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- 4 Le Mans news**
All the gossip and breaking stories in the run-up to the great race
- 8 Test Day**
A detailed analysis of which car did what at the Le Mans test day
- 12 LMP1 cars**
Just how will Porsche and Toyota take the fight to Audi this year?
- 16 Nissan GT-R LM**
Peter Wright investigates the thinking behind Nissan's new LMP1
- 20 Danny Nowlan**
Do the Nissan GT-R LM numbers add up when fed into a simulation?
- 26 LMP2 cars**
A detailed look at all the cars running in the LMP2 class in this year's race
- 32 New LMP2 regulations**
It's all change for P2 from 2017, we look at the controversial new regs
- 34 Wirth HPD Coupe**
Wirth's new LMP2 Coupe was six years in the making. We look at it
- 38 GTE cars**
Details on every GTE car and the controversial Balance of Performance
- 42 Corvette CR.7**
How design optimisation helped to make a better Corvette GT racecar
- 48 Le Mans 1995**
It's been 20 years since McLaren won Le Mans. We revisit the 1995 race



The rapid advancement of technology continues at Le Mans, with huge performance gains year on year from the LMP1 hybrids in qualifying. The pole position times are not comparable to 2014 due to a slow zone practice in the last, dry half hour last year, just as the teams were readying themselves for a final attack at pole, but in 2015 with little dry running, Porsche locked out the first three positions on Wednesday night at record pace. The LMP1 cars did not breach the 3m15s barrier as predicted, but it seems clear that they may have done if challenged.

There has been a dramatic increase in speed at every circuit so far in 2015, demonstrating the advance in aerodynamics, suspension and particularly in the hybrid systems. Audi states that it has gained around 40bhp since 2014 from its electromagnetic flywheel, switching from the 2MJ category to the 4MJ category this year. Such is the pace of the improvement that already organisers

are talking of how to slow the cars for 2016 to keep them suitable for the Le Mans circuit. As detailed in the July edition of *Racecar Engineering*, ACO President Pierre Fillon outlines why he thinks the LMP cars should be slowed, and why a chicane before Porsche Curves is not a suitable alternative.

However, in the paddock, the manufacturers and drivers are asking what's the problem? If the cars are capable of lapping in the 3m15s and are safe to do so, why not allow them? The drivers consider that a greater speed differential to the LMP2 and GTE is perfectly safe; it actually helps if they don't have to 'dive bomb' the slower cars on corner entry but can pass on the straight.

It seems likely that the ACO will regulate the cars for 2016, reducing the fuel allowance by 10MJ as per the regulations, encouraging the teams to go as fast as this year but using less fuel. It may consider going further, but it seems clear that it will meet with resistance from existing competitors.

New LMP2 regulations confirmed

The ACO has confirmed its plan to limit the number of LMP2 chassis manufacturers to just four under the new 2017 regulations. A single engine supplier will also be nominated, as will a single ECU supplier.

The plans, which were first unveiled at Daytona in January, were initially met with



ORECA is thought to be one of the four manufacturers hoping to win the right to produce LMP2 cars from 2017 (pictured is this year's Le Mans P2 pole car, the KCMG ORECA 05). The new regulations will put a limit on number of car makers

resistance from the American Tudor United SportsCar Championship (TUSCC), which has now negotiated a separate deal for its own teams and manufacturers. The regulations announced at Le Mans during the ACO official press conference are for the European and Asian Le Mans Series, and World Endurance Championship only.

The TUSCC will have more freedom, with open chassis and engine regulations, while bodywork will be able to feature design cues from the different manufacturers involved in the series.

The ACO confirmed that the TUSCC competitors will be invited to the Le Mans 24 hours in the same configuration as the WEC chassis and bodywork, and their engines will be performance balanced against the European version, although the specifics have yet to be confirmed by IMSA.

IMSA staff only flew in to Le Mans on Wednesday evening and a meeting was held on Thursday morning before the announcement. It was noted that very little was said

of the TUSCC plans during the announcement, other than that IMSA had actually been part of the process.

Although the technical regulations will be shared between the series, in reality the differences between the IMSA and ACO/FIA plans have blown apart hopes for the LMP2 category to be the global prototype class.

Fundamental differences in philosophy exist, as the American series seeks to encourage manufacturers such as Chevrolet, Ford, Mazda and HPD, while the European series seeks to limit costs for the privateer.

Targets for the normally aspirated, direct injection engine are a peak power output of 600bhp (in a chassis weighing 900kg), an hourly rental of €1300 and a maximum weight of 140kg. The maximum price of the overall car should be no more than €480,000 and the parts limited to 140 per cent of the price of the car.

Safety measures for the new chassis include wheel retention tethers in case of impact, Zylon protection panels and a rear crash structure.

For further information on the LMP2 regulations see page 32 and for more information on the new HPD, which made its debut at Daytona in January, see page 34.

GTE to feature performance window and more power

The future of the top GT class, GTE, was presented at the official ACO press conference on Thursday at Le Mans.

A revised performance 'window', a combination of weight and power into which all GTE cars must fit, has been created after discussion and negotiation with the competing manufacturers, the FIA and the ACO. The plan is that the cars will be more powerful by 15kW (around 20bhp), and lighter by 10kg.

Manufacturers will have specific

areas of freedom for design, including the front and rear fenders, bonnet, splitter, and rear bodywork behind the rear wheels and rear diffuser.

One of the major safety changes for the GTE cars is that they must have a hatch in the roof to help with driver extraction following an accident. This means a major change to the roll cage within the cars, which must be ready for a test at the Michelin test facility at Ladoux, France, in mid-September.

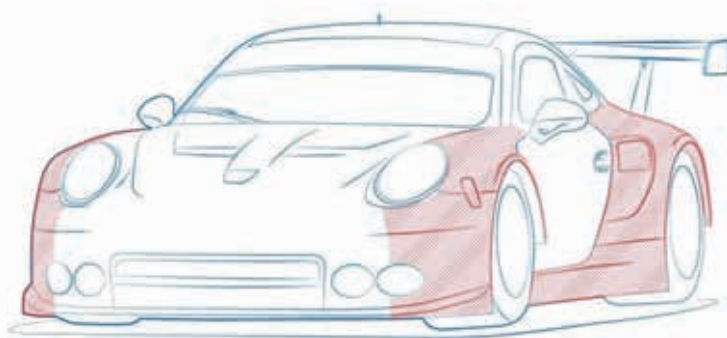
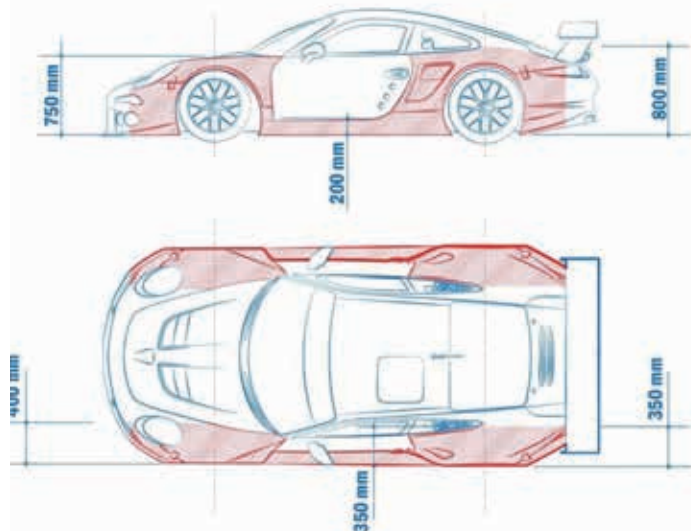
A key problem for GTE is the plan in the Tudor United SportsCar series to integrate GT3 cars into the GTE category, and how to balance turbo engines with normally aspirated power units. Using weight and power should, according to one manufacturer, be enough to balance the cars, while the concept of a spec tyre for the GT3 cars could help to further slow them.

The issue of turbo engines is also solved using the current GT3 system of matching revs with

turbo boost pressure, although the announcement stopped short of announcing how this will be done.

Manufacturers are hoping for a final set of regulations to be with them as soon as possible, with new cars already under construction.

Corvette has confirmed that it will build a new version of the C7.R for next year, and will present the car at the Ladoux test. The new Ferrari 488 will begin testing in July, powered by a turbocharged engine and will also be presented in France.



Manufacturers involved in GTE are to be given more freedom when it comes to aerodynamic modifications, with much more scope for work across the car (some of the areas shown in red). But there will also have to be an escape hatch in the roof

Human waste to power Garage 56 LMP racer

Gerard Welter's WR Racing team will fill Garage 56 at Le Mans – reserved for innovative projects – in 2017, with a car powered by an engine that runs on biomethane, including human waste.

We're told that biomethane is a CH4 biogas produced by re-using waste, which comes from different sources – household, animal, agricultural and industrial waste.

Wind tunnel testing has already been completed on the car, and the monocoque and tooling are in the process of being developed,

as is the 1600cc 3-cylinder 450bhp powerplant. The chassis will comply with the 2014 LMP1 technical regulations.

A cryogenic tank will be integrated into the chassis and filled with biomethane liquid.

According to the ACO, enough human waste is produced over the 24-hour meeting to power two cars.

The announcement puts paid to rumours that BMW will use Garage 56 to debut fuel cell technology ahead of a full LMP1 programme.



Gerard Welter's 2017 Le Mans Garage 56 prototype will run on biomethane fuel

SEEN: Ligier JS P3



Onroak Automotive launched its new LMP3 contender at Le Mans, powered by a Nissan engine and equipped with an Xtrac transmission, as is the case with all P3 chassis. The car is inspired by the company's LMP2 car, the Ligier JS P2. HP Composites is the company's development partner for the chassis, Exa for the CFD, while Stand 21 provides the drivers' equipment.

Porsche on pole at Le Mans

Porsche secured pole position at the Le Mans 24 hours with a record lap of 3m16.887s, set on Wednesday night by Swiss driver Neel Jani.

The lap, which equates to an average speed of 249km/h, beats the previous record of 3m18.513s set by Peugeot in 2008. However, it did not breach the 3m15s lap time that organiser the Automobile Club de l'Ouest worried might be possible; which it thinks is too quick.

Jani's time was set on the second lap of 24 completed during a rain and red-flag hit session, and beat his Porsche team mates Timo Bernhard and Nick Tandy into second and third positions respectively. Audi filled out fourth to sixth positions, while Toyota finished the session seventh and eighth ahead of the two Rebellions.

Porsche was favourite to secure pole having achieved the feat at the opening rounds of the WEC at Silverstone and Spa. The manufacturer appears to have trimmed out the car to run with lower downforce, gaining 10km/h in top speed compared to the test day two weeks prior to the race. During Thursday practice the team had a 'hybrid problem' believed to require a change of the new battery.

Audi and Toyota opted not to challenge for pole, although the latter did

admit that it did a low fuel run early in the session before rain set in on Wednesday night. Neither went for an outright qualifying run on Thursday, preferring to take advantage of the dry conditions to prepare for the race.

The Nissans had a troubled qualifying session on Wednesday, enduring electrical problems around the lift and coast function, but the cars improved during Thursday's first qualifying session. All three cars set times under 3m39s, but not all of the drivers lapped in the required time compared to pole position, and so the cars line up at the back of the prototype field.

Frenchman Nicolas Lapierre set pole position time in LMP2 in his KCMG ORECA-05 Nissan, almost a second ahead of the Greaves Motorsport Gibson 0155 Nissan and Jota Sport's similar car.

In GTE, Aston Martin led the way in both Pro and Am classes. Richie Stanaway set pole time in the Pro class, his 3m54.928s lap almost two tenths of a second faster than the Am class Aston of Pedro Lamy. Ferrari was second in the Pro class, but qualifying ended badly for the Chevrolet team as the it withdrew its No.63 C7.R after it was seriously damaged in a crash. The accident was caused by a 'mechanical issue' according to a release.



Porsche scooped the early headlines with a record lap to gain pole with Neel Jani at the wheel

BMW eyeing Le Mans return with LMP1

BMW is believed to be evaluating a 2017 LMP1 programme, with some well-sourced reports in the German press stating that the design process for the new car has actually started.

Adding fuel to the rumour is the fact that BMW Motorsport personnel have been seen at both WEC rounds so far this year, and that they have been taking a specific interest in the cars contesting the LMP1 class, rather than those in the GTE field.

The German marque, which won Le Mans in 1999 and also powered the 1995 winner, is said to be one of two manufacturers who have made serious approaches to the ACO about a 2017 LMP1 entry, while also enquiring about the direction the rules will take in 2017, when new regulations are expected in the top prototype class.

BMW has not had a major international motorsport programme since it withdrew from F1 at the end of the 2009 season. Since then it has focussed on DTM and customer GT racing, as well as its works United SportsCar Championship team in the USA.

LMP1 is likely to be of interest to the firm due to BMW's advanced position in electric mobility and its development of cutting edge hybrid technologies, such as its patented 'turbo steamer' and thermoelectric generators. The brand has even created its own

alternative fuel and hybrid brand 'i' (as in BMW i8).

The synergy of the current LMP1 rules, which are aimed at advancing technology, and BMW's philosophy of being a leader in this field is clear, and a berth in the Garage 56 — for experimental cars — which had been vacant for 2016 and 2017, might have been ideal for BMW at Le Mans, before a full entry in its second year (the same path taken by Nissan). But it's now been announced that this avenue is closed, as Garage 56 is taken for both 2016 and 2017.

There are some good reasons why a BMW P1 project might not go ahead, though. For instance, some of the technological avenues being pursued by BMW fall outside of the current LMP1 rules structure, while the firm also lacks the capability to develop a modern LMP in house (in F1 it partnered with Sauber).

The lack of in-house capability could easily be overcome with the use of the local supply chain, however, with a wide range of firms in Bavaria such as Holzer, Adess and others with track records in LMP and F1 car construction and development. Through its DTM programme, BMW is developing an engine that could be suited to LMP1. The NRE 2-litre four cylinder direct injection engine will produce in excess of 600bhp.

BMW Motorsport boss Jens Marquardt would not refute the speculation surrounding his firm's 2017 Le



Mans project, but he made it clear that for the brand to enter the rules would probably have to change: 'If you take BMW as a global brand we are not a slow follower or a fast follower, we are setting new paths, which we have shown with 'i', so I don't think we need to follow what everyone does,' he said. 'The WEC is still following and what we need to figure out is a new path that suits BMW, like with 'i'.'

However, Marquardt went on to point out that if the return on investment was worthwhile BMW would certainly consider a new global programme, and that could include a return to Le Mans. 'If a global return on investment is balanced with your investment it can make a lot of sense but it has to be balanced. Some of the championships are a huge investment and a return on investment calculation sometimes in those respects are difficult, but it depends how close these things are to your brand,' he said.

SEEN: Return of the Superbird



The Riley Technologies Dodge Viper GTE-am car has revived the Superbird Road Runner name from the famous NASCAR Cup cars of the 1970s. Due to

its BoP allowing it to have a very high rear wing the team have nicknamed the car the Viper Superbird — with the stickers to match!

Dome and Wolf out of the LMP2 tender process while Gibson and Ginetta put their hats in the ring

Dome and Wolf will not take part in the 2017 LMP2 car supply tender process, but Gibson (pictured), Onroak (Ligier), ORECA, Ginetta and Riley Technologies have all announced that they have submitted tenders.

Signatech (branded as Alpine) is also rumoured to have submitted a tender to become one of the chosen four manufacturers allowed to produce LMP2 cars, while Wirth Research (as HPD) has also expressed an interest.

A number of other companies initially linked to the 2017 car

supply, including Multimatic and Dallara, have also apparently ruled themselves out.

The controversial FIA/ACO plan to reduce the number of car constructors in the junior Le Mans Prototype category emerged in early 2015 and are detailed in the magazine. In addition to the limited chassis supply a single engine will be used in the WEC, ELMS and AsLMS, while in the USA the engine supply will remain open. Mecachrome is thought to be the leading candidate to supply the LMP2 powerplant.



Audi and Porsche trick rear wings deemed legal

Audi and Porsche have found a neat way to improve the airflow over their rear wings at Le Mans, it has emerged.

During the official pre-race test day both the Audi R18s and Porsche 919s ran with interesting two-part rear wing end plates, which feature shaped and angled leading edges. Additionally the Porsche design also features a three dimensional outer section. When first spotted there were mutterings that the designs were 'clearly illegal' and 'I don't see any way that they can comply with the rules,' from some parties.

Looking at the end plates in question and comparing them to article 3.6.2 of the 2015 LMP1 technical regulations it does actually seem that, indeed, both the Audi and Porsche designs are illegal. 3.6.2 states that the end plates must have a minimum constant thickness of 10mm, must have edges rounded with a minimum constant radius of 5mm, the surfaces shall be flat and parallel to the vertical plane passing through the longitudinal centre-line of the car, and that apart from the fixations to the bodywork permitted above, no bodywork elements must be attached on to the end plates. Two part end plates are specifically allowed.

It is clear that some parts of both the Porsche and Audi designs are not flat and parallel to the centre-line of the car (vertical plane). So how is this legal? Well, according to Chris Reinke, head of the LMP programme at Audi Sport, the leading edges are in fact not end plates at all. 'If you look closely you will see that those parts are not attached, they are bodywork and so are not part of the end plate at all,' he said.



Porsche's new end plate features 3D outer section

But even this is hard to fathom, as the rules (3.4.1) clearly state that 'All bodywork behind the rear axle centreline and more than 200mm above the reference plane must form a smooth, continuous, unbroken surface without cuts, and be visible from above the car with the rear wing removed.' Both Porsche and Audi insist that if you look really closely it is possible to see that the design complies with this rule, too. The designs do indeed seem to comply with the letter of the rules, although certainly not the spirit of them.

That said, a close inspection of the Audi end plate from above shows that actually the end plate has an overlapped section with the 'bodywork' forward part. With the 'bodywork' removed the exposed leading edge of the end plate would not be 'flat and parallel' as it would clearly be stepped. An Audi Sport source



Audi says its end plate is homologated and accepted

admitted to *Racecar Engineering* that the solution was not legal in detail but overall it is acceptable. 'Because of the way we made it you can say that it is not legal, we could remake it to be legal and it would not change the external shape of it or the aero effect at all, so we said to the ACO that it is not logical to change it just for this as it makes no difference, now it is homologated and everyone accepts it,' the source said.

Rear wing and rear bodywork design is a particularly touchy subject for LMP1 manufacturers after Porsche was found to have illegal bodywork at last year's test, and Toyota's innovative rotating wing was exposed during the race but deemed legal (and later banned).

Nissan and Toyota are not using the design on their wings, and a paddock rumour claims that the reason that both Porsche and Audi have the concept is that staff have gone from one firm to the other taking information with them. It is not clear which brand thought of it first.

Adess AG reveals LMP3 design



Munich based Adess AG has revealed its new LMP3 design.

The new car, dubbed the Adess-03, will run for the first time later this year and will be available to customers in time for the 2016 season.

Stephane Chosse, CEO Adess AG, said: 'The LMP3 category is new this year, but the field is growing at every race and the future looks very promising. The ADESS-03 has been designed in the spirit of the LMP3

technical regulations which is a good mix between performance and cost. In addition we focused our efforts in designing an easy to service prototype which will be very much appreciated by the race teams.'

Adess says it will offer an on-track spare parts service and a wide range of technical support, tailored to its

customers needs, throughout the entire 2016 season.

The last sports car designed by the firm was the Adess 02 (aka Lotus T128) LMP2. It was also instrumental in the development of the 2012 and stillborn 2013 HRT F1 cars. The Adess will take on cars from Riley Technologies, Pescarolo, Ligier and Ginetta.



Toyota was almost a match for multiple 24 Hour winner Audi in the wet while Porsche (following) showed good straight line speed



Lap analysis seems to suggest that Audi has the most efficient downforce package while it also put in some impressive long stints

Test of endurance

The Le Mans test day may have been on the soggy side but there was still much to take from it says our man at Le Sarthe

By PAUL TRUSWELL



Although much of this year's Le Mans test day was run in wet or damp conditions, there was still something to be learned about the potential of the top cars. Also, the weather forecast for the race week is for periodic rain, and so the running throughout the day provided a useful indicator for what may happen during the 24-hour race.

Porsche, Audi and Toyota all carried out extensive testing in difficult conditions. The day started dry, but inevitably the track was dirty. Initially, it was Andre Lotterer in the Audi R18 e-tron quattro who was quickest, putting in a 3m 25.2s lap with less than 20 minutes of the session gone, and following it with another three laps all under 3m 30s, before pitting. Then Timo Bernhard in the red Porsche 919 Hybrid put in a quicker lap at 3m 23.9s, with less than 40 minutes of the session gone.

A little later Neel Jani in the black 919 set what was to be the fastest lap of all in the morning session at 3m 21.9s, just two-tenths slower than the pole position time from last year's race. In the first hour of last year's test day, the fastest lap was set by Kazuki Nakajima (pole-setter in qualifying), at 3m 26.371s, perhaps the most useful comparison that can be drawn with last year, and an improvement of 2.1 per cent.

As usual though, the Audis were putting in some long stints: Marcel Fässler, taking over from Lotterer, completed 12 laps in one stint, although the weather had deteriorated by the end of it, so calculating average lap times was not really worthwhile by this time.

Endurance testing duties at Porsche were assigned to the white No.19 car, which Fred Makowiecki drove in addition to listed drivers Nico Hulkenberg, Earl Bamber and Nick Tandy.

At the end of the morning session, with the track conditions wet and lap times around half-a-minute off the pace, Tandy served notice of Porsche's intentions in the race, turning in a 15-lap stint. Such fuel economy won't be possible in dry conditions, but the Weissach car will have to be the most economical of all the hybrid cars, due to running in the highest MJ category, and will certainly be capable of 14 laps on a tank of fuel.

The afternoon portion of the test started on a damp track, and none of the leading LMP1 runners were keen to come out straight away. The track was drying out though, and for just under an hour fast laps were possible, before the rain returned and prevented any more quick times being set. Toyota in particular seemed to have a car that uses an effective wet-weather set-up rather better than its dry settings. In the wet part of the morning its cars were within a few tenths of the Audis, but in the dry conditions, earlier in the session, times were more than two seconds slower.

Of course, there is more to the test day than simply the best laps that are recorded, and the table (page 10) shows the average of the best 20 per cent of laps completed in both sessions as well as the result of combining both sessions together. Interestingly, this puts the slowest of the Porsches ahead, and not surprisingly also shows the Audis in a good light.

The table also shows the best time recorded through sector 2, which runs from the exit of Tertre Rouge to Mulsanne corner, and through the Porsche Curves. These two sectors best illustrate drag and downforce respectively.

This would seem to indicate that Audi has the stronger downforce package, and that Porsche is superior in straight-line speed.

Meanwhile, it was clear that the Nissan GT-R LM NISMO drivers were taking extreme caution through the corners, and they were, in fact, under strict instructions not to bend the car for fear of not being able to race due to a shortage of spare parts. Yet the car's strength is its straight-line speed, and the GT-Rs were able to register speed trap numbers that matched, and even beat, the other cars. They were, however, more than seven seconds slower through the two chicanes, while the front-wheel-drive car was around 20 per cent slower than the best Audi through the Porsche Curves.

In LMP2 the new BR01 cars from SMP Racing and the Dome from Strakka both had steady rather than spectacular debuts. The two BR01s completed over 100 laps, with all six drivers taking turns behind the wheel. The fastest time was set by Maurizio Mediani in the afternoon session, more than a second quicker than Nicolas Minassian had managed in the morning.

The new Strakka-Dome S103 was the faster of the two, but it still finished up nearly two seconds slower than the fastest LMP2 car overall, the turbo HPD-engined Ligier JS P2 in the hands of Laurens Vanthoor.



Despite seeing the size of its air restrictor shrink in the name of performance balancing the Corvette was still the quickest GTE on the straights



There was plenty of interest in the GT ranks, too. Balance of performance is always a hot topic in GT racing, and there was drama in the GTE category this year with a dispute over which BoP would be used in the race. The FIA attended the test day to settle arguments after Porsche and Ferrari complained that the Aston Martin would be given a larger air restrictor than in the opening races of the year. The BoP was set after Le Mans 2014 for the Austin, Texas round of the WEC, and teams were told that this would be the settings for Le Mans 2015. Yet at Spa teams were given a different set of regulations with, apparently, a clause stating that these settings would remain for the foreseeable future.

The FIA needed to issue the correct BoP before the test day and did so on Friday night, sticking with the originally stated settings for Le Mans. Aston Martin will therefore run with a larger air restrictor than at Silverstone and Spa, and at 1215kg, while Corvette drops 0.1mm in air restrictor size.

All four manufacturers finished up within a second of each other during the test day, although Darren Turner in the Aston Martin V8 Vantage was the only one to improve during the afternoon session. His best lap was something of a one-off, however — Oliver Gavin and Tommy Milner in the second-placed Chevrolet Corvette C7R completed eight laps that were

faster than the second fastest lap of the Aston.

Although Corvette simulated a 1mph drop in top speed and a second a lap penalty for its air restrictor size reduction, through the speed trap the American car was still more than 1mph faster than its closest competition, the AF Corse Ferrari 458 Italia, and nearly 3mph faster than the best that the Aston could manage.

It is also interesting to note the number of sub-four minute laps from the leading GTE manufacturer cars: No. 97 Aston Martin (one lap), No. 64 Corvette (six), No. 51 Ferrari (three), No. 92 Porsche (two) No. 71 Ferrari (one). Maybe this shows where the true balance of power lies?



HEADLINE

Car No.	Car	Drivers	No of Laps	Longest stint	Best 20% am	Best 20% pm	Best 20% overall	Best S2 (Hunaudières)	Best Porsche Curves	Speed trap
1	Toyota	Davison/Buemi/ Nakajima/ Kobayashi	92	10	3m 31.491s	3m 32.915s	3m 31.611s	1m 18.721s	16.588s	334.9km/h
2	Toyota	Wurz/Sarrazin/ Conway	81	10	3m 28.900s	3m 34.602s	3m 30.816s	1m 19.346s	16.479s	333.9km/h
7	Audi	Fässler/Lotterer/ Tréluyer	95	12	3m 26.230s	3m 27.681s	3m 26.906s	1m 17.590s	15.779s	332.9km/h
8	Audi	Di Grassi/Duval/ Jarvis	98	10	3m 26.594s	3m 26.553s	3m 26.395s	1m 17.659s	15.879s	332.9km/h
9	Audi	Albuquerque/ Bonanomi/Rast	95	13	3m 27.101s	3m 30.592s	3m 28.047s	1m 17.889s	16.027s	332.9km/h
17	Porsche	Bernhard/Webber/ Hartley	75	9	3m 27.867s	3m 32.012s	3m 28.708s	1m 17.472s	15.917s	326.8km/h
18	Porsche	Dumas/Jani/Lieb	88	13	3m 26.455s	3m 30.205s	3m 27.468s	1m 17.132s	16.115s	325.8km/h
19	Porsche	Hülkenberg/ Bamber/Tandy/ Makowiecki	92	15	3m 25.965s	3m 25.075s	3m 25.520s	1m 16.398s	16.047s	325.8km/h
21	Nissan	Ordoñez/ Shulzhitskiy/ Matsuda	36	10	3m 55.873s	3m 58.644s	3m 57.061s	1m 25.445s	20.288s	307.3km/h
22	Nissan	Tincknell/Krumm/ Buncombe	45	10	3m 50.839s	3m 57.147s	3m 53.062s	1m 24.134s	19.639s	333.9km/h
23	Nissan	Pla/ Mardenborough	29	8	3m 45.895s	4m 03.678s	3m 51.034s	1m 23.713s	19.161s	336.0km/h

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PORSCHE 919 Hybrid



Porsche has returned to Le Mans for its second year of the 919 programme with a heavily revised car. The chassis has gone to a one-piece construction, which means a stiffer base thanks to the use of new materials, while Porsche has reduced the car's weight significantly having raced at 30kg over the 870kg limit in 2014, and it has improved the suspension, battery and turbo. The car has also moved into the 8MJ category of the regulations, which means that it can store more

energy and release it over a longer time than those in the 6MJ category, or deliver more power in a shorter space of time. This has meant incredible one-lap performance, although in the races the 919 Hybrid has still proven to be vulnerable.

In testing the car has run into problems and rivals are not expecting this to be Porsche's year. However, with three cars for the first time, with a year of experience under its belt and with a car that ran until hour 22 last year, leading for a time, there

are those that believe that this year at least one car from each manufacturer will finish the race without mechanical problems.

Expect Porsche to do well in qualifying, but in the race it must risk everything to complete four stints on a set of tyres, while Audi has proven in the past that it can do five and be competitive. Porsche may be an outside bet to take the challenge to Audi this year. For full feature, go to the digital back issues section on www.racecar-engineering.com

TOYOTA TS040



Toyota had a huge speed advantage at Le Mans in 2014. The TS040 was superior to the Audi in every area on performance alone. However, the team suffered with having only two cars — one crashed in the rain storm on Saturday afternoon last year, the other had an electrical problem during the early hours of Sunday. This year, the team has added more power to the

hybrid system and has improved the suspension kinematics in a bid to improve tyre wear. But Porsche and Audi have also taken huge steps forward and the advantage that Toyota had hoped to retain has been severely eroded.

The team says that it is suffering in the engine department — the car handles well but just doesn't have the power of the Audi and Porsche from its

3.7-litre V8 normally aspirated unit, which also powered the car last year. Toyota believes that it needs a new engine, probably a turbo, and a new hybrid system. It expects to mount a challenge from the early hours of Sunday morning, but must stay in the game until then if this is to happen. To read the full feature, go to the digital back issues section on www.racecar-engineering.com



AUDI R18

From the moment the cars turned up on track at the World Endurance Championship pre-season test at Paul Ricard, rivals noted Audi had taken the biggest step in performance. Having won the opening two races of the WEC, Audi goes to Le Mans as favourite. Much of the car is the same as in 2014, but the team has switched to the 4MJ category, has introduced an all-new FRIC suspension system and has spent hours in the wind tunnel perfecting the aerodynamics.

The Le Mans low downforce bodywork has a completely new approach, with air flowing through the car from the front, using a similar concept to the R15 and R15 Plus. Power from the hybrid system has increased from 228bhp to 268bhp, and the team has also worked on strategy, optimising the times where the car can use its four-wheel-drive and where it must use two-wheel-drive.

The team has also worked on tyre usage, which means that strategically it has plenty of options for

the 24 hours, while at the Le Mans pre-test Audi methodically worked through its test programme in both wet and dry conditions. Like Toyota, Audi has introduced a new nose that required a new crash test, but the majority of the car is just as it was in 2014. The team has a new car in the pipeline, a successor to the R18, that may include a twin hybrid system. To read the full feature, go to the digital back issues section on www.racecar-engineering.com

NISSAN GT-R LM

Many wondered how Nissan would meet its aim to produce something that was completely different. By effectively reversing the layout of the car, it has done precisely that. The engine, built by Cosworth, sits ahead of the cockpit, behind the gearbox on which the front suspension is mounted. Under the drivers' legs is a mechanical flywheel system while at the rear the wheels are underused, in this iteration of the car.

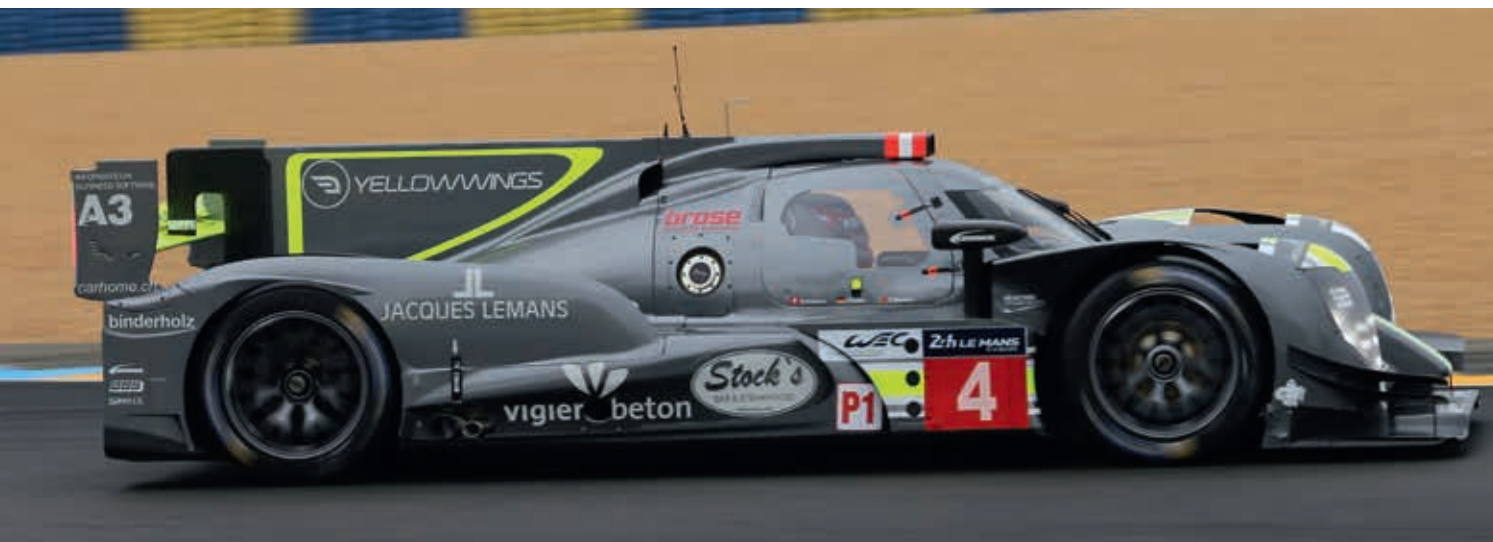
The plan was to have a four-wheel-drive system with much of the energy being delivered to the rear wheels. However, problems hooking up the flywheel power has meant that the system has had to be scaled back, from a planned 8MJ to 2MJ, with two-wheel-drive only, at the front. That has led to a change to the front brakes, and here Nissan has had to revise its brake cooling significantly in order to cope. That, in turn, has affected front wheel size.

The car's strength is its straightline speed, and at the test it was indeed the fastest through the speed traps, but this is the first year of a confirmed two year programme. The issues with the hybrid system has compromised the car's overall concept.

Meanwhile, the drivers report that the car is unpredictable, and brake failures are a concern.

To read the full feature, go to the digital back issues section on www.racecar-engineering.com





KOLLES

The Kolles CLM-01 has been heavily revised for 2015 with a new rear end including a new gearbox and rear suspension, plus new aerodynamics. The car started out life as a Lotus T129, a car that actually appeared to be developed out of the T128 LMP2 car (although this was denied by the team) but, by the time the car was launched, it was rebadged a CLM P1/01. The front suspension was pretty much the same as on the T128, although

the rear of the car is now completely different.

The car was originally supposed to run with the Audi DTM-specification 4.0 litre V8, but eventually the team switched to the AER P60 V6 twin turbo that was designed to meet with the fuel flow regulations that encouraged better fuel economy. The AER has team developed an all-aluminium engine design that could be used as a fully-stressed member of the chassis. The turbocharged engine

is direct injection and features a new cylinder head and combustion chamber design.

The gearbox was designed for use in LMP2 and was not really up to the power of the LMP1 category, and so has been upgraded.

The team ran well at the Le Mans test, although lap times don't reflect its potential. The team that runs the car, ByKolles Racing, is German based but races under the Austrian flag.



REBELLION

This is the first race for the revised Rebellion R-One AER, and so little should be expected of the privateer team this year at Le Mans, although test day performance begged to differ. The customer normally aspirated Toyota engines have been replaced by AER P60 V6 GDI twin turbos, which has meant a heavy revision to the cooling and aerodynamics — basically a rebuild of the back of the car.

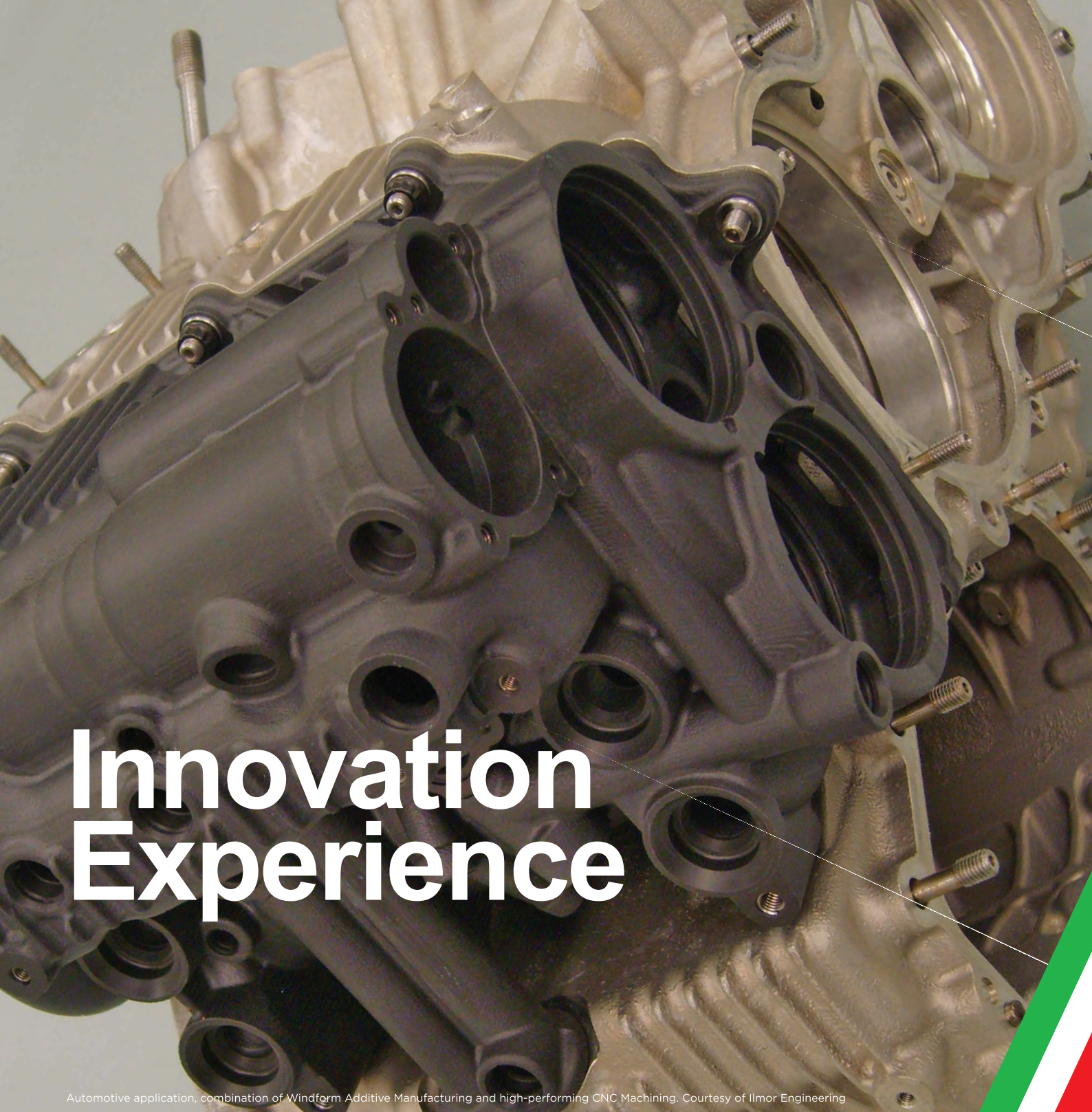
The car was built by ORECA and it took just

15 weeks to adapt the new engine to it. It ran in competition for the first time at the test day at the end of May, where it clocked competitive times.

The team still uses the Michelin tyres, which are developed for the Hybrid LMP1 cars, meaning that the fronts are designed to handle around 300-400bhp to help generate heat into the tyres. The car is entered in the OMJ category reserved for private teams, which means that it will run at 850km/h, will have more petrol energy per lap than

the hybrid cars, a higher petrol flow and will be able to carry more fuel — 75 litres compared to 68.5 litres for the hybrids.

During the test day the cars finished ninth and 12th fastest, Matthias Beche setting a 3m30.508s, nine seconds off the pace of the Porsche, but only five seconds slower than the Toyota TS040. It will be interesting to see how this car fares in qualifying. To read a full feature, check out the August, 2015 edition of *Racecar Engineering*, out soon.



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Head on the block

How Nissan's Ben Bowlby is turning conventional design on its head

By PETER WRIGHT



Throughout the history of motorsport car designers have occasionally stuck their necks out and produced a racecar that bucks all the trends of the day, redefining what a racing car could be. Notable examples include:

- Jim Hall – high wings and fans
- Colin Chapman – skirted ground effect; twin chassis; active suspension
- Derek Gardner – four front wheels; to be followed by Williams and March with four rear wheels

There are two factors all these have in common: they all originated before the early 1980s, and they all ended up banned by new regulations because they had the potential to

obsolete all existing racing cars. Powertrains have fared somewhat better, with turbocharging and diesel engines being accepted, albeit with their performance regulated. Maybe this is because their development is 'relevant', while virtually all racing car chassis innovations are not.

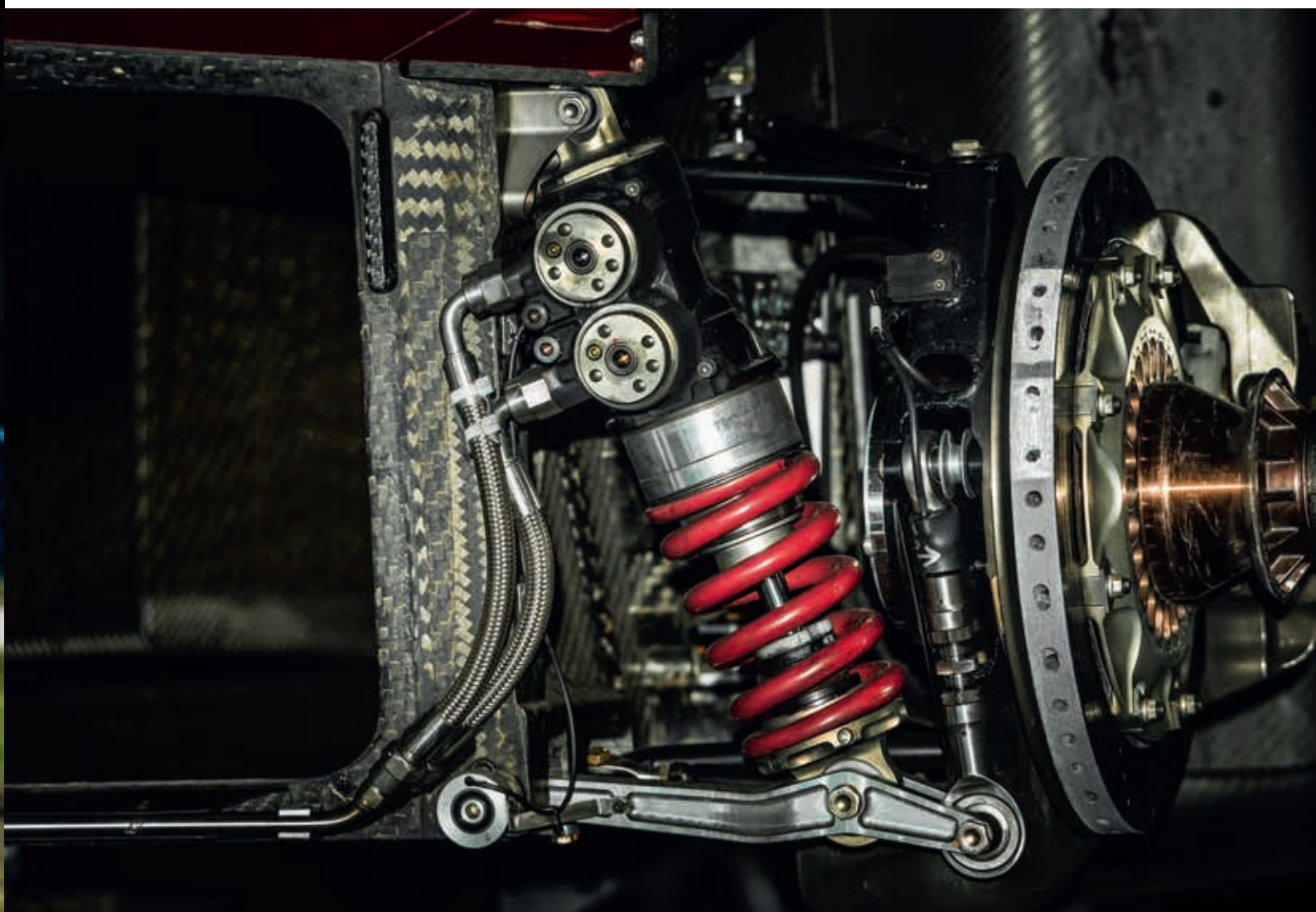
And then, nearly 30 years later, along comes Ben Bowlby and sticks his neck right out, not once, but twice in five years: 'I think I might be slightly addicted to the thrill of laying my head on the block,' he explains.

Bowlby's first attempt, the IRL DeltaWing, conceived as the basis of the IRL's new for 2012 regulations, tore up the existing rulebook. When, almost inevitably, this wasn't accepted, he was so committed to the concept of halving the energy

needed to go racing competitively that he found the one motorsport niche to showcase the car's performance: a small garage, Number 56, at the far end of the pit lane at Le Mans.

Having proved his point in 2012, he helped Nissan use the advantages of such a concept to perform the first all electric lap of Le Mans with the Nissan ZEOD RC. Part of the deal between Nissan and the ACO was that they would come back to Le Mans with an LMP1-H car in 2015, and in doing so Bowlby gained another opportunity to feel the thrill. Nissan isn't in this for the thrill of course, yet it has put its head alongside Bowlby's, and it has done so based on what it learnt in their two Garage 56 sojourns.

I doubt that Nissan would have built the car if the simulations didn't show its potential to be competitive at Le Mans



There will be a huge demand placed on the front suspension as the GTR LM NISMO is deliberately front-heavy; the engine, gearbox and radiators are all ahead of the windscreen

‘As with most things in motorsport, the car is an artefact of the rules’

Where, before the 1980s, normal racecar concepts often ended up being built because they could not be simulated accurately with the technology of the day, more recently many an idea that may have looked good on paper fell-over in the computer. In 1991 at Team Lotus, we looked at a diamond wheel layout, with three-wheel drive (yes, it was perfectly legal), lots of tyre, and active suspension. Put to the test in simulations, it didn't work out, mainly due to aerodynamic reasons.

Forward thinking

Bowlby has all the best simulation and CFD tools at his disposal to allow him to prove his concepts prior to cutting metal. Many people who should have known better rubbished the DeltaWing and were then proved wrong. Many of these same people are sceptical about Nissan's GT-R LM NISMO, with its front engine, FWD and narrow rear tyres, but I doubt

that Nissan would have built the car if the simulations didn't show its potential at Le Mans. Bowlby says: 'As with most things in motorsport, the car is an artefact of the regulations. We studied Le Mans and believe that we need a car with high top speed and exceptional stability and driveability. It needs a huge operating envelope so that the drivers can drive the car without errors in all weather conditions.

'A car that is quick in the corners leads to frustrated drivers who make risky moves to overtake, because they have too much corner-speed. A car that is fast on the straights makes overtaking and driving far easier.'

Le Mans has few low speed corners (three first gear, four second gear); several high-speed corners (one third gear, three fourth gear) and the rest of its 8.5 miles are straights. The key question is whether what it gains on the straights outweighs what it loses in the corners and accelerating out of them. And that is all



Engine is an even-firing, smooth-running, low vibration V6 and has been designed specifically to allow Nissan to compete at Le Mans



Above: The bottom half of carbon fibre tub has a distinct V shape to increase the volume of air passing through the car

Left: The GT-R LM Nismo's engine is based on Cosworth's unraced direct injection 1.6-litre unit originally designed for F1

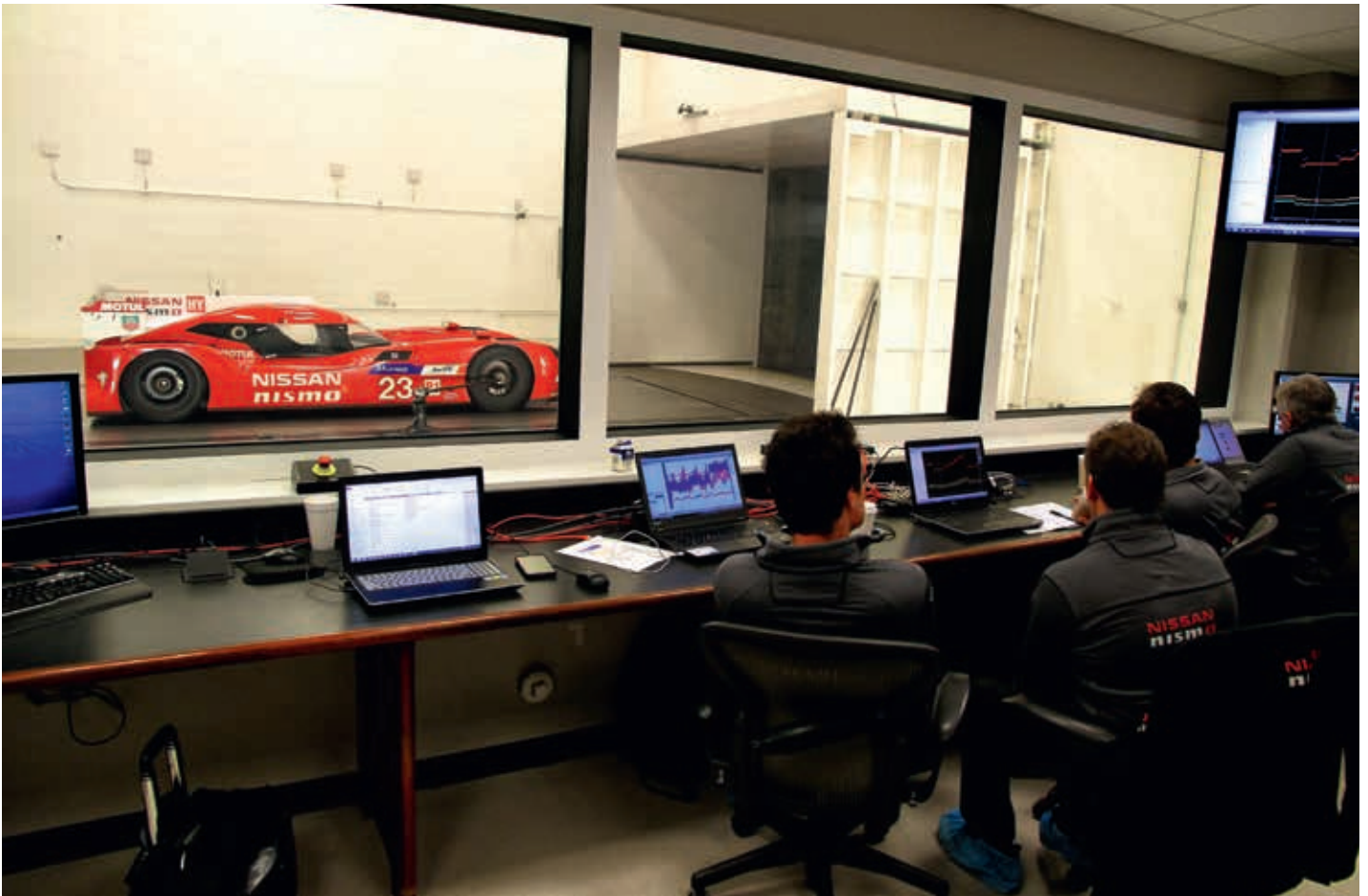
9-inch rears (although at Sebring in March the team tested more traditional 18-inch wheels to accommodate larger brakes). The total tyre tread/tonne is around 17 per cent less than if the maximum width 14-inch tyres had been used all around (it is much more complicated than this simple parameter), and Bowlby acknowledges: 'This is not necessarily a good thing as we will stress the tyres more. We are about where we want to be for Le Mans; it is a compromise. We expect big developments from Michelin; for instance, so far we have not had any wet tyres, so we have run on slicks in the wet, without major problems, thanks to the stability.'

The configurations should certainly work once the speed and aerodynamic downforce is high enough for the car not to be traction limited, and this is the reason why it is a Le Mans car and may not work elsewhere. The team withdrew from the opening races of the WEC so we won't see their potential until Le Mans in June. The simulations indicate that this trade-off works at Le Mans and provided they are validated, the success of the car is likely to centre on the question of stability and control. Bowlby has made it clear why he has put so much emphasis on stability, a quality that the drivers of the Le Mans DeltaWing remarked upon. A stable car by definition returns to its trimmed state when disturbed. The problem with this is the high control forces and moments needed to move it from one trim state to another, such

down to the tyres and aerodynamics, both of which are areas which can be simulated.

The artefact in the regulations that led Bowlby to put the engine and primary drive at the front is that the relatively unlimited diffuser allowed at the front has a better L/D than the highly regulated rear diffuser and rear wing. By designing the car to gain everything it can at the front – hence the large through ducts that exhaust the front diffuser to the back of the car, utilising the low base pressure there that is normally employed by the rear diffuser – the car's overall L/D is maximised. This leads to a forward aerodynamic distribution, and the weight distribution of 65 per cent front and 35 per cent rear, follows. It becomes logical to deploy the majority of the power through the heavily loaded front tyres, and the tyre sizes can then be determined: 14-inch front and

When power is removed from the driven front wheels their cornering power increases, which destabilises the car on entry to a corner



The radical GT-R LM NISMO has been designed with straight-line speed and driver usability in mind, though the front engine and forward bias will also help with its energy recovery

as getting the car to turn in. With cars, because the control force generators – the tyres – are also the main force generators, once they are generating maximum cornering force there is nothing left to generate control forces. This leads to mid-corner understeer and so the driver must resort to using the throttle to change the attitude of the car.

That wonderful pilot's aircraft the Spitfire, an F1 aeroplane if ever there was one, exhibited very high pitch and yaw stability, but also had very large and powerful controls. Because the elevators, which generate the pitch forces and moments used in turning, were separate from the main force-generating wing, the pilot could put in powerful control forces that changed the trim of the aircraft, and the stability prevented overshoot. This is what made the Spitfire such a pilot's aircraft, and such a superb gun platform.

Nowadays, fighter aircraft gain their manoeuvrability by being unstable, but are unflyable without artificial stability built into the fly-by-wire system. Such solutions are no longer permitted on racing cars, although they are now widely employed in road cars.

A precisely manoeuvrable racecar demands low stability and a highly skilled driver. This is

why the greats such as Michael Schumacher desired cars with powerful front ends, while they would look after what the rear end did.

Whether Nissan has the right stability/control balance throughout the operating envelope (low/high speed, turn-in, mid-corner, exit) is, I would guess, a major part of the development testing, and there is not much experience with such a high-powered FWD car.

Safety first

While much of the problem centres on the front axle, suspension, tyres and the likes, the rear is just as important. With so much mass at the front, lateral load transfer could easily overload the hard working outside tyre. This can be relieved by high rear axle roll stiffness, normally undriveable for traction. Bowlby explains:

'We have seen the car performing Touring Car antics with its inside rear wheel. Torque connection between the rear wheels will also stabilise the car, potentially during drop- and trailing-throttle. When power is removed from the driven front wheels their cornering power increases, which destabilises the car on entry to a corner. Rear wheels locked together, as with a spool, provides yaw damping. Quite what

arrangement of rear drive, differential and so on ends up on the car in 2015 is unclear. Bowlby says: 'The KERS Torotrak-Flybrid system is late and not yet developed, therefore in 2015 we will run as FWD only, in an energy class lower than the maximum 8MJ.'

One or two comments have been made about aerodynamic lift-off safety of the GT-R LM NISMO in the event it spins at high speed. But Bowlby is confident that his design has good primary safety. 'The car has a huge aerodynamic stability margin based on its basic layout, which helps prevent spins. We have even tested it! We had a front suspension problem at 300kph at COTA while testing. The car collapsed onto the plank at the front, equivalent to a tyre blowout. No problem, the driver was able to bring it to a halt without losing control. In this respect I would take on our car in a tyre blowout contest,' he says.

So far the team has achieved reasonable reliability and is keen to see how it races at Le Mans. Others have described the design as: 'Brave, but risky'. The last word goes to a driver of another LMP1-H car: 'If the car wins, all the other LMP1 designers will have to resign for not having thought of it first.'



The success of the car centres on stability. The key question is whether what it gains on the straights outweighs what it loses in the corners

Back to front

We crunch the numbers to discover why Nissan's LMP1 GT-R actually makes perfect engineering sense

By DANNY NOWLAN



With the engine at the front, and the centre of gravity further forward than normal, it is possible to generate a huge amount of downforce

One of the great things about what I do is that I am surrounded by high quality people who won't hesitate in telling me I am wrong. When the Nissan GT-R LM NISMO was released in February I took one look at it and thought to myself; you have to be kidding me. Part of that comes from race engineering a high downforce front-wheel-drive Time Attack car, so I know up close and personal what limitations a front-wheel-drive car faces. Then I had a 30-minute chat with a good friend of mine who has been involved in the peripheries of this project, and this is what we'll be exploring in this article.

While they may seem counter-intuitive at first, there are sound engineering reasons in the configuration that Nissan has selected for the LMP1 car, so we'll start by comparing a standard LMP1 car with it's Nissan LMP1 equivalent. We'll

then run some simulations with ChassisSim to fill in the details. This won't be an in-depth analysis, but the numbers will speak for themselves.

The first stroke of genius with this car comes as a direct result of the layout and what you can do at the rear of the car. To illustrate this clearly let's take a look at this rough schematic of the car that is presented in **Figure 1**.

Yes, they have given themselves some huge mechanical and packaging headaches by choosing to run a lot of power and steer through the front wheels. Additionally, they then have to package a driver, which also generates a greater yaw inertia. However, the true genius of this thing is at the rear. Ordinarily for a mid-engined rear-wheel-drive car you have to pack an engine with a bell housing, powertrain and double wishbones, and then all of a sudden you have some major packaging headaches because you

also need to fit things like a diffuser and KERS system inside. Here is where the Nissan has two trump cards to play.

Firstly, as it is front-wheel-drive you have considerable wiggle room at the back of the car which will help the aero. What this means is that you are not hamstrung the way you are with a conventional mid-engined car. Consequently, you have a lot of flexibility in fashioning the rear of the car to help the aero, which is going to help in generating downforce.

The other thing this brings to the party is it allows you to fit a rear-wheel-drive KERS system in the car which you can position anywhere you want. Nissan has disconnected this element for now, but my simulations are for when the car works as designed. If you will recall my articles on electric powertrains (RCE V24 N10), the beauty about electric engines is that they package up

really nicely. You have much greater freedom to locate the battery pack where you want. While batteries are heavy, the upside is that you have a great ballast tool. This, when combined with energy recovery strategies, means you have a lot of tools to dial in when it comes to deciding what you want the chassis to do.

Let's now use ChassisSim to flesh this out. We will run simulations of a standard LMP1 rear-wheel-drive car with KERS and a Nissan GT-R LM equivalent. The highlights of the car configuration are presented in **Table 1**.

Apples versus apples

For the purposes of this article the downforce will be the same as I want to get a like-for-like comparison. In terms of the KERS, this will discharge every straight and our simulations will be based on the full Le Mans circuit.

Our initial lap time comparison shows the conventional LMP1 car is quicker. At Le Mans the standard LMP1 car had a lap time of 3:31.85s and the Nissan GT-R LM had a lap time of 3:35.8s. A lot of this is due to the fact I don't have front-wheel-drive KERS hooked up in ChassisSim in basic analysis mode, although at this point I'm not too worried because there are some base comparisons we need to make first. The first thing to observe is cornering – see **Figure 2**.

The standard LMP1 car is coloured while the Nissan GT-R LM is black. Looking at the first trace the speed carried into the corner and the mid-corner is very similar. However, the Nissan LMP1 suffers a bit more understeer meaning it can't get into the corner as fast. Where the Nissan loses is turn exit where it simply can't get the power down. A comparison of the time analysis shows this is costing about 0.15-0.2s a corner. Again, there are no huge surprises here.

However, the devil is in the detail. One of the channels that ChassisSim returns is the maximum available longitudinal force available from all four wheels. **Figure 3** shows what's happening at the rear wheels.

I would draw the reader's attention to the bottom traces which show the available longitudinal force at turn exit. At a speed of 157km/h we have an available longitudinal force of 710kg per rear tyre. **Equation 1** shows what effect this is having on the available power.

What this means is that we have a potential 606kW on tap at the rear. In reality the figure will be much less than this because the rear tyres have to corner as well. Let's just say, for the sake of the argument, that you can use 300kW of power from the rear tyres. If KERS is used in the right way it will effectively act as a turbo boost. It's worth pointing out that 300kW is effectively 75 per cent of your engine's power – this is money for nothing and effectively cancels out the current losses we viewed in **Figure 1**.

When this was implemented in the simulation it significantly improved matters. The revised lap time was a 3:32.1s lap and a corner snippet is shown in **Figure 4**.

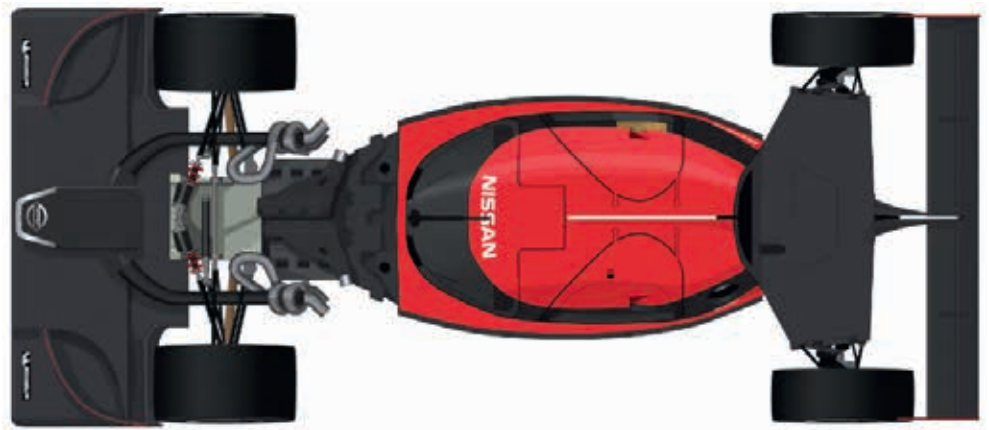


Figure 1: A rough schematic of the Nissan GT-R LM which serves to show the standout features of the radical concept

Table 1 – Comparisons of a standard LMP1 car to the Nissan GT-R LM equivalent

Parameter	Standard LMP1	Nissan LMP1 GTR
Drive	RWD	FWD
Weight distribution	47%	55%
KERS	RWD	RWD
KERS discharge limit	200 kW	200 kW
Engine power	400 kW	400 kW

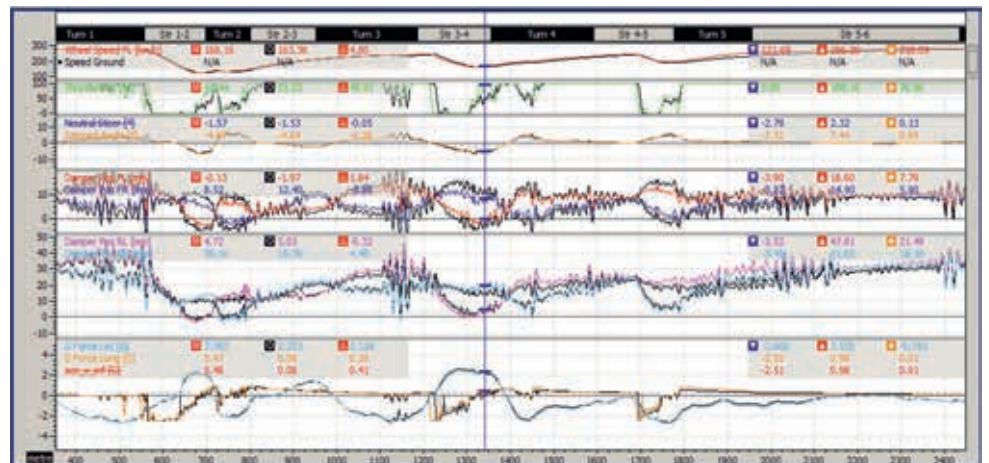


Figure 2: A comparison of medium and low speed corners, where the standard LMP1 is coloured while the Nissan is black

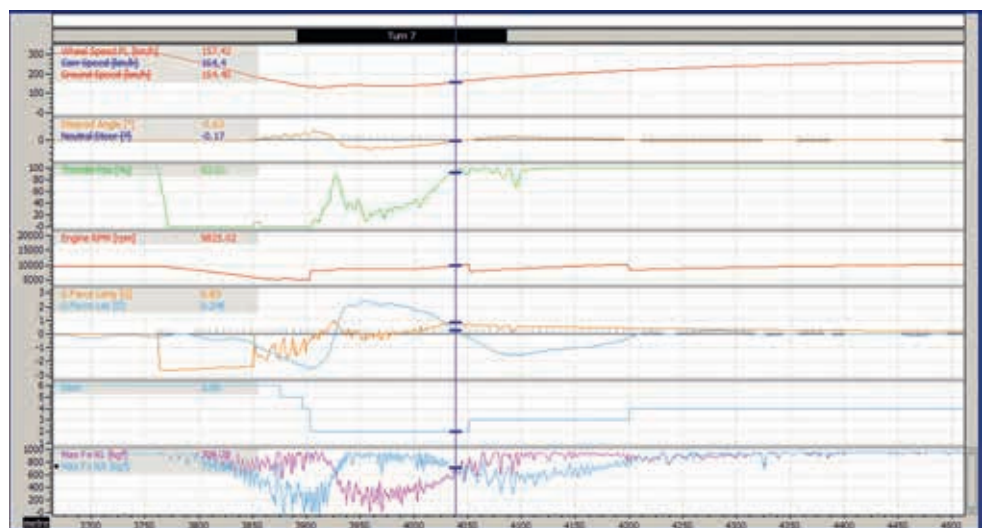


Figure 3: Plot of maximum available longitudinal force at the rear of the Nissan GT-R LM

EQUATIONS

Equation 1

$$P_A = (157/3.6) \cdot (710 + 710) \cdot 9.8 = 606kW$$

Equation 2

$$\begin{aligned} x_{cg} &= \frac{\sum m_i \cdot x_i}{\sum m_i} \\ &= \frac{850 \cdot 1.2 + 150 \cdot 3}{850 + 150} \\ &= 1.47m \\ \therefore wdf &= \frac{3 - 1.47}{3} = 0.51 = 51\% \end{aligned}$$

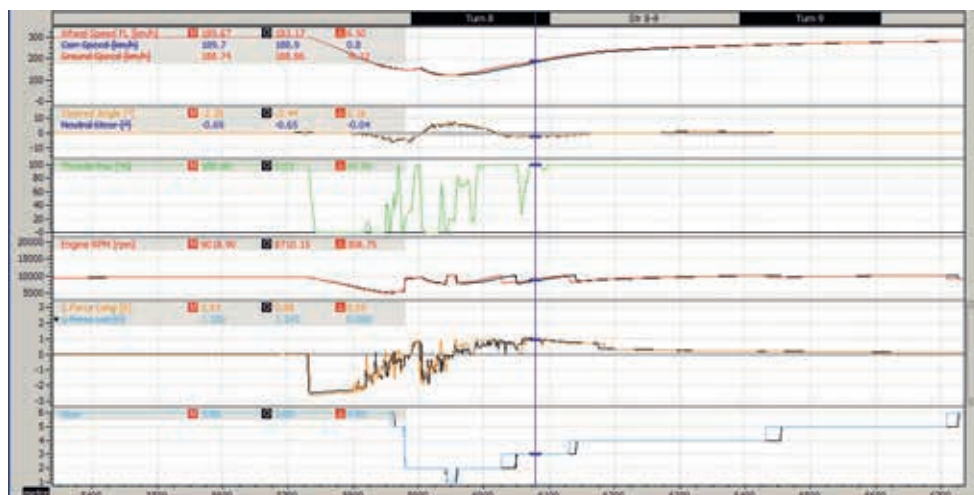


Figure 4: Revised corner snippet For KERS being applied at the rear of the Nissan GT-R LM versus the standard LMP1 car

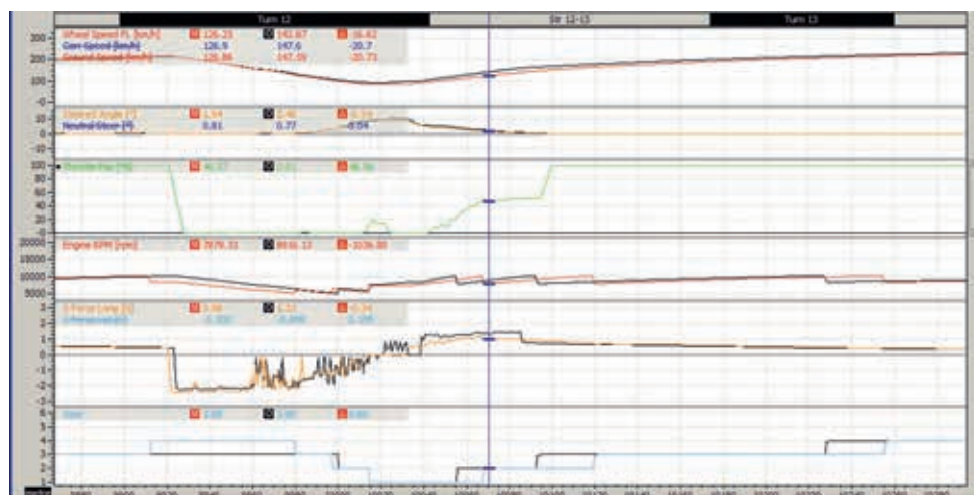


Figure 5: Nissan GT-R LM with 300kW discharge compared to a standard LMP1 car

Table 2 – Limit calculation numbers

Parameter	Mass	xlocation
Car without battery	850kg	1.2m
Battery pack	150kg	3m

Again, the coloured trace is the standard LMP1 car and the black trace is the Nissan LMP1. Looking at the first trace we are paying a little bit for front-wheel-drive due to the increased weight distribution. This means we suffer a little bit getting the car into the corner. However, the longitudinal G traces are very interesting. We have now recovered most of the longitudinal acceleration and in some cases we are better. When looking at the returned longitudinal forces during the simulation it is clear that the limiting factor is our discharge rate.

To explore this further, the simulation for the Nissan GT-R LM was run with the discharge set at 300kW. Before you all say this is rather arbitrary just remember that for a rear-wheel-drive car we already need to transmit 400kW of engine torque. Even assuming the KERS is split 50/50 we are now asking the rear tyres and drivetrain to take 500kW. This is right on the traction limit of the tyres, but more importantly we are subjecting the gearbox and rear axles to an extra load of 20 per cent. Running this simulation we are now looking at a 3:31.8s lap time and the plot is shown in **Figure 5**.

Head-to-head

The trace for the standard car is coloured and the Nissan LMP1's is the black. Look at both the speed and longitudinal G trace (the first and fifth trace). It can clearly be seen that both the speed and the longitudinal G of the LMP1 GT-R is significantly higher than the baseline, particularly at turn exit. In acceleration we are talking 1.3g versus 1.0g for the standard LMP1 car. This is really promising. We are now head-to-head with the standard LMP1 car.

To complete this analysis let's now reset the KERS limit on the Nissan GT-R LM to 200kW and move the aero balance forward five per cent to bring the aero balance into line with the weight distribution. Running this results in a revised lap time of 3:30.7s, meaning we are now quicker than the standard LMP1 car. An example of the simulation is shown in **Figure 6**.

Again, the trace for the standard LMP1 is coloured and the black trace is the Nissan. As can be seen from the speed and steering traces (first and second traces) any semblance of understeer has well and truly been tidied up, allowing the Nissan to make good use of the KERS at the rear to get the jump out of the corners.

As a final sanity check it would be prudent to cross reference how far back we can put the racecar's centre of gravity. We are doing this to make sure the numbers are obtainable, so let's calculate a limit centre of gravity based on the assumptions as outlined in **Table 2**.

The xlocation is measured from the front axle and we are assuming a weight distribution of 60 per cent on the front axle without a battery pack. Calculating the centre of gravity location longitudinally we see **Equation 2**. As shown in the table, the centre of gravity limit is 51, which is comfortably within our limits.

The reason the Nissan is quicker than the standard LMP1 car is a combination of two factors. Firstly, as the rear tyres on a front-wheel-drive car typically don't do very much, we can utilise this for improved power out. This, when combined with moving the aero balance forward, dialled out the understeer that we would experience with a front-wheel-drive car. Effectively what Nissan has done here is to package an all-wheel-drive car, and this is the true genius of this layout. This, when combined with the aero advantages we discussed earlier, should, eventually, make the car a serious contender. At the time of writing there are reliability issues that need to be sorted out with the Nissan GT-R LM, but with something as ambitious as this that is to be expected.

However, as a final bit of this analysis let's consider the case where the Nissan GT-R LM weight distribution is at 60 per cent. When the analysis was done the predicted lap time was a 3:34.0s lap, and a segment of the lap comparison is shown in **Figure 7**.

An important disclaimer

Looking at the speed trace the big thing we are paying for here is understeer. As can be seen this is effecting our cornering and turn in speeds, however I must point out that these results come with an important disclaimer – we have effectively taken an existing LMP1 model and added a front-wheel-drive model, so the front tyre model isn't optimised for this weight distribution. Consequently, this simulation result has to be taken with a pinch of salt. However, it is a risk that must be mitigated for.

In my opinion the weight distribution for the Nissan GT-R LM will head to 55 per cent on the front axle. The first key reason is that once you head north of a weight distribution of 60 per cent you are asking the front tyres to do way too much. This includes steering and power down. This can be offset by tyre design but it is an inherent limitation I've seen time and again. Also, anything north of 55 per cent and you start to press the mechanical and structural limits of the car. I've been up close and personal with both of these factors. Also, as we have seen from our simulation results, it didn't take terribly much to get our P1 GT-R at 55 per cent weight distribution to be quicker than its standard LMP1 counterpart. That in itself is telling you something, but again it's just my opinion.

The Nissan GT-R LM could present a serious challenge at next year's Le Mans if they get the rear-wheel-drive working. As the simulation work shows, the combination of front-wheel-drive and rear-drive KERS has key advantages. This, combined with the aero and weight distribution packaging, means that Audi, Toyota and Porsche will have serious company.

As for Le Mans 2015, it will be worth watching as both a driver and an engineering contest. This is something our business has sorely lacked for a long time.

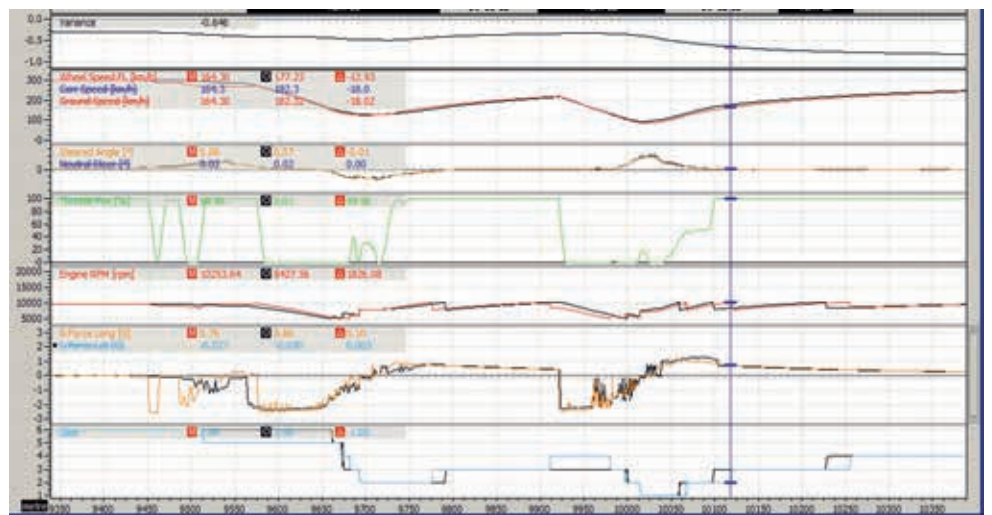


Figure 6: Nissan GT-R LM with an aero balance of plus five per cent versus the standard LMP1 car

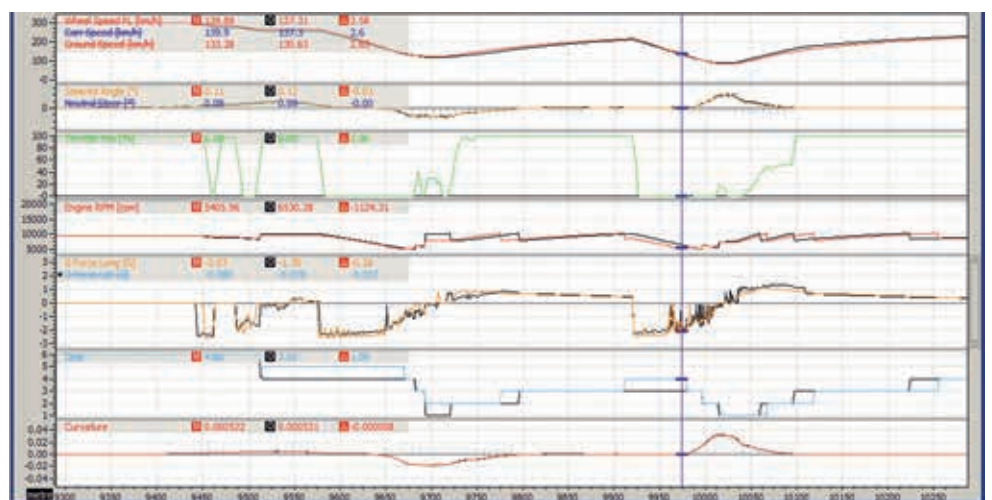


Figure 7: A comparison of the standard LMP1 to the Nissan GT-R LM with a weight distribution of 60 per cent

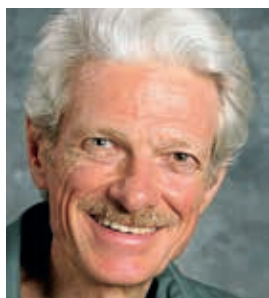
Update

The Nissan GT-R LM did not take part in the WEC pre-season test, called the Prologue, or either of the opening two races at Silverstone and Spa due to development issues.

Reports claim that this was because of problems relating to the interaction between the hybrid system on the car and its brakes. Larger wheel sizes have been trialled at a test in Sebring in order to accommodate some larger brake discs.

The GT-R LM finally made its debut at the Le Mans test at the end of May. Turn to P8 to find out how it fared.

As the rear tyres on a front-wheel-drive car typically don't do very much, we can utilise this for improved power out



Can front wheel drive compete at Le Mans?

Our man considers Nissan designer Ben Bowlby's calculations

Question

It would be interesting to hear your thoughts on the Nissan front-wheel-drive LMP1 car. Is this mainly for marketing reasons? Or is it to take advantage of the aero rules?

The consultant says

Peter Wright has a very good article about the car in this *Racecar Engineering Le Mans* supplement based on his discussions with the car's designer, Ben Bowlby (P16).

Evidently, the idea is indeed to take advantage of the aero rules. I don't think Nissan intends to promote front-wheel-drive, as they are not really more associated with that than any other manufacturer. However, the car does stand to have a marketing advantage of sorts, simply because its unusual design will always attract attention.

Of course, it does no good to attract attention and then fall flat on your face. This isn't a show car – it's a car that has to work, and making it novel doesn't get the job done.

So what is the functional logic of the design? And does it make sense?

This car is about the aero rules. The existing rules strictly control the design of rear wings and diffusers, and are more lenient on front

diffusers. The thinking, presumably, is that the rear downforce automatically limits the front downforce, because if the designer creates too much front downforce with respect to the rear, the car will be aero-loose: it will have high-speed oversteer unless its suspension is set up for understeer, in which case it will understeer excessively at low speed. So any attempt to increase total downforce by increasing only front downforce will be self-defeating.

To get an acceptable understeer gradient at all speeds, the drag and lift forces on the car must add rear tyre load at a greater percentile rate than they add front tyre load. With rear-wheel-drive, we need an extra dose of this because in constant-speed cornering at high speeds the rear wheels are using a large portion of their traction circle or performance envelope for propulsion, and they have less grip available for lateral acceleration. With front-drive, we have a similar effect for the drive wheels, but they're at the front.

In simple terms, the centre of lift/downforce needs to be behind the centre of gravity – more so with rear-drive than with front-drive. If the centre of gravity is further forward, the centre of lift/downforce can also be further forward. If the rules limit rear

downforce but not front downforce, then a nose-heavy front-drive car can have more total downforce without being aero-loose. More downforce; more grip; faster corner speeds; all the requirements for a car to win races. The kicker is that this advantage has to be big enough to trump the considerable disadvantages of front-drive for a racecar.

The fundamental problem is that rearward load transfer under power works against us with front-wheel-drive. The car is therefore at a disadvantage for forward acceleration, up to the speed where it becomes power-limited rather than traction-limited.

To minimise this disadvantage, front-drive cars are always made nose-heavy – typically from 58 to 62 per cent front. They also have equal size tyres front and rear. The result is that they invariably understeer, even when set up to corner on three wheels.

I read in the article that the NISMO is even more nose-heavy than that: around 65 per cent front. However, the front tyres are much wider than the rears. The car reportedly does still corner on three wheels at times, at least in the lower speed ranges where downforce is moderate. That's as it should be and it helps the inside front tyre put power down. So Bowlby has got the tyre sizes and roll resistance distribution right. That will definitely help.

He has also got the wheelbase right: he's made it unusually long. That reduces the rearward dynamic load transfer under forward acceleration. The car therefore has the two main characteristics needed to minimise the disadvantages of front-wheel-drive. Despite this, the car will still have less of its weight on the drive wheels dynamically than a rear-engined car when powering out of low-speed turns.

The other big drawback of front-wheel-drive is that the necessary nose-heaviness is a disadvantage in braking. The front wheels have to do most of the work. Due to load sensitivity of the coefficient of friction, the tyres tend to deliver less rearward acceleration when they are worked less equally. However, when the front tyres are bigger than the rears, the situation is not so bad.

The tyres are only one limiting factor in braking, with the other main factor being

Bowlby has got the tyre sizes, roll resistance distribution and wheelbase right



Nissan's GT-R LM NISMO racecar features a weight distribution of at least 65 per cent front, and 35 per cent rear

the brakes themselves. It is easier to keep the brakes alive if they share the work fairly equally. If the front brakes have to do most of the work, they have to be awfully good to survive an endurance race.

Now, all of the foregoing assumes that the front-wheel-drive car has similar aero properties to its rear-drive counterpart. But what if the front-drive car has a lot more total downforce? Won't it then be capable of outbraking the rear drive alternative?

Answer: yes, at least in the upper speed ranges – provided the front brakes hold out.

Nissan's design team has run simulations that it says support the team's decisions. I can't say whether that's true or not, but I can do simple maths. Let's run some quick numbers. These won't necessarily exactly represent

Front brakes need to do only about 55 per cent of the work, but it's a lot more work. Also, if the car has constant brake bias, this will need to be close to 65/35 to avoid rear lockup in lower speed ranges. Car is decelerating at 3.75g.

Case #4

Front-drive car as in #2, but with same downforce and drag as #3, except downforce distributed 60/40

$.5W/8 = 6.3$ per cent W rearward load transfer due to drag

$1.5(.60)W = .90W$ added to front

$1.5(.40)W = .60W$ added to rear

Rearward force at contact patches = $2.5(1.3)W = 3.25W$

Forward load transfer = $(3.25/8)W = 40.6$ per cent W

Front normal force = $-.650W - .063W + .900W + .406W$

= 1.89W

Rear normal force = $.350W + .063W + .600W - .406W = 1.19W$

$1.89/2.50 = 75.6$ per cent dynamic front

$1.19/2.50 = 47.6$ per cent dynamic rear

Front brakes need to do about 77 per cent of the work if the car has active brake bias control. If not, they still need to do about 85 per cent to avoid low-speed rear lockup.

As in #3, car is decelerating at 3.75g.

Case #5

Front-drive car as in #2 and #4, but now let's suppose that we have the same rear wing and diffuser as in #3, and we get 60/40 downforce distribution by adding front downforce. Let's suppose that the added front downforce acts slightly forward of the front axle, so that net rear downforce is slightly diminished, even though the rear wing and diffuser are making the same forces. Let's also suppose that both have a similar lift/drag ratio. We now have 2.5W downforce total, 1.50W front/1.00W rear, and .8W drag. That's a lot more tyre loading, so let's suppose that $\mu_x = 1.25$.

$.8W/8 = 10.0$ per cent W rearward load transfer due to drag

$2.5(.60)W = 1.50W$ added to front

$2.5(.40)W = 1.00W$ added to rear

Rearward force at contact patches = $3.5(1.25)W = 4.38W$

Forward load transfer = $(4.38/8)W = 54.7$ per cent W

Front normal force = $.650W - .100W + 1.50W + .547W = 2.60W$

Rear normal force = $.350W + .100W + 1.00W - .547W = .90W$

$2.60/3.50 = 74.3$ per cent dynamic front

$.90/3.50 = 25.7$ per cent dynamic rear

This hypothetical car is decelerating at 5.18g! It will clearly outbrake the rear-engined car with the same rear wing and diffuser – provided we can keep brakes and tyres under the thing, and provided the driver's

eyeballs stay in his skull. It will also out-corner the rear-engined car, except perhaps at low speeds

Again, these are hypothetical examples, presented to illustrate general principles. But it should be apparent that, at least in theory, the front-wheel-drive approach does make sense if it buys us a big total downforce increase.


I am reminded of another great exercise in outside-the-box thinking; the Chaparral 2J 'sucker car' of 1970. It achieved more downforce than its competitors, by using powered evacuation of the underside of the car. It was wickedly fast as a result – but only for a few laps. Then the brakes would quit.

Now we have carbon brakes, which didn't exist in 1970. Will this technology make it irrelevant whether the rear brakes do a

substantial amount of the work? Will it mean that tyre grip is now the only thing limiting braking? I guess we'll find out.

Is the NISMO uniquely suited to Le Mans, and will it be uncompetitive elsewhere? Actually, I would expect that in its current state, the Le Mans circuit is less suited to this car than it would have been years ago as lots of chicanes and have been added. There is now much more low speed braking and forward acceleration in a lap than there used to be.

The sort of track that would really favour the NISMO would be one where a large portion of the lap is spent in high-speed cornering, and there is relatively little need for low-speed braking or digging out of slow turns – a track with a lot of sweepers, like Spa in the old days, or Goodwood. Or Indianapolis – the rectoval part, not the infield part.

One other thing is important to note about the GT-R LM: it was not originally conceived as a pure front-wheel-drive car. The idea is to have a kinetic energy recovery system (KERS) braking and powering the rear wheels. The car will run without that this year because it isn't ready yet. So the car will be an interesting case study in the possibilities and limitations of pure front-wheel-drive, but actually that was not the original design intent. 

CONTACT

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The front-wheel-drive approach does make sense if it buys us a big total downforce increase

reality, but they will be close enough to illustrate basic principles and relationships.

Case #1

Rear-engined car of weight W , at low speed, disregarding any aero effects; 60 per cent rear statically; longitudinal coefficient of friction $\mu_x = 1.4$; c.g. height 1/6 of wheelbase

Forward load transfer = $(1.4/6)W = 23.3$ per cent W

Dynamic normal force distribution 63.3/36.7

Front brakes need to do about 65 per cent of the work, since the car should be set up so the fronts always lock before the rears.

Case #2

Similar to #1, but for a front-wheel-drive car with long wheelbase; 65 per cent front statically, c.g. height 1/8 of wheelbase

Forward load transfer = $(1.4/8)W = 17.5$ per cent W

Dynamic normal force distribution 82.5/17.5

Front brakes need to do about 85 per cent of work.

Case #3

Similar to #1, but at high speed, with serious aero: 1.5W in downforce, distributed 30/70, and .5W drag force acting at c.g. height; $\mu_x = 1.3$

$.5W/6 = 8.3$ per cent W rearward load transfer due to drag

$1.5(.30)W = .45W$ added to front

$1.5(.70)W = 1.05W$ added to rear

Rearward force at contact patches = $2.5(1.3)W = 3.25W$

Forward load transfer = $(3.25/6)W = 54.0$ per cent W

Front normal force = $.400W - .083W + .450W + .540W = 1.31W$

Rear normal force = $.600W + .083W + 1.050W - .540W = 1.19W$

$1.31/2.50 = 52.4$ per cent dynamic front

$1.19/2.50 = 47.6$ per cent dynamic rear

Dome

The Dome S103 is perhaps the last Le Mans Prototype from the extremely innovative Japanese constructor. It should have made its debut at Le Mans last year but production issues and ongoing aerodynamic development delayed its race debut until 2015.

Unlike previous programmes conducted by Strakka Racing, its new LMP2 project sees the organisation play a key role in the car's development. The new car has been designed by DOME at its facility in Maibara, Japan, while the construction of the car, and its marketing, is being undertaken by Strakka Racing at Silverstone, England, so it is named Strakka-DOME S103 in deference to this.

Strakka had hoped to make the car available to customers but the ongoing uncertainty over the 2017 regulations in LMP2 has seen all interest dry up. In fact, the team has announced that it no longer sees its future in WEC but could either race the car in the United SportsCar Championship in the States, or fit a different engine and step up to the LMP1 class using the same chassis — an LMP1 aerodynamic package has already been designed for the car.



SMP BR01

The new car from SMP racing is something of an unknown, having only raced once before arriving at Le Mans.

Designed by Paolo Catone, the chassis appears to be neat and well engineered while the Nissan engine is a known quantity. Surprisingly, the front suspension does not feature a torsion bar layout, but in its stead are two spring damper units, mounted behind the bulkhead and actuated by pushrods.

The SMP BR01 is perhaps just that little bit too new to be a major challenger for LMP2 class honours at this year's running of the Le Mans 24 Hours.

The car will be looked at in detail in a future issue of *Racecar Engineering*.





Pescarolo



The Morgan chassis being used by Pegasus Racing and Morand are in reality Pescarolo 01s, which have been heavily updated over the years by Jacques Nicolet's Onroak engineering company.

It's a well proven and reliable chassis and

one example is powered by a Nissan engine while the other is running an unbranded Judd. Development of the design has essentially stopped and both cars are running in the same specification that the Pescarolos have used at Le Mans for the last few years.

ORECA



Pictured above are the two types of ORECA contesting Le Mans in 2015. Likely to be the faster of the two is the new 05 (top) which is built around the Rebellion R1 chassis. Many of the sub systems in the car's design are very similar to that of the R1 but it uses lower grade materials (steel rather than titanium for example).

The 05 has already proven to be very fast in

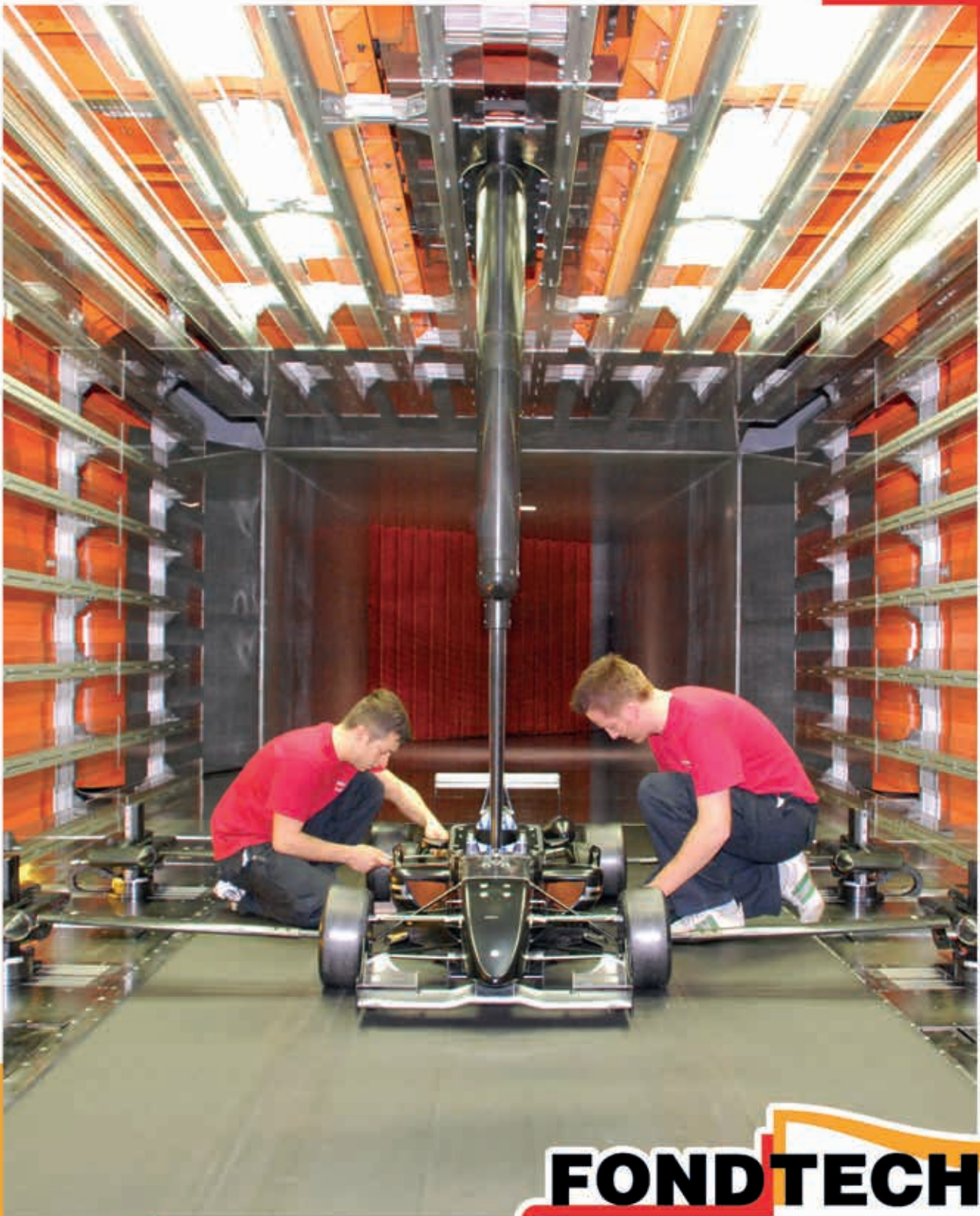
the WEC and ELMS races so far this season, but the teams using it, KCMG and TDS Racing, are both still learning how to get the best out of it. This is the only car in the LMP2 field that is built to the 1900mm 2017 maximum width, the others are all slightly wider. This in theory gives the car a smaller frontal area and a higher top speed.

Meanwhile the Courage LC70 chassis (now

known as ORECA 03) remains one of the best in the field despite its advanced years. Running in low drag 03R spec it is one of the fastest through the speed traps. Ibanez Racing were using it to collect data to aid the design of the 2017 Wolf chassis.

Murphy Prototypes continues with its strong line up and the Signatech car (branded Alpine A450) is also expected to go well.

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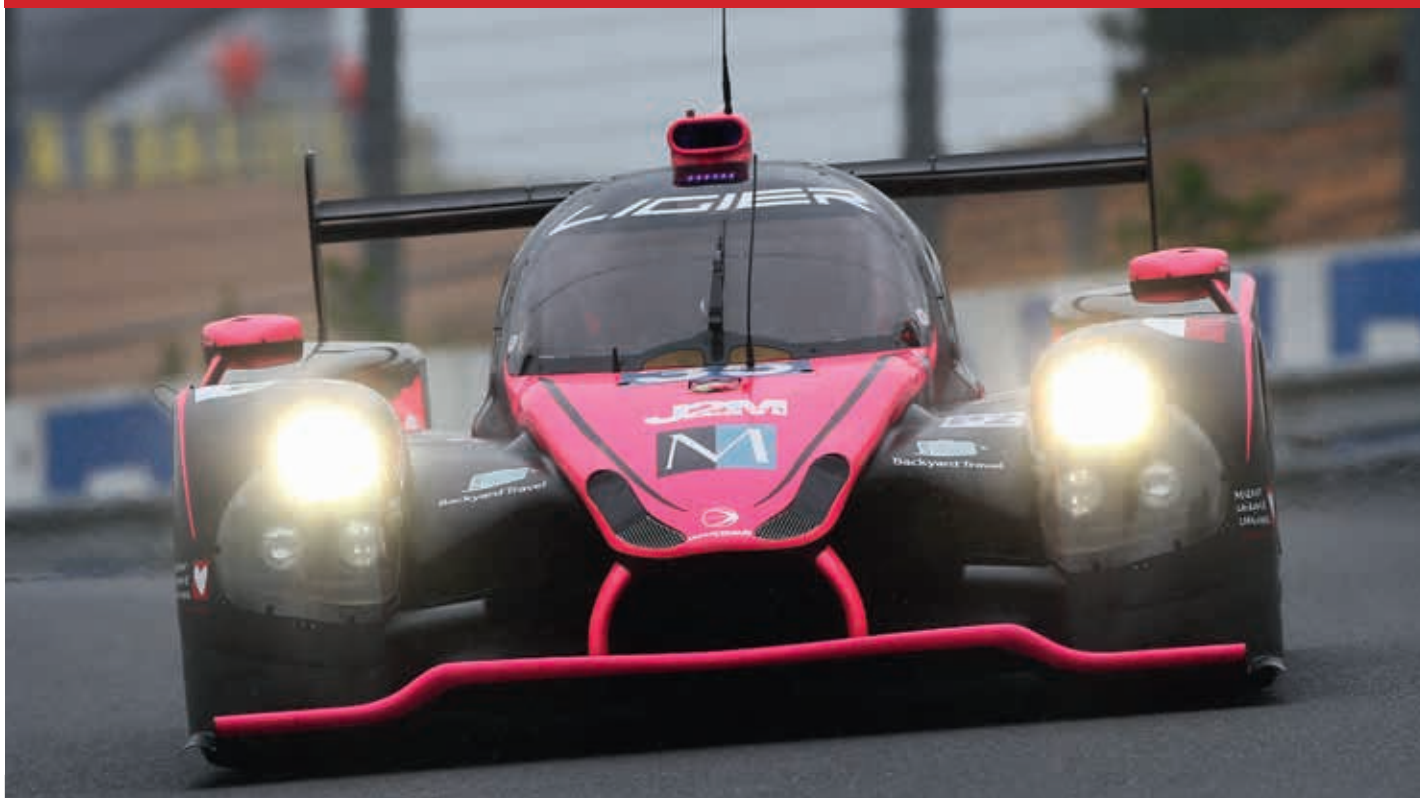
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Ligier JSP2



The Ligier contested Le Mans for the first time last year, but was perhaps a bit too new, and reliability gremlins saw it lose out to some of the older cars in the class.

The car's aerodynamic concept actually sees air flow through it using a concept very similar to

that of the original Audi R15 and in 2015, with a full year's running behind it, the car is now extremely competitive and reliable.

The ESM team has handed back its pair of new HPD chassis in favour of using the Ligier (though it kept the engines), while company owner Jacques

Nicolet's Oak Racing team is running four examples, two under the G-Drive banner using Nissan power and two under the Oak name, one of them using the Nissan V8 and the other Honda's V6. Tracy Krohn's privateer entry is the only Ligier fitted with a Judd engine.

Gibson / Zytek



The Gibson name is new to Le Mans, but its product is not. Bill Gibson's company Zytek was divided and part of it sold off, including

the brand name. So the Zytek 07S chassis are all officially now called 'Gibson', yet this is the exact same design that won the LMP2 class at Le Mans

last year. Greaves Motorsport and Jota continue to run this well proven design, both predictably powered by Gibson-tuned Nissan engines.

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Standing at the crossroads

Proposals for the future of customer prototype racing are being hotly debated

By ANDREW COTTON

The future of LMP2 has been confirmed. One engine manufacturer is to be nominated and four chassis manufacturers will be selected via a bid process to supply the European and Asian markets. The American IMSA organisation is still to outline its plans, but it will remain open regarding engine suppliers as it features LMP2 as its premier class.

Already the bid process has begun and several teams have opted out (see news), while the favourites to be nominated include ORECA, Onroak, a conglomerate of manufacturers led by Bill Riley, and a fourth manufacturer, believed to be either Ginetta or Alpine. The cars will be faster, and safer, with side impact protection.

At the heart of the proposals, discussed with teams and with manufacturers, is cost-cutting, and in the March World Motor Sport Council meeting representatives green-lighted the

single engine supplier plan. A single ECU, also open for tender, will be used in the European, Asian and American regulations to further help to keep costs under control.

At Le Mans in June, the proposals were confirmed at the official ACO press conference, with the ACO presenting draft figures that highlight the escalating cost of competing in the WEC as an LMP2 team, and its reduction plan. The figures announced suggest that the costs have risen from €2.2m in 2012 to €3.2m in 2016. Under the proposals, the plan is to bring the costs down to €2.8m in 2017.

History making

At Daytona in January, representatives from the major organisations including Bentley, Volkswagen, Ford, Riley and Scott, Mazda, General Motors, Coyote, Wirth Research, Engine Development, Lamborghini, Dallara, Nissan, ORECA, Onroak and HPD met with the FIA, ACO and IMSA to discuss the future of LMP2.

There, the plan was presented that unified the three organisations with a single set of

regulations. IMSA and the TUSCC will allow styling variants to fit with their philosophy, already introduced into the Grand Am series, of having manufacturer styling cues.

While Europe will have a single engine supplier, according to the proposal and subsequent announcement, IMSA teams will have multiple engine specifications, and engines will be balanced by a balance of performance process.

Fierce resistance

The performance targets were set at a 10kph increase compared to current WEC cars, and the engines to produce an extra 50bhp, similar to the current TUSCC performance level. Tyres proposed were GT3/GTE specification and the original proposal was to have a single tyre supplier. Existing LMP2 and Daytona Prototypes would be grandfathered for a year.

This led to an outcry, particularly from manufacturers that had produced cars to the existing formula, including HPD and DOME, whose cars debuted in competition at Daytona in January and Silverstone in April respectively.

'Someone at the end has to be responsible for the package as a whole, not a la carte shopping for bits and throw them together'

LMP2 manufacturers say that there is enough diversity under current regulations and question the need for change



says HPD's Stephen Erikson of the proposal for multiple manufacturers to produce the US car. 'When we signed up for this next generation P2 car, we understood that it would be a six-year car; three years, a small adjustment, and then another three years so your investment is secure for six years and the maths suggest that is fine. All of a sudden it is three years, and one of those is grandfathered, so that has turned things on their head, and I don't understand. When you look at how many cars are out there now, and even not out there now but are planned or discussed, what are we doing changing? It is

on December 15. The first cars will debut in September 2016, and will race in the following January's Daytona 24 hours.

The powerplant specifications are for a bespoke race engine, with a 90-degree normally aspirated petrol V8 with direct injection, of not more than four litres and at 140kg. The target cost for running the engine is €1300/hour, all-inclusive apart from the electronics. Engines will come with a warranty, maps will be frozen and individual support will be forbidden.

The electronics will be sold to the teams at a cost per kit of €20,000, which includes

any final details because we are still waiting for the final copy,' continued Neveu.

At Silverstone in May, the ACO cancelled a press conference planned for Saturday morning to discuss LMP2 and instead issued a press release that only confirmed the limitation of the number of chassis constructors. However, even this was met with resistance from P2 manufacturers, including DOME which issued a statement confirming that the S103 would be made available to customers.

'The LMP2 category has been one of the great motorsport success stories, and the ACO

'The initial concept is to reduce the technical costs by 20 per cent'

working as it is. I have been advocating since day one that you have a great skeleton. You have FIA crash tested, safety approved monocoques, nose box, crash structure, engines, gearboxes, suspension, uprights. If the important thing is to make the car have a more recognisable reference to production cars, you can do that with the existing car. You don't have to throw it out and start all over again.'

Other chassis constructors with cars unveiled or proposed include BR Engineering and Pilbeam, while Ligier, Gibson and ORECA have cars already in use and competitive in the European Le Mans Series.

Timetable agreed

At a meeting in Paul Ricard at the end of March, a timetable was laid out for the creation of the regulations. On May 1 there was a call of interest for chassis constructors and the spine of the technical regulations was specified. The first selection of chassis constructors will take place in June, post Le Mans, while the tender for FIA/ACO engines and the electronics will take place by July 10. On July 15, the four chassis constructors will be selected and by September 1, the engine and electronics suppliers will be named. Between August and November, the four selected chassis constructors will form a Technical Working Group to form the regulations, which will be published

the engine control unit, gearbox control unit, chassis control unit, logger, steering dashboard switch panel and power box. The proposed rebuild cost is €2000 and it will be mandatory to support series around the world.

After resistance from the tyre companies, including Dunlop, the tyre formula is to remain open in the European series despite a proposal from Hankook to take over the entire LMP2 supply, with marketing spend behind it. That, and a proposal for a single tyre supply in the European Le Mans Series, also cost Pirelli's participation in the series.

'Around the table we have the actors of the LMP2 programme and all the family, chassis manufacturers and engine manufacturers. Private teams are involved in a technical group to find a final proposition for this regulation and the philosophy is to pay attention to the running costs and create a sustainable and good business for the future,' said WEC general manager Gerard Neveu at Paul Ricard in March. 'This is a private team category, we cannot compare with the LMP1-H, so the framework has to be correct to engage for a long-term future of the category because this is in the interests of the ACO, and the last point is to do a harmonisation between the different continents in North America, Europe and Asia to provide a good future for LMP2 worldwide, for the WEC and for Le Mans. I won't give you

is very proud of what has been achieved,' says the ACO president, Pierre Fillon. 'We are in consultation with the manufacturers and the teams to find the best solution for the new 2017 regulations. We must remember that LMP2 is for teams and drivers, it is not a manufacturer category outside of North America, and we must build a sustainable business model for teams, cars and engine manufacturers.'

'Twenty-one engine manufacturers were consulted about the best way to reduce costs and the universal opinion was that the only effective way forward was to have a single supplier. This was recently announced by the World Motorsport Council and the tender process for this will begin in the summer.'

'The initial objective is to reduce the technical costs in LMP2 by 20 per cent [this figure to be confirmed once the discussions within the technical working groups to define the details of the new regulations are finalised] without affecting the quality of the racing and also to build cars that can be raced in America, Europe and Asia. We are going to make sure the LMP2 category provides the best solution for teams and drivers wishing to compete in a Le Mans Prototype in endurance racing for many more years to come.'



Design for the masses

After six years Wirth Research's Coupe has finally hit the track. Yet, with new LMP2 regulations due for 2017, will it ever run at Le Mans?

By ANDREW COTTON

It was six years in the making, but the Wirth Research Coupe finally hit the track at the opening round of the Tudor United Sports Car Championship at Daytona in January, where the HPD ARX-04b was debuted by the ASM team in the 24 hour race.

The car was originally designed as Honda's new LMP1, and a three-year programme was on the cards before the financial crisis hit. Wirth Research continued to develop the coupe concept and it was ready to race in 2011-2012, but the 2014 change in regulations put off interested manufacturers and the project was again shelved. When the 2014 regulations were finally introduced, Wirth and HPD were

working closely together again on the new Indycar programme, and so there was another delay until the two companies started to think once again about returning to the Le Mans Prototype class. They originally planned a full LMP1 programme before Honda made the decision to return to F1 with McLaren. At that time the relationship between Wirth and HPD was strong enough to withstand the decision, and so the two companies started to look at LMP2 possibilities.

'Honda was looking at the hybrid regulations, and we eventually got together again, and they liked the car,' said Wirth Research founder Nick Wirth at Daytona. 'We started down the P1 route

because of hybrid, but it got to the point where Honda was starting to think about F1, and doing two hybrid projects, with different technologies, didn't make sense. The other change that happened was that in HPD's back yard in North America, IMSA came under the NASCAR banner, and then the P1 class was killed off. The reason for HPD to do a P1 car in North America was gone so HPD said "let's look at P2", and that is how it was born. More than any other project, this was a joint project. HPD had a limit on what they felt was right to spend on P2, and we co-invested in it, but I am very proud that HPD decided to take on the project and continue the run of results and championships that we had.'



The 2.8-litre turbo has achieved some great successes, including victory at the Sebring 12 Hours and the 24 Hours of Le Mans

HPD had developed a strong LMP1 engine, but that was put to one side and as the team pursued the LMP2 path, it reprised the 2.8-litre engine that had been used since the ACO introduced the cost-cap in 2011 and the team took time to optimise the installation of the engine into the new chassis which was, as is the Wirth way, designed entirely in CFD before it was validated on the circuit. 'The principle has been proven and we have won championships with these guys,' says Wirth. 'The technology is very stable, it was not on other projects but it is in the sports car, and was a big help in designing a car to the new rules. We are pretty happy with it.'

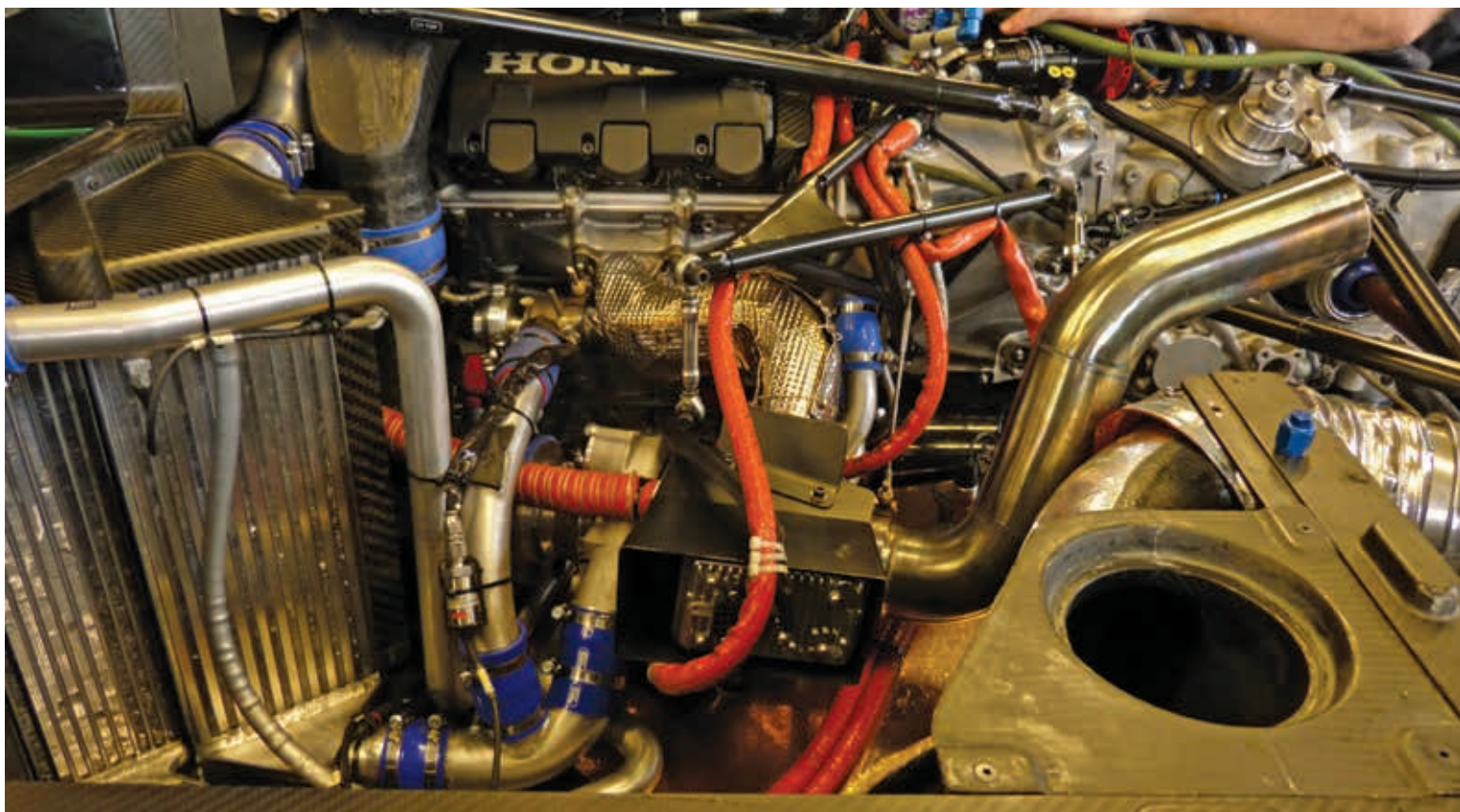
The ARX-04b is fully compliant with the new ACO LMP2 regulations, and exceeds the latest safety standards of the new enclosed-cockpit configuration. The 2.8-litre twin-turbo, direct injection, production-based Honda HR28TT V6 powerplant now includes a regulation compliant drive-by-wire throttle system and fresh air valve system, eliminating turbo lag and providing improved reliability and performance.

'We are very excited for our new HPD ARX-04b LMP2 Coupe to see the light of day, combining all of our successes in international sports car racing with the very latest regulations for closed-cockpit prototypes,' said Steven Eriksen, HPD vice president and COO. 'Our

production-based Honda HR28TT engine has powered all of our LMP2 sports cars since the ACO regulations set the new cost-capped direction in 2011, and since its introduction the 2.8-litre twin-turbo V6 powerplant has achieved some truly great successes around the world – including multiple engine manufacturer championships, victory at the Sebring 12 Hours and the 24 Hour of Le Mans, as well as powering the first LMP2 FIA World Endurance champion.'

The ARX-04b will continue the HR28TT powerplant, developed by HPD from the production Honda "J35" series of V6 engines currently found in the Acura MDX and RLX in North America, in addition to the upcoming





The 2.8-litre twin-turbo V6 powerplant uses more than 400 production parts for improved reliability – the technology is proven and has won multiple races and championships

2015 Acura TLX. The racing engine uses more than 400 production engine parts, including the engine block and heads, crankshaft, direct-injection fuel system, valve train components, drive-by-wire hardware and even the stock Honda oil filter. While there is little else carried over from the ARX-03a, the basic concept for many of the components remains the same. 'We have tried not to introduce new issues,' says Allen Miller, manager and principle engineer at HPD.

The car features a new gearbox having switched to Xtrac's 1059 'box as that was an off-the-shelf component and the team felt that would help to keep down the cost of the car. The paddle shift system changed to Megaline, but the team uses a Shift Tech controller so that it can more easily control the ECU.

Slimline

Walking around the car, the design is more compact than the ARX-03a although the design team has worked to ensure that the car can still be worked upon easily. The front steering rack,

for example, is easily accessible, and although the packaging has been brought closer to the centre of the car, there is still room to make changes where required.

'The upper plenum is flipped around, so the throttle body is now at the back of the bulkhead. It is the same airbox, whether on the Ligier or here, but it is turned around, and we have put a different fuel line to it,' says Miller.

With the production-based engine, weight was clearly an issue. Despite IMSA raising the minimum weight of the car (along with increasing power as part of the balance of performance measures with the Daytona Prototypes), the ARX-04b was still over the 940kg limit and needed extra work to reduce the weight. 'At the end of the year, we started to save weight going to a carbon airbox,' Miller adds. 'We went to the ACO and said we needed some weight off it, there is no performance gain. They upped our power, and then upped the weight to make a balance. This is 940kg, the Ligier is 940kg, so if it has our engine it is 940kg, but the Ligier Judd is 900kg and it is pretty close in performance to where we are. The monocoque has the Zylon panels in the side [to conform to new safety regulations in the LMP classes], and fitting them was a big deal.'

As the team changed both the monocoque and the gearbox, the front and rear suspension have had to be redesigned, although they remain the same in concept. The uprights are more fabricated than previously used on the ARX-03a, and engineering firm Pankl has completed most of the work. The brakes are

carried over from AP due to their reliability, and although the axle design is similar in concept, it too has had to be modified.

With so much time to think about the chassis, from concept to delivery, it is little wonder that the design appears to be both compact and efficient. 'From the chassis side, it was the opportunity, working together, to put the P1 engine to one side, put the P2 engine in there, and see what opportunities we had to optimise the powerplant and chassis to work together,' says Wirth.

'We didn't even carry the suspension over from the P2 project. The P2 project was born from the Acura programme which was competing against Porsche, so we had some quite exotic parts, but we had to get the costs down. The manufacturers of those bits had been working for so long, the tooling costs had gone, and we bought lots at once. Instead of five or 10, we bought 20 to get the unit costs down. In re-doing the suspension, which we had to do because we have a new transmission and a new monocoque, so we couldn't really carry bits over, we have brought those costs down in the design, but tried to keep the benefits of the suspension. This car retails for less than many supercars on the road, and when you look at the technology it is amazing. We are very proud of the engineering in it.'

Good visibility

As the LMP1 and LMP2 regulations allow for the same monocoque to be used, new visibility regulations meant that the cockpit area had to

'This car retails for less than many supercars, and when you look at the technology it is amazing. We are very proud'



The distinctive twin holes in the car's nose channel air straight into the cockpit, saving weight and removing the need to fit an energy-draining air conditioning unit

be redesigned from the original concept. The roof was raised, and attention was paid to the A pillars to ensure that the drivers could see into the corners more easily than had been the case with the old LMP1 cars. Blind spots were reduced, and the HPD has a clever solution to the mirrors, hidden inside the bodywork, yet still able to be seen clearly by the drivers. 'They now don't feel any more hindered than in an open car,' says Miller.

The car has other rather natty design cues, including quick-change bodywork front and rear, and improved airflow through the nose of the car into the cockpit, as the team hopes to avoid having to use an energy sapping air conditioning system. Two holes in the nose of the car funnel air directly into the cockpit to help reduce temperatures, while indents into the bodywork behind the doors provides the exit for increased circulation. The car has also been designed to be low-drag to improve efficiency, and an innovative Honda refuelling safety interlock system is fitted to reduce the potential for pit fires resulting from leaving the pit box with fuel hoses inserted (applied to all IndyCars since 2011).

As part of their after-sales support services, HPD and Wirth will provide teams with technical assistance and bulletins, as well as additional options available for purchase. Bespoke options include driver-in-the-loop simulator sessions, data-logging, race and performance engineering, and MuRiTyre and Apotheca software.

One of the topics of discussion at Daytona in January was the future of the top category. Although it was pretty much written in stone that the category will switch from the Daytona Prototypes that have run since 2003 to a P2 only category in 2017, there seemed to be a challenge to that decision. Full details of the proposed new regulations appear in the news section of this supplement, but HPD had offered its chassis unbranded to other manufacturers to allow them to compete for a reduced entry cost.

DP platform

The whole issue of having a Daytona Prototype in the top class of the TUSCC has been discussed and there is a consensus that a move to a carbon tub car is the safest option available. IMSA has accepted that the cost of carbon cars has reduced significantly since it was last properly considered in 2003. 'None of us are comfortable, if we are doing a new car, to not do something based around a well-researched, crash-tested FIA regulation monocoque and we have a very low cost one,' says Wirth of the possibility of having Daytona Prototypes as the top class in the US. 'We have a roof on, not just for aero, but so that people like Ed Brown would not be worried about getting hit by something. We think that this is an ideal platform on which to build the new Daytona Prototype. It doesn't have to have this bodywork, but that's what we would be interested in going forward. If our customers want to run in Europe they can run the Le Mans bodywork. It gives people options.

'HPD has taken the step to say that if other current Daytona Prototype manufacturers want to have our chassis, they can have it. They can buy it at low cost, and build their own prototype. They can use all the dollars that we have spent in R&D, and have the car. We want the series to prosper. The monocoque is owned by Honda, they bought the IP from us and we developed it, but if someone wanted to re-homologate it, I am sure that is possible if that meant that we could have these cars as a basis. What we like the idea of is that it is reliable, safe, and we understand the technology. Daytona Prototype racing is all about balance of performance. You all go to the wind tunnel, you all get adjusted, it is not like the P2 cars where we are trying to gain an aero advantage. If it makes the series prosper, safe and affordable we are all for it. Chevrolet could come and take the monocoque and rename it a Chevrolet. There is no problem with that. What is the point of Chevrolet spending millions to come up with the same thing as us?' ®

'If other manufacturers want to have our chassis, they can have it. They can buy it at low cost, and build their own prototype'

CORVETTE



Corvette Racing makes a huge deal out of strengthening the relationship between road car and race car, and the C7.R is a case in point. All cars, when they are released, are said to be stiffer and lighter in the chassis department, but Corvette put some figures into the equation, and claims it has saved 90lbs in weight, and increased the stiffness by 40 per cent. The drivers immediately concurred — this car rides the bumps better than

any other that they have driven under the Corvette Racing banner. Much of the C7.R is a carry-over from the C6.R, including the direct injection 5.5-litre V8 engine which is a known quantity and meets all the requirements of the FIA and ACO in terms of rebuild times and costs.

When the car was introduced at Daytona in 2014, the shifting mechanism was improved to speed up gear changes, the suspension was

changed to help with tyre wear, and safety had increased markedly — the car carries a Bosch-developed radar detection system at the rear, which helps the drivers to identify the faster cars, particularly in poor conditions including rain and fog. One other point of interest, the air conditioning system is taken from the Chevrolet Volt.

To read a full feature, go to the digital back issues section on www.racecar-engineering.com

PORSCHE



Porsche has developed tyres specifically for the unusual weight distribution of the 991, and it introduced them at Spa this year. It was a step in the right direction for the team, which has always argued that the regulations should be changed so that it would be able to run different size tyres. Instead, it was allowed to run bigger rear wheels.

Introduced in 2013, Porsche turned up in Bahrain that year with a completely revised car that

took the opposition by surprise. The team was able to introduce one major upgrade in the first two years of the car's life, and did so before the end of the first season of competition. But, it still does not have the direct injection engine that the new GT3 car, launched in May, will feature, and that is a big disadvantage for the team.

At Sebring, a new refuelling system was introduced to the car. With a single filler on the left or right, rather than requiring a breather on the

opposite side of the car. It was a lot of work to route the fuel filler through the chassis at the front of the car, but the team believed that, by the Spa race, the issue had been sorted.

Tyre wear is the nemesis of the Porsche 991, although on top speed and overall lap time it will be able to challenge the top cars in the category. To read the full feature on the Porsche 991, go to the digital back issues section on www.racecar-engineering.com



ASTON MARTIN

It will be 2017 before the Aston Martin V8 Vantage replacement will be introduced, and that moment cannot come quickly enough for the British team. It knows that it has a disadvantage on fuel economy in the six-hour races, although that has been mitigated at Le Mans with a larger fuel tank. It has also been given a larger air restrictor and less weight than it has raced so far this season, was fastest at the pre-race test, and must be considered to be a potential race winner.

That does not make it a perfect car — a lot has had to be done to get the car into that ballpark. The larger air restrictor means higher fuel consumption, the maximum speed of the car is famously low due to a high frontal area — Darren Turner set fastest time at the test, but was 7km/h slower than the quickest of the Corvettes!

The V8 Vantage was allowed to run the exhaust down the side of the cockpit when it was updated in 2013. This was agreed by all teams, but it did

mean that the Aston Martin was therefore able to run with a wider floor area and therefore could produce more downforce.

In 2014 the team partnered with Hanergy and has since experimented with solar panels on the roof of the cars to power the air conditioning system.

To read the full feature on the Aston V8, go to the digital back issues section on www.racecar-engineering.com

DODGE VIPER



Watching the Riley Technologies Viper from the trackside there are a few distinguishing features. The first is the noise, the 8-litre V10 engine blowing out of the side exhaust is pretty noticeable, as is the frankly obscene rear wing that actually sits above the roof line of the car.

The factory pulled the Viper programme at the end of the 2014 season, and Bill Riley continued

to campaign it in the Tudor United SportsCar Championship and then gained an entry to the Le Mans 24 hours. The car runs at 1245kg, along with the Corvette the heaviest in the class. It also runs with a 29.8mm air restrictor and has been given 10 litres more than the 90 litre maximum fuel tank capacity. That puts it in line with the Aston Martin, both racing with 100 litres, although the Aston is 30kg lighter! However, it is the mammoth

rear wing that sets the car apart in the Balance of Performance, 100mm above the roofline compared with, for example, the Aston Martin that runs with it level, and the Ferrari that has to have it 100mm below the roofline.

During the test day the car was nearly 6km/h slower in top speed compared to the AF Corse Ferraris, but was sixth fastest in class, 3.1 seconds slower than the Aston Martin that set the pace.

FERRARI



This is the last year of the Ferrari 458 GT yet, thanks to the Balance of Performance, there is no reason why the now aged car should be uncompetitive against the updated cars such as the Corvette. The mid-engine layout means that the car is nicely balanced over the course of the 24 hours, and that has meant that it is eminently raceable, particularly in the wet. The advantage from its DI engine has been reduced with all cars now capable of running 14 laps on a single tank of fuel. The team developed the car for the start of the 2015 season, but to make the Balance of Performance work properly, the teams have had to bring precisely the same cars as they had at Le Mans in 2014. Items such as improved wheel-nuts have therefore had to be discarded for this event only.

The new car is scheduled to run in July, and early indications are that Ferrari is building a turbo engine, although the regulations have yet to be confirmed. Should the regulations not favour turbos, the existing normally aspirated engine is considered to be a viable alternative. To read the full feature, go to the digital back issues section on www.racecar-engineering.com

Adjustment of performance

Decision N°: 15-D0023-LMGTE – 30/05/2015

LMGTE PRO	CAR WEIGHT (kg)			2 x RESTRICTOR DIAMETER (mm)			GURNEY HEIGHT (mm)			FUEL TANK CAPACITY (liter)			FUEL RIG RESTRICTOR DIAMETER (mm)			HEIGHT OF REAR WING (mm)		
	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final
PORSCHE 911 RSR (991)	+1245 kg	-10 kg	+1235 kg	28,6 mm	+0,7 mm	29,3 mm	25 mm	-	25 mm	90 l.	+5 l.	95 l.	28,0 mm	+2,5 mm	30,5 mm	-100 mm	-	-100 mm
FERRARI 458 ITALIA	+1245 kg	-10 kg	+1235 kg	28,3 mm	-	28,3 mm	25 mm	-	25 mm	90 l.	-	90 l.	28,0 mm	-	28,0 mm	-100 mm	-	-100 mm
ASTON MARTIN V8 VANTAGE	+1245 kg	-30 kg	+1215 kg	28,3 mm	+1,1 mm	29,4 mm	25 mm	-25 mm	0	90 l.	+10 l.	100 l.	28,0 mm	-	28,0 mm	-100 mm	+100 mm	0 mm
CORVETTE C7-Z06	+1245 kg	-	+1245 kg	27,9 mm	+1,2 mm	29,1 mm	25 mm	-25 mm	0	90 l.	-	90 l.	28,0 mm	-	28,0 mm	-100 mm	+75 mm	-25 mm

Note: Adjustments below are made with the waivers required, with the data and information provided by the manufacturers until now, with the data of Ladoux test and with analysis made by FIA/ACO

LMGTE AM	CAR WEIGHT (kg)			2 x RESTRICTOR DIAMETER (mm)			GURNEY HEIGHT (mm)			FUEL TANK CAPACITY (liter)			FUEL RIG RESTRICTOR DIAMETER (mm)			HEIGHT OF REAR WING (mm)		
	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final	base	adjust.	final
PORSCHE 911 GT3 RSR (997) - model 2012	+1245 kg	-55 kg	+1190 kg	28,6 mm	+1,6 mm	30,2 mm	25 mm	-10 mm	15 mm	90 l.	+5 l.	95 l.	28,0 mm	+2,5 mm	30,5 mm	-100 mm	+100 mm	0 mm
PORSCHE 911 RSR (991)	+1245 kg	-10 kg	+1235 kg	28,6 mm	+0,7 mm	29,3 mm	25 mm	-	25 mm	90 l.	+5 l.	95 l.	28,0 mm	+2,5 mm	30,5 mm	-100 mm	-	-100 mm
FERRARI 458 ITALIA	+1245 kg	-10 kg	+1235 kg	28,3 mm	-	28,3 mm	25 mm	-	25 mm	90 l.	-	90 l.	28,0 mm	-	28,0 mm	-100 mm	-	-100 mm
ASTON MARTIN VANTAGE - model 2013	+1245 kg	-30 kg	+1215 kg	28,3 mm	+1,1 mm	29,4 mm	25 mm	-25 mm	0	90 l.	+10 l.	100 l.	28,0 mm	-	28,0 mm	-100 mm	+100 mm	0 mm
CORVETTE C7-Z06	+1245 kg	-	+1245 kg	27,9 mm	+1,2 mm	29,1 mm	25 mm	-25 mm	0	90 l.	-	90 l.	28,0 mm	-	28,0 mm	-100 mm	+75 mm	-25 mm
SRT VIPER GTS-R	+1245 kg	-	+1245 kg	28,1 mm	+1,7 mm	29,8 mm	25 mm	-5 mm	20 mm	90 l.	+10 l.	100 l.	28,0 mm	-	28,0 mm	-100 mm	+200 mm	100 mm

Note: Adjustments below are made with the waivers required, with the data and information provided by the manufacturers until now, with the data of Ladoux test and with analysis made by FIA/ACO

To be used with minimum length of fuel hose of 480 cm.

The Balance of Performance table is the same as that from Austin, Texas, in 2014, the first race post Le Mans and one which featured the revisions based on the performance seen during the 24 hour race. There was some argument over whether or not it should be this table (issued again in May, see above) rather than another issued in March. Compared to the BoP issued on March 13 2015 the Porsche has gained 10kg (1225kg to 1235kg), and the fuel tank is five litres larger to ensure that the 991 can go 14 laps on a single fill. The Ferrari 458 loses 10kg and will race at Le Mans at 1235kg. It also

races with a slightly larger fuel tank, 90 litres, again to ensure that the car is able to do 14 laps on a tank of fuel. The direct injection engine is able to use less fuel in a six-hour race, and so it normally races with an 85-litre fuel tank.

However, it is the Aston Martin V8 Vantage that has proven to be so controversial. It will race at 1215kg, 10kg less than in the 'sprint' six-hour races. It also has a larger air restrictor, going from 0.8mm to 1.1mm over the base 28.3mm restrictor. Its Gurney height is increased from 10mm to 25mm, and it is given a further five litres of fuel, from 95 litres to

100 litres. Its fuel restrictor limit has been reduced, meaning a slower refuelling time. This is all to balance out the cars, but Ferrari and Porsche pointed out that the Aston Martin was competitive even with the smaller air restrictor.

The Corvette C7R has a slightly reduced air restrictor compared to at Le Mans in 2014, and the team has calculated that costs around 1mph, and a second a lap. Never the less, the cars were second fastest at the test, around a tenth of a second slower than the Aston Martin, and were fastest through the speed traps. This will be an interesting race!

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Better by design

Corvette Racing has subjected its C7.R GTE contender, which debuted in 2014, to computational optimisation techniques that have produced dramatic results

By SIMON McBEATH

The renowned and long-running partnership between Chevrolet and Pratt & Miller, which builds the racecars and operates the competition programme, began in 1999 and has produced a string of high profile wins including seven Le Mans titles in the GTE Pro class. The programme began with the C5-R, which ran through to 2004 with GTS class wins at Le Mans in 2001, 2002 and 2004. The C6.R followed that with Le Mans GT1 class wins in 2005, 2006 and 2009 and the newly instigated GTE Pro class win in 2011. Then there's the tally of 82 ALMS race wins and 10 manufacturer wins.

In its debut season in 2014, the C7.R finished second in the GTE Pro class at Le Mans and claimed four race wins in the new Tudor United SportsCar Championship GT Le Mans class. And the most recent success saw the team enjoy a win and third in GTLM at Daytona in January.

Pratt & Miller Engineering (PME) design engineer Grant Browning proudly asserts that each Corvette model redesign was a step forward from the previous one, and that each model possessed sufficient potential to compete at the top of its class against the factory-backed teams. This was also the philosophy behind the C7.R programme, with design commencing at PME in 2013.

As in all top level race teams, PME has at its disposal the usual

computational modelling and simulation tools, with VR&D's GENESIS structural optimisation software among them.

Browning takes up the story: 'GENESIS software was a tool we'd had at our disposal for two years, but until the C7.R design, it was only used in individual component or sub-assembly designs or redesigns.

'However, since our introduction to GENESIS, the implementation of optimisation to drive our designs

has grown. The C7.R was the first full car design where PME had the opportunity to implement optimisation into every facet of car design, thus providing a direct comparison to the C6.R GT2, an already well-developed and very competitive car, to evaluate the influence that GENESIS had.

'As the build [of the C7.R] progressed and our seemingly over-optimistic predictions began coming to fruition, the impact of optimisation

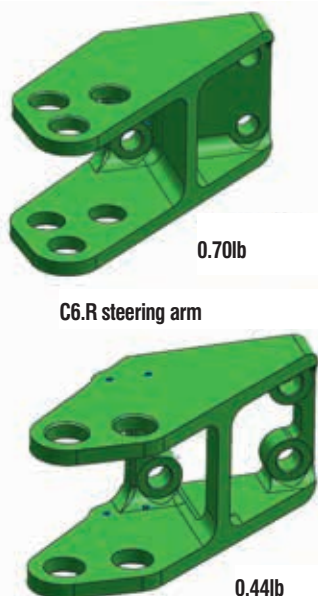


Figure 1: PME's first optimisation study focussed on the Corvette's steering arms

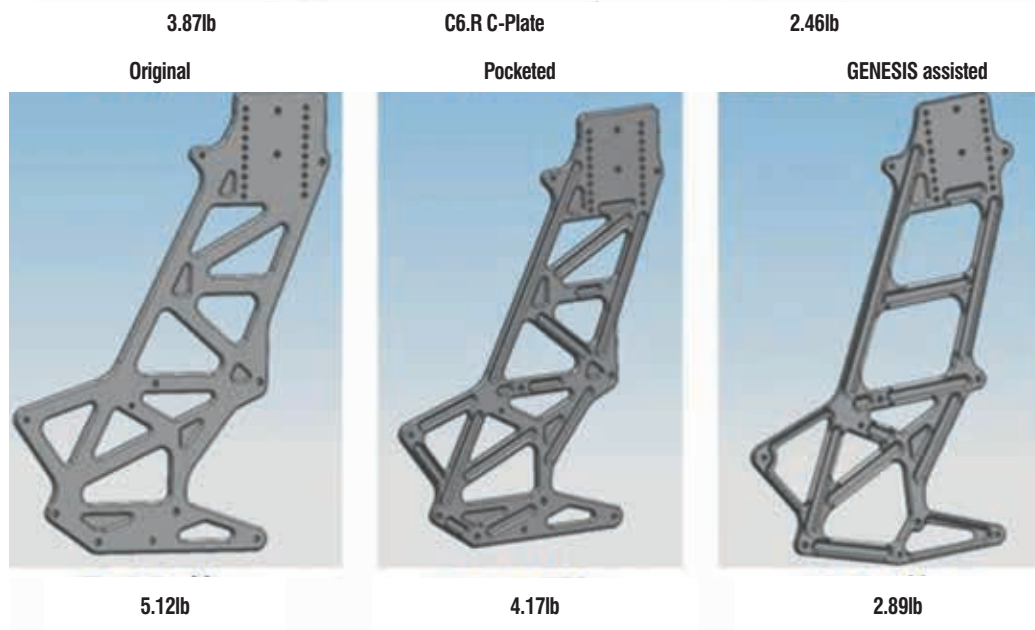
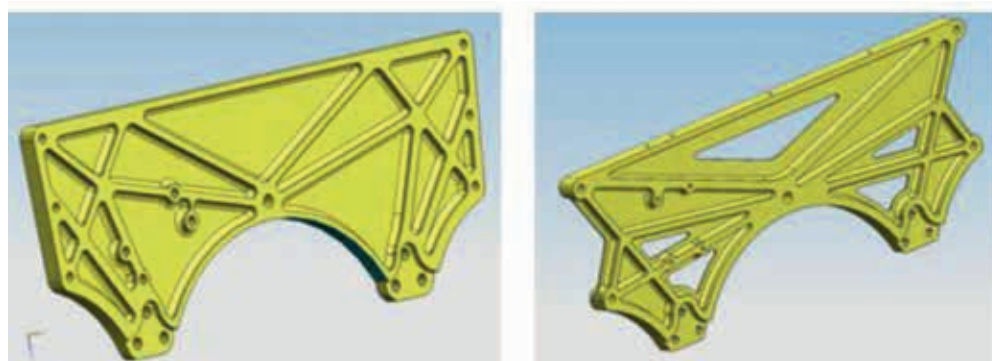


Figure 2: Other early PME optimisation projects

became obvious. The C7.R test car's torsional stiffness was 50 per cent higher, while the overall weight of the structural components was reduced by more than 65lb (29.5kg).

As track testing began the feedback continued to be positive. From lead engineer on car number 4, Chuck Houghton, came this: 'It seems like the increased chassis stiffness has helped a lot of the strange chassis dynamics that we used to have. We don't see the rear moving around as much as we used to and the racecar recovers a lot better over the kerbs and bumps.'

Once the race season started and the cars began to clock up miles and experience racing incidents the structural components continued to prove their worth.

Yet interestingly there was some initial resistance within PME to the design directions being signposted by the results emerging from GENESIS, illustrated by a new steering arm design (Figure 1), the first part to be optimised using GENESIS.

The optimised design, a machined alloy part, was 37 per cent lighter than its predecessor, saving 0.26lb (119g) per side, but apparently it took some persuasion to get a sceptical race crew to fit it. Grant Browning explains that 'once the crew had come around to the new design there was an incident that buckled

'We don't see the rear moving around as much and the racecar recovers a lot better over the kerbs'

the steel tubular steering link but the steering arms remained unscathed. This opened the door for us to begin further implementing this approach to the design process.'

There was another unintended impact test, too: 'In the second half of the season the number 3 Corvette, the car winning the championship at the time, was involved in a serious accident with another car, one that sent both drivers involved to the hospital and completely destroyed the car's chassis. Fortunately, the Corvette Racing crew was able to get our C7.R reassembled and ready for qualifying just two hours later.'

'This was more a test for the full car; uprights, control arms and roll cage. These had all been drastically lightened as optimisation had been heavily ingrained into the entire car design and pushed further than some of our earlier optimisation projects.'

The incident confirmed that the weight saving and stiffness increases found in the optimisation work of the car (Figure 2) had not compromised its resilience.

So, substantial improvements in stiffness and weight had been achieved in individual components and importantly in the car as a whole. Browning is pragmatic about how these gains were found and quite naturally asserts that in a team of clever and experienced designers and engineers improvements are to be expected anyway. But he also gives credit to GENESIS, and perhaps more importantly to his team's use of the software, and says: 'The influence of GENESIS was not only felt through direct simulations run on the C7.R racecar, but also through the insight and understanding gained from our team through our previous use.'

'The reason that this secondary impact is so substantial is because we do not just take optimised results straight from the software and use the more efficient shapes created as a basis to make physical parts; rather, we see GENESIS as a tool to generate ideas, and also as one that can produce new metrics for evaluating and understanding. GENESIS, in

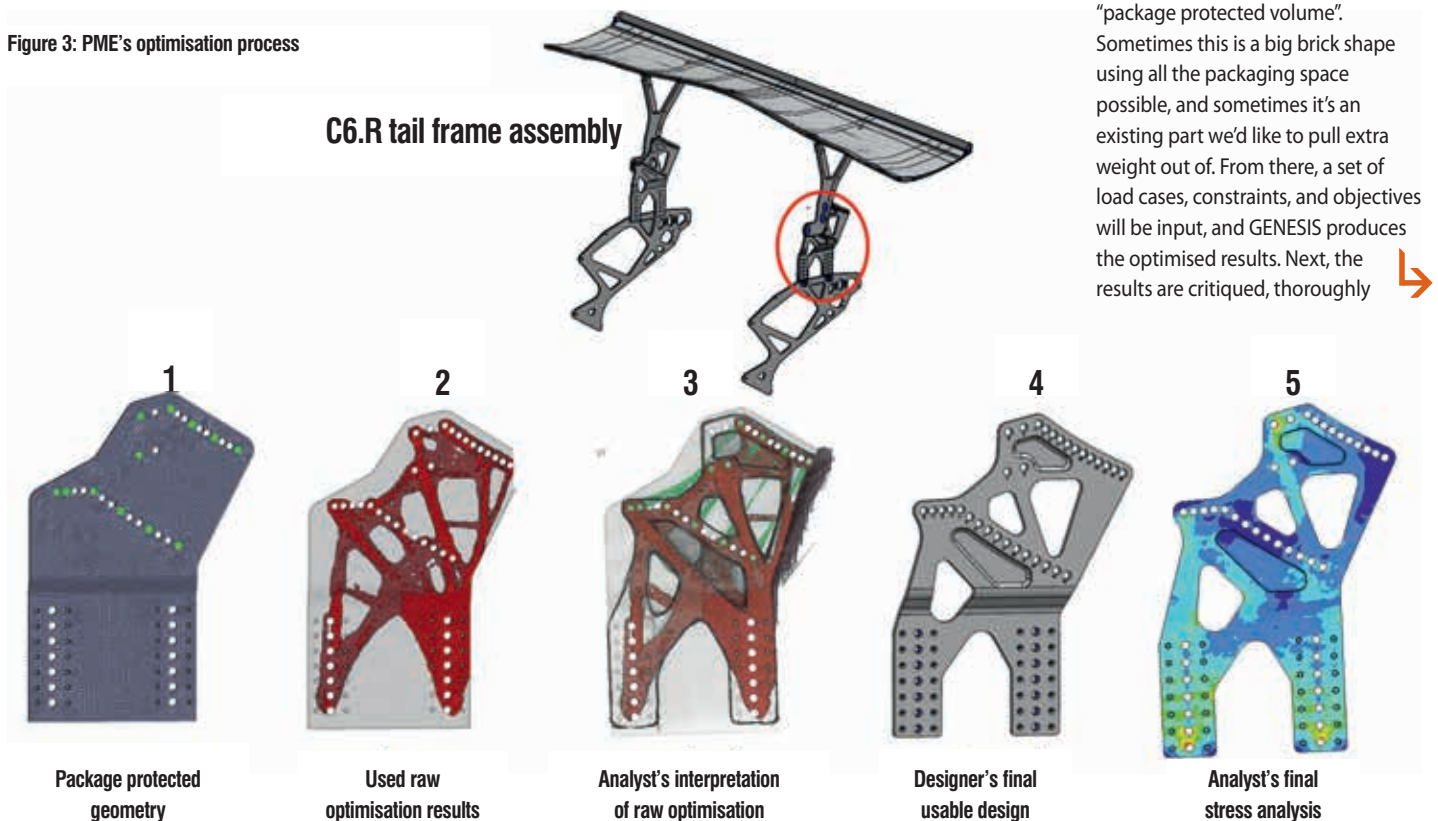
our hands, quickly became a tool that didn't simplify or accelerate our design process, but one that we pushed further to increase the potential for understanding, to achieve gains in our structural components and to give us an advantage on the track.'

This last point is taken up by Martin Gambling, managing director at GRM Consulting: 'Design time can be less with optimisation. Good use can add time but produces better results. However, you need to run different targets to see a range of results to understand the process, for example, when determining whether a component needs to be stiff or strong in bend, and so on, and avoid over emphasis on a dominant load case. With wing supports the loading is not only downforce we need to cater for; there are other forces which need to be taken into account, such as the car being manually pushed along by the wing...'

Browning goes on to describe how the deployment of GENESIS has developed over time at PME: 'Our process for implementing GENESIS has been refined over the last couple of years and is typically used with topology optimisations, but it is similar for all our uses. Every case is a little different, but our general process has matured into common steps.' (See Figure 3).

'The process starts with a "package protected volume". Sometimes this is a big brick shape using all the packaging space possible, and sometimes it's an existing part we'd like to pull extra weight out of. From there, a set of load cases, constraints, and objectives will be input, and GENESIS produces the optimised results. Next, the results are critiqued, thoroughly

Figure 3: PME's optimisation process



understood, and interpreted by the analyst. We have found these optimisation and interpretation steps to be critical in successfully implementing GENESIS.

'From there, the analyst and designer (which is sometimes the same person) will review the interpretation of the results and produce a usable design. The final step is to run a finite element analysis (FEA) on the components, ensuring

that stresses and stiffnesses are acceptable. In most situations, the last two steps are cycled through a few times to minimise weight within our acceptable stress limits.'

Taking up Gambling's point about the importance of understanding the process, Browning continues: 'Everything down the line is based on the raw optimised results and these results are incredibly dependent on the many variables.

'The first variable to address is the load cases. One might imagine that anyone implementing structural optimisation would already have a handle on the load cases because they've been running structural FEA to check stresses on components. In our experience, a model being optimised from scratch tends to be more susceptible to overly focused load cases than a design that took its shape because the designer thought it looked like it would do the job.

'Understanding these sensitivities and susceptibilities when using optimisation as an idea generator is critical to avoiding oversights that can lead to undesired behaviours or even component failure. Too heavy a reliance on the results without comprehending why they occurred can lead to problems.

'However, once these sensitivities are understood they can be utilised to gain knowledge and insight into a component and how it functions structurally. We regularly use a series of overly focused load cases to see how the optimised shape changes for each case and to gain an insight into how a different shape can influence our targeted responses.'

'We would not use these responses as a design; they are just used as a metric for evaluation. Good results are dependent on a well-rounded set of load cases.'

'In practice, components are exposed to an infinite number of loads. A finite set of load cases that sufficiently captures the possible loads is therefore required.'

In general, PME has found that understanding these responses is also important when weighting the relative importance of load cases. For example, when looking at the chassis of a racecar the usual objective is to improve its torsional rigidity, while yield stress is just a constraint that needs to be met. 'Yet torsional load cases are of the order of 20 times less than the maximum stress load cases,' explains Browning. 'This mismatch of load cases creates an optimisation run that always biases the design towards the maximum stress load cases, even though optimising for torsion may be the original intent. This method of gaining a comprehensive understanding instead of just producing a base shape to design from can help to catch these types of issues.'

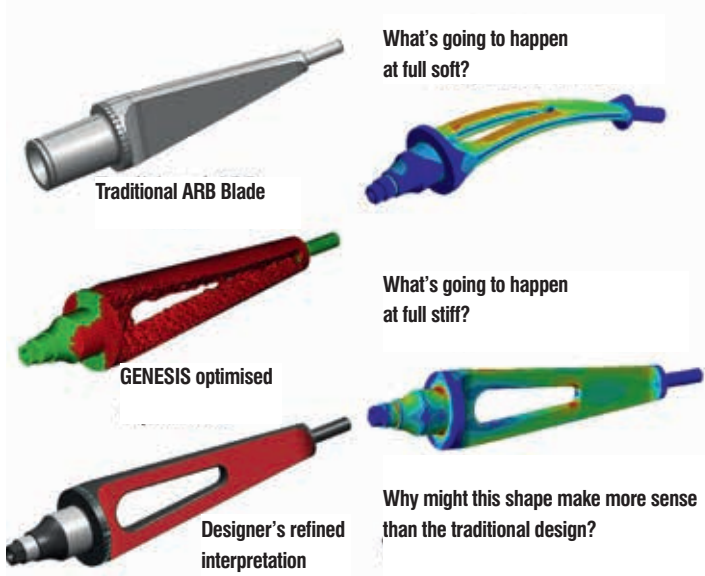
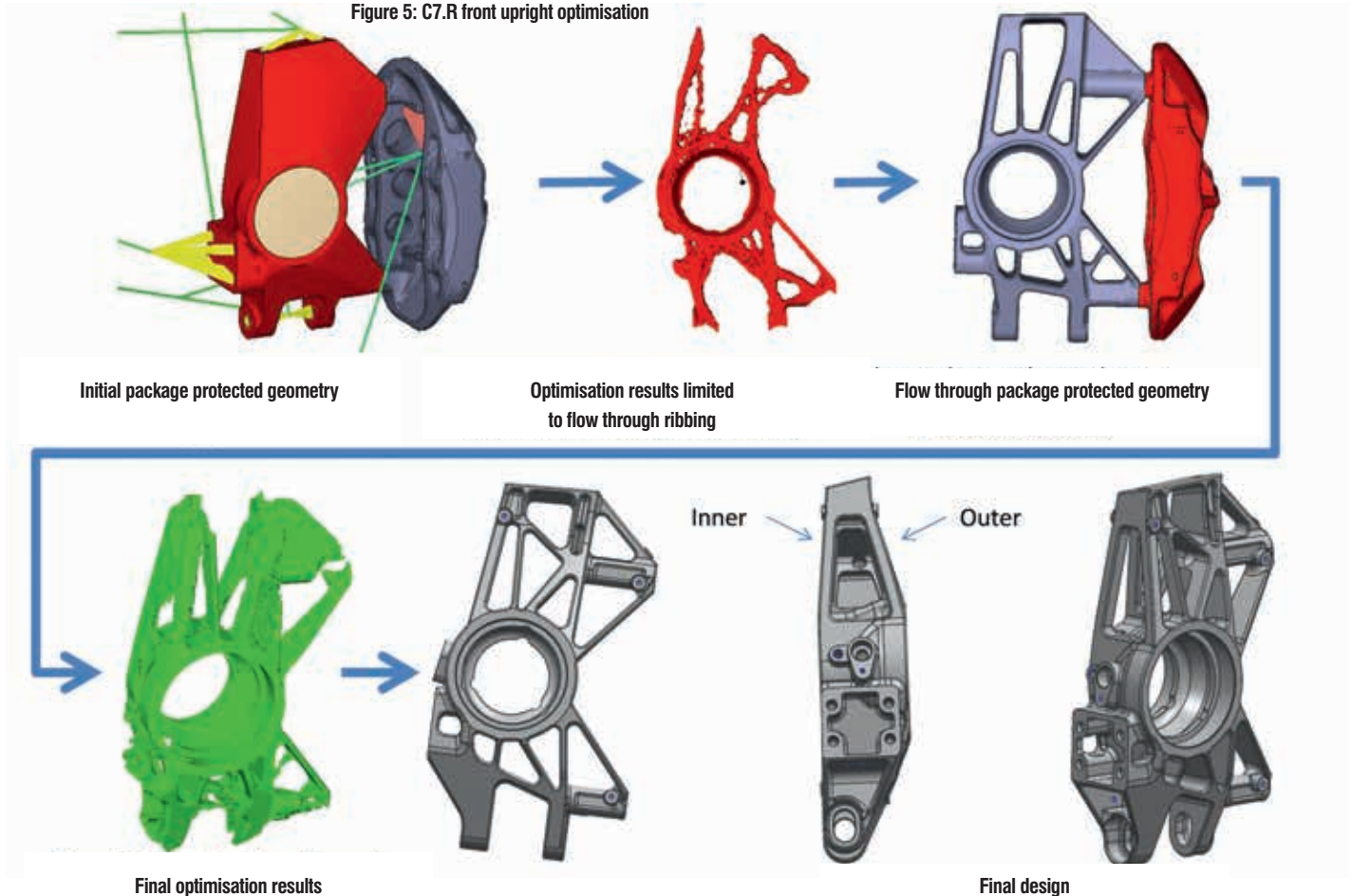


Figure 4: Answering key questions helped to understand responses, as in this ARB study

Figure 5: C7.R front upright optimisation



Some specific component studies further illustrate the importance of understanding why certain results and responses occur. PME looked at an anti-roll bar (ARB) blade to ask and answer some key questions, and

Figure 4 shows the process involved. Browning says: 'As we asked the questions we came to the following conclusions: at full stiff, the centre of the blade does not have much load going through it because it's on the

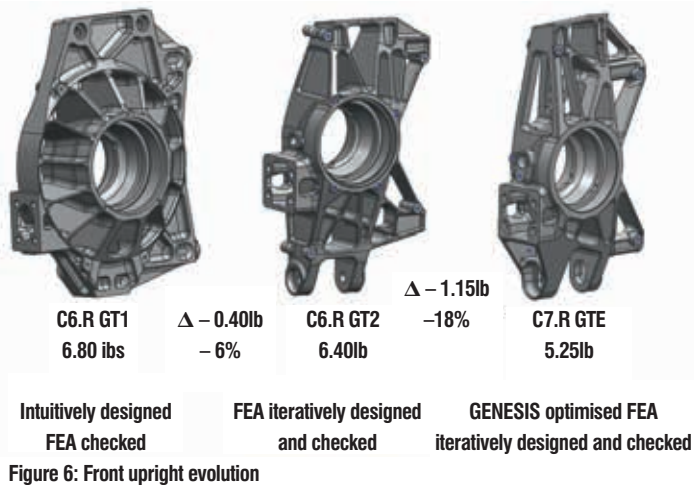


Figure 6: Front upright evolution

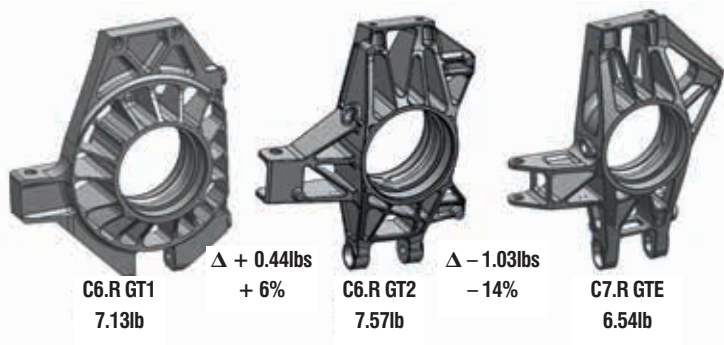


Figure 7: Rear upright evolution

neutral axis; at full soft, the centre of the blade does affect the stiffness, but that will only result in a larger range of adjustability; this design should allow for a higher maximum stiffness and lower minimum stiffness at a lower weight for the same packaging area. So, if we can keep the blade and bar combination stresses within our acceptable limits at maximum deflection, then this design could produce some advantages.'

The C7.R incorporated many such approaches, and overall knowledge was gained by regularly using GENESIS and endeavouring always to fully understand the results.

Upright advantage

Taking a closer look at a key component, the suspension uprights, is also very instructive. Clearly the

uprights are critical, high-value components, being fundamentally the structural connections between the wheels and the suspension, and as such they have to deal with all kinds of loadings. They also make up a large proportion of the car's 'controllable' unsprung mass and are an obvious candidate for optimisation.

PME studied the front and rear uprights using essentially the same process described earlier, but with what GRM Consulting's Martin Gambling described as a 'clever modified approach to work around something of a shortcoming in the software' to address a specific requirement. Browning continues the tale: 'To some degree, the process followed our general optimisation design process, except that the first optimisation cycle produced the



Figure 8: Gains on the C7.R

GRM Consulting and structural optimisation projects

GRM Consulting, the UK-based engineering design consultancy that, as a part of its business, is the UK and European distributor of VR&D's GENESIS, is constantly involved in interesting racecar projects and is a software supplier to most of the F1 grid. We saw in December 2012's issue (V22N12) a rather special case study on composite lay-up optimisation that used OptiAssist, a software package that extends the capabilities

of GENESIS specifically to aid the optimisation of composite laminates. In that case the application was a hypothetical study of how optimisation software could be used to help make an F1 car's front wing predictably flexible, a hot topic at the time and since – see **Figure 9**.

Less controversially, the Caterham F1 team (among others) was using the same set of tools to optimise its chassis ahead of the 2014 season. Through careful management of

laminates and properties (ply numbers and orientations) and in spite of much of the laminate and structure effectively being defined by specified lay-ups and impact structures in key areas, as well as almost constantly increasing load test standards, they were able to make an approximate 10 per cent weight saving on each of their racecar's chassis – see **Figure 10**.

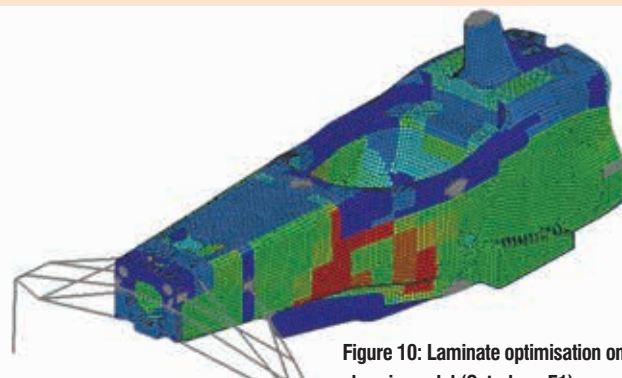
Currently GRM is involved in an automotive project that will surely

have motorsport applications in the future – optimising driveline components that incorporate complex hybrid housing structures. The company has developed some new software techniques that can handle more types of load inputs than was previously possible and so tackle stress targets as well as vibration and stiffness targets. GRM is justifiably excited about the possibilities of applying this technology in motorsport.

Figure 9: Front wing flex, courtesy of OptiAssist and GENESIS



Figure 10: Laminate optimisation on a chassis model (Caterham F1)



Structural optimisation with GENESIS

We asked GRM Consulting's managing director Martin Gambling to explain how structural optimisation works. 'The typical CAE [Computer Aided Engineering] process is for a designer to develop a design and then the performance is assessed using CAE techniques. In terms of structural loading, the Finite Element Analysis (FEA) technique is often used. Using FEA, a design is assessed under one or more loading requirements and its performance is then quantified. If the design does not meet the required performance the FEA analyst, or the designer, will then revise the design iteratively until the performance is achieved.

'An optimisation code such as GENESIS, rather than being simply an analysis (FEA) code, is an optimisation code that can automatically change a design, iterating specific parameters in

order to achieve specific performance requirements. Several different optimisation methods are available, which are defined by the changes to the design that are being made.

'One of the key strengths of GENESIS is its ability to consider more than one loading requirement. A good engineer can arguably develop the best design for one requirement, possibly even two. The GENESIS optimiser can consider many requirements and develop the best overall design to meet all of them in the most efficient way. These may be stiffness, strength, vibration, buckling, heat transfer and more.

'GENESIS provides a complete suite of optimisation capabilities. Each method is available for all analysis methods within GENESIS and can efficiently consider combinations of multiple loading requirements. The methods are shown in **Figure 11**:

- **Topology optimisation**, which optimises by using only the required parts of the available design space.
- **Sizing**, which changes the thickness of panels (pressed steel panels, etc).
- **Topography**, which changes swage patterns.
- **Shape**, which unsurprisingly changes part shape.
- **Topometry**, which changes the thickness of material (in castings and mouldings, etc).
- **Composites**, where changes are made to ply shapes, their angles and the number of plies.

Topology optimisation is the process of determining the optimal material layout within a given design envelope. The example in **Figure 12** shows how only the material required to support vertical loading on the hook is retained.

design space for the second,' as seen in **Figure 5**. The reason for using this modified process is that we required an upright that allowed air to flow from the inner side of the upright to the outer side in order to cool the brakes. If an unrestricted optimisation were to be run, the inner and outer faces would be solid, blocking any flow through. We overcame this with a fabrication constraint, which through our normal process got us to a result that was then used as the package protected area for the final optimisation run. From there the design process continued as described earlier. **Figures 6 and 7** show not only the C7.R uprights and their weights, but also the C6.R GT1 and GT2 uprights for an idea of the changes and gains/losses made at each incremental design step.

Value added

Grant Browning sums up PME's take on the use of structural optimisation software: 'GENESIS has been an invaluable tool that has yielded substantial growth in structural development. A breakdown of some weight and stiffness gains throughout the C7.R racecar illustrates this point (**Figure 8**). When we began using GENESIS, our initial expectations were that it would provide a quicker way to get to our final designs by cutting down on the iterative process between FEA analysis and design revisions, and improve those final designs.

'Once we recognised the further potential of GENESIS as a tool, we expanded our uses far beyond our initial intentions into not only an idea generator but also a means of producing an increased level of understanding in load cases, structural responses and efficient structural patterns.

'When weighing the benefits and costs after exploring these additional facets we willingly abandoned the possibility of simplifying or streamlining the design process and instead pushed for more considerable gains in weight, stiffness and understanding that could yield advantages on the track, in exchange for the practical investment in further time and complexity.'

Racecar Engineering's thanks go to Grant Browning at PME, and to Martin Gambling and Oliver Tomlin at GRM Consulting.



FIGURE 11: GENESIS optimisation capabilities

- Genesis provides the most complete suite of optimisation capabilities
- Each capability is available for all analysis methods within Genesis and can efficiently consider a combination of multiple loading requirements

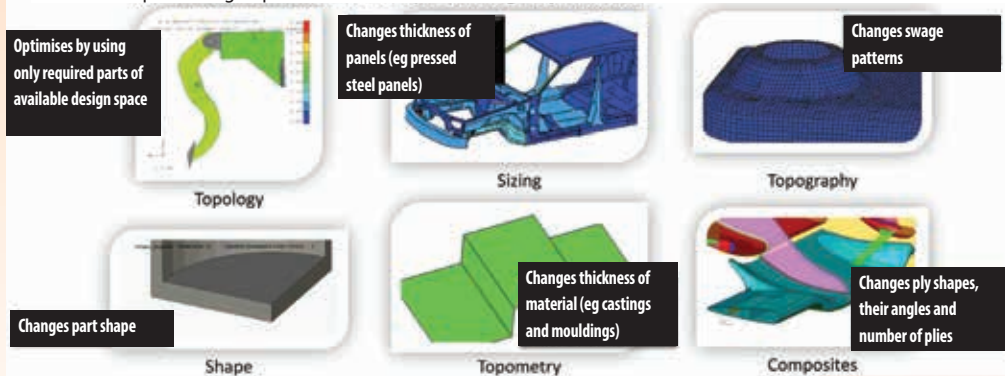
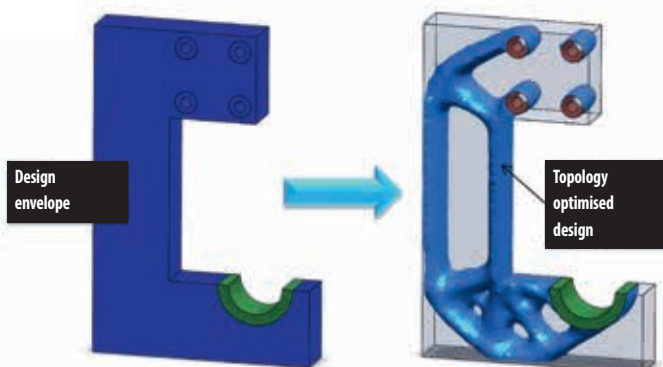


Figure 12: Topology optimisation

- Topology optimisation is the process of determining the optimal material layout within a given design
- Example shows how only required material is kept to support vertical loading in the hook





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The Racecar Engineering App



CLASS OF '95



This Japanese-entered F1GTR held off the best of the prototypes to achieve an unexpected debut triumph for McLaren Cars.

Discounting the outrageous, Porsche 962 based 'Dauer LM GT' of 1994, the Le Mans 24 Hours was won by a production-based GT car for the first time since 1979 when, as in 1995, rainy weather played a major role in the race. The winning car was the original, prototype McLaren F1GTR, raced by Yannick Dalmas, JJ Lehto and Masanori Sekiya. This was the first Le Mans victory by a manufacturer on its debut since 1949, and the first by a BMW powered racecar. What did it tell us about the state of GT racing?

By QUENTIN SPURRING

Astonishing even itself, McLaren Cars brought five of seven F1 GTRs to the finish of Le Mans 1995, in first, third, fourth, fifth and 13th places. This was a striking tribute to the integrity of Gordon Murray's design. Among the crowd, it should be said, it was not the most popular result.

The spectators were solidly behind the best of the prototypes, the Le Mans built Courage-Porsche raced by Mario Andretti, Bob Wollek and Eric Helary. The crowd was enthralled by their comeback chase after a long delay early in the race. In truth, there was only a slim chance that they could retrieve a victory for their old, converted Group C racecar. They came close, but had to settle for second place.

The Le Mans 24 Hours has now made up the ground it lost through the ill-advised interference of the FIA in 1991-92. For the 63rd edition of the marathon, the ACO was again free to open it up to just about all the bewildering range of competition sportscars that are currently racing in International events. The response was an all-time record entry of 99, up from 84 in 1994.

From this number, 76 were chosen either to attend as invited entries, or to endure a prequalifying session at the end of April. These incorporated no fewer than 27 passenger car manufacturers and racecar constructors. Such was the hurdle of prequalifying, the final 48 (plus four reserves) whittled these down to 21.

The mainstream manufacturers which made the race were Chevrolet,

Ferrari, Honda, Jaguar, Nissan, Porsche and Toyota. The low-volume 'supercar' specialists were Lister, Marcos, McLaren, SARD and Venturi. All are involved, with or without formal factory participation, in the various GT categories, which are governed by complex regulations setting vehicle weight against engine swept volume and air restrictor diameters. For the purpose of this event, the ACO helpfully placed the GT entries in only two groups, defined as 'LM GT-1' and 'LM GT-2' - the former having greater engine and aerodynamic freedoms and wider tyres.

The racecar constructors were Courage, Debona, Ferrari, Kremer, Kudzu and WR. Their purpose-built, open-cockpit cars were either IMSA World Sports Cars (with a few rule adjustments by the ACO) or specially

LE MANS 24HR

designed 'LM Prototypes'.

Although the little WR-Peugeots in the LMP class were briefly very effective, the rules encouraged a technical contest for the overall victory between the best cars from the 27-car GT-1 class and the six-car WSC group. The key factors were pace, fuel consumption and, of course, durability.

The WSC cars were clearly faster than the GTs, but their fuel tankage was restricted to 80 litres. The quickest of the GT-1 cars were only 5-10sec slower around the lap, and were allowed 100 litres. The prototypes, then, needed to make maybe six more fuel stops than the GTs. The main battle that evolved, between the Courage team's C34 and those unexpectedly pacy and reliable McLarens, encapsulated the theme of the 63rd Le Mans. It was a pity that the prototype group was quickly decimated, leaving the Courage to offer the only live challenge to the McLarens.

A light but steady drizzle began to soak the Circuit de la Sarthe after only an hour or so of racing, and endured for almost 11 hours. After that, this unpleasant but consistent weather gave way to sporadic showers. These conditions tended to reduce the performance differential between the prototypes and the GTs. They were ideal for the drivers of the McLarens that went far ahead after an unexpected incident befell the Courage.

The C34 was running second just before quarter-distance when Andretti came up close behind the secondstring Kremer K8 — the yellow WSC racecar that had won at Daytona in February. Andretti was caught out by the slow pace of its Brazilian rental driver, braked to avoid a collision, locked up and slewed into a lurid spin into a wall. Back in the pits, the crew repaired the car in 29min, and returned it to the action in 27th position, six laps behind the race-leading McLarens.

An hour before halfway, a glimmer of hope did appear for the Courage squad, who had regained fourth place, and taken back two of the lost laps. The leading McLaren stopped at the pits with a busted clutch, and was then crashed out. Even so, a victory for the Courage was beyond it unless both the McLarens remaining ahead encountered mechanical difficulties. Only one did.

Perhaps it was best for the image of Le Mans that the 1995 race was not won by a converted Group C design. The result provided a pointer to the longterm future of the GT racecars, and posed a question about the short term.

"Le Mans 1995 served to convince its promoter, more than ever, that it will be able to maintain the success of its 24-hour race whatever happens to the rules"

TABLE 1: 1995 LE MANS PERFORMANCE PARAMETERS

No	Car	Weight (kg)	Engine BHP	Engine Volume	Restrictor No x mm	BHP/kg	BHP/litre
WSC							
1	Ferrari 333SP	894	600	3997	N/A	0.704	157.61
3	Kremer K8	925	540	2995T	2 x 34.5	0.583	190.30
4	Kremer K8	919	540	2995T	2 x 34.5	0.587	190.30
5	Kudzu DG3	820	480	196Z	N/A	0.585	244.64
11	Courage C41	851	560	5000	N/A	0.658	112.00
12	Courage C34	901	550	3000T	2 x 34.5	0.610	183.30
LMP							
8	WR LMP4	642	400	1905T	1 x 42	0.623	209.97
9	WR LMP4	623	400	1905T	1 x 42	0.642	209.97
14	Debra LMP295	700	400	2000T	1 x 42	0.571	200.00
LM GT-1							
22	Nissan Skyline GTR	1370	600	2568T	2 x 42.6	0.437	233.64
23	Nissan Skyline GTR	1285	600	2568T	2 x 39.9	0.466	233.64
24	McLaren F1 GTR	1125	640	6064	2 x 39.4	0.568	105.54
25	McLaren F1 GTR	1135	640	6064	2 x 39.4	0.563	105.54
26	Sard MC-8	1273	600	4000T	2 x 40.7	0.471	190.00
27	Toyota Supra GT	1245	650	2140T	1 x 55.9	0.522	303.73
30	Chevrolet Corvette	1281	570	6300	1 x 58.9	0.444	90.47
34	Ferrari F40LM	1061	640	2936T	2 x 38.1	0.603	217.98
36	Porsche 911 RSR	1138	600	3600T	2 x 40.4	0.527	166.66
37	Porsche 911 RSR	1129	600	3600T	2 x 40.4	0.526	166.66
40	Ferrari F40GTE	1114	600	2988T	2 x 38	0.538	200.13
41	Ferrari F40GTE	1124	600	2988T	2 x 38	0.533	200.13
42	McLaren F1 GTR	1189	640	6064	2 x 38.4	0.552	105.54
43	Venturi 600LM	1153	600	2975T	2 x 38	0.537	208.40
41	Venturi 600SLM	1066	600	2975T	2 x 38.1	0.562	201.68
45	Venturi 600LM	1119	600	2975T	2 x 38	0.536	201.68
46	Honda NSX	1080	410	2977	1 x 55.1	0.390	137.72
47	Honda NSX Turbo	1054	600	2977T	2 x 37.1	0.569	201.54
49	McLaren F1 GTR	1128	640	6064	2 x 38.4	0.567	105.54
50	McLaren F1 GTR	1158	640	6064	2 x 39.4	0.552	105.54
51	McLaren F1 GTR	1130	640	6064	2 x 39.4	0.566	105.54
52	Lister Storm	1270	600	6996	2 x 43.4	0.472	85.76
54	Porsche BTR Turbo	1156	730	3820T	2 x 41.4	0.617	189.47
55	Porsche RSR	1180	550	3600T	2 x 40.4	0.466	166.66
57	Jaguar XJ220	1170	600	3498T	2 x 38.9	0.512	171.62
58	Jaguar XJ220	1171	600	3498T	2 x 38.9	0.512	171.62
59	McLaren F1GTR	1137	640	6064	2 x 38.4	0.562	105.54
LM GT-2							
70	Maroco LM900	1191	530	6300	2 x 36.4	0.445	84.12
71	Maroco LM900	1167	530	6300	2 x 36.4	0.454	84.12
73	Callaway Corvette	1233	500	6243	1 x 53.2	0.405	90.08
75	Callaway Corvette	1110	500	6243	1 x 50.8	0.450	90.08
76	Callaway Corvette	1116	500	6243	1 x 50.8	0.447	90.08
77	Porsche 911 RSR	1178	450	3600T	2 x 33.8	0.382	125.00
78	Porsche 911 RSR	1169	450	3600T	2 x 33.8	0.384	125.00
79	Porsche 911 RSR	1177	450	3600T	2 x 33.8	0.382	125.00
81	Porsche 911 RSR	1175	450	3600T	2 x 33.8	0.383	125.00
82	Porsche 911 RSR	1201	480	3600	2 x 33.8	0.398	125.00
84	Honda NSX	1055	390	2977	1 x 46	0.369	131.00
91	Porsche 911 RSR	1154	450	3600T	2 x 33.8	0.389	125.00

The pointer is that — notwithstanding the current boom in Super Touring — there is clearly substantial interest in this type of track racing from both passenger car manufacturers and the motorsports community.

After what happened to the Sportscar World Championship, however, both these groups remain cautious in interpreting the increasing interest in GT racing that is being shown by the FIA. It is up to the governing body to convince the existing and intending participants that its intentions are entirely benevolent and crucially to create, if possible, Technical Regulations that are compatible worldwide.

As the FIA and the other interested organisations already know very well, of course, this is no straightforward matter. There are obstacles in the form of localised commercial requirements, especially in the USA. But, as shown by the participation at Le Mans by a round dozen passenger car manufacturers (from all the automotive industry centres of Britain, France, Germany, Italy, Japan and the USA), it is a matter of high priority.

The peace that appears to have bro-

ken out between the FIA and the ACO can contribute much towards resolving the difficulties. That said, Le Mans 1995 served to convince its promoter, more than ever, that it will be able to maintain the success of its 24-hour race whatever happens to the rules.

The question leads to others. It is: who will challenge McLaren Cars at Le Mans 1996? The cars from Woking, UK, may have been outqualified by the three Ferrari F40s in 1995 but, in every other respect, they proved themselves already to be a very long way ahead of the current opposition. Given the familiar caution of the Japanese manufacturers, the official disinterest of Ferrari, and the lack of adequate funding that restricts the other European 'supercar' makers, the emerging GT racing community is calling upon Porsche to revive its roots in endurance events, by creating a car capable of beating McLaren.

A tall order, certainly. If Porsche can do it, who knows what other volume manufacturers may follow? If it cannot, or will not, will GT racing remain (as some of its participants desire) merely an agreeable motorsports backwater for wealthy private entrants?

LM GT-1 CLASS

McLaren's Triumphant Dark Horse

EARLY IN MAY, the original prototype McLaren F1GTR had successfully completed a 22-hour test at Magny-Cours, mainly to evaluate gearbox modifications. Even so, designer Gordon Murray came to Le Mans more than apprehensive about the chances of McLaren Cars in its first 24-hour race.

A Le Mans endurance kit was made available to any team running a composite monocoque, 6.1-litre BMW V12 engine McLaren (right and below), and willing to pay the price. The package included CI carbon-carbon brake discs, and NACA ducts to cool them in the upper surface of the nose and engine cover. There were also alterations to the underbody, added protection for the radiator inlets, and strengthened lower rear suspension arms.

All seven F1GTRs that had been produced thus far were entered, and all ran with the revised Xtrac transverse gearbox. It now incorporated a dry-sump oil system in an effort to avoid the transmission failures that had occurred in some of the four-hour events. The French-owned racecars of Giroix Racing and BBA Competition were the only ones to retain the original cast-iron brake disc package. The cars weighed between 1125-1160kg (2480-2557lb). The engines are formally rated at 640bhp at 7500rpm, breathing through two air restrictors each of 39.4mm diameter (see Table 1).

A number of the customer teams were dismayed by the appearance of the '01' prototype F1GTR, run by a number of McLaren Cars personnel and the Lanzante Motorsport team (which normally runs a Porsche in the BPR GT series).

There were complaints that this looked like a works entry, but McLaren Cars insisted that it had been leased to a Japanese-owned company called Kokusai Kaihatso UK. This translates to "International Development UK".

Further dismay arose when some teams found themselves still waiting for certain parts of the Le Mans kit as qualifying began, although the Kokusai car already sported a few 'Mk2' parts - it remained the only F1GTR to run with additional lights in its bonnet panel. McLaren Cars pointed to a production backlog, caused by the reluctance of customers to place orders for the Le Mans kit until after the endurance test.

The new gearbox lubrication system met with approval among the teams. Inspection during the pre-race rebuilds revealing no telltale pitting of teeth on the ratio sets. The teams' main problem was selecting a clutch to run in the race. McLaren Cars counselled that, in its opinion, the sprint unit would not survive for 24 hours, but some teams were concerned that the endurance clutch would overstress the activating mechanism and release bearings.

The carbon-carbon brake package was also well-received, there being no reports of problems with cooling. However, some teams reported that brake wear was not as light as anticipated. Due to the greater weight of the McLaren, compared with the LMP and WSC cars, teams such as GTC planned three pad changes and two front disc changes during the race.

Conventional wisdom states that a manufacturer will not win Le Mans at its first attempt, but



McLaren Cars did just that, emulating only Ferrari in 1949. From the second hour, indeed, the 1995 Le Mans was a McLaren rout. The two cars tended by Dave Price Racing dominated the next 15 hours - except when one of the two Gulf GTC cars assumed the lead during the fifth hour, before crashing out. The controversial Kokusai car then also briefly spoiled DPR's show. DPR lost one car after a clutch failure and a spin into a gravel trap, but the other retook the lead in the 19th hour - and held it until delayed in its final pit-stop, when the driver had difficulty engaging a gear. The sinister grey, utterly reliable Kokusai car, race-engineered by Graham Humphrys, took over at the front, and held on to win.

Porsche 911 RSR

For many years, Porsche 911 variants formed the backbone of the entry for all endurance races. For Le Mans 1995, the ACO effectively placed a limit on the number of these cars by seeding the entry. Thus only four RSRs passed through scrutineering for GT-1, three of them run by Caen-based Larbre Competition.

Porsche's customer GT-1 racecar comes with the M64/B3 air-cooled, 3.6-litre flat-six, with a TAGtronic 3.8 engine management system. The drive is handled by a six-speed Porsche/Getrag manual gearbox with synchromesh, located ahead of the engine. The limited-slip differential gears are also supplied by Getrag and are contained in a Porsche casing. The front suspension is by Macpherson struts, the rear utilising a multi-link layout. GRP nose, tail and door panels are fitted in the interest of weight reduction, along with a plastic rear wing.

A front-runner in BPR racing, Larbre was the third team to receive formal factory backing at Le Mans. Two of its cars carried the very latest factory specification engine which included a new intake manifold, connecting rods, pistons and camshaft, and uprated KKK turbochargers. In this form, the engine produces approximately 600bhp at 7200rpm. The new specification (facing page, top and top right) also included a taller rear wing assembly (with enlarged side ducting for the turbocharger inlet air), lightened doors, and revised arches to take wider tyres (10in front, 12.5in rear). An improved ABS with Brembo-manufactured four-piston callipers and bigger brake discs (380mm diameter front, 322mm rear) completed the package.

Although these Porsches moved into top-ten placings during the first half of the race, both were crashed out. There was only one 911 running in GT-1 at the finish - the 3.8-litre, 720bhp example of Freisinger Motorsports.



CLASS OF '95

LM GT-1 CLASS



Even with its latest updates, Porsche's Norbert Singer conceded that the GT-1 RSR was no match on top speed for the front-running McLarens and Ferraris in the class: "The Carrera GT-1 is a GT-2 car with more power and wider tyres – but still a GT-2 car. This race has shown us that the (lower) weight and power we have is not enough. The McLaren has taken the GT racecar a step further on from the Porsche."

Asked whether Porsche would now consider a mid-engine GT design, like the McLaren, Singer was non-committal: "No decision has been made yet on the direction we will take." Has the 911 finally had its day as a front-line GT racecar?

Ferrari F40LM

Fast, but fragile, the Ferrari F40s continued a run of class pole positions at Le Mans, all three out-qualifying the McLarens. The Ennea team's so-called F40GTes, race-prepared by Ferrari Club Italia, qualified sixth and eighth, sandwiching the Aldix Racing F40LM, which was one of the light-weight chassis prepared for IMSA GT in 1990 (centre right).

Ferrari's customer GT racecar, produced by Michelotto, comes with two IHI turbochargers fitted to its 3-litre V8, which develops between 600-640bhp at 7500rpm. A Magneti Marelli ECU controls the electronic fuel-injection and ignition. Japanese-made IHI turbochargers are also used in the road car, but those fitted to the racecar are larger and more durable under racing conditions. The five-speed transmission and the double wish-bone suspension systems are taken from the aborted F40LM IMSA racecar project. The now classic F40 aerodynamic shape is altered to provide enhanced front-end downforce by the addition of a small splitter, and there are detail changes to the rear wing.

Although the Maranello-based Ennea cars were said to have "back-door" works support, Stephane Ratel's F40LM, race-prepared in Le Mans by RF Sport, was the only Ferrari to finish strongly, in 12th position after various driver-induced delays.

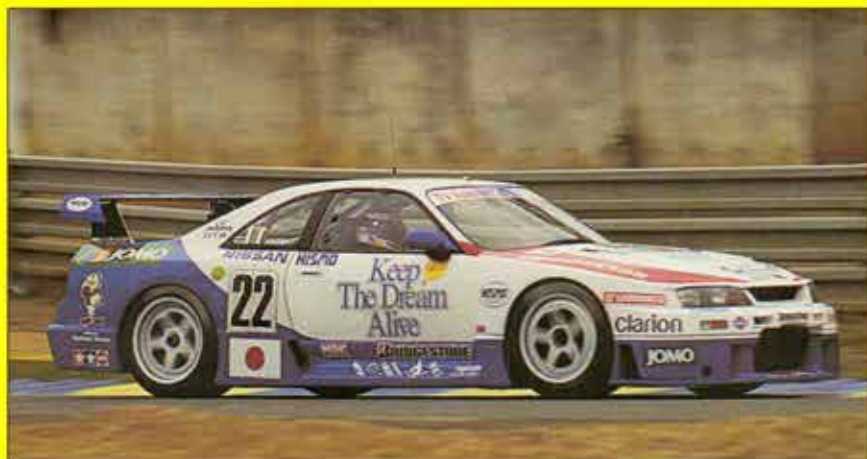
Nissan Skyline GTR

Two of NISMO's angular and heavyweight Nissan Skyline GTRs (bottom right) came to Le Mans as leaders of the All-Japan GT series, but were faced with sterner opposition here. Although equipped with carbon composite bodywork, and here with CI carbon-carbon brake sets, the lighter of the two cars was 130kg (287lb) heavier than even the metal-braked McLarens.

The Touring Car based, front-engined GTR is powered by a 2.6-litre, 24-valve, straight-six ▶



"Even with its latest updates, the GT-1 Porsche RSR was no match on top speed for the front-running McLarens and Ferraris in the class. Has the 911 finally had its day as a front-line GT racecar?"



CLASS OF '95

LM GT-1 CLASS



► engine with two Garrett turbochargers, rated at 600bhp at 7600rpm. One of these factory team cars had a six-speed Xtrac sequential gearbox, the other a five-speed unit with manual operation.

Reliability was said to be the strong suit of the Nissans, but only one made it to the finish, after a cautious run. The lighter and faster climbed as high as fifth overall before running into problems with its six-speed transmission, which failed terminally at daybreak.

Toyota Supra

The first appearance by a Toyota Supra racecar outside Japan was a salutary experience for Shin Kato's SARD team, which started Le Mans week with optimism. Toyota's board decision to proceed with a GT racing version of the Supra (top left) had been taken in the Spring of 1994 and the first car had been tested in good time, in August. The proven, 2.1-litre, four-cylinder Toyota 3-S GT engine, turbocharged and intercooled to produce 700bhp at only 7500rpm, had seen extended service in both Group C and IMSA GTP, and was installed with Xtrac's six-speed sequential gearbox in a rugged chassis. Former Dome engineer Ken-ichi Mitani was responsible for the chassis and suspension design, using CAD and FEA in the process, and for the aerody-

namic development in Toyota's full-scale, fixed-floor wind tunnel.

After the Trust team's Supra had been destroyed in a testing accident, only one of five existing racecars appeared at Le Mans. Its run was thwarted before halfway when the team had to undertake a gearbox repair. Throughout the rain, the drivers struggled with aquaplaning, and the Supra finished 14th.

Sard MC-8

On paper, Shin Kato's interesting, Toyota MR2-based project (top right) looked a strong contender, calling on 600bhp at 6100rpm from its mildy KKK turbocharged, 4-litre Lexus V8. However, this was its first race, and it was beset by new-car and other problems. A drooping diffuser in qualifying hindered its recognised drivers, and technically the failure of the third driver (a Japanese TV celebrity) to qualify made it impossible for the car to complete the race.

Before this consideration came into play, the Sard started 90min late from pit-lane as a result of a clutch problem encountered in the warm-up. A few laps later, the car returned to the pits for another new clutch. Eventually it consumed the team's stock of both AP Racing and Tilton units, and was parked.



Honda NSX

John Thompson's TC Prototypes organisation set up its own race team to run a pair of the GT-1 Honda NSX cars that it had built on behalf of the factory. Project designer Doug Bebb based the new chassis on TCP's neat GT-2 car, as run in the 1994 race by Kremer Racing. However, a fundamental change was to turn the transversely aligned, RX-306 V-Tec 3-litre V6 through 90deg. The change in driveline orientation allowed the NSX to utilise Hewland's six-speed sequential inboard transverse TGT gearbox. The longitudinal arrangement added 100mm to the wheelbase.

In addition, one of the cars carried an engine fitted with twin turbochargers, raising the peak power figure of 410bhp at 8000rpm of the naturally aspirated unit to a more realistic 600bhp at 1.2bar, also at 8000rpm.

After gearbox problems, the turbocharged car (bottom left and right) qualified 5sec slower than the Nissan which headed the Japanese contingent (although this was 15sec off the GT-1 pole time), but in the race it completed just seven laps before suffering a terminal clutch failure. The N/A Honda was crashed in the rain during the third hour, incurring damage taking nine hours to repair. An oil leak caused further delay before the finish, at which the car was not classified.



CLASS OF '95

LM GT-1 CLASS



Jaguar XJ220C

Brands Hatch-based PC Automotive brought two of the same TWR-built Jaguar XJ220C racecars (top left) back to the scene of their subsequently forfeited 'class win' in 1993.

The XJ220C power unit is a 3.5-litre V6 with two Garrett turbochargers, producing about 600bhp at 7600rpm and driving through a five-speed transmission produced by FFD-Ricardo. Giving away around 50kg (110lb) and 40bhp to the McLarens, the XJ220C drivers pinned their hopes on reliability and, in the race, the team exploited this attribute.

After eight hours, both cars were running in the top ten – one of them as high as fourth. However, this fine run came to an end with an engine failure, while the other car suffered accident damage and was withdrawn.

Venturi 600LM

Less numerous than in recent years, the three French-built Venturis were nonetheless an effective presence, thanks mainly to the factory team's so-called 600SLM car which qualified 10th (bottom).

The Venturi engine is the 'PRV' 3-litre V6, equipped with two Garrett turbochargers to pro-

duce about 600bhp at 7500rpm, driving through a five-speed Sadev gearbox with Hewland internals. In the SLM, the turbocharger specification was uprated and the engine was equipped with a new butterfly throttle arrangement. The lightest of the trio at 1066kg (2350lb) thanks to new advanced composites bodywork, it also had a new front splitter, rear diffuser and rear wing.

After spending the first three laps of the race in sixth position, the SLM was stopped for two hours while the crew replaced a turbocharger. It was not classified, and the other Venturis failed to reach the chequer.

Lister Storm

Lawrence Pearce's Leatherhead, UK-based Lister company had worked wonders to get its Storm into the qualifying sessions, and benefitted from withdrawn entries which put this substantial car – weighing 1270kg (2800lb) – into the race.



Employing a 7-litre, 24-valve Jaguar V12, prepared by TWR Engines to produce 620bhp at 6500rpm, and a five-speed Hewland SGT gearbox, the Storm project (top right) was started as late as October 1994. Nonetheless, the carbon-bodied car proved surprisingly quick, and strong, notably with hefty, double wishbone suspension arrangements front and rear, the former using pushrods and fabricated steel bellcranks.

After only four hours, the Lister's clutch was wrecked during a trip through a gravel bed.

Chevrolet Corvette ZR-1

Out of Plymouth, Minnesota, Doug Ripple Motorsport's IMSA contender (above) was one of the heaviest cars in the field at 1261kg (2824lb) and was powered by essentially a road car engine. As standard, this 6.3-litre, 32-valve version of the LT5, developed by Lotus only for use in the ZR-1 Corvette, is rated at 550bhp. A change of camshaft specification and an EFI engine management system uprated power to 575bhp at 6800rpm, delivered through a Weissman gearbox.

Covering a ladder-frame chassis and a tubular upper frame, the carbonfibre bodywork was the last Corvette racecar body commissioned by GM, designed by Bob Riley for use in 1987-88-89 IMSA GTO and Trans-Am. The fixed, single-plane wing, as originally designed for this programme, had not been used prior to Le Mans 1995.

Race-engineered by the experienced Tommy Sapp, the car lost compression in one cylinder during Thursday qualifying. The team was told by Callaway that it had encountered a similar piston ring problem in 1994 when using the organisers' Esso fuel. With ACO dispensation, Sapp switched to Elf for the race, but the car was in the pits after only two laps for water, and later stopped out on the track with the temperature off the gauge. Back in the pits, another ring failure was diagnosed. The team rebuilt the engine *in situ* but its overheating problems were ultimately terminal.

Alan Lis



CLASS OF '95

WORLD SPORTS CARS CLASS



Courage Close with Porsche Spyder

FINALLY MAKING its racing debut, the Paolo Catone designed Courage C41 (bottom) impressed in terms of its build quality and on-track performance in qualifying. Even so, the Le Mans based team wished to run two Porsche-engined cars and only one of the new C41s. Refused leave to change its entries, it had to complete a second race-ready chassis and source an engine.

Thus the original car ran with a naturally aspirated Chevrolet V8 prepared by Katech, similar to that used for testing, producing about 610bhp at 8200rpm. The newer chassis was equipped with a similar 5-litre, 16-valve engine, but prepared by Comptech. The California company received an order for two engines in mid-May but, despite the short lead time, was able to meet the order, and also sent over a representative to oversee the installation.

As reported in our description of the C41 (V4N5), the very rigid monocoque is made from carbonfibre laminates over aluminium honeycomb core material by the French specialist, Compositex. The gearbox is a longitudinal, five-speed unit developed in the UK by SDC (now known as Internotion).

Yves Courage's team suffered a major setback when it allowed the Comptech C41 onto the track in final qualifying no less than 17kg (37lb) underweight — as measured by the ACO's pit-lane scales at the end of the session. A team source claimed that the discrepancy had arisen from the installation of the aluminium block engine (instead of the Katech cast-iron block for which the car had been engineered), and a switch from iron to carbon-carbon brakes. However, another source reported that the only major differences between the two Small Block versions are in the cylinder head: Katech's heads are based on production-line castings, Comptech's on different, aftermarket castings. Whatever, the car was summarily excluded from the race, amid a surely inaccurate

rumour of a political background to the affair involving the car's wealthy Balkan rental driver.

Conforming with IMSA's rules, the C41 was designed with iron brake discs. It had not been tested with carbon-carbon discs prior to Le Mans, so the team ran different setups on each car to make a comparison. There was concern over cooling, since the front brakes draw non-pressurised cooling air from under the nose, the rears from the water radiator inlet ducts. These provisions, while more than adequate for ferrous discs, were possibly marginal for carbon-carbon. The team had the option to create a dynamic pressurised inlet in the nose panel under the lights housing.

The surviving C41, race-engineered by Ricardo Divilla, started from the second row. It

ran strongly in the top-six, but was halted in the third hour by low fuel pump pressure. A weakened battery, resulting from a failing alternator, was later diagnosed.

Courage hedged its bets by entering a converted Group C chassis (top) alongside its new, stockblock-engined WSC cars.

Based on an original design dating back to the mid-1980s by Alain Touchais and Jean-Claude Rose, with aerodynamic input from Marcel Hubert, the Courage C34 was again powered by Porsche.

This attracted overt support from Porsche in the form of works engines and engineers to oversee them. It also gave Courage access to two of the drivers who were to have raced the works-backed, TWR-built WSC cars until the factory pulled its entries.

Reliant on a mechanical package that must have known its own way around the Circuit de la Sarthe, Wollek headed the timesheets after ▶

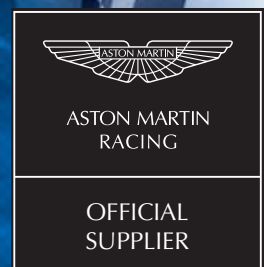


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WORLD SPORTS CARS CLASS



Kudzu DG-3

Invoking the spirit of Mazda's 1991 Le Mans victory, the Kudzu of the Downing Atlanta team was painted in the same green and orange colour scheme (below). However, IMSA's rules, and even the ACO's interpretation of them, restricted it to the triple-rotor engine, rather than its much more powerful quad-rotor version.

The team's Le Mans plan received a setback when its intended chassis was written off in an accident at Sebring, although the replacement performed well enough in pre-qualifying to book a place in the race.

Strong support came from Mazdaspeed in Japan, which bolstered the 13-man US contingent to no fewer than 40, and also engaged Nigel Stroud, the British designer of the victorious Mazda 787B, as race engineer.

Based on a 1989 Camel Lights design by Sam Garrett, with updates by David Lynn, the Kudzu DG-3 monocoque is formed primarily in aluminium honeycomb material, with advanced composite structural panels in the flanks and over the cockpit area.

► first qualifying, ironically with one of Courage Competition's own engines. This was replaced by a factory unit for Thursday evening, which implied relocation of the turbochargers among other alterations.

Despite reducing his lap-time by a further 5sec, Wollek slipped to third on the grid behind the featherweight WR-Peugeots.

Race-engineered by Dominique Meland, who runs a factory-backed Suzuki motorcycle endurance team, the C34 was the WSC pace-maker, and would surely have won had Andretti not been tripped up by a backmarker. A tremendous comeback performance, by all three drivers, eventually recovered second place. Wollek took a whole-hearted tilt at the win but, after his final fuel stop, with a heavier car on worn rubber, he settled for that position.

Ferrari 333SP

Entered by Antonio Ferrari's Indianapolis based Euromotorsport team, the yellow Ferrari was arguably the star car in the 48-strong Le Mans field (bottom). However, it was immediately in trouble.

First in line for scrutineering, it was detained at the first check for almost an hour while the team and the organisers argued. The ACO insisted that it would fit its own device for checking that the 10,500rpm rev-limit for the Ferrari at this weight – 893kg (1969lb) – would not be infringed. The team ultimately had to bow to the organisers' wishes. Consequently the car sat out first qualifying while a Stack recording tachometer, with its flywheel pickup and reader, were fitted to the V12. On the second evening, the car qualified 17th.

Despite this lowly grid position, it started as one of the favourites. It was equipped with Maranello's endurance racing package, including the endurance version of the 4-litre V12 (offering increased torque), and strengthened gearbox internals.

After a surging early run towards the front, however, the whole sorry episode came to an end when the car stopped out on the track on the seventh lap.

A catastrophic engine failure was feared, but the fault was later traced to stone damage to the crankshaft-mounted ignition trigger. After the car had been recovered, and the broken component replaced, the V12 fired up in the garage...



CLASS OF '95

LM PROTOTYPE CLASS

WR-Peugeot Upsets the Formbook

The suspension systems feature double wishbones and pushrod-actuated Penske dampers with concentric springs.

The team prepares its own engines, under the direction of Rick Engeman, and called upon 465bhp at 8200rpm.

The transmission is the March 88T five-speed manual unit. Under the ACO version of the WSC rules, the DG-3 was able to run with carbon-carbon brakes.

During qualifying, the team had repeatedly to make suspension adjustments raising the car's nose, to avoid contact with the road surface: it was only in the Saturday warmup that a failure of the nosebox structure was discovered. Its replacement meant that the Kudzu started the race from pit-lane, its front end set up for a solid nosebox by 'guesstimate'.

The low weight and low downforce characteristics of this car were such that it could run three stints on a single set of tyres in the rain. At the finish, it was seventh overall, the first genuine WSC car home (beaten only by two Porsche powered 'LM-WSC' entries).



Kremer K8 Porsche

Erwin and Manfred Kremer returned to their Porsche roots for Le Mans 1995 following a disappointing liaison with the Honda NSX project in 1994. The Porsche engined K8 (above) had little to prove in terms of reliability after its Daytona win in February, and in view of its ancestry, the Porsche 956/962 having won Le Mans no fewer than seven times.

Built in Köln, Germany, this open-top racecar was fully described in VSN1. The two cars at this race were both equipped with the latest works specification Porsche flat-six, this reflecting a quasi-works status for the team which was assisted by a number of Porsche factory personnel, including the 'father' of the 956/962, Norbert Singer. Although overshadowed by the Porsche engined Courage in qualifying, the latest, advanced composite monocoque K8 started from fifth on the grid, while the older, aluminium honeycomb chassis was 16th.

Both Kremers started the race on dry settings and, as the rain set in, a handling problem developed on the newer car. Later, after an unscheduled stop to replace a punctured tyre, Hans Stuck was sent out on intermediates, these being the only full set available at the time. Unaware of the changed tyre pattern, he spun and hit a wall on his 'out' lap. The repairs cost several laps, but the car ran to the end and eventually finished sixth, without changing brake discs or pads. The older car inadvertently played a major part in determining the winner of the race by tripping up Andretti's Courage. It escaped without damage, only to be retired due to an electrical failure.

Alan Lis

ONE OF THE most gratifying achievements of Le Mans 1995 was that of Gérard Welter's enthusiastic, Thorigny based team of friends and helpers. They not only tied up the front row of the grid, but then led the first hour of the race, with their distinctive, central-seat WRs.

Mechanically these neat, aluminium monocoque cars were little changed from 1994.

Driving through a five-speed Hewland DGB manual transmission, Welter Racing's chosen power unit is a 1.9-litre, four-cylinder Peugeot 405 T16. Similar to that used by the factory team Rally Raid cars, it is equipped with Magneti Marelli fuel-injection and ECU and with a single Garrett turbocharger. An ignition problem in first qualifying prevented either engine from running above 6000rpm. The fault was traced to incompatibility of new sensors with the Marelli management system. These were changed for Thursday, when the drivers were able to use the engine to its full potential (rated at 400bhp at 7000rpm). William David's pole position was driven in daylight with the lighter of the carbon/Kevlar bodied WRs, weighing only 623kg (1373lb). Then, in darkness, Patrick Gonin secured the front row.

The cars ran first and second throughout the opening hour of the race. Of course, it was too good to last. In the second hour, the leading car was in for a new LH driveshaft. The rubber boot on the outer end of the production-based component had broken, and the UJ had seized without lubrication. The team improvised additional seals on the remaining boots, and called in the sister car for a precautionary seal change.

Later, the ACO's course cars were sent out after Gonin had moved off-line in heavy rain to overtake another car, and aquaplaned into a major accident. The other WR also went off the road twice but, on each occasion, was able to reach the pits for repairs. Race engineer Vincent Soullignac reported that the cars were running four stints on a single set of tyres, and that the tyres were too hard for the wet conditions. The remaining WR raced on until late on Sunday morning, when the fuel pump failed.

The ACO is due to introduce new Le Mans regulations for open-top sports-prototypes in 1997, drafted in consultation with IMSA to secure the participation of its WSC cars. WR hopes that provision will also be made for the LMP class. Lest this is not the case, the team has already started preliminary design work on a WSC chassis.

Debora LMP295

Didier Bonnet was back at Le Mans for the fourth year with a two-seat sports-prototype. For 1995, however, the Alfa Romeo V6 used in his Besancon team's previous efforts was replaced with the four-cylinder, 2-litre engine of the Ford Escort Turbo, prepared by FocheAuto to deliver 450bhp at 9000rpm with a single Garrett turbocharger.

This engine and a five-speed manual Hewland FGC gearbox were attached to an aluminium monocoque, designed by Roger Rimmer, fitted with carbon/Kevlar bodywork designed by Bonnet himself. The Debora had a lacklustre run into 20th place, the last finisher.

Alan Lis

CLASS OF '95

LM GT-2 CLASS



Honda Defeats Callaway Challenge

THE GT-2 HONDA NSX returned to Le Mans for the second time in the hands of one of the teams running in the All-Japan GT series. Largely unchanged from 1994, the NSX, built around a carbon-skinned aluminium monocoque and powered by the 3-litre Honda RX-306 E4 V6, showed greatly improved reliability.

The Kunimitsu Team entry outqualified its naturally aspirated GT-1 counterpart and was just 5sec slower than the turbocharged GT-1 NSX, despite a peak power deficit of more than 200bhp. Starting from pit-lane after a small oil fire, the car nevertheless ran second in class at the end of the first hour. Shortly after, replacing the exhaust system cost a delay, but the drivers recovered well, helped by the fuel-efficiency of the Honda engine and a high rate of attrition among the opposition. With six hours to run, the Honda moved past the works Callaway to take the class lead, and finished seventh overall.

Callaway Supernatural Corvette

WHILE CALLAWAY Competition continues the construction of its new C7, the 'Supernatural' Corvette continued as its front-line GT racecar (top left and right). The Supernatural is not merely a modified production Corvette. The car is built at the company's Leingarten, Germany base, under the supervision of Ernst Wöhr, around a central structure formed by specially commissioned, steel pressings, half the production thickness. The engines are supplied out of Callaway's Connecticut, USA facility. These 6.3-litre, 16-valve units are built around Callaway's own aluminium castings, based on the classic Chevrolet Bow-Tie block. With ignition and fuelling regulated by an EFI management system, peak power is quoted as 480bhp at 6250rpm.

Following a number of good performances in 1994 GT races, Callaway took orders for four customer Supernaturals. Two were entered at Le Mans by Agusta Racing, alongside the works Supernatural, the same chassis that had run impressively here in 1994.

Agusta, managed by Keith Greene, made modifications to its cars including centre-lock hubs (the works car retained the standard five-stud wheel fixing), additional stiffening in the bodywork, relocation of the rear wing, and changes to the engine and gearbox mountings.

While Greene race-engineered one car, the other was run by Lucien Monte, owner of the Synergie company which ran a Bugatti EB110 here

in 1994, and which prepared a neat Aston Martin DB7 that narrowly failed to prequalify in 1995.

The team started first qualifying with Xtrac's purpose-built sequential GT gearbox in one car and a manual six-speed ZF unit in the other. The ZF was expected to be more reliable, the new Xtrac unit yet to prove its ability to endure a 24-hour race. Early in the session, however, the ZF car was in the pits, the driver unable to select a gear. A second ZF was installed, only for the same problem to occur. Subsequent inspection pointed to incorrect assembly. An Xtrac gearbox was fitted so that this car could take the GT-2 pole in second qualifying, but it was switched back to another new ZF for the race.

Both the works Callaway and Agusta's Xtrac car led GT-2 during the race, but were eventually beaten into second and third in class by the Honda NSX. The second Agusta car was retired at the pits with irreparable accident damage.

Porsche 911 RSR

Although outgunned in GT-1, the Porsche 911 is still a potent GT-2 car. In this guise, the familiar pressed steel central monocoque carries a 3.6-litre, twin KKK turbocharged version of the air-cooled, two-valve M64/81 flat-six that produces 450bhp at 6800rpm.

Of the six 911s, three made it through. Unfortunately, the casualties were the fastest of the contingent, and every one was crashed out.

The Stadler Racing car had reached a startling sixth overall during the seventh hour, at which point it led the GT-2 class by four laps.

Marcos 600LM

The two Marcos 600LMs were the first cars produced by the Wiltshire, UK based manufacturer to race at Le Mans since 1967. The car (bottom) is based on a square-section tubeframe chassis with MacPherson strut front suspension and a double wishbone rear layout. Power is derived from a 6.3-litre Small Block Chevrolet V8, prepared by Lozano Bros in the USA. Controlled by an EFI management system, the engine is rated at 530bhp at 6250rpm.

Transmission is by a Hewland five-speed manual gearbox, attached to the engine by a Marcos-produced bellhousing, and an Intermotion (née SDC) limited-slip differential.

Both cars started towards the back after qualifying in race setup. The Marcos run by Colin Denyer reached 18th place before a long delay while the exhaust system was changed, later to be retired with a broken driveshaft UJ. The other, managed by Roy Baker, had its gearbox changed after it leaked oil in the warmup, and then an electrical failure stranded its driver on the track. Ingeniously restored to the race, it ran reliably enough to the finish, but was not classified.

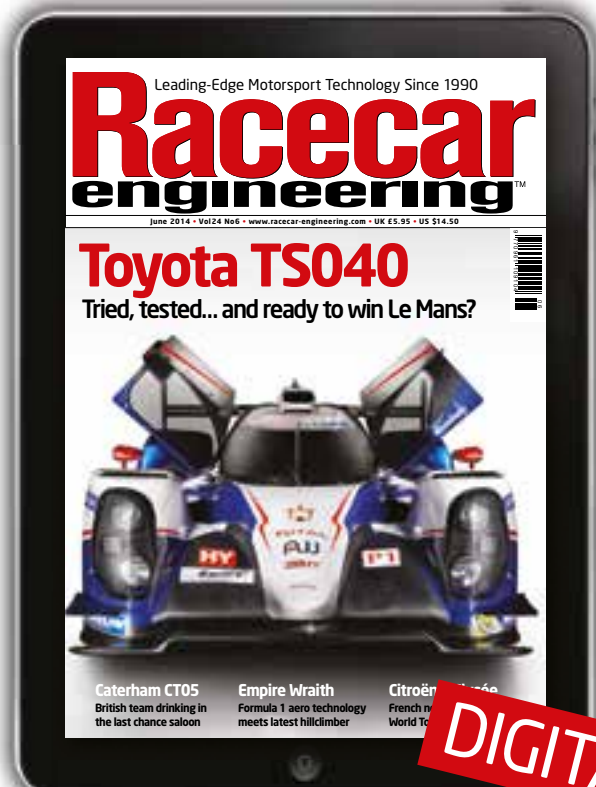
Nevertheless, there were later broad smiles on the faces of its mechanics when they were awarded the ESCRA Prize for the quality of their technical assistance...

Alan Lis



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The big picture

Looking beyond one's own nose, or wallet, is key to survival in motor racing

The schedule for Silverstone's (excellent) WEC race stated that nobody under 16 years old was permitted on the grid walkabout. Given that there are 15-year-olds driving in F4, and F1 newcomer Max Verstappen would not have met this requirement only a couple of years ago, the world is a puzzling place sometimes.

But then 'stupid' seems to be a popular word recently. Toro Rosso's Franz Tost used this term to describe anyone querying Verstappen becoming a F1 driver at just 17. Cyril Abiteboul of Renault F1 explained early power unit failures as being due to a 'stupid part'. Stupid decisions sometimes get made in regulation-making. The attitude of some team owners in many formulae can be stupid; so can that of certain drivers.

Acting stupidly – and let's be a bit kinder and include 'without good judgement' – is something of which we are all guilty and is often the result of not looking at the big picture. Being one of the stupid people referred to by Tost – but comforted by the fact that others in this category include Adrian Newey, a man not noted for his lack of brain power – it seems obvious to me that this remark was made with typical motorsport blinkers on. The issue is not about the capability to drive the car. It is about responsibility and the increasing trend to develop what are worryingly close to child freaks, whose so-far short lives have been entirely dedicated to being a racing driver to the exclusion of almost everything else. After all, what's the rush? We are all supposed to live and work longer, so why the need to start a career – if it actually becomes one – earlier?

Working together

The big picture was obviously not on Renault's agenda when Abiteboul made his remark about a certain broken engine component. How can any part of a racing engine or power unit be stupid? All parts are included for a purpose and failure of any one of them, no matter how minor, will almost certainly lead to a compromised result or even a DNF. Therefore all items, no matter how small, require the same scrutiny and attention. Perhaps the desperation to increase performance led to such an attitude, which is very surprising considering the level at which Renault has operated in the past.

However, the big picture is alive and well in endurance racing. Although I personally (therefore you may well say 'so what?') do not agree with some aspects of the ACO/FIA technical regulations, the WEC and its headline automotive manufacturer entrants appear to be well aware of the need to look beyond their immediate and individual racing objectives and consider what it is they are trying to achieve. Fundamentally, it is to sell more of their products at a higher profit and in new markets by demonstrating their technology and engineering excellence, and by introducing excitement into their image. Success in high-exposure competition also increases awareness of their brand and therefore its value. According to Interbrand, one of the world's leading consultancies in this field, the value of the Honda brand name increased by 17 per cent – to US\$21.673 billion – following their

is proved, and there is the risk of the championship collapsing, as has happened so often in the past. It can also be a big negative in a marque's popularity if it keeps winning easily. Thus, the WEC is run to a cleverly-conceived set of rules that delivers great, competitive racing incorporating interesting and varied technical approaches. Importantly they also have relevance to production car development and environmental issues. This has tempted in, and retained, no fewer now than four car manufacturers, all of whom can have a realistic chance of on-track success, including at the massively-prestigious Le Mans 24 hour race.

Time for a fresh start

Why endurance racing is succeeding where F1 is failing is perhaps due to these large corporations being run by professional management. They

possess less of a cavalier approach to business matters and prefer patient negotiations behind closed doors than the egoistic public utterings by those in F1 who should know better. The fact that they do not have to be in motor racing for their survival must also be a factor. So also may be the fact that the WEC is run by an organisation not entirely dedicated to making money.

GT racing promoter Stephane Ratel saw the big picture and the need for bringing in a much wider range of manufacturers and affiliated teams, hence the concept of GT3 was born. Balance of Performance, brought in by the FIA under the stewardship of Max Mosley to deal with the Maserati MC12, is not popular with everyone,

admittedly, but almost overnight exotic production cars that would not have been competitive in GT racing – too heavy, lacking good aero – were able to participate and win. Subsequently the GT3 concept has been enormously successful worldwide, and the BoP idea has been adopted for other categories. In World Touring Cars the organisers have grasped that giving it greater exposure and credibility, including the need to attract more manufacturers, means the need for events at circuits well-known to the public. Thus the WTCC now includes the Nürburgring.

Only big picture thinking will allow motor racing to continue healthily, but the problem is that some of the main players in the sport unfortunately have yet to understand this.



Big picture thinking is required to maintain interest from the fans, and from participants too

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announcement of re-entering F1, although it's fair to speculate that it may have dropped a bit since. Such matters are important to shareholders, investors and the directors of these companies.

There are other benefits of course; genuine advances in innovation, attracting quality employees, in-company training and motivation and so on. Taken together, this understanding that there is more to gain than just the next race win has led them to positively work together with the championship promoters in a sensible and mature dialogue. Even if one manufacturer wanted to dominate by outspending its rivals the realisation is that this would defeat the reason for its involvement. Without strong competition little





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