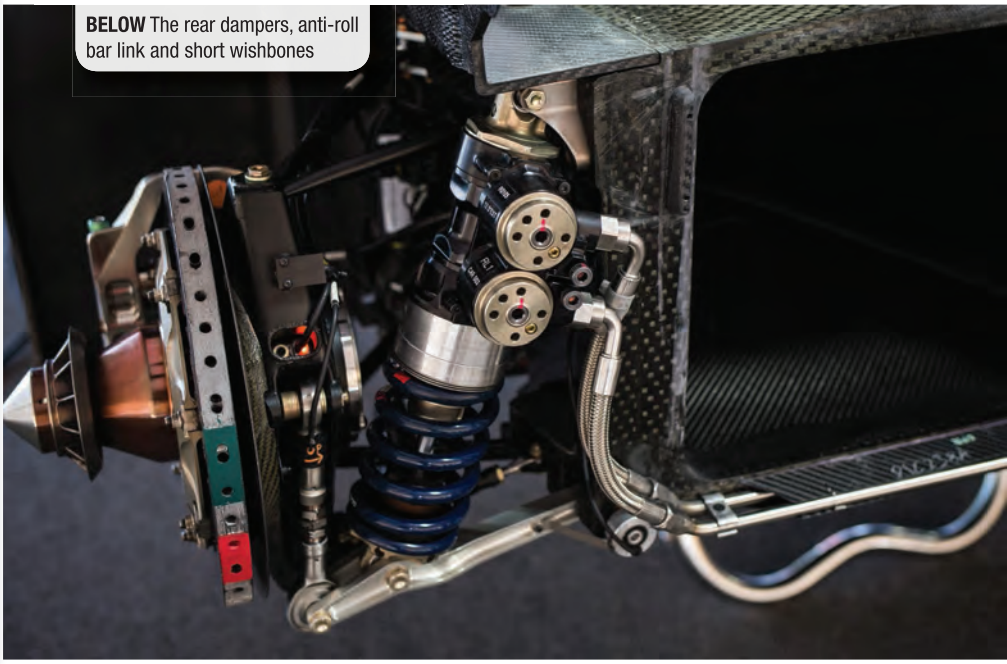
Despite some very tight packaging inside the front end, cooling has proven to be better than might have been imagined for the engine, electronics and driver. "The airflow around the car is very counter-intuitive," explains Bowlby. "There's a big circulation that goes around the car and it's very difficult to keep a rear-engined car cool compared to a front-engined car. Also just having the radiators at the front we can have very efficient coolers, not struggling for flow or any of that. We've looked at lots of different water-cooled charge coolers. We've looked at Mezzo stuff, something we use a lot of to get that sort of high efficiency cooling."

As a result the cooling package of the turbo intercooling is water-to-air based, the two large front microtube radiators cooling both the engine water and the intercoolers. These vent over the top side of the engine cover, in line with the turbo exhausts.

The exhaust flow vents through the bonnet outlets. The radiator exit flow also joins this flow to trail over the sides of the car. Bowlby points out the bodywork joins enable cool air entry into the engine bay, further reducing the need for draggy inlets. Furthermore, the radiator exit flow is also used to cool the brakes, further reducing drag from unnecessary inlets on the bodywork.

VICTIM

Allied to the IC engine is a flywheel-based kinetic recovery system. This has been a victim of the compressed development time, forcing chassis compromises along the way. The concept was to have the flywheel system mounted behind the engine, feeding back through a driveshaft to the differential at the rear axle. From there driveshafts would lead it out the rear wheels. Engineering this was quite a feat, according to Bowlby: "The driveshafts that go between the floor and the base of the through-duct are only about 28 mm ▶



BELOW The rear dampers, anti-roll bar link and short wishbones

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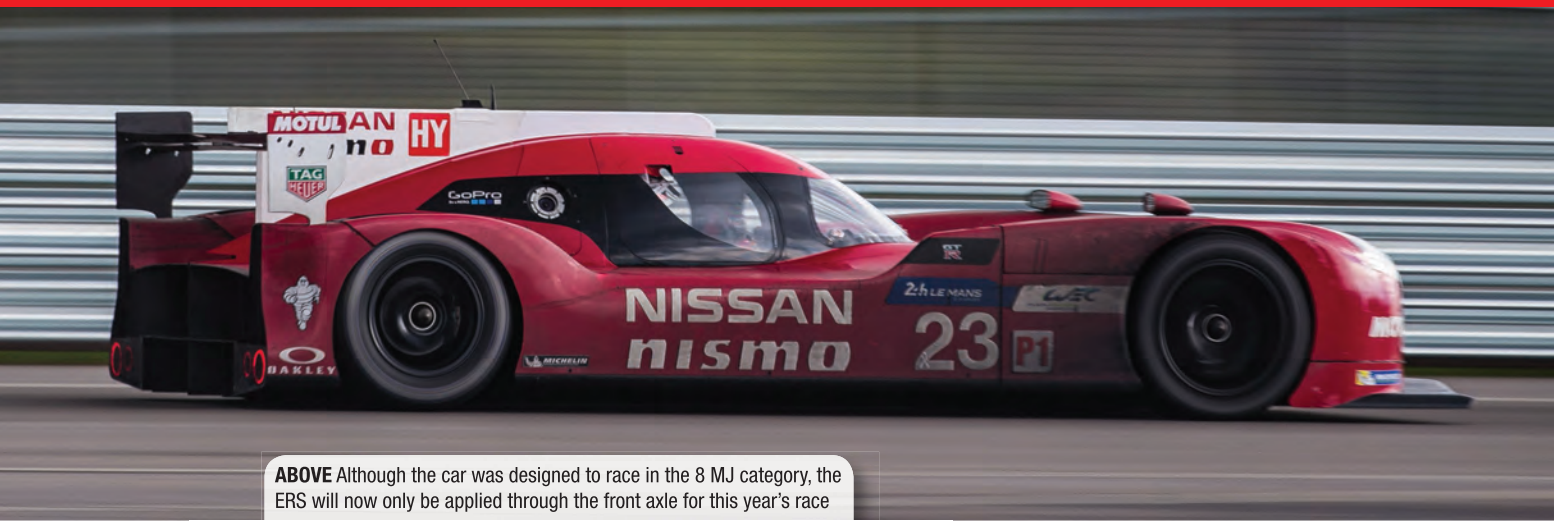


ABOVE Although the car was designed to race in the 8 MJ category, the ERS will now only be applied through the front axle for this year's race

diameter, it's possible for them to handle it because ERS is only deployed at high speed."

It was anticipated that the car could race in the 8 MJ category, but circumstances have meant the ERS will now be applied through the front axle. "We struggled to get hold of a mechanical ERS, which could be our Achilles heel in 2015," he confesses. "I'm very sad about that situation, as we've got a good concept. So we've reduced the engine class we've gone into."

NISMO is not saying what class the car will be entered into until the homologation process is complete. With fears for the ERS and with Le Mans rewarding reliability, my opinion is it will opt for a low category and focus on the added fuel flow for the IC engine, perhaps even the 2 MJ category that won the race for Audi last year.

Front-wheel drive is known for traction problems out of corners, with tyres coping with both lateral and longitudinal acceleration. However Le Mans is so governed by the long straight, NISMO can focus purely on straight line acceleration. Again we see the Le Mans special status means that racecar conventions may not apply here, according to Bowlby: "We initially set out to make a car that biased towards having a longitudinal acceleration, which led us to go to 16" front wheels instead of 18". That was all looking very promising until we ran into challenges from the ERS; the whole thing was built around an 8 MJ ERS system. Because we biased the weight, tyre and aero for this, it was well within the physics to solve. So we didn't need very big brakes."

However the desire for traction at the front and the subsequent dropping of the RWD system for 2015 means some rethinking was required, as Bowlby details for us: "This means the mechanical brake has to do relatively more work. You can't make a very big mechanical brake within a 16" wheel, so we've gone back to 18. Fortunately, a lot of the 18" Michelins are capable of putting torque through the front tyres. So we've been able to make a very easy transition to run 18" on the front and 16" on the back, with the same tyres width-wise as we already had."

With so much focus on the front, the rear has not been missed out as again opportunities lay in store for the front-engined concept. The rear set up defies convention with short wishbones mounted to an out-rigged beam structure. There were other options, Bowlby explains: "We had to find a rear suspension that doesn't get in the way. We looked at a swing axle, just like a Mini. It would not have been that bad. With the beam it was going to be relatively clean and we've gone to unconventional tiny rear wishbones. The first aero runs were extremely encouraging."

MINI INSPIRATION

With short wishbones, I pointed out, wouldn't dynamic geometry change be a problem? Again Bowlby points to the Mini and its front suspension this time, adding, "It's just an unequal length wishbone, it's fine. We're totally dominated by the front end; the rear is just a passenger, and all it has to be is light and stiff."

Oddly the rear dampers have hydraulic pipework emerging from the end joining the middle of the car. Was this a remote heave element or front-to-rear lining? Surprisingly open, Bowlby says: "We use it as an anti-roll bar; we didn't want a bar across the car, as it was long and not very stiff. We wanted very stiff roll stiffness at the back: we can lift an inside rear in the corners."

Equally the large through-duct and the wide beam structure surrounding it suggests a largely fixed aero set up at the rear. I asked if this was a problem and could the beam be sufficiently stiff? "We've got a pretty fixed box," comes the reply. "We've made it as big as we can possibly make it. It's actually the same as a wing root of an F-111 (an American swing wing Jet aircraft), where you've got jets feeding through each side of the wing spar. You have a wide, high I-value beam top and bottom connected by vertical members. So we've made a strange beam structure. We loaded it up the first time just to check it. It can take it and it's been very simple."

In preparing for the Le Mans event the cars have been assembled by NISMO, but most of the manufacturing has been outsourced. Bowlby cites there being nearly 3,000 people worldwide making parts for the car, where NISMO has just four CNC machines for making parts. He adds, quite modestly, that the team simply assembles the cars!

The cars have tested exclusively in the US, with tracks laid out to replicate the straight and chicanes at Le Mans. The last test usefully provided a large dose of rain to prove the car's stability and traction in wet conditions. The next steps are homologation, the confirmation of the energy class the power unit will race within and then final testing before the race week.

It's hard to judge how an unraced car will perform at its first Le Mans. NISMO appears to be well experienced and well prepared. Certainly the reduction in ERS energy and instead a stronger focus on the IC engine should aid reliability, if not overall pace. One could argue a race finish would be a good enough result, but there's a feeling that Nissan and NISMO want to take the fight to the big teams. Realistically, this would need weather conditions to play into its hands.

If it should be wet, then the front-engined concept needs to be proven. If outpaced in the wet, I fear the whole concept as it stands may not bring enough to genuinely fight Audi, Porsche and Toyota.

Having heard Bowlby enthusiastically evangelising about the concept, I believe given the resources and time the idea may work, albeit purely as a Le Mans special. But certainly as a more serious contender than a mere garage 56 special. RT

81.25%!

Not a bad win ratio, is it? Audi's 13 victories suggest that, yes, winning the WEC is nice, but there's no substitute for Le Mans glory. Our **Expert Witness** considers the unique challenges posed by the race, and reflects on whether anybody can stop number 14…

Audi

ABOVE Audi's 13 Le Mans-winning cars assembled for the first time. That streak was achieved from only 16 races

THERE is something rather special about the Le Mans 24 Hours. Not just the obvious all day and all night format, and the history, but the sheer challenge it represents for the whole team to blend pace, consistency and reliability to get a result.

For the drivers, it's regarded as one of motorsport's Triple Crown, along with the Indianapolis 500 and Monaco Grand Prix. These are the races that really prove you are in an elite class and winning all three is a feat so far achieved only by Graham Hill.

For the engineer, as for the driver, the Le Mans 24 Hours remains an inimitable challenge. Different tracks have different requirements and sensitivities that your car or package need to be accurately dialled into to be truly competitive. That is easy, or easier, if the track is generic or a more typical one on the WEC calendar. Le Mans has moved in this direction over time. Nevertheless, a combination of three things – the event's importance, the track's remaining specifics, and the magnification of any performance weakness over the length of the race – means unique packages are created.

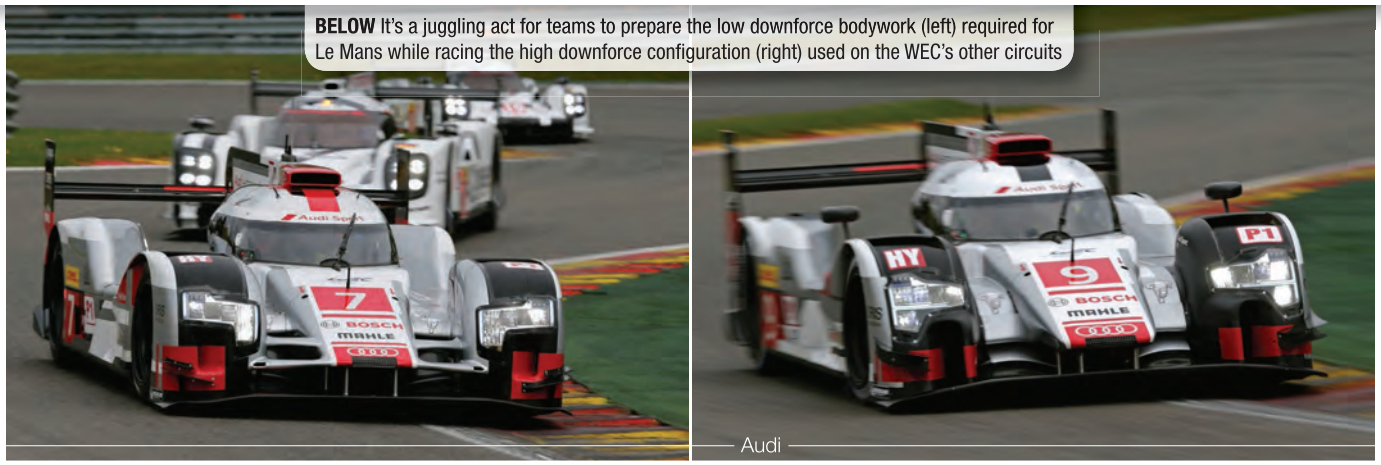
PUBLIC ROADS

The track layout is a mixture of mainly high-speed bespoke racetrack turns, particularly returning to the pit area, with a slow-speed chicane sequence at the very end. The circuit's character is dominated by its use of public road. This is most notably the case on the Mulsanne straight, which comprises 6 km or almost half of its 13.63 km length.

The nature of the layout was fundamentally changed in 1990 when, following safety concerns, two chicanes were introduced that divided the straight into three almost equal parts. Despite this the demanding high-speed nature of the track still firmly remains. It puts a premium on low drag, engine power, maximum throttle reliability (80 per cent of the lap is spent at full throttle), braking – given the ▶


Audi

ABOVE The class system and disparity in driving standards combine to produce formidable closing speeds in traffic



BELOW It's a juggling act for teams to prepare the low downforce bodywork (left) required for Le Mans while racing the high downforce configuration (right) used on the WEC's other circuits

Audi

multiple stops from very high speeds – and tyre life and consistency.

Coupled to these demands is the unusually long lap distance. With most other tracks a third of the length, this poses a particular set of problems.

The first is fuel usage. With the requirement to spend as little time in the pits as possible during the 24 hours, fuel economy is extremely important. However, because of the lap length, to run an extra lap compared to your competitors over a stint requires around an 8% improvement, a very big step.

Another factor is weather. As at Spa, but compounded by race length and running at night, you can have very diverse conditions at different parts of the track. Choosing wet or dry tyres can be a difficult enough decision without being only half right: the worst case scenario is the Mulsanne being dry and the car on slicks, only to get to the braking zone at the end of it and find it is wet…

Communication can also be an issue. With reliability so important, but the race so difficult to complete trouble-free, cars will often become stranded and will require the driver to effect a repair (legality) to get it running again. So can they diagnose the problem successfully, via radio, potentially in the dark, on ever more complicated hybrid technology, without having the correct tools (weight) with them? Team members and mechanics are allowed to get to the scene, which may be 7 km away cross country, and offer tools, advice and encouragement. But they are not permitted to work on the vehicle unless it is able to return to the pits.

The combination of classes (prototypes and GTs) and drivers (professional and amateur) with very differing performance presents the next difficulty for all the competitors: speed differentiation. Even remembering it is a long lap, the lap time difference between the front LMP1 car and slowest GTE Am car on the grid in 2014 was almost 50 seconds – or, perhaps more correctly, the GTE Am package was 25% slower.

Add to that the fact that there are 54 cars on the startline, plus the race context. It means the chance of losing time or making a catastrophic misjudgement in traffic is extremely high.

INCIDENT AND DEVELOPMENT

With such an iconic race there are occasionally events, good and bad, that shape what happens afterwards, or certainly stick in the memory.

The 1988 WM Peugeot falls into this category. While an official entry into the overall race, the team's objective was to break the 400 kph barrier down the original 6 km straight. The car, 'Project 400', was an extreme execution of the low drag approach. Legend has it that the cooling was taped up, and the turbo boost turned up, before what was to be a record 405 kph peak speed run. The team actually denies taping over the ducts but it is beyond dispute that the car retired with overheating issues.

The following year's more conventional Sauber-Mercedes pole-winning car achieved 401 kph in qualifying. The rising speeds, combined with a number of accidents, were the catalyst for the introduction of the chicanes on the Mulsanne for 1990, cementing WM's ▶

ABOVE You wouldn't get this in a GP! Mike Rockenfeller struggles manfully to repair his Audi after crashing at the exit of Tertre Rouge

Dole/LAT

BELOW WM's 'Project 400', dedicated to cracking the 400 kph barrier, remains one of the most daring (crazy?) feats in the race's history

unusual objective into the record books.

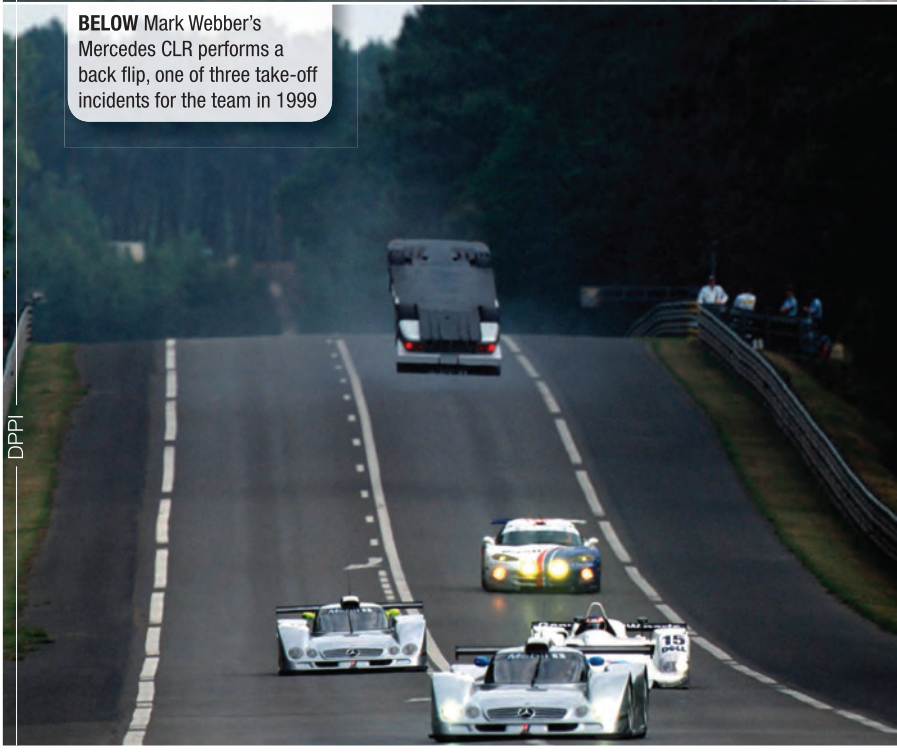
In 1999 it was not the low drag aspects of aerodynamics that were gaining publicity, but the rather more worrying ones of instability. A trio of serious accidents befell the Mercedes CLRs, with Mark Webber's car performing a 'back flip' (on two separate occasions!) at high speed in pre-event running.

The final incident, during the early part of the race, provided the narrowest escape. Peter Dumbreck's CLR took off into the trees at high speed, landing the right way up in an area recently cleared, a tree stump impaled up through the underneath of the tub remarkably just missing both the driver and the fuel tank.

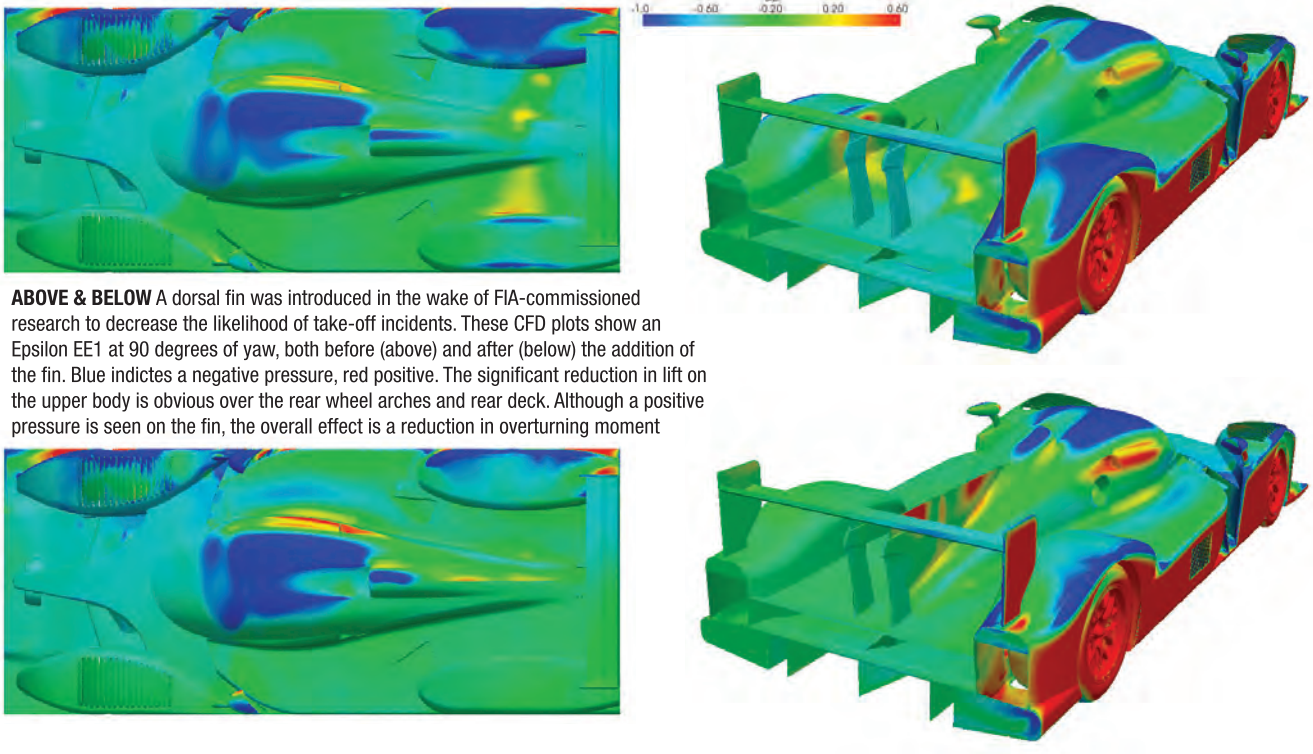
The LMP1 crashes of Allan McNish in 2011 and Anthony Davidson in 2012 illustrate the difficulties of the disparities in closing speeds, going for gaps around much slower GTE cars that led to contact and serious incident. But the accidents of Mark Gene in 2008 and Loic Duval in 2014 still show we have a lot to learn, explain and counteract regarding high speed sports car stability.

With highly curved upper surfaces, the traditional problem that Le Mans prototypes have is that these create suction and lift. If the car then moves into a yaw or slip condition, or worst of all starts to spin, areas such as the wheel arches and the engine cover have a much more cambered rate of curvature, which generates even more lift.

Much has been done recently with the adoption of engine cover central fins and open tops to the wheel arches to counteract this effect. Also changes to the floor regulations have helped provide a way to balance this, but floors too lose downforce rapidly in an increasing yaw condition. When coupled to this track's low drag, high efficiency demands, the set up target inevitably tries to trim the components out to a most slippery but less stable configuration. ▶



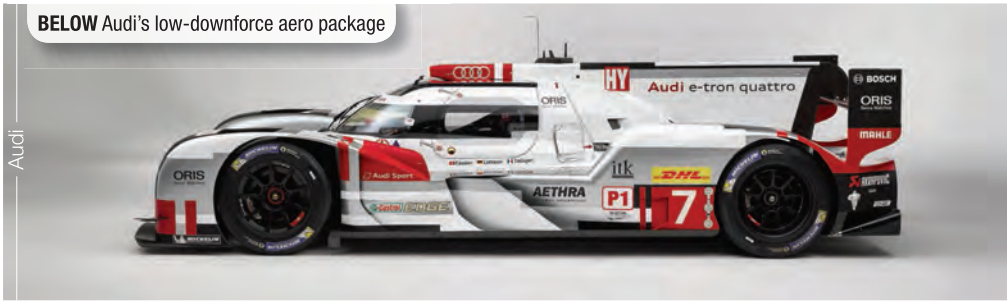
BELOW Mark Webber's Mercedes CLR performs a back flip, one of three take-off incidents for the team in 1999



ABOVE & BELOW A dorsal fin was introduced in the wake of FIA-commissioned research to decrease the likelihood of take-off incidents. These CFD plots show an Epsilon EE1 at 90 degrees of yaw, both before (above) and after (below) the addition of the fin. Blue indictes a negative pressure, red positive. The significant reduction in lift on the upper body is obvious over the rear wheel arches and rear deck. Although a positive pressure is seen on the fin, the overall effect is a reduction in overturning moment

The Class of 2015

With four manufacturers fighting for ultimate honours at this year's race, I will run through a few of the packages' strengths and potential weaknesses and try to predict the outcome.



Audi

BELOW Audi's low-downforce aero package

AUDI

Despite successfully holding back the challengers at last year's Le Mans, it was not before the cars had betrayed a lack of outright pace in qualifying and the early part of the race. Multiple winners in recent years, in terms of preparation, reliability and continuity they know exactly what is required to get the job done. Also in 2015 it appears they have responded strongly to the new competition and Toyota winning the 2014 WEC honours.

The car is all-new apart from the monocoque and the gearbox casing, has aggressive aerodynamics developed with the help of Sauber's excellent facilities, and has moved up to the 4 MJ class for energy recovery. Add to that their 100% win rate at Silverstone and Spa already this year, the second with their heavily revised and amusingly named "Low Drag" package for Le Mans, in deference to it being low downforce. The middle aero sector at Spa does seem to exactly bear this statement out however: where downforce is particularly important through the high speed turn 10 and 11 sweeps of Pouhon, the Audi was quickest, against still standard spec rivals…

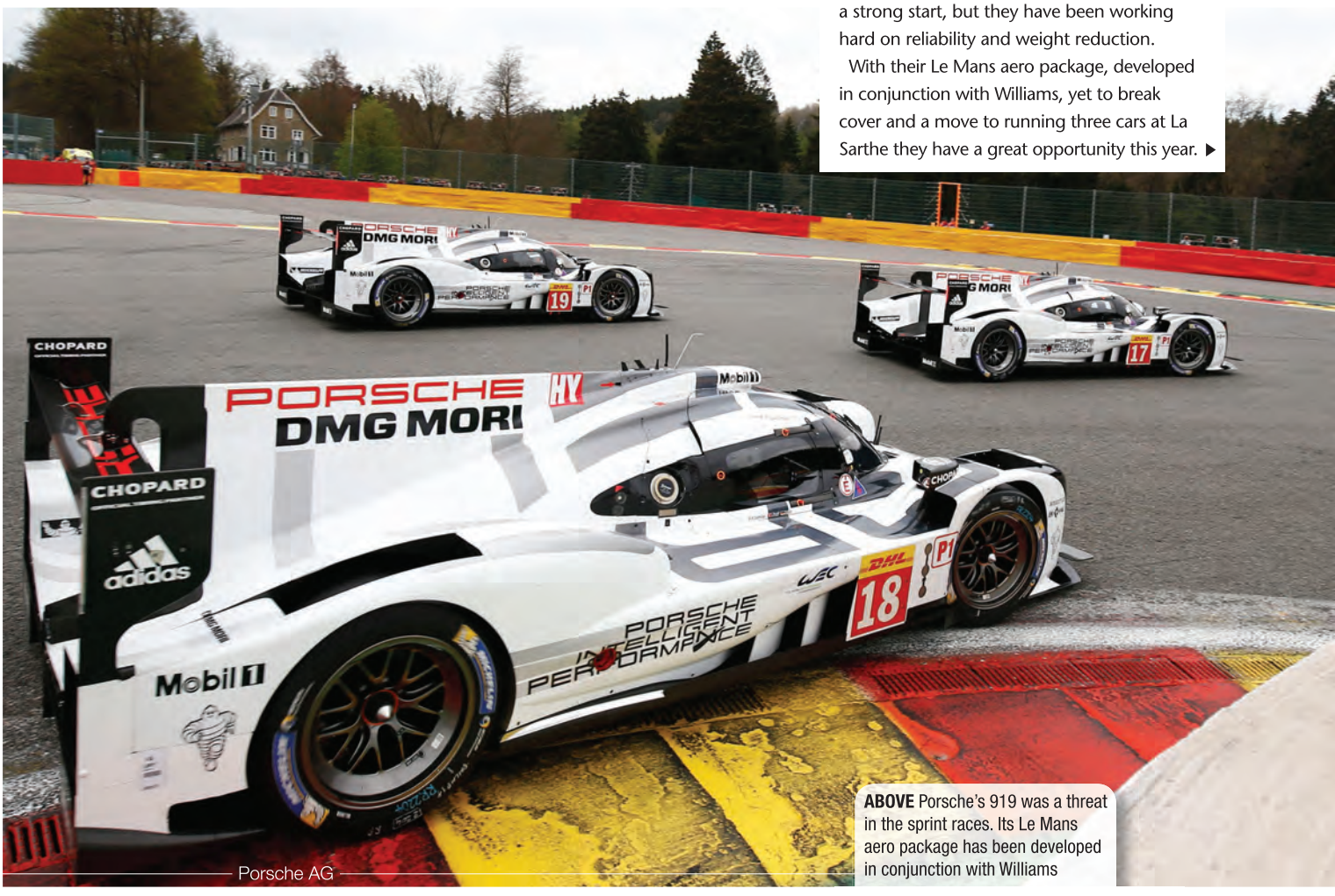
Oh, and they also seem to be kind to their tyres, allowing strategic double-stinting as and when required. This has already proved crucial in the build-up events and is an important weapon to have in the armoury for the 24-hour race.

PORSCHE

Winning in its first season back in endurance racing, Porsche's new team, its car, and the interesting dynamics compared to its brother team Audi, provided one of the talking points of last year's WEC. Pace, particularly in qualifying, continues to be strong, but tyre usage and reliability issues are the areas that the team need to put in place to really challenge this June.

With the car expected to run with 8 MJ energy recovery, its speed and power through the speed traps has already impressed. I felt when it was launched that this season's challenger looked too 'evolutionary' after such a strong start, but they have been working hard on reliability and weight reduction.

With their Le Mans aero package, developed in conjunction with Williams, yet to break cover and a move to running three cars at La Sarthe they have a great opportunity this year. ▶



Porsche AG

ABOVE Porsche's 919 was a threat in the sprint races. Its Le Mans aero package has been developed in conjunction with Williams

TOYOTA

After such a strong championship-winning 2014, they must be kicking themselves that they did not turn that pace into a Le Mans win. It was bad luck (flash weather incident) and reliability, not performance, that hampered their attempt.

Still only campaigning with two cars, a decision that may be budget-related, this does not help you against the laws of probability in the 24 Hours. The worry this year, though, is now of lap time; it feels like they may have been left behind in the accelerating development race.

The data and also the downbeat comments from the team post-Spa, where they were three laps down and 1.6s slower than the Audi in the race, suggest as much. The Le Mans package has run already at Paul Ricard, but it will only make its race debut at Le Mans.

BELOW Running only two cars could hurt Toyota

TMG

NISSAN

The extremely radical car reviewed and featured comprehensively in our April issue has yet to appear in competition, the team choosing not to participate in the first two rounds 'to concentrate on Le Mans'. This can be interpreted a number of ways, but there are reports of both reliability and competitiveness difficulties.

I think this means that, despite the immense interest and discussion the concept has provoked, the targets for its debut will only be to run as long and as respectably as it possibly can. The technical potential of the layout, given more time, we will have to wait and see.

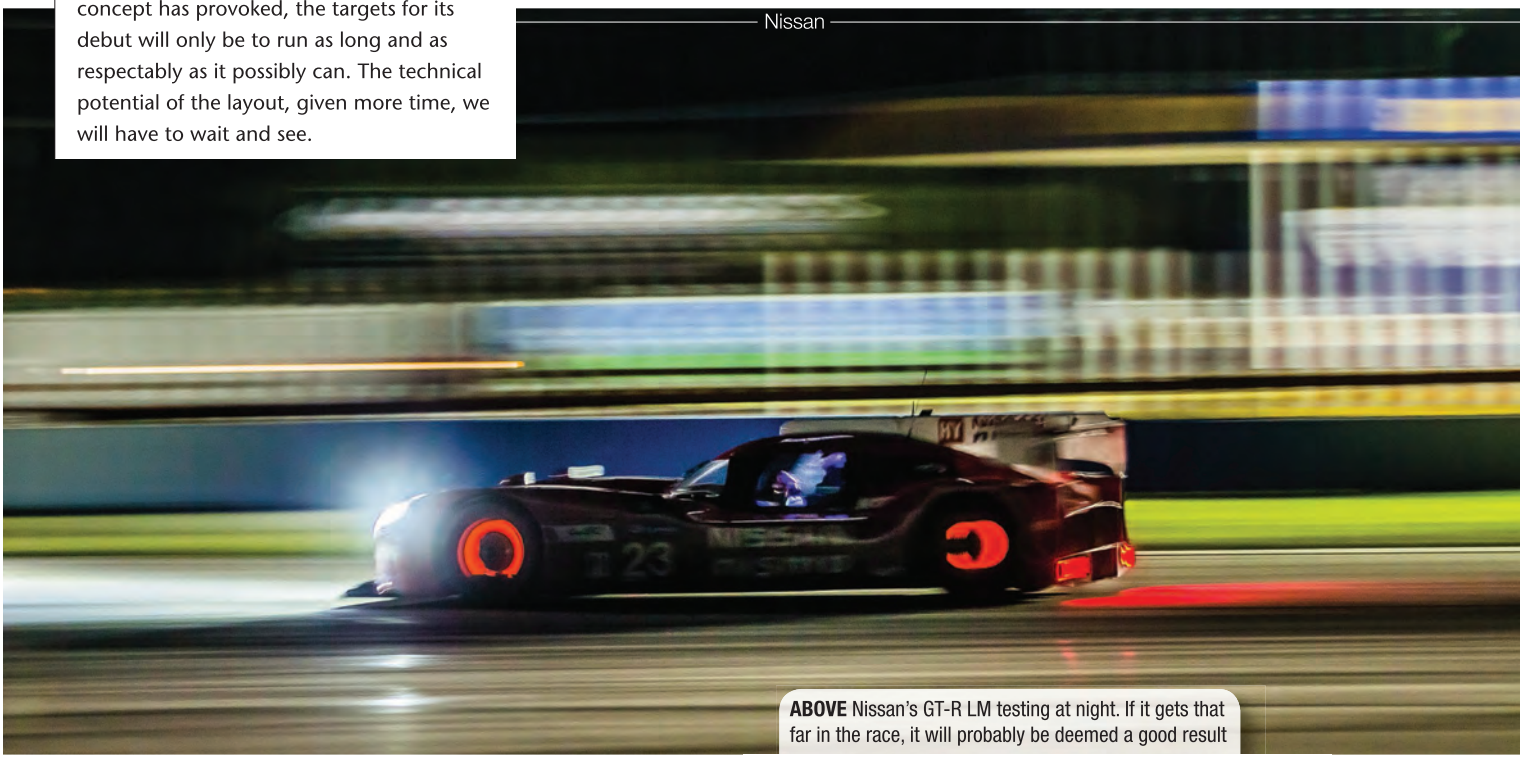
VERDICT

It is looking like a two-horse or manufacturer race between Audi and Porsche. The former has only been beaten twice in the last 15 years and one of those defeats was to a Bentley brand featuring its support; the latter last won back in 1998 with the GT1.

My head tells me it must be Audi. But my heart and the ramping of effort, the still unknowns of the Le Mans package and the unpredictability of the event, says it just might be Porsche.

Finally, the only guaranteed non-winner this year, after winning the race a record nine times, six consecutively, in 18 attempts, for both of these manufacturers is the great Dane Tom Kristensen, having retired at the end of 2014. Respect.

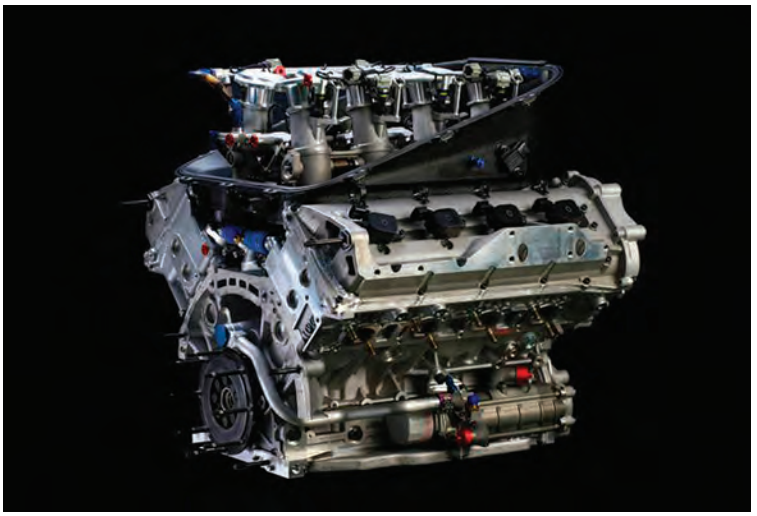
Nissan



ABOVE Nissan's GT-R LM testing at night. If it gets that far in the race, it will probably be deemed a good result

UPROAR BEFORE THE 24

The proposed switch to a single engine supplier has sparked controversy in the LMP2 ranks. **Chris Pickering** consults an all-star panel for their views ahead of the ACO's key announcement at the Le Mans 24 Hours



ABOVE Gibson Technology, which developed the successful Nissan VK45DE LMP2 engine, is one of the companies contemplating whether to throw its hat into the ring for the new engine contract

SPORTSCAR racing is facing a brave new world. Sweeping changes to the LMP2 technical regulations look set to substantially remodel the category – at least in the World Endurance Championship (WEC) – while over in the States P2 has found itself in an uneasy marriage to the Daytona Prototype class.

Ironically, things on this side of the Atlantic are looking pretty rosy. The LMP2 grid substantially outnumbers LMP1, with no less than 19 cars expected at Le Mans this year and entry lists in double figures for both the WEC and the European Le Mans Series (ELMS). If you count GTE Am and GTE Pro as two separate categories that leaves LMP2 as the single biggest class on the grid, and often the most hotly contested.

Some would argue that LMP2 doesn't need rescuing. In particular, the decision to appoint a single engine supplier from 2017 has raised more than a few eyebrows in the paddock as well as attracting some slightly quizzical expressions from the fans.

So why do it? The answer, according to the ACO, is cost. Despite placing a cost cap of €80,350 on the engine (and limiting rebuild costs to €37,500), the overall price of running in LMP2 appears to be going up and the organisers are understandably keen to nip this in the bud.

ACO president Pierre Fillon has set out a target of reducing the cost by 20 per cent. "We must remember that LMP2 is for teams and drivers," he commented earlier this year. "It is not a manufacturer category (outside of North America), and we must build a sustainable business model for the teams, cars and engine manufacturers."

Details of the new spec engine have yet to be confirmed, but it's likely to be a naturally aspirated 90-degree V8 of at least four litres in capacity, with the exhausts down the outside and the intake in the centre of the vee. Direct injection is thought to be a requirement and there are understood to be some pretty stringent guidelines on the size and weight of the major components, including a maximum all up weight of 140 kg. Target power appears to be around 550 bhp, while cost obviously needs to go down and rebuild life needs to go up.

Overall, the response has been positive from the engine builders, but not everyone is happy and there are some details that nobody seems to agree on.

To get a better idea of the situation, we spoke to three of the key players to find out what they thought of the new regulations and what features they'd like to see on the new LMP2 engine.

KEY PLAYERS

Our panel is something of an all-star cast. Between them, John Judd, managing director of Engine Developments, Steve Eriksen, chief operating officer at Honda Performance Development, and John Manchester, operations director of Gibson Technology, represent every engine supplier on the current LMP2 grid.

Perhaps surprisingly, given one of them could well end up as the designated supplier, all three agree they would rather see open competition in LMP2.

"I think having different engines and chassis types competing against each other is part of what makes P2 so attractive and interesting," comments Manchester. "Nothing stays the same for ever, but P2 is thriving currently, it's the best it's ever been and I think you need to be careful not to break something when it's working well. Any decisions will have to be made very carefully to avoid damaging P2 when it's so strong."

Judd concurs: "I think the overall idea is pretty good, but I would prefer it, from a sporting point of view, if it was not one-make. Even if we were to get the contract... it's more fun with someone to compete against."

Over in the States the situation is slightly different. As it stands right now, it looks like LMP2 and Daytona Prototype will merge into one formula with open competition between multiple engine manufacturers in the TUDOR United SportsCar series. It's thought these cars would still be allowed to run at Le Mans under a performance balancing system, while the WEC cars would be eligible to compete Stateside with the new spec engine.

It's worth noting that LMP2 (or whatever prototype class replaces it) would still represent the top tier of sportscar racing in the TUDOR Series. With no LMP1 class above, it's likely to be the category of choice for North American manufacturers, with Ford and Chevrolet both rumoured to be keeping a close eye on the situation. In a somewhat ▶

convoluted way this does tie in with the ACO's philosophy of allowing manufacturer involvement in the top category, but it still creates a divide within LMP2.

Returning to WEC, I put the same question to Eriksen: Is a single engine supplier a good idea? "It isn't for us, to be frank," he replies. "Honda is the largest producer of internal combustion engines in the world, and having someone else's engine with our name on it just doesn't make any sense to me. I understand the logic behind a low-cost spec engine, but it's not something that we – as a manufacturer – would find valuable."

PRODUCTION OR PROTOTYPE?

The ACO is understood to have specified that the new engine must be a purpose-built race unit, rather than a production-based design like those currently in use. Again, most of our panel were in favour of this idea, but it still proved to be one of the more contentious topics.

"The power target of the new rules appears to be about 20 per cent more than at the moment and I wouldn't say our current BMW-based engine has the potential to deliver that," admits Judd. "The base engine was made for a road car and there's no real reason it should be suitable for racing. What you end up doing is trawling through production engines trying to find one that presents the least disadvantage.

> *"We found the whole idea that production-based engines are expensive to be completely false"*

"Having to use someone else's base engine only puts the cost up. Taking the BMW-based engine as an example, we pay £2,200 for a machined cylinder head instead of buying a bespoke casting for £400. And we then have to go off and modify as we would with a casting anyway. Similarly, the blocks are £4,500 and then we have to go and modify those."

Extracting the right level of durability from a production engine isn't always easy, he explains: "Initially [with the current engine] we had a problem with cracking on the cylinder heads. But the same thing must have happened on the road cars, because we later found that BMW had changed the production castings, which solved the problem for us too. With higher cylinder pressures and largely full throttle running it's much harder to make things like the head gaskets, head bolts and block faces work."

Manchester also supports the idea of using a purpose-built race engine, pointing out it can take a large amount of money to convert a road car unit. But not everyone is convinced.

"We participated in the original discussions for production-based engines in P2 and there was definitely a mindset that it would be more expensive to modify a production engine than to just start with a clean sheet," says Eriksen. "We hadn't done a production-based engine at this sort of level so we were a bit naive and we just said, 'Let's give it a try'."

The resulting engine contains no less than 420 components that are taken straight from the production line and it has certainly left the HPD boss a convert: "We found the whole idea that production-based engines are expensive to be completely false. If you look at the 3.4-litre V8 that we raced in P2, and ultimately in P1, that was a clean sheet design with bespoke castings and it ▶

Ebrey/LAT

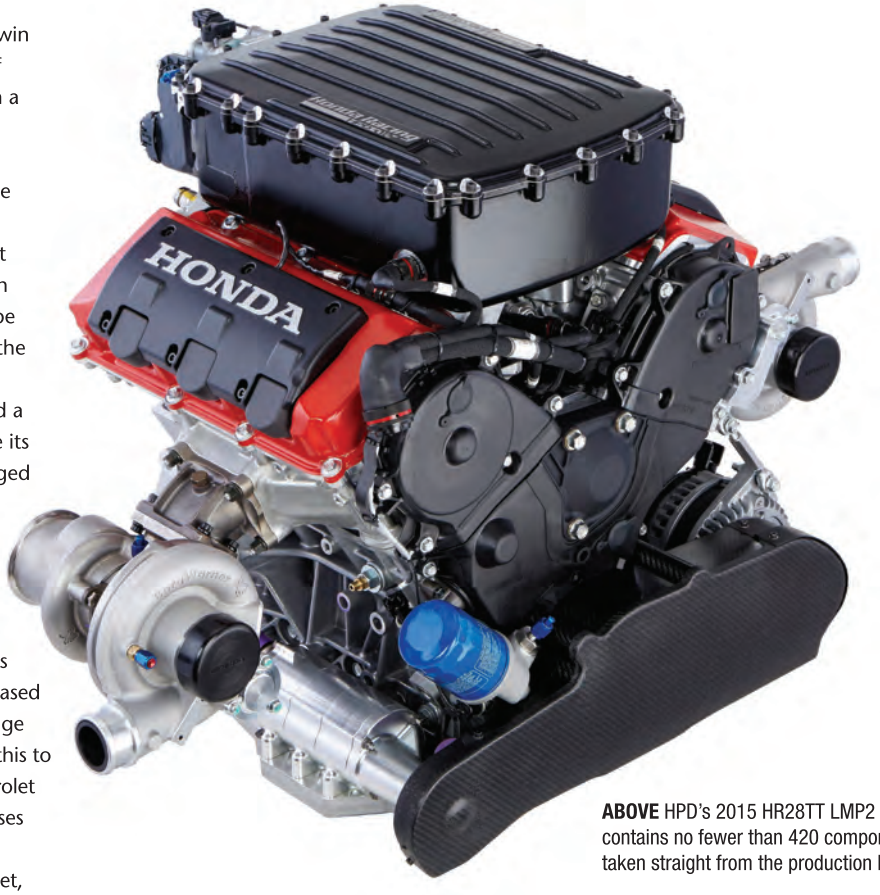
BELOW The timing of the decision came as a surprise given the success of LMP2 in Europe

was five times the cost of the 2.8-litre twin turbo engine we now produce. Hats off to anybody who can go out and design a bespoke engine and beat that price."

Admittedly, HPD has access to the knowledge and experience of one of the world's largest car companies, not to mention a healthy development budget of its own. Another possible explanation for this difference in philosophy could be the use of turbocharging. At 2.8 litres, the current HPD V6 is still a relatively large engine yet it has two turbochargers and a generous intake restrictor area, to make its power. More fundamentally, turbocharged engines tend to rev somewhat lower than their naturally aspirated equivalents, potentially making it easier to achieve the required durability with stock components.

The current LMP2 cars are by no means the only prototypes to use production-based engines. The Le Mans Prototype Challenge (LMPC) class in the TUDOR series takes this to extremes with a virtually standard Chevrolet LS3 engine, while the new LMP3 class uses a Nissan V8. Both produce around 430 bhp – some way short of the ACO's target, admittedly – but they dramatically undercut the cost of an LMP2 engine.

"Honestly, if cost reduction is the main target I would just go out and pick the LMPC engine and be done with it," comments Eriksen. "We understand that engine costs around $15,000 – when they reach the end of their service life the teams can transfer the bits over and throw the old engine away."



ABOVE HPD's 2015 HR28TT LMP2 engine contains no fewer than 420 components taken straight from the production line

THE DIRECT APPROACH

When it comes to road relevance, few technologies in racing have the same significance as direct injection. Once considered exotic, it is fast becoming a prerequisite for fuel consumption and emissions reductions in the road car market.

"I think direct injection is probably a red line as far as the FIA is concerned," remarks Judd. Like the other engineers in our discussion, he expects it to be a mandatory requirement on the new engine, whoever wins the tender.

From a marketing perspective it's easy to see why direct injection would be a good move. On a racetrack, however, the engineering argument is far less clear cut.

Direct injection really comes into its own on engines that spend a large proportion of their time on light throttle openings. Here the extra flexibility and precision afforded by direct injection allows you to inject during the compression stroke to achieve an ultra lean burn, resulting in very low fuel consumptions and CO_2 emissions. In a racing duty cycle, however, the amount of time you can capitalise on this effect is greatly reduced. Furthermore, the benefits of direct injection really come into their own on a turbocharged engine, and the new LMP2 engine is expected to be naturally aspirated.

> *"I think direct injection is probably a red line as far as the FIA is concerned"*

"I'd question the need for direct injection," says Manchester. "It's not going to offer any real performance gain and very little in the way of fuel consumption gain for a race engine. Its benefits are mostly for road cars operating on light throttle openings giving improvements in fuel economy. In a racing engine it would add additional cost and complexity."

One of the engineers we spoke to estimated the cost of developing a bespoke direct engine system at £10,000 per engine – around a fifth of the total cost. Even Eriksen, whose twin turbocharged V6 uses a stock direct injection system, believes creating one for a bespoke race engine would be an uphill struggle. "You're talking about a very expensive proposition unless you can use completely stock components from a stock engine," he says. "The only cost-effective way I could think of would be to pick a stock direct injection system and design the whole engine around it."

The incremental gains offered by direct injection would be easier to justify if there was a competitive advantage to be had, but the whole point of a spec engine is to rule out such distractions. That said, it's worth bearing in mind that Toyota claimed the WEC crown with a naturally aspirated port injection engine last year and team president Yoshiaki Kinoshita has gone on record to say this presents no disadvantage. Whatever the reason, it seems like a costly concession to road relevance in a formula that will probably (and quite wisely) use a large capacity naturally aspirated base engine. ▶

Initial rumours suggested the FIA and the ACO were pushing to see the new V8 based around the four-cylinder Global Race Engine (GRE) architecture used (in naturally aspirated form) in Formula 3. If true, this could explain the apparent insistence on direct injection. It's also interesting to note that the Volkswagen Audi Group – a real endurance racing powerhouse these days and originator of the GRE concept – was conspicuously well represented at the joint FIA, ACO and IMSA meeting at Daytona in January, where the new regulations were first discussed. One of our panel also highlighted the fact that the proposed dimensions for the engine are quite tightly defined for a one-make series, suggesting the governing bodies already have a very clear idea of what they want.

NEW FROM OLD

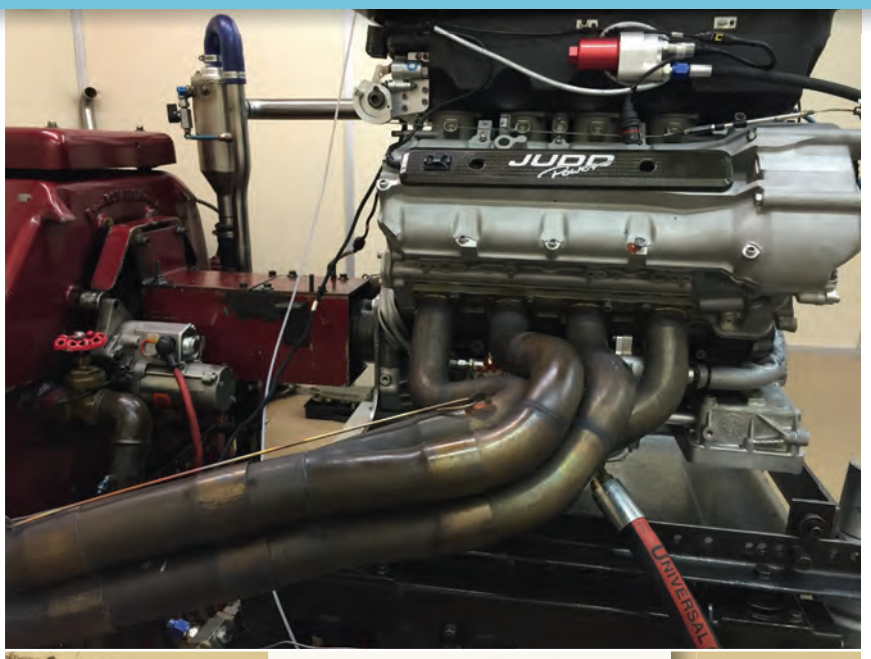
At least one of the engineers we spoke to was of the opinion that grafting two four-cylinders together could prove to be a deceptively expensive way to create a V8. However it's done, the consensus amongst our panel is that the new engine is highly likely to be a derivative of an existing design.

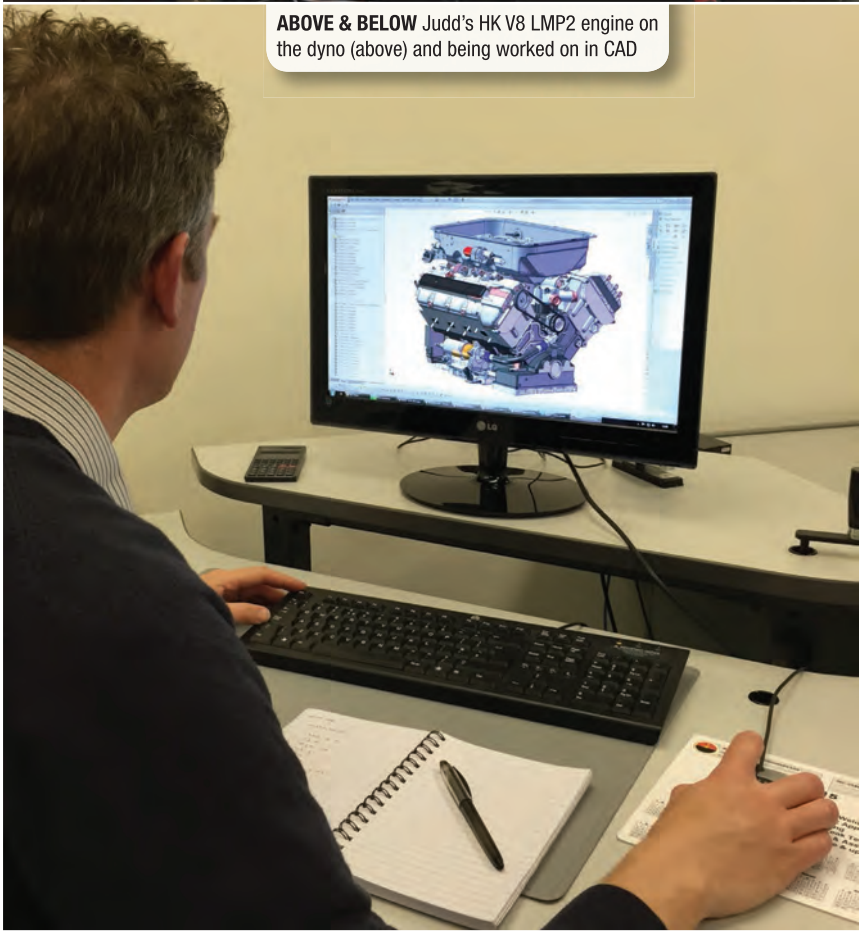
"It costs millions of pounds to start from scratch to design a new race engine. Unless it is funded by an automotive manufacturer, the most cost-effective way to make it a viable proposition economically would be to base it on an existing race engine design... I'd be quite surprised if people will not be doing that," comments Manchester.

Eriksen is firmly in agreement: "There's no way [a clean sheet design built to the current cost cap] could be profitable. At least not in my experience. It's a challenge even with a production-based engine."

Of course, it all depends on what you define as a clean sheet design. It's often said you can't 'unlearn' what you've done in the past and arguably most engines are in some way a derivative of something else.

"We've got V10s that started off as V8s and V8s that were V10s and all sorts of things," comments Judd. "You tend to stick with what works, as a result of many years of blood, sweat and tears. As a result, you end up with a common architecture. On our engines, for example, we've always used a gear-driven cam drive at the back of the engine; having done that for many years we wouldn't stick it on the front just to be different."





ABOVE & BELOW Judd's HK V8 LMP2 engine on the dyno (above) and being worked on in CAD

COUNTDOWN

It seems the basic outline for the new engines has been well received, even if those on our panel are lamenting the lack of competition and questioning the need for direct injection. Of course, the current proposals are nothing more than that; we will have to wait for the press conference at Le Mans to find out what exactly the ACO has in mind.

Whoever gets the job, they will have to be ready to supply engines and support for 20+ cars in time for 2017. Reliability counts above all else in one-make competitions and thousands of kilometres of durability testing will need to be undertaken.

If the single-make engine proves a success it will cement the category's status as a force to be reckoned with in endurance racing. But the popularity of the current format could prove a hard act to follow.

CREATING THE FRONT GARDEN

From the home of motor racing to largest science park in the realm, Silverstone is undergoing a massive expansion. **William Kimberley** talks to developer MEPC's CEO James Dipple and the person he has appointed to lead the transition, Silverstone Park commercial director Roz Bird

TO VERY many people Silverstone means but two things: motor racing and getting windswept. However, if MEPC is successful in its mission, this image will be supplanted by a global business destination for the high performance technology and motorsport (HPT&M) industries while still adhering to its motorsport legacy.

Silverstone is still privately run. It is owned by the highly respected British Racing Drivers Club which can claim some of the most distinguished racing drivers, both retired and still active, among its 850 members.

In the modern era of hosting a grand prix, which costs millions, the BRDC has done an incredible job of retaining the British Grand Prix unlike its counterparts in France, Germany (at the time of writing), San Marino and so on. However, the cost is high, amounting to around £15m a year, especially with Formula One Management taking TV, advertising and corporate money, meaning that ticket sales are virtually the circuit's only money-making opportunity during Formula 1 grand prix weekends.

All this was taking a toll on the club so it was not that surprising when it announced in September 2013 that it was selling a 999-year lease on 131 acres of development land around the circuit for £32m – to MEPC, a company that has expertise and a proven track record in successfully developing large business estates. This included the existing Silverstone industrial estate and the development land around the outside of the circuit (collectively known and heavily re-branded by MEPC as Silverstone Park), but not the management or development of the circuit itself. A further carrot for the buyer was that the land being leased had been granted planning permission (2.7m sq ft to be precise).

At the time of the transaction, MEPC CEO James Dipple spoke about developing the site into one that capitalised on its location and legacy: "As a long-term investor we are delighted to have secured this opportunity to create a large, commanding commercial estate with a key technology driver which will benefit hugely from its location, infrastructure and association with the home of world motor racing at Silverstone."

VALUABLE BRAND

Dipple brings us up to speed. "We took on the lease because we knew Silverstone was a valuable brand and is in the heart of the country," he says. "It has development plans and planning consent already in place, and it's all about high performance technology and motorsport so for us, who are experts in developing business parks, it was a natural fit.

"The planning consent enables us to deliver buildings to companies who want their own bespoke buildings as well as build speculatively and also enables us to attract companies who will benefit from being close to Silverstone Circuit and part of an HPT&M cluster."

The person he has tasked with pushing this vision through is Roz Bird, who has already won her spurs for MEPC at its Granta Park site in Cambridgeshire where she was instrumental in creating a special science community as the estate director. It was then sold to BioMed Realty Trust Inc in June 2012 for a handsome amount.

She then became head of business development, working across the MEPC portfolio formulating and implementing its good practice in business park management. Following the BRDC deal she became commercial director of Silverstone Park with the task of developing the 2.7m sq ft of planning consent over the coming years to create a world-renowned HPT&M centre.

"My first mission was to meet all the existing companies and ask why they were here, what they liked about the place and what would they change if they could," she explains.

"It's a given that MEPC can build buildings that will stand the test of time so beyond that we consider what else we can do that will attract businesses to Silverstone rather than to another industrial estate down the road. It is all about the customer experience, enabling them to impress their clients and motivate staff. We know they want to attract the best skills and work with like-minded companies so we have developed a social committee and business networking events which further help and encourage them to play to their advantages."

Dipple, meanwhile, was quick to spot a golden opportunity to enhance Silverstone Park's stock by adding industrial units constructed by Eddie Jordan as part of the estate. Within little time the deal was done with the ex-F1 team owner to acquire all 82,500 sq ft of them – they have since been ▶

ABOVE & BELOW MEPC's proposed development of Silverstone Park is expected to create up to 8,000 jobs

"The business epicentre for a world-leading cluster of HPT&M companies"

re-named Buckingham Road and have under MEPC's management started to fill up fast with high-end HPT&M companies.

The part of the land that MEPC manages trackside (ie right next to the Silverstone GP circuit) is home to the Porsche Experience Centre. "What we did was work with Porsche so it could more or less double the size of its facility with a number of new circuit configurations," adds Dipple. "Its driver training facility is now regarded as the blueprint for other similar Porsche venues being built around the world.

"Ducati also relocated its UK HQ to Silverstone because of the profile-raising name offered by the site and it has teamed up with the California Superbike School which is also here to run events on the circuit two or three times a year."

Notably 14 more HPT&M companies – from start-ups and SMEs to larger national and even bigger international operators – have moved to Silverstone Park in just the past three months alone, with MEPC working closely with each one to deliver for them the right office and workshop space and environment.

Another recent development at Silverstone Park has been the UK Government's approval for a metrology centre. MEPC has worked in collaboration with the Northamptonshire Enterprise Partnership to secure the funds via a detailed proposal, submitted to and now agreed by the Department of Communities and Local Government. The proposal has received additional generous support from the Buckinghamshire Thames Valley and South East Midlands local enterprise partnerships.

MAJOR COUP

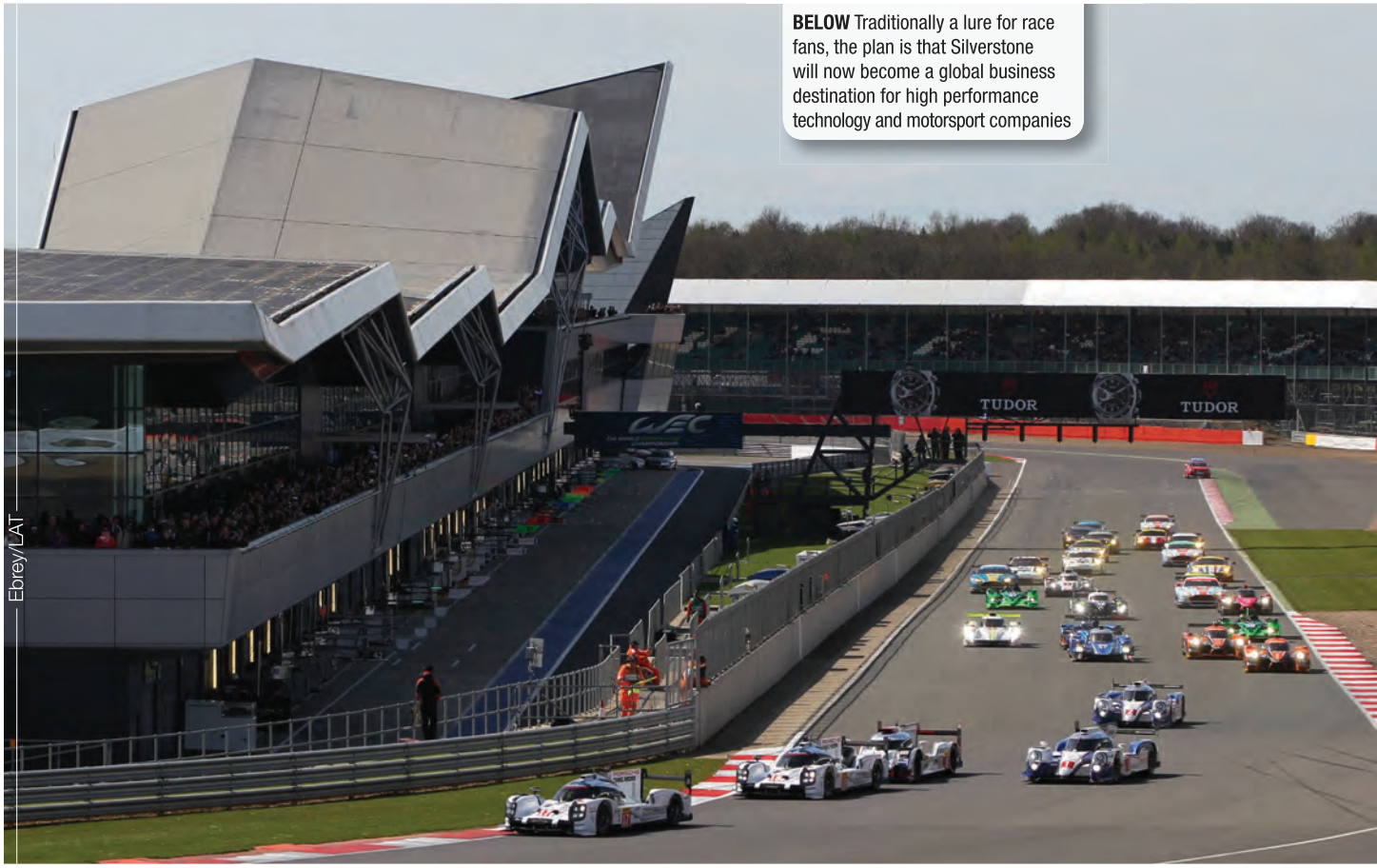
"It's a major coup and also absolutely fantastic news for those working in HPT&M who are based here and in the surrounding region as it will be accessible for all," says Bird. "MEPC knows from past experience managing Granta Park in the Cambridge biotech cluster that access to specialist facilities benefits small high-growth companies enormously, so this metrology centre will provide a valuable facility for small to medium-sized HPT&M companies. It will enable them to gain access to state-of-the-art equipment which they couldn't afford to buy. It will also enable them to develop new products and processes, retain existing customers, win new clients and create new jobs. There's no other facility like it in the area.

"It is also therefore a vital part of the skills agenda, providing young people in college with a great opportunity to learn how to use cutting edge equipment. So it will be a win-win situation for everyone in and around Silverstone Park."

When it is all built out MEPC's development of Silverstone Park is expected to create up to 8,000 jobs. Hotels, R&D facilities, offices, industrial units and automotive brand centres are all included as part of the project as the estate becomes the business epicentre for an already existing world-leading cluster of HPT&M companies.

"We want to be part of the HPT&M cluster but we want to put more definition into just what that term means for increased credibility at government level," stresses Dipple. "We want this area to be known for the skills and the business activity, innovation and entrepreneurship and not just the circuit, although that is very important.

"They run world-class events; we're making their front garden look really good. It's important that what we do is recognised by the government because it gives confidence to investors and venture capitalists." RT



Ebrey/LAT

BELOW Traditionally a lure for race fans, the plan is that Silverstone will now become a global business destination for high performance technology and motorsport companies

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New light on an old problem

Chris Pickering reports that it's no longer quite so lonely being a long-distance runner: plenty of companies have invested time, money and expertise to make endurance racing easier

FCA US LLC

ENDURANCE racing is the ultimate challenge in motorsport: man and machine flat-out for 24 hours, racing through the darkness. LMP1 teams cover the distance of an entire Formula 1 season in a single visit to Le Mans, putting their equipment through an incredible amount of wear and tear.

Virtually every aspect of the car and the team can be optimised for the demands of endurance racing. From lighting to fuel systems, this unique branch of motorsport has spawned a plethora of ingenious adaptations. Ahead of the Le Mans 24 Hours we take a look at some of the best and the brightest.

MELECTRONICS

One of the key differences between endurance racing and sprint events – certainly where 24-hour races are concerned – is darkness. Anyone who's ever been out to the Mulsanne Straight at night will know just how dark it gets away from the floodlights.

While Audi may have stolen the headlines with its laser-powered high beam units, LED lights are proving to be a far more widespread innovation. Teams in both the GT and prototype categories are adopting this technology as an alternative to High Intensity Discharge (HID) units for headlights, taillights and apex lighting.

"The drivers are continuously after brighter and brighter lights and the engineers are always looking to improve efficiency," explains Steve Mellish, managing director of Melectronics Systems, which manufactures a range of LED lighting systems for motorsport. "The HID units that have traditionally been used in motorsport consume a lot of power and they tend to result in a single fixed beam without much adjustability."

Some teams have elected to do away with the HIDs altogether, while others use the LED lights to supplement them, lighting individual areas of the track that wouldn't otherwise be covered by the single beam.

"As an overall package, LED lights are a lot more space efficient, because the individual units are significantly smaller and they are self-contained with no ballast boxes to mount externally," notes Mellish. "They tend to be somewhat lighter overall too, but the biggest benefit comes in terms of power usage. Our flagship Miniature High Beam consumes about 13W; you'd probably want to pair them up [circa 26W] to achieve the same light as a typical 50 or 60W HID unit, so it draws around half the power like-for-like."

> *"This unique branch of motorsport has spawned a plethora of ingenious adaptations"*

Melectronics' lighting options can be mounted as a direct replacement for HID

ABOVE & LEFT Melectronics Systems manufactures a range of LED lighting systems. Customers include the SRT GT Vipers

or halogen lights, with no modifications to the loom. Supplied in 'native white' the temperature of the light is similar to that of HIDs, while the LEDs can also be supplied in 'native yellow', which some teams prefer for use in fog and wet weather.

The only potential drawback with LED lights is their heat production. Thermal management is one of the areas where lighting manufacturers like Melectronics really earn their keep, and all products are internally managed to prevent failure if they do get too hot. The company is even toying with the idea of a CAN interface for future models, which would add a diagnostic capability.

ATL

Fuel management is critical in endurance racing. And that means that fuel tank design is even more important than it is in a sprint competition.

Aside from the obvious difference in capacity – a GTE car's tank carries around twice as much fuel as that found in a World Touring Car – there are a whole host of detail changes. A lot of sprint racing cars, for example, don't bother with a fuel level gauge – in some instances they don't even have a low fuel warning light – while refuelling often isn't a factor in short-distance racing.

There's something of an art to ensuring the fuel goes into the tank as rapidly as possible during refuelling. Similarly, the designers strive to ensure that as much as possible can be picked up by the pumps, eliminating the 'dead weight' that arises from unused fuel trapped in the darker recesses of the tank.

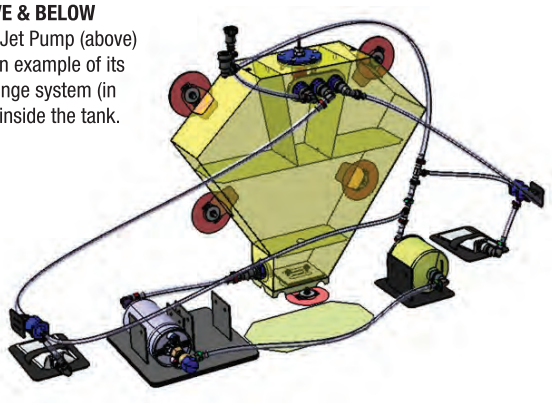
"We have a few little tricks up our sleeves to speed up refuelling," comments ATL's James Gornall. "For endurance racing it's also not unknown for people to build in redundancy: one team we dealt with not only had spare fuel pumps built into the tank, but spares for the spares!"

One of ATL's trademark designs is its 'Last Lap Tank' design. Here the collector volume is large enough to sustain the car for an entire lap. This means at somewhere like Le Mans the drivers know they will be able to get back to the pits once the fuel light comes on.

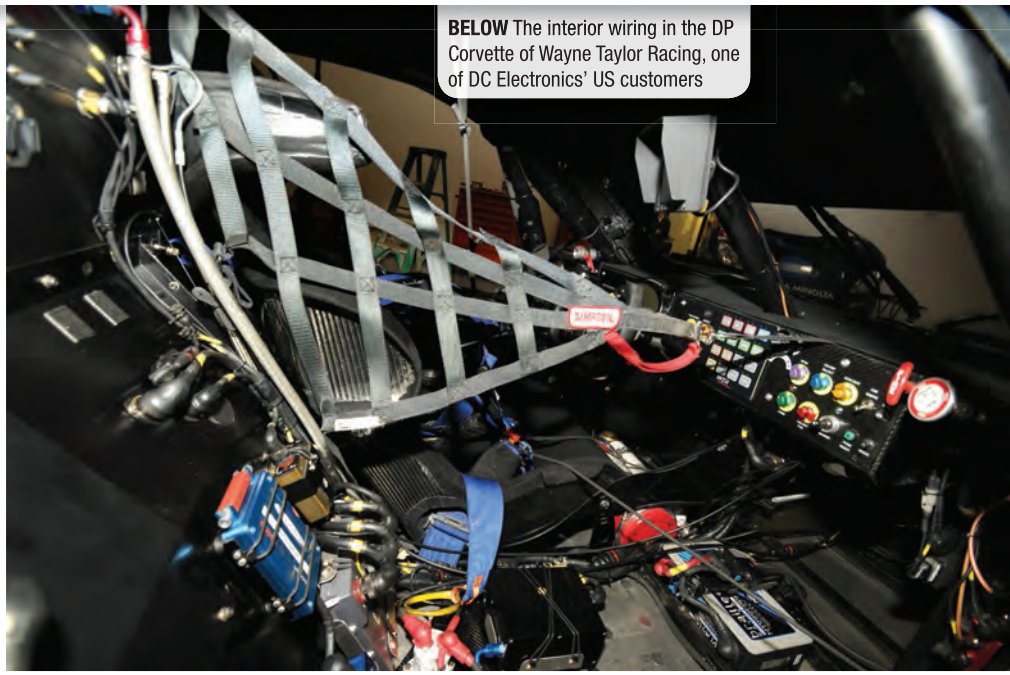
"You've got a lap once the light comes on, so as long as you don't pass the pits with the light on you know you won't run out of fuel," comments Gornall. "The same principle is used in sprint tanks – we have a series of veins, baffles and trapdoors to channel the fuel into the collector. We also incorporate lift pumps to feed the collector, from where it is picked up by the main fuel system."

Traditionally these lift pumps have been electrically driven. The mainstream automotive industry sometimes uses venturi pumps, which rely on suction from the main fuel line to draw fuel up from the tank, but these operate at low pressures, not normally suitable for motorsport. ATL, however, has taken this principle and used it to develop a high-performance variant that it calls the Jet Pump. Relying purely on the suction from the high-pressure pump, this eliminates the moving parts normally found in a lift pump, along with the associated current draw and much of the weight.

"The Jet Pump represents the ultimate in reliability," comments Gornall. "It's a direct replacement for a regular lift pump that's been in use for a little while now. There are three connections – two inlets and one outlet; you take a feed from beyond the high-pressure pump and scavenge a little bit of that feed to draw fuel from the tank, like a lift pump, pushing it into the collector. It uses what would otherwise be wasted flow to scavenge up to 300 litres per hour. The concept was fitted to the Le Mans GTE-winning Ferrari last year and we have cars running on Jet Pumps alone with no conventional scavenge pumps." ▶



ABOVE & BELOW ATL's Jet Pump (above) and an example of its scavenge system (in blue) inside the tank.



BELOW The interior wiring in the DP Corvette of Wayne Taylor Racing, one of DC Electronics' US customers

DC ELECTRONICS

Some degree of redundancy is a common feature on endurance racing products, and no more so than in electronics. Just like the aviation business, where it's routine practice to duplicate or even triplicate electronic systems to prevent total failures. It can be simple things like separating the wiring loom for the headlamps into a left hand side and a right hand side, so the car can still get back to the pits if one side shorts out following an accident.

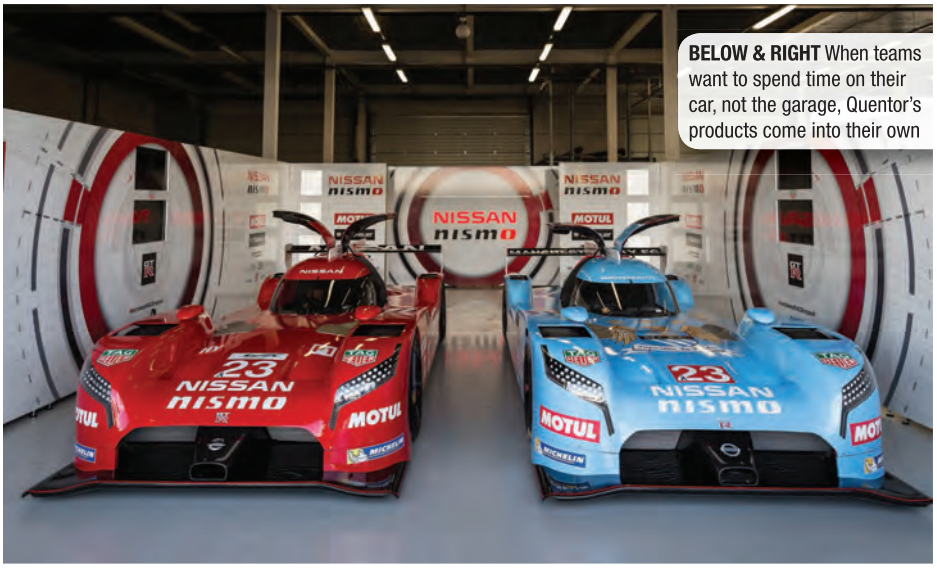
Most modern endurance racing cars also use power distribution modules in place of traditional relays and fuses. In contrast, some sprint racing cars have no circuit protection whatsoever, because the teams deem the risk to be preferable to the weight of a power distribution system.

"In sprint racing light weight is the key," explains David Cunliffe, managing director of DC Electronics. "Clearly that's still very important in endurance racing, but there the overriding factor is reliability. The materials tend to be slightly beefier to give the mechanical strength. A sensor wire for an F1 loom, for example, might be 30 swg, while the equivalent item in LMP1 might be 24 swg. It even applies to the heat shrink – you might use a thicker material on an endurance loom to protect against abrasion. It doesn't sound a lot, but when you carry it through the entire loom it can save a reasonable amount of weight."

Connectors are another important factor. "The top end teams are using things like the Deutsch Autosport connectors and cable sizes have tended to come down. They tend to be quite expensive compared to an OEM-style connector, but the reliability is much better," he says.

"High-quality motorsport connectors are designed to withstand a high number of mating cycles, but OEM parts are often really only designed to go together once on a production line. If you start pulling them apart regularly the contacts can open up and potentially introduce an intermittent fault. It's something that often gets overlooked in production-based categories like GT racing, where teams can be tempted to use more affordable OEM sensors or connectors."

DC Electronics is currently working with a number of endurance racing teams and manufacturers from its UK and US offices. In North America, the team supplies Wayne Taylor Racing's Corvette Daytona Prototypes and the Riley Technologies Vipers. European customers include Ginetta, which is planning to build no less than 20 LMP3 cars with the company's looms.

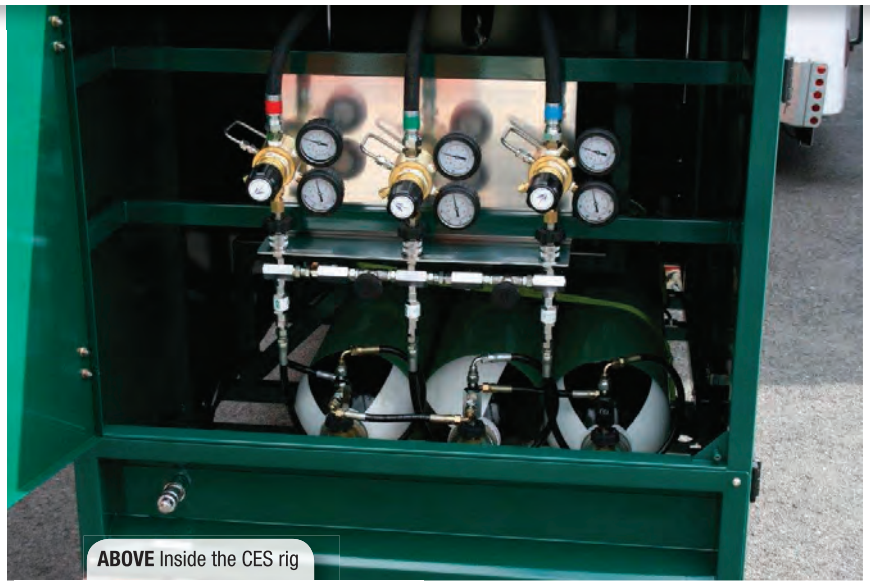


BELOW & RIGHT When teams want to spend time on their car, not the garage, Quentor's products come into their own

QUENTOR

Sometimes you could be forgiven for thinking a team at an endurance event had taken up permanent residence in their pit garage. The draughty old shell of the garage gives way to an immaculate temporary structure, so smart it could double as part of the corporate headquarters. Anyone who's visited one of the major factory teams at Le Mans will be familiar with the sensation.

The job of creating these mobile masterpieces falls to companies like ▶



ABOVE Inside the CES rig

Quentor. The Norwich-based family firm now works with a number of top teams, including Aston Martin Racing, Toyota and the new Nissan LMP1 squad.

"The teams can't afford to waste space or carry extra weight, so we specialise in packing things down to the absolute millimetre," explains Quentor managing director Kate Asbury. "For example, our garage walling uses single-piece boards designed to slot into a custom-designed case."

Quick deployment is vital, with teams keen to spend time preparing the car, not the garage, when they reach the circuit. Quentor says its Fast-Track system dramatically reduces assembly times compared to traditional frame walling.

The walling panels are manufactured from lightweight aluminium honeycomb and are linked with hidden quarter-turn latches, with no need for the vertical struts. This means large logos and graphics can be printed right across the surface with no interruptions. Using a modular principle the same system can be applied to whole rooms, featuring shelves, workbenches, cupboards and sliding doors. The range even includes tool cabinets with in-built wheel gun systems.

The walling panels can be secured directly to the garage wall, and without any external framework there is the potential to open up extra space. This can add up to an appreciable increase in usable area, Asbury points out.

Pit perches are another speciality. Barring the odd loo break these stands can be home to the senior team personnel for 24 hours solid. With this in mind, Quentor can provide seats with extra padding, lighting and other little luxuries that aren't usually considered a necessity for a half-hour sprint race.

CES

There's an old adage that it's not time on the track but time (or rather lack of time) spent in the pits that wins endurance races. Over the course of a 24-hour race cars will typically visit the pits 20 to 30 times, so a few seconds gained here or there can add up to a race-winning margin.

Over the years there have been a number of different designs for the FIA-approved air and fuel rigs for endurance racing. The regulations for size, height and minimum ballast weight mean these all tend to look fairly similar; usually they are based around a 2m x 1m x 1m box.

The internal space around the fuel churn and the gas cylinders tends to be used for the storage of various ancillaries such as wheel guns and associated boxes, explains Tony Giles of CES: "The teams are paying for volumetric weight so the use of the internal space is critical. What they require is a solid structure, capable of withstanding the rigours of racing and designed to accept the 240 kg cylinder weight (three full-size cylinders without any extra weight in regulators etc.) without distorting any of the flush fit access doors."

CES can design the system so compressed air cylinders can be filled externally without the need for dismantling of parts and connections. The company can also provide advice and support to achieve all of these specific criteria, supplying items of equipment that are cost-effective stock products, tried and tested in endurance racing. Alternatively, the team's existing cylinders and regulators can be used.

"We always design in an easy access panel for regulator adjustment and visibility to check for damage to any of the equipment. Air couplings are fitted to match the pressure requirements of the equipment and self-venting products that connect and disconnect at zero pressure are specifically recommended," explains Giles. "We use anti-kink hose assemblies for ease of use. We can also provide high-pressure compressors in various models and sizes and will quote filling times accordingly."

LAZER LAMPS

Lazer Lamps is another major player in motorsport lighting. Earlier this year the UK-based company announced the launch of its new Triple-R range of auxiliary LED driving lights. Designed with the motorsport market in mind, they feature a number of clever touches, including patented systems for optimising light output.

The standard Triple-R model features vacuum metalised hooded reflectors that redirect and focus 100 per cent of the light emanating from each high-output LED. Like all Lazer Lamp products, the temperature of the LEDs is controlled, in part, by the company's Dynamic Drive Modulation system, which maintains the drive current at the optimal level for the environmental and thermal conditions of the lamp. There's also an aluminium heatsink, which has been ▶

ABOVE Lazer Lamps' new Triple-R range of auxiliary LED lights feature many clever touches

optimised in CAE to provide the right level of heat dissipation. An improved silicon-coated Gore-tex breather membrane and a virtually unbreakable polycarbonate lens cover help to maintain the integrity of each lamp.

The top-spec Triple-R Elite model uses uprated LEDs that are around 20 per cent more powerful than the equivalent Standard lamp, giving more light, while the (optional) addition of magnesium outer components shaves a third off the weight of the equivalent aluminium parts. A 'Charged Air Cooling System' further improves the unit's thermal management by channelling cooler ambient air inside the lamp, via the Gore-tex breather membrane, to assist cooling of the internal circuitry.

Possessing over five times the peak intensity of Lazer Lamps' ST/RS range of driving lights, but without the same spread of light, even the base model Triple-R 750 Standard delivers 1 lux (enough to read a newspaper) at over 430m. That's especially impressive when you consider the lamp weighs less than 800g. Move up to the Triple-R 1000 Elite and 1 lux extends a full 665m, while the 0.25 lux line reaches out well over a kilometre!

"We've taken the time to listen to valuable feedback from many of the world's most high profile track and rally motorsport teams, and developed a range of ultra long-range driving lights which we can be very proud of," comments Lazer Lamps managing director, Ben Russell-Smith. "Tested earlier in the year, the outstanding performance of the Triple-R range was proven at the legendary Arctic Lapland Rally, helping guide seven-times Finnish Rally Champion, Juha Salo, to first place."

The lights are tested to IP67 specification and covered by a three-year warranty. As with all Lazer Lamps light units, the Triple-R range comes supplied with a centre mounting bracket, with additional mounting options and wiring kits available.

XTRAC

It's easy to forget just how far endurance racing has progressed. Go back a couple of decades and the drivers, whether they admitted it or not, would often have to employ a degree of mechanical sympathy if they wanted to reach the end of the race. Back then transmission failure was one of the prime causes of 'DNFs' and it was particularly prevalent in endurance racing, but these days it really can be a sprint all the way to the chequered flag.

Ironically, as the governing bodies have pushed for longer and longer component life, the design philosophy applied to sprint racing gearboxes has become closer to that in endurance racing.

"We all think of Formula 1 as being a sprint race, but the gearboxes now have to last for six races – 3,300 km without a rebuild," comments Xtrac technical director, Adrian Moore. "Before these regulations came in we would design gears that would really be used for a single race and there was no real limit on how narrow they could be. Now you can boroscope inspect the gearbox and change the oil, but you can't get into it to change anything without a penalty.

"You could argue there's no such thing as a sprint racing gearbox any more... we follow the same design philosophy and use the same tools for endurance racing. The duty cycles are longer and the safety factors we use for things like bearing life have been developed over the years for endurance racing, but fundamentally it's the same concept."

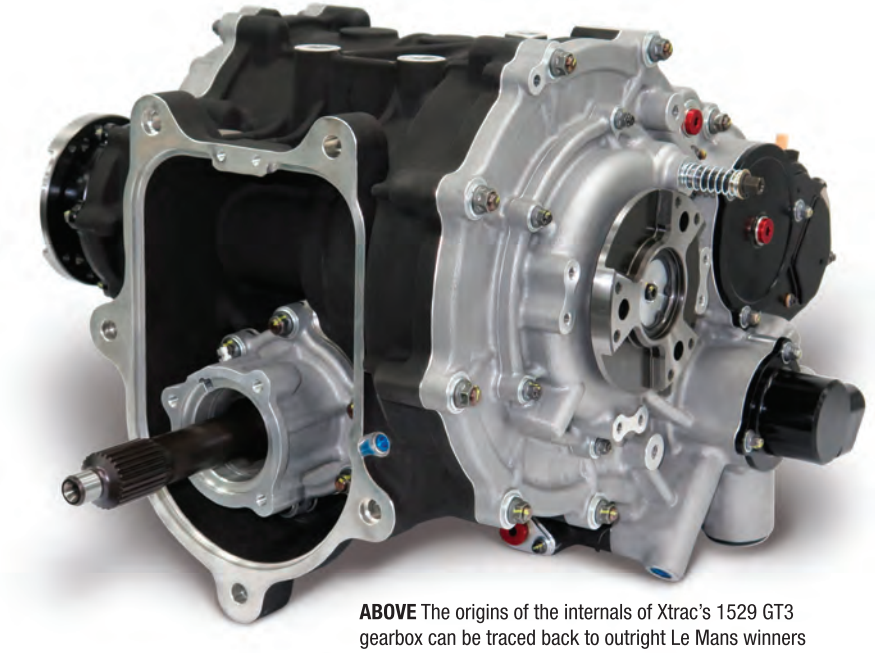
Of course, there's more to a drivetrain than simply the gearbox. Xtrac also produces differentials, both as standalone units and – in most GT and prototype applications – as part of a transaxle. Here the watchword is consistency, Moore explains: "You don't want to be chasing decaying differential performance as the mileage increases. The friction materials we use and the testing we carry out on our QTDTR rig to characterise the differential performance over its entire operating envelope are vital in ensuring consistent performance."

Material choice is also critical elsewhere in the gearbox and differential. "We have the steels specially made to our requirements by TATA Steels in the UK," he says. "We have very clean double vacuum re-melt steels that provide excellent fatigue life. All our quality is carried out in-house, so one batch is exactly the same as the next."

Xtrac's 'four-square' rig is used extensively to evaluate the fatigue properties of new materials. In each case a gear coupon – a small gear designed to fail quickly – is run to destruction on the rig in order to generate fatigue data.

A lot of the technology developed for the factory LMP1 programmes eventually finds its way down to the GT categories. The internals found in Xtrac's 1529 gearbox, launched last year for GT3 cars, can actually trace their origins to the Le Mans-winning BMWs and Bentleys from the turn of the millennium. Now produced in comparatively high numbers, it brings the entry price of this technology down to a more affordable level.

"I think people have realised that if you put a higher specification part into the cars you get better durability and the cost of operating the car goes down overall," says Moore. "The service life for these gearboxes is 10,000 km, so if you're doing sprint racing in GT3 the expectation is you could do an entire season." ▶



ABOVE The origins of the internals of Xtrac's 1529 GT3 gearbox can be traced back to outright Le Mans winners

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ABOVE Greaves Motorsport is one of the teams to employ the expertise of System Store Solutions

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The road to Le Mans is a journey formed many months before the race day preparations begin. The commitment, ambition, drive and long-term planning have to be embraced by everyone in the team.

The backbone of this is back in the workshop, where the cars live and sleep throughout the year. The pressures on teams and drivers today to continually be at the top of their game with turnaround times and preparations from one race to another are relentless.

Building a clean and efficient workshop is paramount to this process. Tool location, assembly area cleanliness and ease of access all play a part. As do the building layouts themselves; many teams now have specialised rooms for each process: machining rooms, clean rooms, engine and gearbox assembly rooms and parts and tool storage areas. Design consistency, sightlines, storage product usability and durability all play their part to give the people behind the scenes what they need to hand the cars over to the drivers for the next outing.

"Commercially, for teams wanting to pull in the top drivers and attract and excite sponsors, their workshops must reflect the calibre of work and methodology adopted by the team. The workshops are part of this presentation, not just an asset," comments David Price, managing director of storage specialists System Store Solutions, which supplies, designs and builds everything from single units to complete workshops.

As well as building custom workspaces, System Store Solutions can provide help with consultation, project management and installation. Clients include the likes of Greaves Motorsport, the Jota Group, Carlin, Strakka and the University of Bolton's Centre for Advanced Performance Engineering (CAPE), which will be running the world's first university-owned Ginetta Nissan LMP3 car in collaboration with Ginetta and RLR Msport.

PAGID

Developing brake compounds always involves a fine balance between pad life and friction. When it comes to endurance racing this only gets harder.

The pads on GT cars with cast iron discs can be made to last for the duration of a six- or 12-hour race, but when it comes to 24-hour events the expectation is still that the car will come in to change pads. Nonetheless, extending the life gives you a wider operating window, with more options for pit stop strategy. What you don't want to do is change the discs as well.

"We know in principle which screws you need to turn to modify the friction or the wear rate, but it's all about finding a compromise," comments Michael Schorn, director of engineering and product development for high performance applications and racing at bt Bremsen Technik, which produces the Pagid brand. "You need a material that works well at ▶

ABOVE Pagid's RBD disc range caters for endurance and sprint spec

high temperatures without being too abrasive and wearing the disc out rapidly."

Pagid's RSL endurance racing range has been designed to be what Schorn terms 'disc-friendly'. The RSL 1 is a comparatively high friction pad by long-distance standards, while RSL 2 concedes around 10 per cent in friction to provide a longer life. Intended for series like GT3 and GTE, they each have to be suitable for cars both with and without ABS.

"For GTE cars where you have no ABS the modulation and controllability of the brakes is more important than, say, GT3," comments Schorn. "When you have ABS you just hit the brake pedal and the electronics do the rest. Without ABS you need more predictability and progression to avoid locking the brakes. If you take Sebring as an example, it's a very bumpy surface and the GTE cars without ABS need very stable friction and very good modulation to avoid locking."

Two years ago Pagid introduced its RBD disc range in two different variants. The sprint design uses a slightly thinner friction surface with larger ventilation channels in between to try and remove every last gram. The endurance version, on the other hand, has a thicker surface with a greater heat capacity that tends to lower the peak temperatures and reduce the risk of cracking.

The downside is increased unsprung mass, but it's a price worth paying, Schorn points out: "You don't want to change a disc in the middle of a race, so you might accept 500 or 800g more mass to prevent that from happening."

ABOVE Seven Y-shaped spokes provide 14 contact points between wheel and rim, distributing loads evenly

BBS

At one time there was quite a significant difference between the wheels used for endurance racing and their sprint racing counterparts. Lately, however, the gap has narrowed, or in many instances disappeared completely. In GT3, for example, there is now a minimum wheel weight which is easily achievable with an endurance racing wheel, so the manufacturers no longer offer a more fragile lightweight variant. Another advantage of this minimum weight limit is that more flamboyant designs can be used on custom projects for individual teams or manufacturers without compromising on strength.

In the case of BBS's GT range, each individual wheel is designed to last for a minimum of 7,500 km, but each car can have 10 or more sets once you multiply out all the different tyre compounds and spares. The end result is that a wheel can last for three seasons or more, with BBS offering a crack testing and repainting service for the duration.

The German company is famous for its cross-spoke wheel designs. In most cases, its racing wheels feature seven Y-shaped spokes, providing 14 contact points between the wheel and the rim. This distributes the loads very evenly and improves the chances of the wheel surviving an impact.

"You tend to have a very stiff area just next to the spoke, but weaker areas in between the spokes where they are not supported," says BBS managing director Erich Gissler. "If you get an impact on one of these unsupported areas you're more likely to get a defect [so a Y-spoke design can be stronger]. Plus, if you sustain damage to one of the spokes or start to develop a fatigue crack, the other spokes should be strong enough to get you back to the pits."

Such things are not uncommon in endurance racing. "In theory, you might expect the drivers to be a bit more careful in a long-distance race, but in reality it's still very competitive and you can get drivers using a lot of kerb," comments Gissler. "Secondly, over a long-distance race the drivers can get tired and lose concentration or you can get problems with the car, so they can end up going off the track and hitting something or picking up gravel."

Teams are recommended to keep a log of the mileage and type of use for each wheel, just as they would for the dampers or gearbox ratios. Because wet conditions are less frequent and result in lower forces on the wheel it makes sense to alternate the wheel sets to maximise their life. Some teams have taken to using RFID tags, as is increasingly done with the tyres, and BBS can accommodate this if required. This tracking can even extend to data on the materials, heat treatment and quality controls used in the original build. RT

WEIGHT SAVERS

ABOVE Composite optimisation is key to lighter, higher performance structures

William Kimberley explores motorsport's development of a design tool that will bring benefits to other industries

IN RECENT years, the need to reduce carbon emissions has led major automotive OEM manufacturers to seek out lightweighting solutions to reduce the mass of their vehicles. One of the solutions being considered is the introduction of carbon fibre into mass-produced vehicles. Since the introduction of John Barnard's innovative carbon fibre monocoque McLaren MP4/1 Formula 1 chassis in 1981, the motorsport world has been dominated by such structures. The lightweight, strong and stiff properties of the material make it ideal for high performance, lightweight structures.

However, the anisotropic nature of carbon fibre, coupled with the high material and production cost, makes it a difficult material to work with on a volume production scale. While the cost of production is being addressed by more efficient manufacturing methods, a key cost-saving can be achieved through the reduction in component masses, leading to a decrease in the material used. To address this, many OEMs are turning to methods of composite laminate optimisation, which is widely used within the motorsport industry.

Composite optimisation has been used for many years, utilising a Finite Element Analysis (FEA) approach to simulate many loadcases simultaneously. It will also produce a laminate which is able to meet the specific performance requirements of the loadcases. This is a process used by nine of the past 10 F1 Drivers' World Championship-winning teams, all using OptiAssist, a complete composite analysis and optimisation environment developed by UK engineering consultancy GRM. Based upon the well-established FEA solver, Genesis, OptiAssist provides the engineer with a series of tools, enabling them to understand, analyse, develop and optimise a composite laminate. Through this process, it is possible to increase the performance of a component, whilst also saving weight.

The composite optimisation process itself is actually quite simple. It begins with a CAD model of the component with a candidate stack of plies containing the range of desired orientations and ply types. Each of these plies is then designed using a process called topometry. Topometry divides each ply into smaller pieces; it then designs the thickness of each area to meet the required performance target. By stitching together areas of similar thickness, the boundaries of the composite plies can be derived.

Using the tools first pioneered by OptiAssist in 2004, a concept solution can be produced and then easily transferred back to the design team for integration into the CAD model. Further laminate refinement can also be carried out by designing the ply orientations, or designing only the thickness of specific plies.

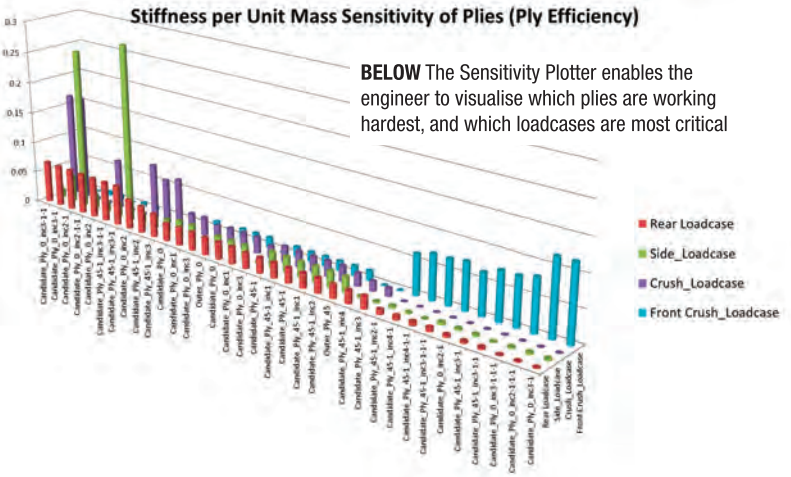
Recent additions to OptiAssist include the Sensitivity Plotter – an extremely useful tool enabling the engineer to visualise which plies are working hardest within a laminate, and which loadcases are most critical. These results can be plotted in terms of mass, to give a further understanding of the mass efficiency of the laminate.

In the motorsport industry, the composite optimisation process has been successfully used to design monocoques, suspension components and gearbox casings. It has also been successfully used to develop wing laminates, meeting regulatory loads while also tuning stiffness to maximise aerodynamic advantage. Through continuous development of the process, one Formula 1 team claims a 10% mass reduction of its chassis year on year, since it introduced the composite optimisation process into its workflow back in 2010. This was achieved despite the increased severity of FIA mandatory crash tests.

In the automotive world, composite body structures are being seen as a significant opportunity to reduce vehicle mass. Composite optimisation can play a key role in developing these complex structures while considering the huge variety of loadcases an automotive body must meet, including stiffness and crash performance targets.

Recent cases of composite body structures include BMW's new i8 sports car, which utilises a carbon fibre 'life module'. The use of lightweight materials gives this car a kerb weight which is around 100 kg lighter than similarly-sized vehicles, despite the extra mass of an electric powertrain. Jaguar Land Rover currently uses Genesis and OptiAssist in its composite BIW (body-in-white) research activities, adopting and expanding the same methods that have been utilised by the motorsport industry. The body is designed to meet all legislative crash loads, alongside JLR's stringent internal stiffness and vibration targets. The tools provided by OptiAssist also allow the designed result to be exported for analysis in JLR's standard FE solver codes and CATIA design software.

In summary, the uptake of carbon fibre as a lightweight material within the automotive industry is encouraging OEMs to turn to composite optimisation in order to maximise their potential for mass savings. The process is key to enabling the design of products which are lighter, higher performance structures using less material, ultimately leading to a saving in production costs. RT



BELOW The Sensitivity Plotter enables the engineer to visualise which plies are working hardest, and which loadcases are most critical

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Optimising the parts others cannot reach

A powerful simulation tool facilitated a project to investigate the benefits of ancillary hybridisation on LMP1-H cars. By **William Kimberley**

WITH the new LMP1-H regulations that were introduced into the World Endurance Championship and the wider use of Energy Recovery Systems, it became apparent that one of the key limitations of the internal combustion engine was its thermal efficiency.

One of the common ways to improve internal combustion engine efficiency is to reduce both parasitic and drag losses within components like gears, bearings and ancillary loads so that the useful power at the flywheel is maximised. This in turn led to work on optimising every single component that comprises the power unit.

Recently UK systems engineering company Claytex collaborated with Oxford Brookes University in a project that investigated the benefits of ancillary hybridisation on LMP1-H cars. The study focused on two particular benefits of ancillary hybridisation: to improve performance; and reduce fuel consumption.

The engine ancillaries modelled were the oil pump, the oil scavenge pump, the water pump and the fuel pump. These ancillaries supply the engine with fluid – cooling, hydraulic, lubrication and fuelling – power and are all "useful energy" losses for the engine, but they are also essential for the engine operation.

The idea of hybridising the drives to the engine ancillaries is to choose the most efficient way to drive the ancillaries, hence reduce energy losses during vehicle operation. The reduction in losses leads to less fuel used in the internal combustion engine and reduces the amount of fuel stops during the span of a race, thus improving vehicle competitiveness. To assess the ancillary hybridisation effectiveness, the whole vehicle model is simulated, including the powertrain, and then virtually run round a lap of Le Mans using a combination of electrical and mechanical ancillary drive propulsion strategies – electric motor or internal combustion engine-driven.

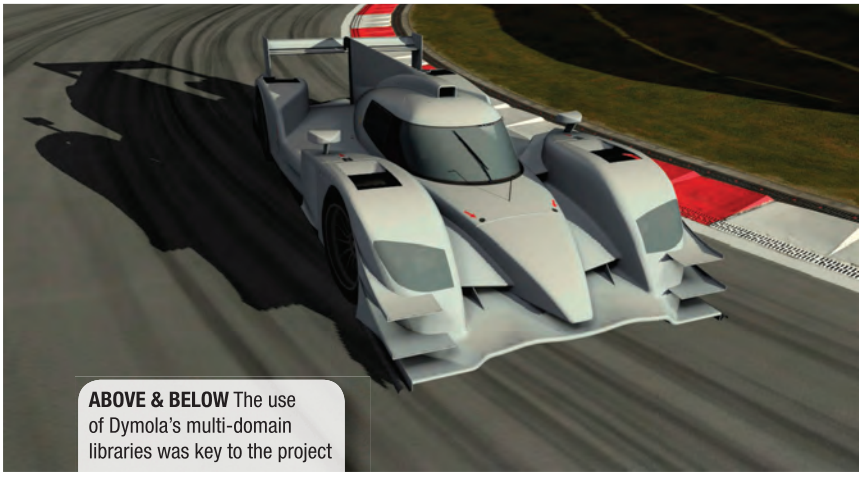
In order to be able to simulate this multi-physics model, Dymola, a physical modelling and simulation tool for model-based design of complex engineering systems, was used to simulate and integrate all aspects of the vehicle. The program is used by companies operating in many industries including automotive, aerospace, motorsport, energy and high tech.

Multi-domain libraries covering the mechanical, electrical, control, thermal, pneumatic, hydraulic, powertrain, thermodynamics, vehicle dynamics and air conditioning domains can be coupled together to form a single complete model of the system.

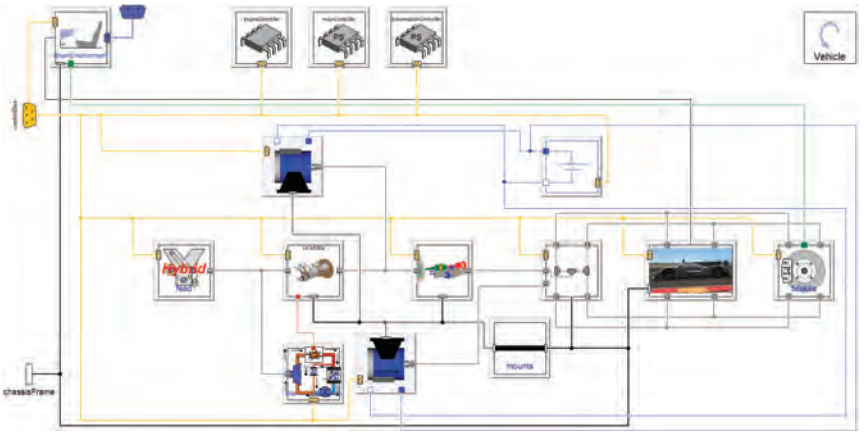
The Modelica modelling language used to define models provides the user with open access to the language. This means that users are free to create their own model libraries or extend from the existing ones to accelerate development times, reduce maintenance efforts and improve the level of reuse across projects. This allows customisation of existing components and the creation of new ones where required. It's also one of the reasons why Dymola is already widely used within Formula 1 and NASCAR for desktop, trackside and driver-in-the-loop simulator use.

The benefits of the hybridisation of the engine ancillaries were reduced fuel consumption and increased acceleration performance leading to a possibility of reducing the number of stops during the race and, in terms of vehicle performance, allowing quicker acceleration to reach the top speed.

The simulation and analysis of the complete vehicle by means of integration of all vehicle subsystems would not have been possible if not for the multi-domain capabilities of the simulation tool used in this study. It saved not only track time and costs but also engineering and prototyping costs for development of multiple design iterations of the hybrid drives. RT



ABOVE & BELOW The use of Dymola's multi-domain libraries was key to the project



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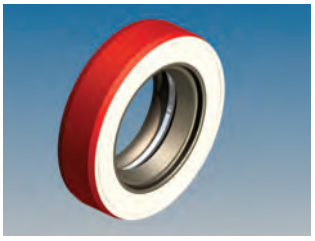
Compact Water Pump Seals

RACE-TEC Sealing has now brought its PTFE-lined seal technology to a range of Compact Low Friction Water Pump Seals. This latest seal design is now race-proven and running in some of the most prestigious series in Europe and North America.

"The most commonly used seal type in automotive water pump applications remains the traditional mechanical face seal. However, this type of seal can create problems for the motorsport design engineer, as they tend to be large, lacking in performance and, when sourced in relatively low motorsport quantities, very expensive with prohibitively long delivery lead times," comments Race-Tec Sealing technical sales manager, Gary Williams.

For some time PTFE radial lip seals have been considered for use in water pump applications, but they have often been found to have a very limited life in high performance applications. "The harsh environment of high speed, pressure and the lack of under lip lubrication has generally led to very unsatisfactory results," notes Williams.

During in-house performance testing, run at 12,500 rpm and a continuous 5 bar, Race-Tec says the seal life was shown to be well in excess of 100 hours. The company also reports a reduction in friction over mechanical face seals, which meant the seal life could be significantly extended. Further to this, the new Compact Seal only requires a radial section of 4.5 mm and an axial width of 6.0 mm. RT



Nissan GT-R Transmission Brace

THE Nissan GT-R has proved to be a phenomenal build platform for tuners and race teams since its debut in 2008. Under higher loads, however, the factory GR6 aluminium casing has been found to flex; a problem amplified by the use of stickier tyres causing mis-shifts or catastrophic failures of the gearbox.

Titan Motorsports' new GT-R Transmission Brace is CAD designed, laser cut from a combination of 1/4" and 1/2" steel, TIG welded in a structural jig and then powder coated. The mount incorporates multiple points of contact with the factory castings at crucial points to reduce torsional flex under load. It also features integrated solid mounts that replace the factory rubber mounts and provide an additional reduction of flex.

Installation requires removal of the transmission from the car. Taking this into account it can still be completed in a matter of hours and requires no permanent modification to the vehicle's chassis. RT

VP introduces CHP+ race fuel

VP RACING Fuels has announced the launch of CHP+, a new leaded, oxygenated race fuel that improves on the power and performance of the company's CHP fuel that has proved so popular on dirt tracks .

"CHP+ will make 20 to 30 more horsepower than premium pump gas and will also outperform E85 by 5 to 7 per cent," says Steve Burns, founder and director of R&D at VP Racing Fuels. "Significantly, it means carrying about 50 per cent less weight in fuel compared to E85."

Burns points out that the improved fuel vapourisation offered by CHP+ gives a wider tuning window on account of its superior fuel distribution and flame speeds. "CHP+ has to run 6 to 8 per cent richer than nonoxygenated fuels, which, combined with better fuel distribution, provides even more on-track protection against detonation than its 99 MON rating (107 R+M/2) would indicate," he adds.

CHP+ is designed for naturally aspirated engines in a wide variety of applications ranging from crate engines to open engine combinations. It may require a modified fuel system and it is not recommended for nitrous applications, or for engines with compression ratios over 12.5:1. RT

Stratasys uPrint SE Plus

WITHIN motor racing, 3D printing technology decreases lead times and reduces costs, while increasing the flexibility for race teams to be creative and enhance performance. The uPrint SE Plus 3D Printer from Stratasys is designed to offer enhanced control over the modelling process, as well as a larger build envelope than the standard uPrint SE.

Offering model materials in nine colours and using production-grade 3D printed materials like the mechanically-strong ABSplus thermoplastic, the Stratasys uPrint SE Plus enables race teams to undertake a full spectrum of part testing and production. This can include everything from wind tunnel testing of accurate, scale model parts to fully functional durable prototypes for track testing, as well as the nirvana of high performance race-ready end use parts – and even tooling.

In addition, two layer thicknesses (0.330 mm and 0.254 mm) offer the choice to print models 30 per cent faster, or at a finer resolution, while optional dual material bays help to boost productivity. RT

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And OFF goes Pickering!

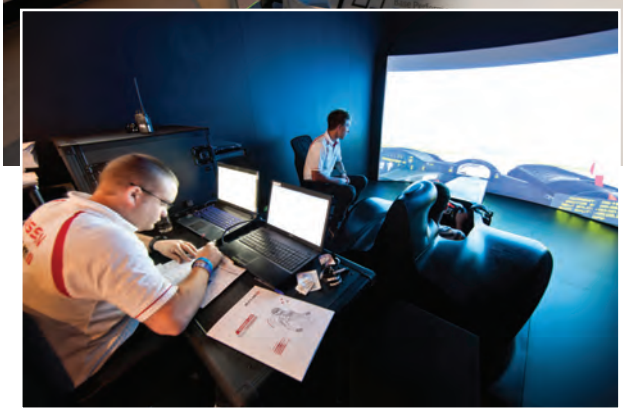
Wrong racing line or simply the wrong profession? **Chris Pickering** clambers into the cockpit

THERE are good days in life and there are bad days. Heading backwards across the grass, well into three figure speeds, in someone else's Aston Martin would typically come into the latter category. Presumably, if it was owned by a double Le Mans class winner and Aston Martin works driver it would make the resulting conversation even more uncomfortable. "A fox ran out in front of me" wouldn't quite cover it.

Fortunately, in this instance, the car in question is made of nothing more than pixels (well, that and several hundred thousand pounds' worth of simulation equipment). It's also anchored firmly to the ground in a converted agricultural building in a picturesque corner of rural Oxfordshire; all of which adds up to a very good day as the reset button is hit and I make another attempt to improve my so-far dismal line through the Maggots/Becketts complex.

The venue for my automotive misadventure is Base Performance Simulators. Owned by Darren Turner, it's a deceptively Tardis-like establishment that houses two different simulator rigs, plus a build area for custom projects and an office populated by a small but dedicated team of staff.

My first taste of the company's GT simulator – complete with bodywork and even a roll cage – uses a physics model that cherry-picks the Aston Martin back catalogue. The chassis and powertrain are basically taken from the V12 Vantage GT3, whereas the aero package comes from the top-level GTE car. This is the model that Base uses for corporate entertainment days and I think the idea is that it's virtually idiot-proof. I may have just disproved that.



ABOVE & LEFT
The simulator is a powerful tool for driver coaching

The session is being run by Matt George, himself an accomplished driver, both in the real world and the simulator. For the pros, the two tend to correlate almost perfectly, he tells me. That doesn't bode particularly well for my chances, given that I'm still a good five seconds adrift of his time.

"Let's try something different," suggests Matt. "If you found that tricky, this will put you off simulators forever," he adds with a grin.

The next car is a faithful model of the Nissan GT-R Nismo GT3 you'd find in the likes of the Blancpain Endurance Series, and I set off with a degree of trepidation. It turns out it's keener to oversteer, but the signals coming back through the steering are clearer and it actually feels more natural overall.

Just as I think I'm starting to get the hang of it Matt tactfully points out that time is getting on and we decide to call it a day.

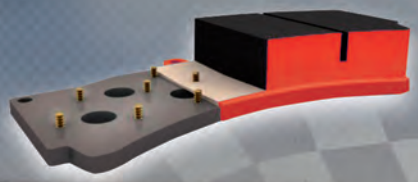
The experience of driving in a simulator can be a strange one. I've played my fair share of computer games, but even though the graphics are now a match for the professional simulators it's a very different sensation.

Surrounded by a huge wraparound screen, placed far enough away to trick your eyes into thinking they really are focusing on objects tens or hundreds of metres away, your brain can't quite reconcile the lack of motion. This is something encountered on all simulators and Base has deliberately elected to do without a motion platform so far. That's about to change with updates to the firm's single-seater rig, but even the best cueing systems can't replicate the sustained g-forces you experience in real life. I'm not sure if it's due to this mismatch between vision and balance or simply the sleep-deprived miasma of a new parent, but I crawl out through the door bars of the roll cage feeling a little woozy.

There's no doubt I have a much better idea of where the Silverstone Grand Prix circuit goes now, though, and it's clearly a powerful tool for driver coaching. We've not been taking things remotely seriously, yet Matt has already identified a few bad habits that tally perfectly with my (limited) real-world experience. And most importantly it's been a lot of fun. A good day indeed.

PAGID RACING

Brake control from green light to chequered flag.



PAGID RST

Double DTM Champion Mattias Ekström has clinched his first-ever FIA World Rallycross Championship victory after a flawless drive in the Audi S1 EKS RX in Holjes, Sweden. In his RX campaign, Mattias relies on the supreme stopping power of PAGID RST racing brake pads – high initial bite, constantly high friction over temperature with excellent modulation over the whole temperature range. With the highest degree of braking performance, PAGID RST racing brake pads deliver the competitive edge that successful drivers demand.

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