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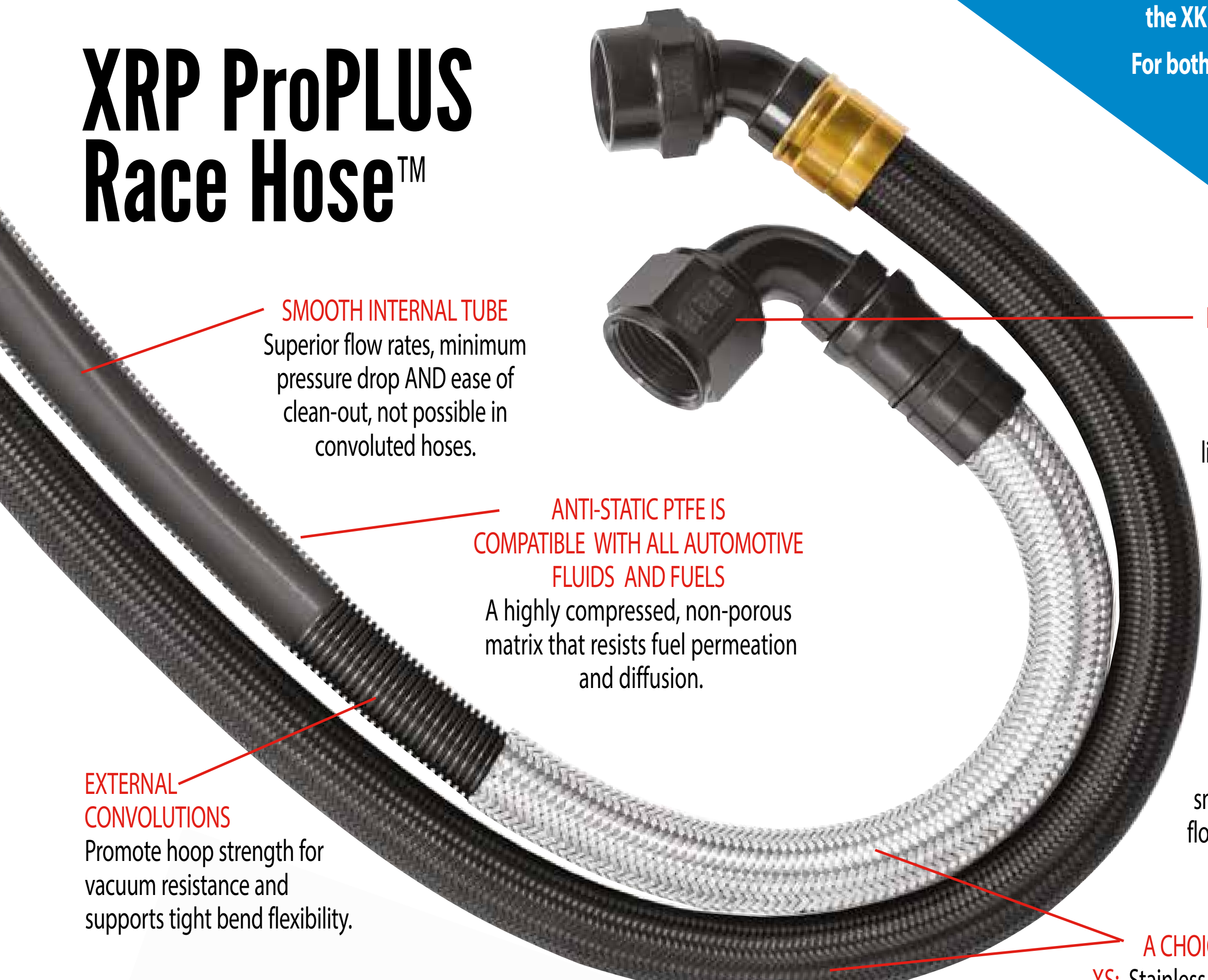

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The new Ford GT made its international debut at the Daytona 24 Hours at the end of January

The wages of sim

Motor racing simulation has come a very long way in the past 20 years

Way back in the 1990s there was a particular problem in Formula 3000. It was a support series to Formula 1, and used the sessions available between running the F1 cars, which meant that there were only two qualifying sessions, and no free practice. An added factor was that the first session was immediately after Formula 1 running, and due to the rubbering up of the track the first five minutes were at least two seconds faster than later on, putting a premium on driver experience.

Drivers in their second year in F3000 had an unfair advantage due to knowing the track and car. Rookies had a problem in finding their marks and posting that all important time on the second lap, before the track degraded.

Having had experience during my basic flight training with flight simulators, the idea arose of using some sort of credible simulation to at least teach the drivers the track layout.

Game theory

My particular choice for the 1994 Formula 3000 championship was to train the drivers on Geoff Crammond's *F1GP*, the second serious 3D polygon-based racing simulation, after the Papyrus *Indy 500*.

These two simulations were the very first to implement something close to 'real world' racing physics; accurate track modelling and car handling that required skills somewhat similar to real-world driving to perform well. They were also the first to offer realistic options to tune the behaviour of the cars through important variables, such as gear ratios, tyre compounds and wing settings, which did make an actual difference when driving.

The accurately modelled tracks gave the player a good reference of location and references on the real-life circuit. The detailed physics engine provided a more realistic driving experience than had ever been seen before, and the drivers could easily experience the differences in handling depending on how you entered a corner and how soon or late you accelerated out of it

Crucially, the combination of good graphics and physics meant players could predict how the car would respond. Details such as tyre wear were modelled in to the race, and for qualifying we used the qualifying tyre model, as the tyre degradation reflected quite well the real time drop off as the Formula 1 rubber wore away. Best of all, the 16 F1 tracks in *F1GP* matched the circuits we would race on in F3000. The difficult part was fitting an analogue steering wheel and pedals, at the time these were far from mainstream.

The proof that the concept worked was our run of five pole positions out of eight races, four for Frank Lagorce (plus three third positions) and more remarkably one for Emmanuel Clerico, an absolute rookie, at Estoril – not the easiest of tracks to learn – plus two thirds, one fourth and two sixths. That year we had competitors such as Jean Christophe Bouillon, Gil de Ferran, Vicenzo Sospiri, Kenny Brack, Max Papis, Didier Cottaz, Jordi Gene, Marc Goosens, Tarso Marques, Oliver Gavin, and not least David Coulthard and Allan McNish, although the last two did not do all of the races.

There is a war to develop the most realistic F1 simulator

Ferrari's simulator cost around $6m and it is controlled by 10 big multi-processor computers with more than 60 gigabytes of RAM

It did come with a penalty at Spa, though, as Clerico's cutting of the kerbs at the Bus Stop was very fast in simulation but cost us a monocoque as the kerbs were a little bit higher in real life.

Sim-biotic

By the time I was racing in Japan in 1996 in Super GT, now known as GT500, the state of the art was improving rapidly, and at Nismo we had visits from Polyphonys coders to collect data from the real cars and validate the game's physics engine – which, by the way, ended up being better than our own vehicle dynamics programs. We also had the drivers try out the handling and response.

We learnt back then that they can simulate better than us, but we can design better than them. But I don't know for how long.

The resulting released product was *Gran Turismo*, and Kazunori Yamauchi's Playstation game turned into the reference, having sold over 76 million copies as of the end of 2015.

The relationship between Polyphony and Nissan eventually spawned the GT Academy, a driver discovery/development programme initiated in 2008 through a partnership between Sony Computer Entertainment Europe, Polyphony Digital Inc., and Nissan Europe.

Online qualifiers are held within the *Gran Turismo* game, and the top qualifiers are invited to national finals in each participating country. The winners of each country's competition are sent to Race Camp at Silverstone, for the final selection. The winner of this then undergoes an intensive Driver Development Programme designed by Nissan, which will train and turn them into a professional driver, competing in races worldwide.

RAM raid

There was initially some scepticism from other drivers about the ability of the *gamers* to compete, but the string of successes and championships won by them has put that doubt to bed and, from my side, I can only say that the drivers I have engineered from the GT Academy have demonstrated levels of professionalism, technical feedback and ability that match the pros, plus they are refreshingly free of the vices drivers will accumulate, as anyone that has had to learn the ropes in the conventional way will do.

The racing manufacturers intensive use of simulators has now created a new class of professionals, the simulator test and development driver, and routinely car manufacturers use simulators to try out and develop cars that only exist virtually, before building and testing them in reality.

At F1 levels there is a war between the different teams in developing the most realistic simulator, with simulator drivers being poached and the envelopes being pushed routinely. A 2012 investment of $6m at Ferrari for a 4000lbs, fully enclosed simulation pod on six massive actuator struts, controlled by ten multi-processor computers with more than 60 gigabytes of RAM, is a demonstration that it has now fully come of age.

The final proof was Fernando Alonso's matter-of-fact comment about the 2014 Ferrari 'The new car already feels better in the simulator than last year's car.' That was before it ever ran on track. And there is more to come!

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Japanese whispers

Is the Super Formula single seater series one of motorsport's best kept secrets?

To reveal that the fastest-cornering road racecars in the world are to be found in a national championship might raise some eyebrows. Yet this is the case with Japanese Super Formula, formerly Formula Nippon. Since Japan's financial crisis in the 1990s the series' quality and depth waned and the technical regulations moved away from the European ones that it previously closely shadowed. In recent times SF has partially recovered, but still has the image of being, at best, a refuge for Western drivers unable to progress internationally in single seaters.

The news that McLaren's nascent F1 star Stoffel Vandoorne is keeping his hand in by racing in Super Formula until a suitable Formula 1 seat becomes available may well have dealt this under-recognised championship a good hand. From relative media obscurity outside of its homeland coverage, it could propel SF into the attention of the motorsport world once again.

Old school racing

Super-talented Vandoorne undoubtedly is, but the GP2 ace will not find it easy. In addition to adapting to a very different culture, the circuits, tyres and aero will be the three key challenges that Vandoorne, like any SF rookie, will have to surmount. As Kondo Racing's front-running British driver James Rossiter summarised for me; the circuits are mostly old-style, narrow with fast corners and little run-off. Young drivers with experience only of the sanitised tracks now so common will find this exhilarating if they are sufficiently brave and committed, or too frightening if they are not. In particular, with limited testing, tyre warmers forbidden and a new set of rubber as much as one to one-and-a-half seconds quicker for one flying lap, the first corner in qualifying requires huge commitment.

Then, there is the heat and humidity of the summer months, and the tyres giving the capability to race flat-out from start to finish. Fitness is essential, because there is no easing back to avoid tyre degradation in Super Formula, as there is in almost all other top formulae. The change to Yokohama from Bridgestone has not altered this, according to recent testing.

Also, in contrast to F1 Pirellis, the wet tyres are traditionally 'amazing' according to Rossiter, even in the torrential rain typical of this part of the world. Add to the tyre grip the great downforce of these cars. The sophisticated Dallara chassis, with 600bhp turbo engine, possesses a large diffuser. Thus SF cars are faster in corners than GP2 and F1, despite being pegged back with weight and air restrictor regulations – every time they embarrass F1 lap times at Suzuka! With serious impact with the Armco a likely consequence of getting it wrong, bravery as well as technical skill is a must to make a mark in these projectiles. Yet, contrary to many views otherwise, the combination of sticky tyres and high downforce still permits frequent overtaking. Perhaps the blinkered F1 decision-makers (decision-fluffers?) should take note.

As a further challenge, the standard of teams and drivers is high. Technological developments in F1 especially are very closely studied and implemented where they are felt to be beneficial. Three-times Le Mans winner and Audi LMP1 driver Andre Lotterer is an example of the experience and quality on the grid, along with the aforementioned F1 reserve and test driver James Rossiter, multiple F3 championship-winning Joao Paulo de Oliveira and until recently Loic Duval and Tonio Liuzzi. Japan's very own Kamui Kobayashi and Kazuki Nakajima, ex-F1 men both, plus upcoming Hiroaki Ishiura, should not be underestimated either.

Super Formula provides a huge challenge for both drivers and engineers and its Dallaras are said to be the fastest cornering racecars in the world

SF, together with Super GT, is remarkable in being a relatively expensive championship (circa minimum $2m for a two-car team excluding engine manufacturer support) that relies almost solely on domestic exposure. Only the USA (Indycar and NASCAR) and Germany (DTM), can compare. Although significant financial assistance comes from engine protagonists Toyota and Honda, sponsorship is otherwise no easier to find than elsewhere. However, most of the European drivers who make up a significant part of the grid are paid to race, or at least their seats are heavily-subsidised. Most top-up their income and track time by also competing in Super GT, where there is a great deal of tyre-testing. The knowledge gained from this, and working with these large manufacturer teams, is something from which Vandoorne, for example, could usefully try to benefit.

Big in Japan

Japanese spectators (averaging around 25,000 per event but up to 50,000 at peak) display huge enthusiasm, with dedicated driver fan bases very popular – and also good for sponsors. Also, while being extremely professional and competitive, the 11 current teams (19 cars) are very committed to the sporting ethic of racing and work together to keep the seven-event championship in good shape. Rossiter and other *Gaijin* (foreign) drivers find this attitude refreshing compared to the politicking that blights much of Western racing.

Surely the progress of Vandoorne will be eagerly and closely followed by those who previously have paid scant notice to the Oriental happenings. To take full advantage of this exposure, however, Japanese focus must extend beyond the national coastlines and embrace a less inward-looking mentality (a contributing factor for Honda's difficulties in Formula 1, I believe).

The SF calendar has finally been scheduled to avoid conflict with WEC events, so that drivers such as Lotterer can compete in all rounds of both. This is a step forward. But other than full-event domestic J Sports TV coverage, there are only race highlights broadcast in Japan and in adjacent South East Asian countries, and not as much exploitation of social media as there ought to be. More effort in these areas could bring in additional sponsorship opportunities and allow the championship to grow and further establish itself as an important international category for aspiring, as well as established, drivers.

Meanwhile, those drivers that are already competing in it relish the high-*g*, ballsy racing on proper tracks that is Super Formula and don't want these aspects to change. Any drivers not up for it – keep away!

The circuits are mostly old-style, narrow with fast corners and little run-off

A car for **all seasons**

The Ferrari 488 GTE can serve both GT3 and GTE customers with only an engine change required, but this all-new racear's not just about adaptability

By ANDREW COTTON

The Ferrari 488 GTE car made its public debut at the Daytona 24 hours pre-test, a car that succeeds the successful 458 with an all-new turbo engine, and aero upgrades according to new regulations for the 2016 season. Yet, under the skin, the car has also undergone some major development work, reducing weight and increasing efficiency ahead of what is expected to be a tough season ahead on both sides of the Atlantic.

It's not just the look of the car that is interesting, though, because with the 488 Ferrari has taken an unusual approach, in that the GTE and GT3 cars share many common components. Some slight changes to the aero, and a different, production-based engine, are the only differences between the two versions of the car. Indeed, some of the GTE car components have even been dumbed down in order to service the needs of the GT3 customers.

The close relationship between the two cars has meant that the cost of the GT3 version is more than €500,000, the only model to break that barrier. However, this is another car that was clearly built with successful convergence talks in mind (see our feature on the BMW M6, page 16).

Aerodynamics

Ferrari's change in philosophy regarding the aero performance is one of the major shifts in its approach. Previously, the 458 went for low downforce in order to produce competitive top speeds, but this was a matter of coping with the Balance of Performance. The 458 was originally the baseline model of the category, yet changes had to be made because its direct injection engine and aero efficiency could save it a pit stop over the course of a six-hour World Endurance Championship (WEC) race.

Ferrari's change in philosophy regarding the aero performance is obviously one of the major shifts in its approach

The Ferrari 488 testing at Daytona. The turbo engine is new, and the entire car has been developed with an increase in aerodynamic downforce very much in mind


The engine in the GTLM version of the 488. The 3.9-litre turbocharged unit comes with a weight penalty. Due to the weight of the turbocharging system, the car has had to go on to something of a diet to hit the minimum weight


Ferrari has switched to this Xtrac transverse gearbox in order to allow the rear diffuser to rise further forward in the 488 than it did in its 458 predecessor. Meanwhile, the gearshift mechanism for the car has switched from Hewland to Megaline

There has been much work on the braking system, partly aimed at easing the car's balance shift during weight transfer in the braking zone. The uprights are not hand crafted, as they were on the 458, to keep the costs down for GT3 customers

But with the 488, Ferrari has gone for downforce. At the Ladoux test in the south of France, it was at the top end of the aero window. Part of that is due to the new regulations, which allow the front splitter and the rear diffuser to stick out further than the bodywork. That is a change from the 458 – Ferrari was not allowed to extend its splitter beyond the nose, as this was not a feature of the street car.

One of the issues of these extensions is what happens in close racing. The chances of either the front or the rear getting hit is moderately high, and these are exposed pieces of carbon. Ford has a quick release system for the front and the rear that includes the bumper and splitter or diffuser, and so would be able to service the car quickly. Ferrari does not have that facility, and would have to go 'behind the wall' in the US and use the high stands to effect repairs.

This could be particularly relevant in its European campaign, where caution periods are dealt with very differently. In the US a caution can lead to wave-bys and time lost in the pits can be gained on the leader in class. However, in Europe cautions are more likely treated with slow zones, virtual safety cars or, at Le Mans, possibly with three safety cars. Time in the pits is therefore far harder to make up on track, which could give riavls a telling advantage.

Perfect pitch

One of the most obvious changes to the car is the design of the front splitter. The centre of the splitter is raised, a design that NASCAR considered with its latest models. The raised section in the centre of the nose helps the car to cope with the pitch sensitivity that the 458 suffered from as there is less of the splitter running close to the ground, a particular problem under braking.

Ferrari has spent a lot of time perfecting the braking characteristics of the car, a particularly important area for US racing in the IMSA series where the GTD cars, now with GT3 machinery have ABS, and are therefore better in the braking zones than before.

The sensitivity at the front is critical in a GT car because there is little that you can do to balance it, other than to play with the rear wing angles, although Ferrari has worked on the suspension and chassis kinematics to help produce a more balanced car. The splitter has been described as 'more of an underwing' by one observer. It has a very defined non-linear shape to it, which is made to channel air to the diffuser. There are still strakes in the splitter at the front.

There has also been a useful change to the weight distribution thanks to the single front mounted radiator, as opposed to the twin radiators that sat in either corner of the front bumper on the 458.

One of the obvious changes to the car is the design of the front splitter

Ferrari has also worked on the suspension and chassis kinematics

Ferrari's aerodynamic philosophy with its new 488 GTB racer is radical and centred on downforce. Its aggressive rear wing is part of a sophisticated package

A new regulation allows the front splitter and the rear diffuser to protrude further than the edge of the car's bodywork, which could make these complex parts susceptible to crash damage

The power steering system is the same as on its predecessor, but the gearshift mechanism has switched from Hewland to Megaline, in line with the new gearbox.

Safety-wise, the car complies with the new regulations, with the compulsory roof hatch to help the driver in case of an accident, (which in turn leads to a certain design of the roll cage inside the cockpit) and with a fixed drivers' seat, which will affect the speed of driver changes in a pit stop – but this is the same for everyone.

New engine

The switch from a normally aspirated engine to the 3.9-litre turbocharged engine in the 488 created issues Ferrari needed to solve, primarily due to weight. Ferrari has had to work very hard to bring down the weight to meet with the 1235kg minimum weight. That work includes switching from a lead-based battery to a lithium battery, a saving of around 30lbs.

Meanwhile, the complexity of the turbos and intercoolers has meant that Michelotto has had to modify the rear of the chassis. The turbos are mounted low and Ferrari has switched to a transverse gearbox to allow the rear diffuser to begin to rise further forward than with the 458.

GT Balance of Performance – IMSA style

IMSA has introduced a new computer system designed to monitor the GT cars and help to balance them in a more scientific way. IMSA representatives attended the official GT test at Ladoux, and subsequently validated not only the aero findings, but also the Le Mans bodywork at the Windshear facility in North Carolina. The computer system is built by DEKRA and based on the FIA's own model.

'It has been a little difficult to implement with the teams because there are a lot of sensors, and looms and so it has been a bit front-loaded, but the message we sent by how thorough it is, it says that we get it, or that we are trying harder,' says Geoff Carter, WeatherTech senior series and technical manager.

'With the new system, with the Lambda controls and timing, it is becoming more difficult [to fool the system],' Carter adds. 'If they are running to a lean map, we see that now. If they are short shifting, if they are rolling in the brake zone, if they are managing the performance, we absolutely have a chance to see it. In the past we did timing and scoring analysis from A to B, but the new logger tells us how they got from A to B and with this new partnership with DEKRA and new app for the inspection process, we can tell the configuration of the car, we can see how the car got from A to B and what A to B was.'

Big data

'In terms of volume, 7Gb of data per session is what we are pulling,' Carter continues. 'Which is a huge amount to sift through.

'At the moment, post event analysis, we have a mechanism in place where we are pushing the information through a funnel so we have some filters that kick out certain things, or if we see a circumstance in the timing and scoring it will allow us to pick out that data. It is not necessary at this point to have a room full of engineers poring over a terabyte of data, it is putting automated triggers in place, whether it is a percentage of deviation from the sector time, or some other triggers, it shows a spike. We have literally a flag that pops up, and in the spreadsheet it turns the box a certain colour and we can go back and look at that.

'Because we have everybody's data, we can overlay. We can pick a fast lap, take the top 20 per cent, we can take all the laps within half a per cent of the fastest lap, average them, find the data and overlay the speed traces, calculate the gear ratios and make sure they have the proper ratios,' Carter says.

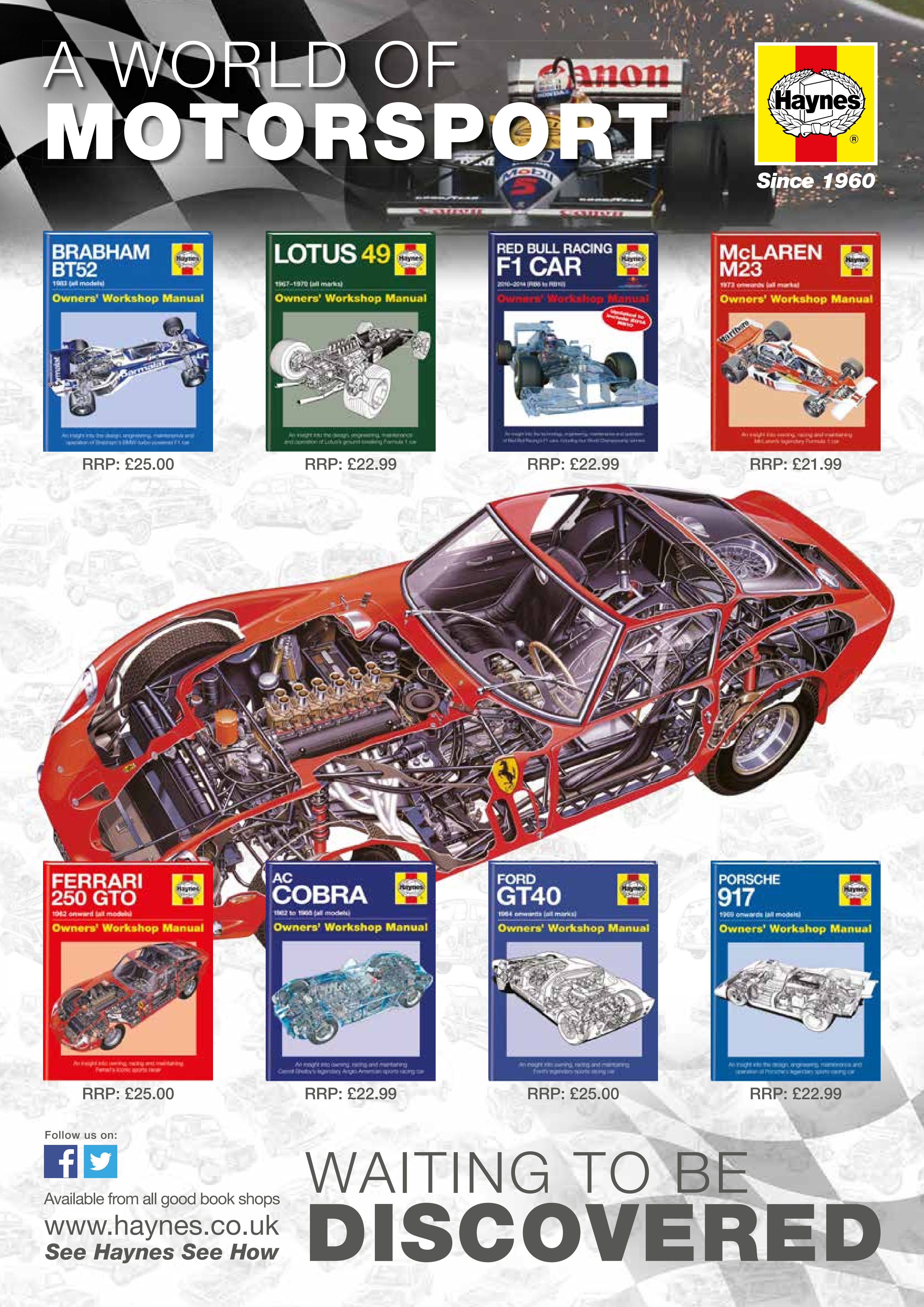
FIA influence

The system was modelled directly on the FIA standalone scrutineering logger that they use at Ladoux. 'It would have been the same system but we have a different vendor,' Carter says. 'This is out of a partnership with the FIA and the ACO with different hardware but common practice.'

He added: 'We have four data engineers that are working with this system, two full time and two that are track side support, and then we have three dedicated Bosch engineers for the year, so you could say that we have seven. We have a very specific overboost protocol and it is more than just a spike, it is the severity and the duration, and there are other interventions that happen, whether it is a shift spike, a plateau, and whether it is traction control, shift spike, shift cut, creep on a constant boost. So there are different circumstances but it is pretty clear in our data when those interventions happen.'

IMSA is using the FIA-augmented system to balance the turbo engines. 'The rpm specific boost tables are a very good way of shaping the power curve, and are way more effective than a constant boost, maximum boost pressure with a restrictor,' Carter says. 'They are much more tunable to shape the curve. The power output of a turbo is very different to an NA car so you can shape the curve to match the torque and horsepower curve of an NA engine. It is much more accurate, much more tunable.'

'It's difficult to get [the teams] to play together, but now there is another tool in the box to balance them,' Carter says.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WAITING TO BE
DISCOVERED

The new front splitter is a beautifully sculpted appendage, designed to better direct air to the diffuser. There are still strakes in the splitter, but these are now in the open area, all in the quest for improved pitch sensitivity

IMSA rules allow for four sets of gear ratios to be used in its series; the two sets that are used in the WEC, one set for the Daytona 24 hours, and one set for the street races that are unique to the IMSA series for GTLM cars.

Fuelling the issue

Fuel consumption remains high on Ferrari's list of priorities and, particularly in the US, it could be a deciding factor in the race results.

Under IMSA regulations, teams can refuel and change tyres at the same time, with the refuelling deliberately slower than the tyre changes. This effect is exacerbated in 2016, as the refuelling tanks will be dropped in a bid to increase the refuelling time by up to five seconds. That places an emphasis on short-filling the tank in order to jump the opposition in the pits, sometimes a critical factor in the sprint races.

In the WEC, the advantage of the direct injection 4.5 litre engine in the 458, which led to the Ferraris able to complete a six hour race on one stop fewer than the opposition, was taken away with a reduction in fuel allowance. This has led to an interesting debate in the US series regarding what will happen to the Balance of Performance should the Ferraris be able to short-fuel.

Manufacturers state their lambda values at the start of the season, and IMSA uses that as an indicator (see sidebar) in determining the relative performance of the cars. However, if Ferrari does have an advantage over the opposition, particularly BMW which has declared a lambda figure that points to outright power, will the allocation of fuel be cut?

At the pre-season test at Daytona, the Ferrari was clearly down on straight-line speed. One observer noted that the 488 was losing more than half a second per lap on the banking to the opposition which, in the inevitable sprint to the finish, could be costly. But the test is notorious for sand-bagging and it is hard to judge whether or not this is a real factor. IMSA says that it has a handle on that through its data logging system, yet Ferrari claims that there is a clear case for increasing its power in order for it to be able to compete. In the BoP tables for the Daytona 24 Hours, modified after the cars had tested early in January, all of the GTE turbo cars had large-scale boost pressure reductions, while the Corvette had a reduction in air restrictor.

Brakes and suspension

Handling-wise, Ferrari has had to work hard on the suspension due to changes in the regulations. There have been some large-scale changes to the suspension, which has been reduced in complexity compared to the 458, and increased in weight to be able to cope with the anticipated demands of the GT3 customers (Ferrari has stated that it intends to build more than 150 racing 488s over the life cycle of the model). The uprights from the 458 were hand-crafted and expensive, while the new ones are machined from billet aluminium. Even with the minimum weight limit in mind, this was a cost saving measure that Ferrari felt was necessary.

No longer can inertia dampers be used in the suspension, and so Ferrari has gone for conventional DSSV dampers. Front and rear roll bars are the same, but teams have noted a change to the spring rates compared to the 458, with stiffer springs required. By regulation, the wheel changing has been improved with Formula 1-style retained wheelnuts.

Ferrari has produced a completely new car, one that rivals have noted will be a threat as it is developed. Initial indications show that it lacks top speed, and so it will take until the middle of the season, after Daytona, Sebring and Long Beach, and the introduction of Michelin's new tyre post-Sebring, to accurately gauge how good it is.

Six appeal

When convergence talks between GTE and GT3 came to nothing BMW's M6 GT LM for the US scene was a very welcome by-product

By ANDREW COTTON

The M6 will race in the US this year where it has already shown eye-opening straightline speed at Daytona – partly due to turbo boost pressures, and partly aerodynamics carried over from GT3

It could be argued that BMW should not have been in the IMSA GT LM category for the past 15 years. The M3 GTR, with a 4-litre V8 engine that raced in the American Le Mans Series was, according to rivals, brought in under false pretences; the extremely limited run of production cars barely materialised. The Z4 was a GT3 car that was brought up to GTE specification and now, the M6 has similarly been adapted from GT3 specification to race in the WeatherTech Sportscar Championship in the US.

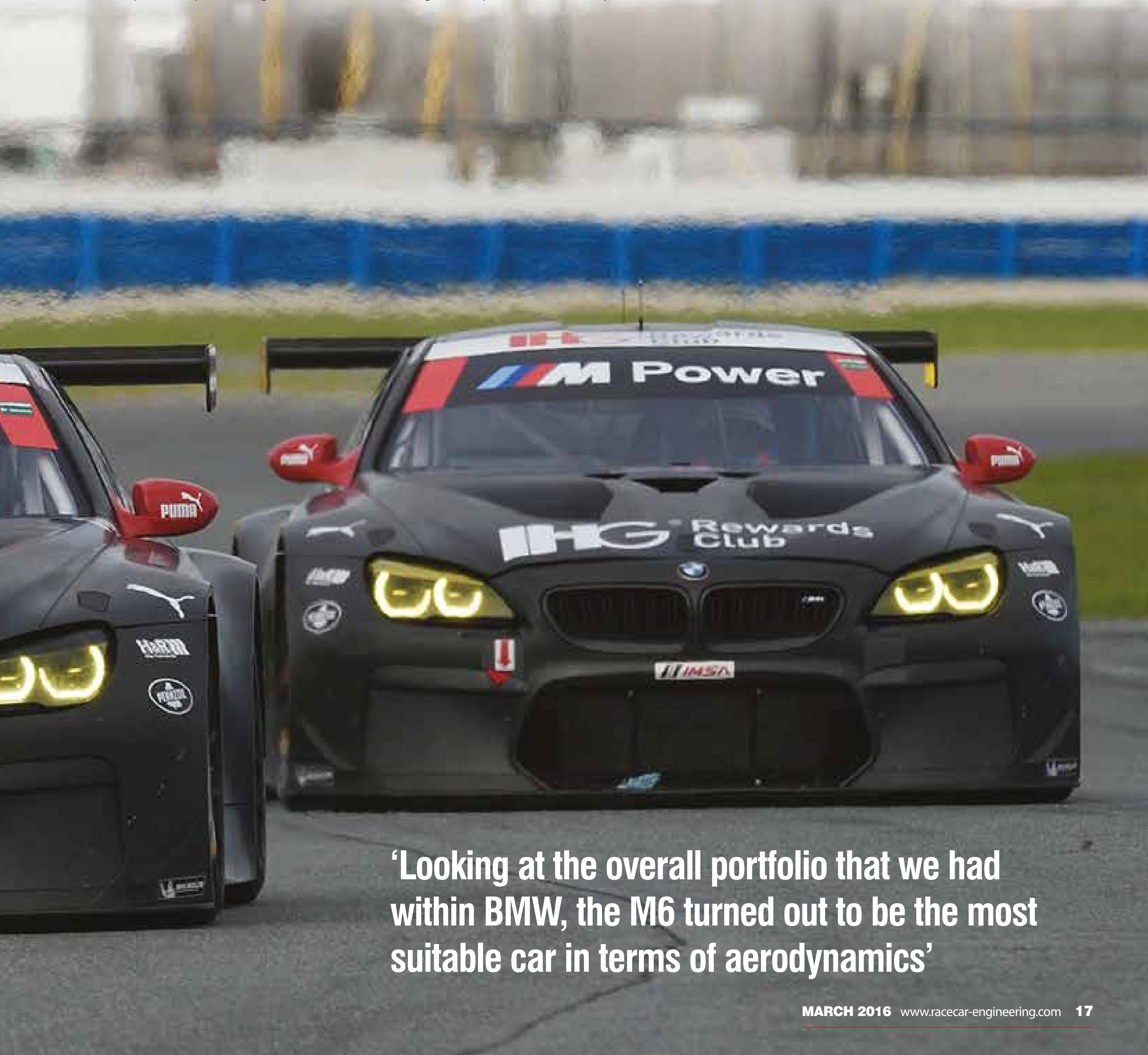
There is, says BMW, no other option. The company just doesn't produce a car that is GTLM compliant and so agreement was sought from the rival manufacturers to allow the conversion. That was given on the basis that BMW does not (at time of writing) have a global race programme that reaches North America.

The M6 kept much of its GT3 specification, incluidng a long rear diffuser, and was balanced up to GTE speeds using the new FIA performance 'windows' that govern the Balance of Performance for GT3 and GTE. Gone from the GT3 version are the ABS brakes, the GTLM car is 50kg lighter than the GT3 car and has a slightly longer wheelbase. Tyre sizes are different, and the new M6 GT LM runs on Michelin tyres.

With the Z4 racing programme having run its course, work started on the M6. 'We looked at the Z4, which in its time enjoyed quite a bit of success, but had some disadvantages, and we tried to figure out which base model would we use to get rid of some of those disadvantages,' says BMW Motorsport director Jens Marquardt. 'The powertrain was where we could see some improvement. We tried to squeeze every bit of torque out of the 4.4-litre engine, but it was the area that we struggled, and in that respect, the M6 base engine was the best base package. Also, looking at running costs of the GT3 car which was the base that we developed, having an engine that produces 600 horsepower is a good base to have a powertrain that is not very different from the production powertrain, thus giving the customer a very good cost for mileage which was a target for that car.

'Looking at the overall portfolio that we had within BMW, the M6 was the most suitable car in terms of aerodynamics and so on. We also wanted to strengthen the dynamic and sporty image of the car with the sister car that we have on the production line up,' Marquardt added.

Like Ferrari, BMW was a fan of the convergence talks, a system that would allow manufacturers to use common parts across GT3 and GTE and to use the performance windows to balance the speeds. But these talks fell down in 2014, largely due to the engine regulations surrounding the use of sonic air restrictors, and costs, with the GT3 prices expected to rise significantly. With the talks failed, teams such as BMW had already started to build their cars. 'I still believe it was a mistake when the decision



'Looking at the overall portfolio that we had within BMW, the M6 turned out to be the most suitable car in terms of aerodynamics'

‘We had a clear decision in 2014 that we had a base car with the GT3 car that we developed. Unfortunately convergence didn’t go through’

M6 engine produces 600bhp in road-going trim, which is a great base for this GT3 power unit. The turbo engine was suitable for both GT categories with minor modifications to allow the car to fit into the FIA performance windows

Switching to a dry sump has freed up space underneath the power unit and so the engine has been dropped in the chassis. The V8 engine suffered from overheating early in its development so it was tested in colder climes to begin with

was taken not to go for convergence,’ says Marquardt. ‘I hope that this discussion can be opened up again. It will benefit the customers, and the pro side of things.

‘We had a clear decision in 2014 that we had a base car, that was the GT3 car that we developed. After our decision was made and we started development, convergence didn’t go ahead. We had to make a decision and the programme in the United States is important to us, so we sat down with IMSA, and said we had a problem here. We were basing all our decisions on the fact that we assumed convergence would happen, and it didn’t. If we cannot find a decision all together, including IMSA and our competitors, it would force us out of the championship. Thanks to IMSA and the competitors, they were open to that discussion.

‘We sat together with IMSA and looked at the GT3 car. From the regulations point of view, there was a lot of our systems that we could use. And then we went to them for aero, where we could find the compromise and say, is that something that is reasonable for the approach, and go step by step, and find a solution that IMSA was happy with, to be closer to GTLM regulations and have a special homologation on the M6, to have the car in the championship,’ Marquardt said.

Lower engine

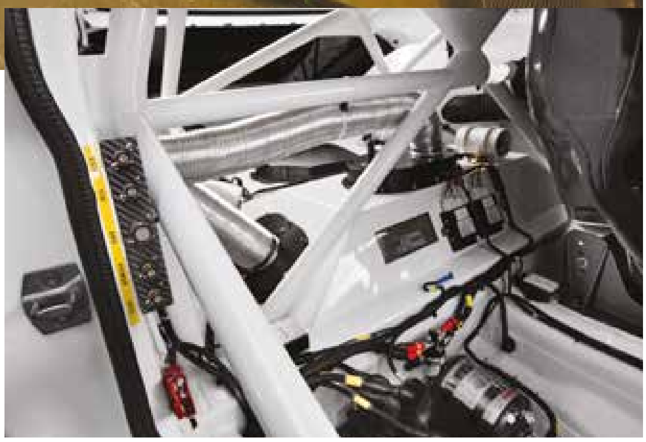
The engine is based on the production unit as per the regulations, but switching to a dry sump has freed up space underneath, and so the engine has dropped by 100mm in the chassis. Overheating was a major issue in the first months of testing, and so the car could only be run in cold countries towards the Arctic Circle.

‘The ECU is different, and everything related to the engine had to be adjusted for that,’ says Marquardt. ‘The air intake and exhaust is different, but for hardware we haven’t changed a valve or a camshaft. The variable valve train we had to lock, but apart from that hardware-wise it comes out of BMW production. Variable valve timing and variable lift are both banned by regulations. That is the work that we had to do mapping it, and going to a different ECU, you go over everything anyway.

‘Hardware-wise, the turbochargers and everything is exactly like the production car. The heat exchanger is different – the production car uses air to oil, this uses air to air. The starter motor is moved to the transaxle and the oil system, the sump and the scavenge pump is different because you need it to adjust it to the g-forces, which even for an *M* car are definitely a step ahead,’ Marquardt said.

The heavily developed Ricardo-supplied transaxle gearbox is shared with the GT3 car.


PROGRESS.
From the base up.



Above: Suspension is double wishbone at the front and rear, with an anti-roll bar at both ends of the car. The dampers are 4-way adjustable **Right:** The M6 provided a suitable base model for GT3 and although the convergence talks failed in 2014, it is this chassis that is carried over into the GT LM class in the US only

TECH SPEC

BMW M6 GT LM

Dimensions:
Length: 4944mm
Width: 2046mm
Wheelbase: 2910mm
Weight: less than 1250kg (without driver)

Engine
Model: P63 production engine with M TwinPower Turbo Technology
Type: V8
Capacity: 4395cc
Output: Up to 585bhp (depending on classification)
Oil supply: Oil system is based on a dry sump, which has been specifically developed by BMW Motorsport

Chassis
Self-supporting steel chassis, welded safety cage in line with latest FIA standards, Carbon-fibre crash structure at front and CFRP crash element at rear

Wheels/tyres
Wheels: FA: 12.5 x 18n, RA: 13 x 18in
Tyres: FA: 300/680 x 18in, RA: 310/710 x 18in

Driver aids
BMW Motorsport traction control

Suspension
Double wishbone axle at front and rear, Anti-roll bar on front and rear axle (adjustable from exterior), shock absorbers at front and rear (4-way adjustable)

Transmission
Low position powertrain, transaxle gearbox, mechanical differential lock, sequential electronic transmission

Tank:
FT3 safety tank, capacity: up to 120 litres (depending on regulations and/or BoP)

Brakes
6-piston, fixed calliper at the front, 4-piston, fixed caliper at the rear

One of the main issues of the car in its first tests were the high power figures. Ferrari estimated that the BMW had 100bhp more than the new 488 GTB, while Porsche estimated it to be closer to 70bhp more than anyone else. Even the prototype drivers on the Daytona banking reported that the car's top speed was rather unbelievable, and IMSA reduced the power a little between the car's debut at the Daytona test, and the race. BMW was predictably unrepentant and says that it fits into the performance boxes mandated by the FIA. 'It is the package, that is what the FIA and IMSA have defined,' says Marquardt. 'Our car is in that window, and that leads to a powertrain performance to balance the two.'

A long rear diffuser has been kept from the GT3 car. 'It is an evolutionary process and with the new performance windows that were specified, until the Ladoux testing, you are not sure that you fit everything that you were supposed to fit,' says Marquardt. 'Every aero measurement process produces slightly different results. We were confident with the results that we did, but we were not sure how that would correlate to the Ladoux testing, or the Windshear testing, but apparently, looking at the feedback from the FIA and IMSA, we were where we thought we would be, and we have been quite repeatable as well. With FIA and with IMSA we have had intensive and productive communication and that is the only way to have an efficient development process when you work closely with everyone involved. With the data that can be accumulated through sensors, logging, and GPS monitoring, you can always try, but to out-smart someone in a big way is never going to work. What we want is a good racing product that excites the fans in the stands, not to play the smarter game between the authorities and teams or manufacturers.'

BMW has developed the suspension for the GT LM version of the car, but shares the same geometry with the GT3. 'A customer is happier to run parts that last 10,000km, rather than 5000km, but doesn't want to spend the money on a lightweight part,' Marquardt says. 'It is small areas where there are changes, and differences between the two, but they are in areas where for a GT car you are focussing on efficiency regarding running costs. On a works programme, your tendency is more for the GT3, running cost efficiency. On the GTLM it is more performance and if you need to change the part every race, you do so. There are some lightweight parts in the suspension configurations in the GTLM car.'

The tyre sizes are different between the GT3 and GTLM versions of the M6, but that is by regulation. In GT3, teams can have the same tyre sizes on all four corners, but in GTLM the front tyre size is smaller (width12.5 inch fronts, 13 inch wide rears, and a maximum of 690mm diameter front, 711mm rear).

In a balance of performance category the M6 will likely be competitive. Whether the company will ever build a car that will produce a suitable base model for GT LM racing is a moot point. For now, though, BMW continues its North American racing programme with a GT3-based car, and relies on Balance of Performance to make it work.

'What we want is a good racing product that excites fans in the stands, not the smarter game between authorities and teams or manufacturers'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Porsche is back

With a GT3 991 now on its books Porsche Motorsport can once again do what it's always done so very well – sell customer racecars to eager punters

By ANDREW COTTON

Porsche's endurance racing heritage is built on customer racing, so it was no small hole in the marque's arsenal that it didn't have the latest GT3 model for sale in one of the fastest-growing categories.

That all changed with the arrival as the head of motorsport of Frank-Steffen Walliser, who pushed through the development of the GT3 and, at his insistence, the new direct injection engine. The development of the engine has caused the car to be delayed, and it was a race against time to prepare it for its debut at the Daytona 24 hours at the end of January.

However, now that the company has re-started the programme, it has already sold more than 30 cars, an impressive figure given the lack of Audi-style support for so many years. 'It was obvious that the car was missing after the 997, and after the change of the board for Motorsport we took the decision because we had to,' says Sascha Pilz, Head of GT Customer Racing. 'People were demanding it. This is Porsche, and GT3 is customer racing. We were pretty late and missed the decision, it should have been taken much earlier.'

The Porsche 991 was not the only car that was considered to carry the mantle in the GT3 category. The company also considered the mid-engine Cayman, but decided that would be its GT4 car. Even then, the decision regarding the model was not set in stone. There was a choice of using the turbo engine, taking advantage of the BoP system that accommodates the technology. Ultimately, however, Porsche opted for the 4-litre flat six naturally aspirated engine.

Engine choice

'First we were thinking about the turbo, and then we moved on to the RS because that was coming, and that was a good decision,' says Pilz. 'We could develop the GT3 R on the GT3 RS. The RS is, from the package and the lightweight concept chassis wise, a better base. [But] the engine, you can talk to three people and have four opinions, but we wanted to stay with the NA engine and that was the philosophy.

'The GT is also the mentality of normally aspirated. We have the BoP that can help in the case of turbos. You would then have more weight in the rear, and although you can play on the straight, then cornering is a bad thing.

'We have the direct injection, and it is around 40-50 per cent cheaper to run than the old car per kilometre. We had the car developed and nearly homologated with the old engine, and then we made the swap in December last year when Dr Walliser made the decision,' Pilz said. But Porsche first studied the performance window to see what it could do with the old Metzger engine, and looked particularly at its running costs. 'The Metzger engine would be more expensive year-on-year because we are running out of parts,' Pilz said candidly. 'We are not producing the engine anymore, it is a spare parts business and the moulds are getting old. So, we said no way, we need to do that swap. [But] if you do the engine in eight months and get it in the car, it is quite tight.

'The engine is lighter than the Metzger engine, and we have a wider torque range because the old engine didn't have the camshaft timing that we have now. Direct injection also means double throttle body which we didn't have before; throttle response is better; peak torque and power we widened a lot. It is more fuel efficient, too. Oil consumption was a problem before, which is reduced to a minimum now; and then running time, we are now talking 50 hours before a service, and as this is now based on a production engine you can take the parts out of the line and not go to a supplier to ask for another two crank-cases,' Pilz says.

The majority of GT3 racing takes place on Pirelli tyres, but in the US the cars also run on Continentals, and for the VLN, tyre choice is open. Porsche therefore spent a lot of testing time working on the suspension and ride height settings for the individual tyres, and has produced a sales book that gives its customers

The GT3 R marks Porsche's return to the customer racing arena and it's selling very well indeed. Above: the 2016 GTE and GT3 cars debuted at the Daytona 24 Hours in January

'As this is now based on a production engine, you can take the parts out of the line, and not go to a supplier to ask for another two crank-cases'

a fighting chance at finding a perfect set-up. It also has the different settings in terms of traction control and ABS to allow the teams to extract maximum performance from the cars.

Adaptable package

'The development package was to have focus on all the series,' confirms Pilz. 'We knew that IMSA would adapt to GT3 regulations and we had to build a car that runs everywhere, also with different ride-heights.'

There have been changes to the GT3 R that have helped to improve the reliability and the chances of finishing races. The radiators, for example, have been moved from the outer corners at the front to the centre of the bumper, improving the weight distribution and also, hopefully, helping to avoid the sight of a Porsche with a front corner damaged and fluid gushing all over the circuit. 'On the chassis, the centre radiator helps, if you hit someone, it usually led to the finish of the race in 90 per cent of the cases,' confirms Pilz. 'The centre of gravity moved to the rear, too, for the weight distribution this has helped a lot.'

The car was tested extensively at Sebring, Pilz tells us, which can be quite hard on a car. But much of its development had actually been finished by then, including a switch of Bosch ECUs. 'We moved from the MS5 to MS6.4; with the double throttle body there was a lot to do for applications and for things like launch control, because PWC is running that, so you need that functionality too.'

Pilz has worked in GrandAm, so says he knows the mentality of IMSA, which will help. 'I know the regulations well, and for the American teams [it's a bigger step] for GT3 R than other teams, from the 997. They are used to modifying the car a lot, and now they are forced to stick with the car because it is homologated. They are not used to the aero load on the car. The GTD [forerunner of the GT3 in IMSA racing] was a former GT3 Cup Car with nearly no downforce. This is a different set-up. They need to experience the car and trust us', he says.

One of the main issues that Porsche faces is the location of the engine, and not only for weight distribution purposes. It also creates a problem for the diffuser. While others may have the space to lift the diffuser with their front or mid-engine layout, Porsche has an engine and gearbox in the way.

Up against the extreme aero of nearly all of its competitors, the Porsche by contrast looks positively tame. Predictably, the manufacturer says that it should be the benchmark in terms of aero development. 'You don't have much room at the back,' says Pilz of the 991 GT3 R. 'By regulation they limit you to the amount the diffuser can rise, the shape of the bumper and so on. The others have an advantage over us, but it is also the philosophy and the thinking. We think in customer racing, it is customer and production based; parts wise and development wise. I know that the flips are bloody expensive, and we don't want the downforce of a DTM car, because we are talking of customers.

'I think that this should be the limit already, and that should be recognised by the FIA. GT3 is not like GT1, the costs would be too expensive, and the teams can't afford it anymore and then it will die. If you look at the Nurburgring, they are looking to reduce power and aero.'

The car has a wheelbase 8.3cm longer than the previous incarnation of the GT3, and by the weight of the chassis has also reduced dramatically. Weight saving is actually at the very heart of this racecar. The roof, bonnet, wheel arches, doors, the side and rear sections are all carbon, and for the first time the windscreen is polycarbonate, as are the other windows in the car.

Another development focus was on the safety features of the GT3 R. The capacity of the further-reinforced FT3 safety fuel cell was increased by 12 litres to now hold 120 litres, with the tank also featuring a fuel cut-off safety valve. Meanwhile, the doors and the side windows can be removed, and the escape hatch in the roof is now larger. Also, in the event of an accident, the new racing bucket seat offers drivers even better protection.

Porsche has returned to GT3 customer racing in a big way. Now it's time to see how the car fares against its more extreme rivals.

The GT3 R is an aerodynamically uncluttered car and Porsche believes that this is the essence of customer racing, feeling that over-developed aero can drive up the costs. Porsche has worked hard to reduce weight, with plenty of carbon body parts

The sting in the tail: Porsche deliberated over whether it should use a turbocharged engine but in the end opted for the familiar 6-cylinder boxer in the GT3. The positioning of the engine means the diffuser cannot be lifted to a higher position

TECH SPEC

Porsche GT3 R (991)
Customer race car based on the Porsche '911' GT3 RS

Engine
Water-cooled six-cylinder boxer engine (rear mounted)
4-litre; stroke: 81.5mm; bore: 102mm
Output: over 368kW (500bhp) subject to fitting of an FIA BoP air restrictor
Four-valve technology
Direct fuel injection
Dry sump lubrication

Transmission
Porsche sequential 6-speed constant-mesh gearbox
Mechanical slip differential
Pneumatic gear-shift activation (paddle-shift)

Bodyshell
Lightweight body featuring intelligent aluminium-steel composite design
Integrated (welded) roll-cage according to FIA Appendix J
Removable escape hatch in roof
Lightweight exterior design:
CFRP doors, rear cover, rear wing, wheel arches, front and rear fairing
Polycarbonate glazing
Removable polycarbonate door windows
FT3 safety fuel cell, approx 120 litres, with fuel cut off safety valve in accordance with FIA regulations
Air jack system (four jacks)

Suspension
Front axle: McPherson strut, adjustable in height, camber and toe
Wheel hubs with centre-lock wheel nuts
Adjustable anti-roll bar blades (left and right)
Power-assisted steering with electro-hydraulic pressure feed
Rear axle: Multi-link independent rear suspension, adjustable in height, camber, toe
Wheel hubs with centre-lock wheel nuts
Adjustable anti-roll bar blades (left and right)

Brake system
Two separate brake circuits for front and rear axles; adjustable by driver via brake balance bar system
Front axle: Six-piston aluminium monobloc racing brake caliper
Ventilated and grooved steel brake disc; 380 mm, aluminium disc bell
Rear axle
Four-piston aluminium monobloc racing brake calliper
Ventilated and grooved steel brake disc; 372 mm, aluminium disc bell

Wheels/tyres
Front axle: One-piece BBS alloy wheels to Porsche specification and design
Front: 12.0J x 18 offset 17, tyre dimension: 300/650-18
Rear: 13J x 18 offset 37.5, tyre dimension: 310/710-18

Electrics
Cosworth power module IPS32
Race ABS
Traction control

Weight/dimensions
Total weight: 1220kg (subject to BoP)
Overall length: 4604 mm
Overall width front axle: 1975mm
Overall width rear axle: 2002mm
Wheelbase: 2463 mm

Car price
429,000 euros plus country-specific VAT

Extreme machine

For the 2016 season LM GTE cars will be a little bit wider and wilder – but 40 years ago Porsche's production-based Group 5 935 took body and aero modifications to a whole new and exciting level

By SERGE VANBOCKRYCK

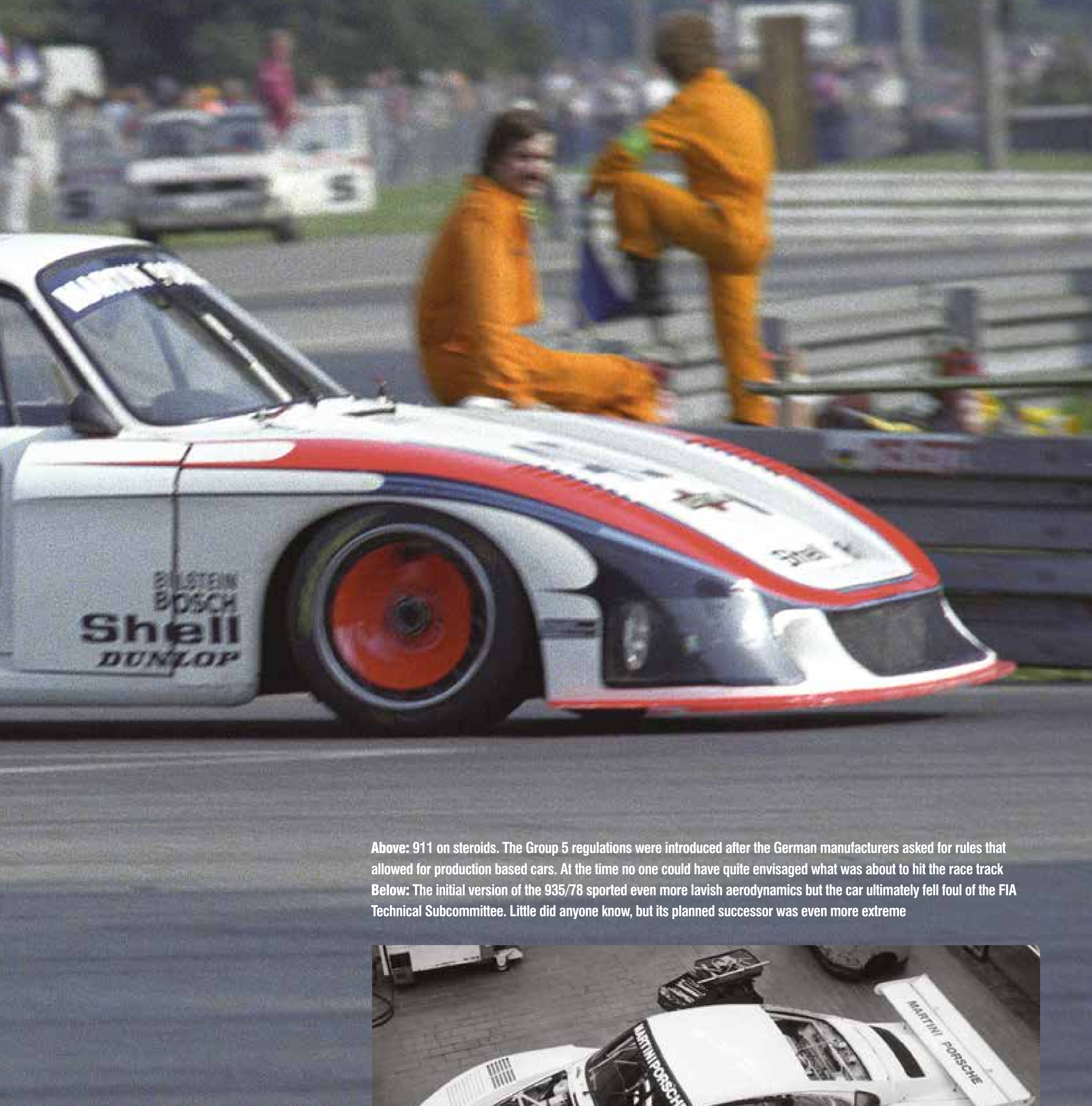
When the World Championship for Makes, the predecessor to the WEC, ran out of steam in the first half of the 1970s, new rules were required to revive the championship and rekindle the interest of the manufacturers. Thus, in 1976, under pressure from West German manufacturers, it was decided that the emphasis would be on volume-produced GT cars, such as the Porsche 911, Ford Capri and BMW 3.5 CSL. The new generation racecars were referred to as silhouettes, but the new category was formally known as Group 5.

While these cars would retain the shape and basic architecture of a production GT car, the technical rules allowed for some liberal changes, especially when it came to the engine and the aerodynamics of the cars. The engine had to stay in the same position as in the homologated road car, but it only had to retain the original block, while turbochargers or superchargers could be added. Minimum weights were defined by engine capacity, while turbocharged engines would have their swept volume multiplied by 1.4, so that the normally aspirated cars would not be at a disadvantage.

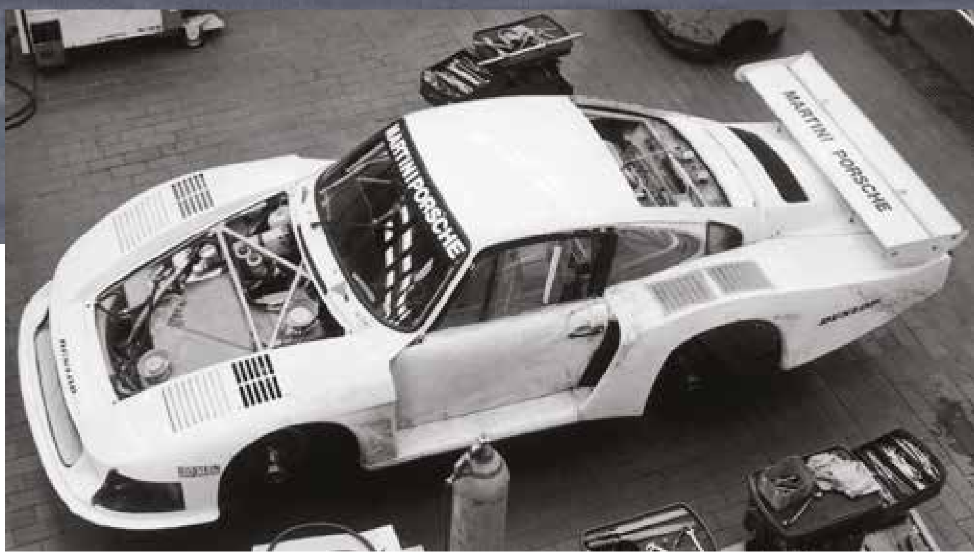
Fashionable flares

As for the bodywork, all four fenders could be flared to accommodate much wider wheels, while spoilers, splitters and wings could be added. Doors, engine cover and bonnet, as well as the windows, could be made of other materials, as long as they remained interchangeable with the original parts. In other words, a rear wing could be added to the 911's engine cover, as long as an original engine cover fits snugly in place on the Group 5 version of the car. Giant rear wings, like those seen on Porsche's 1974 Carrera RSR, were now banned by fine-tuning the regulations so that now the rear wing support had to stay within the vertical shadow of the wing, while the wing could not pass the outline of the frontal area. Put in simpler terms, it should not be seen when the car was viewed from head-on.

Porsche's new technical director in



Above: 911 on steroids. The Group 5 regulations were introduced after the German manufacturers asked for rules that allowed for production based cars. At the time no one could have quite envisaged what was about to hit the race track
Below: The initial version of the 935/78 sported even more lavish aerodynamics but the car ultimately fell foul of the FIA Technical Subcommittee. Little did anyone know, but its planned successor was even more extreme



charge of road car-based racecars, Norbert Singer, probably knew better than any of his contemporary colleagues just how to read the rules and regulations – and especially how to read what was *not* written. When the Porsche 935 made its debut at Mugello in 1976, it caused a stir at scrutineering, as the headlights had been relocated to the front fender, resulting in an aerodynamically much smoother front end which reduced drag and also produced some more downforce. The scrutineers didn't like it at all, but in the end couldn't do anything about it since it was allowed by the rules. It wasn't Porsche's fault that it was the only one with headlights sitting in the fenders while the other cars' headlights sat in the radiator grille. And the shape of the fenders, front and rear, was free.

By the end of the 1976 season, the rear fenders had been lengthened and sculpted to mimic an integrated wing shape, further increasing the aerodynamic efficiency of the car. Porsche won the championship from BMW at the final round at Dijon, and while the boys from Munich persisted with their new 3 Series replacing the CSL, the decision makers at Ford decided to stick to the German national DRM championship instead, and not to bother with trying to beat Porsche on the world stage.

The fifth-scale model of the Porsche 935/78. The nose of the full scale mock-up is on the right in the background of pic. Note that smoking in the workplace was not a problem back in 1978!

Shaping the very slick body buck for the 935/78 Group 5 racecar on an older model 935 – slippery aero was a must for the Mulsanne Straight at Le Mans

Porsche 935/78 undergoing its build process. Black roof and A- and B-pillars of the road car can be seen; the original body parts remaining once the 911 was transformed into a racecar

Moby Dick during first track tests at the Paul Ricard circuit. The Herman Melville inspired nickname was in recognition of the car's outlandish whale-like styling

For the 1977 season, Singer figured that the best defence was attack, and further improved what was already the most competitive Group 5 car by far. The aerodynamics were further refined with a completely revised front end with rear view mirrors integrated in the fenders. Those front fenders, as well as the rear fenders, had increased in size and were connected by so-called 'running boards', while the rear fenders were stretched back, effectively turning the 935/77 into a *Langheck*.

The rear wing assembly was of a completely new and extremely intelligent design. Singer's clever reading of the rules had produced a second rear window sitting several inches over the original one, effectively raising the roofline and connecting it with the engine cover in one, smooth and more horizontal plane, thus feeding cleaner air to the revised rear wing. Singer could do this as the rules stated that any aerodynamic device at the rear of the car was accepted on the condition it did not exceed the profile of the car when viewed head-on. It was, however, unlikely the rules makers had double roofs and ditto rear windows in mind when they wrote the rule.

Norbert Singer knew better than most how to read the rules

The engine for the 935/77 was the air-cooled Typ 930/78, still with a 2806cc capacity like the mixed-cooled Typ 930/72 from 1976, but with two smaller KKK turbochargers instead of one, each with its own wastegate. A new water-cooled intercooler now sat in front of the engine, after a rule was issued that said the firewall between the engine compartment and the cockpit could be moved forward by 20cm. The new package was good for 630bhp at 8000rpm, an increase of some 40bhp over the previous year's model.

On the stopping side of things, a servo was installed between the brake pedal and the dual master cylinders, although this was discarded during the season as it appeared to double the brake pad wear on the Typ 917 brakes. Power steering was also tested, but not used in races.

The 935/77's season was one of ups and downs, with as many wins as DNFs for technical reasons – mainly engine related issues. But Porsche again won the world championship thanks to a flotilla of privateer 935s.

Long before the 935s started dominating the 1977 WCM season the governing body (the CSI) had agreed to some technical leniency towards Ford and BMW for 1978, at the request of the latter, but only if the other manufacturers agreed to this rule change. Thus, at a meeting at the end of 1976, the CSI and the manufacturers agreed to allow the floor pan of the cars to be cut and raised. BMW, and also Ford, felt they were disadvantaged by the fact that they ran front-engined cars, which meant that they had to run more ride height to allow for the exhaust, muffler and heat shields under the cars' chassis. As such, they were indeed disadvantaged *vis-à-vis* the Porsche, which could be run as low as the rules permitted since engine, turbo and exhausts all sat in the back.

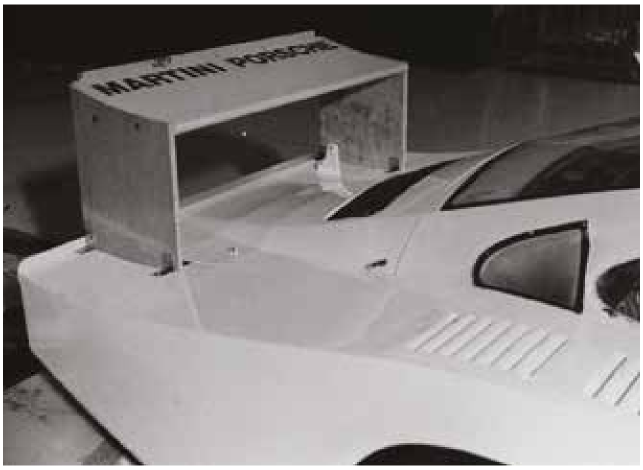
Trojan horse

Porsche gallantly agreed to this new rule and the CSI, as well as Ford and BMW, were pleased by what they saw as a nice gesture for the good of the championship. However, they didn't realise they had just let in a Trojan horse. Singer – clearly in a league of his own when it came to fast and forward thinking – had his own use for the new rule. 'The approved wording of the regulation was not specific to the exhaust and it gave us the opportunity to cut the side panels of the 935 and lower the whole car,' he says. 'We made a new floor with an aluminium frame and glass-fibre sandwich and lowered the 911 chassis height by 60mm, to 1110mm.' Thus the first spaceframe Porsche 935 was born.

One of the more extreme aerodynamic packages to be tried out on the Porsche 935. This features a full width wing with a second aerodynamic element over the rear windscreen

Porsche decided to switch from the wide and low rear wing (above) to a narrow, high wing (below) at the same time as the controversial door design was changed

Just half the door was covered in compromise version of Moby Dick. When the FIA decided to reverse its decision to ban fully covered doors Singer opted to stick with this solution anyway



This is the first test version of the narrow and high rear wing. The wing is supported by the end-plates here, but would sit on struts on the racecar

The height of the new 935/78, however, was the only aspect that decreased, as every other measurement was seriously increased. The front track grew by 128mm to 1630mm, while at the rear the increase was 17mm to 1575mm. Entirely built for speed on the Le Mans six-kilometre Hunaudieres Straight, the car also received a tail 21cm longer than that on the previous model, with a low rear wing sitting across the entire width of the car. The first iteration of the wing was supported by end-plates attached to the outer fenders.

The doors were now completely covered with a widening second skin, effectively linking the outer edges of the front fenders with those of the rear fenders – a king size NACA duct feeding fresh air to the side-mounted radiators. The front of the car was extended as well, to suit Singer's aero needs. The rules didn't limit the overhangs anyway. The front fenders were given a concave, downforce-creating shape ahead of the actual wheel arches. At the rear, the inclination and size of the chord of the wing allowed for almost as much downforce as one wanted, but adjustable aerodynamic appendices at the front were not permitted, bar a horizontal splitter. Therefore, to increase overall downforce Singer looked at ways to up the figures at the front of the car, but the sculpted fenders ultimately never made it beyond 1/1 scale wind tunnel testing.

For better weight distribution on the clockwise turning circuits the driver was sitting on the right side of the car, while power was supplied by a specially designed, fully water-cooled, 24-valve, twin-turbo 3211cc unit with welded cylinder heads, good for some 750bhp at 8200rpm with 1.5bar boost. Porsche had just created a car nobody had ever envisioned when Group 5 was established just two years earlier.

Moby Dick

'After lowering everything we could on the car, we had to turn the gearbox upside down so that the driveshafts would not be inclined at an impossible angle,' Singer says. 'Spaceframes carried the front and rear suspensions and the stiffness of the chassis was increased by more than 40 per cent compared with the 935/76. We had to keep the original doors, but there was nothing that said we could not cover them, so we did. When the FIA delegates (famed technical journalists Paul Frere and Curt Schild) saw the car for the first time, in February 1978, they were completely shocked.' When the first pictures of the car were published, painted all white with just a few Martini logos, it was immediately given a nickname which would stick forever: Moby Dick, the legendary white whale from the Herman Melville novel.

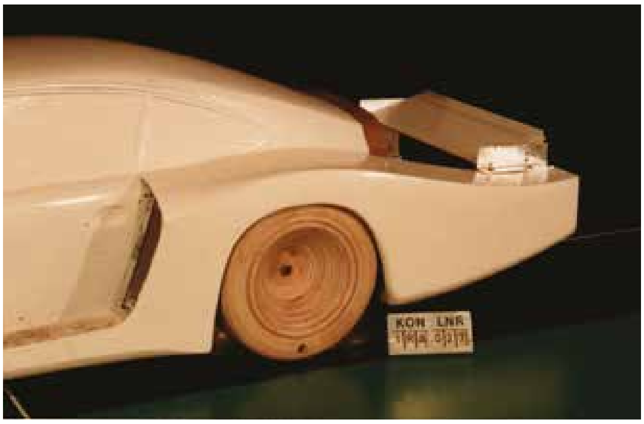
But the FIA delegates objected to the fully covered doors, so Singer developed an interim solution by covering just half of the doors. At the same time as changing the doors – though not aerodynamically working with each other – the low and wide rear wing was changed for a more conventional one, narrow and high-mounted.

In the end, the FIA back-tracked on the doors, but Singer was happy with the way the car was now and so didn't bother changing them again. There wasn't enough time to do so before the first race anyway.

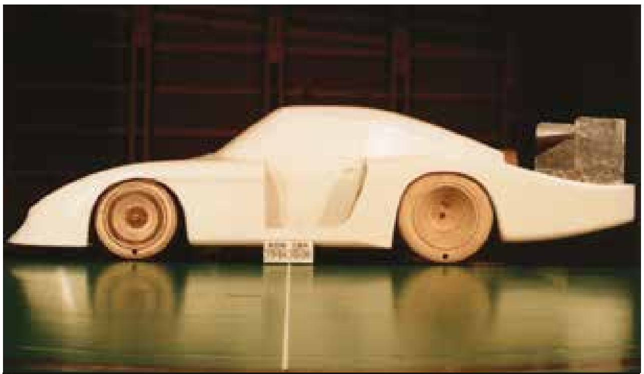
Moby Dick's first race was the Silverstone 6 Hours, then the traditional test for any team ↳

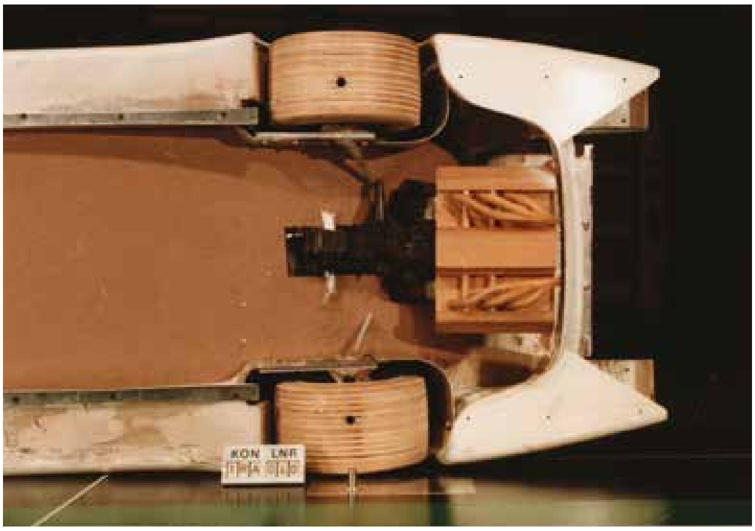
'After lowering everything on the car we had to turn the gearbox upside down'

Jacky Ickx testing the revised version of Moby Dick at Paul Ricard. Norbert Singer stands on the left in white jacket – the rule book allowed him to use his imagination to the full with the 935

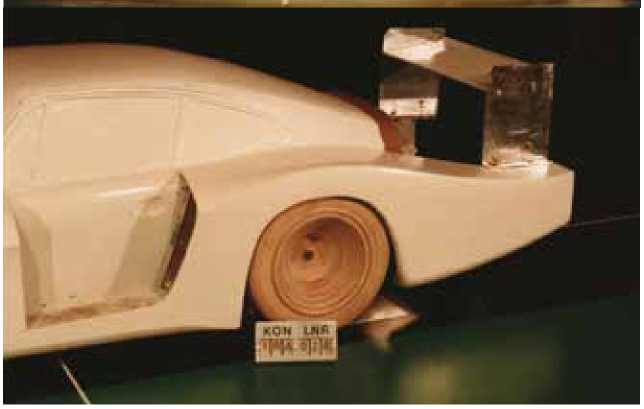


Porsche 935/80 wind tunnel model with low rear wing over the open engine bay





Massive wing profile underneath the 935/80; the fixed skirts and splitters can clearly be seen. The engine would have been shrouded and sealed off from the airflow going underneath the car



Here the Porsche 935/80 wind tunnel model is seen with the high rear wing over open engine bay. The air was to be directed from the venturi under the rear wing

serious about Le Mans. Jochen Mass duly parked the car on pole in a new record time, and he and Jacky Ickx disappeared into the distance once the lights went green. The car won the race with a seven-lap margin.

Le Mans, however, proved to be a disappointment. The high fuel consumption meant that it would have to refuel every 10 or 11 laps, and any advantage gained by the car's supreme top speed (it was the fastest at 227mph) would be immediately annulled by the frequent refuelling stops, an estimated 35 stops over the course of the 24 hours. As it turned out, Moby Dick would be plagued by all sorts of smaller problems, too, such as the throttle not closing fast enough on over-run, a water radiator leaking, the windscreen coming loose, ignition distributor problems, a misfire, an accident and finally an oil leak – resulting in Rolf Stommelen and Manfred Schurti finishing in eighth place overall.

After Le Mans, Porsche decided that it had little or no competition left in the World Championship and that whatever competition there was, would easily and swiftly be dealt with by the customers. The 935/78 appeared only twice more, at the famous non-championship Norisring race in Nuremberg, where Ickx retired, and at Vallelunga, the final round of the World Championship. After some initial set-up problems, Ickx qualified on pole by over two seconds, and he and Schurti comfortably led the race until 10 minutes from the end when the injector pump belt drive was cut by a stone. It was an abrupt end to a great success story, for soon afterwards sponsor Martini announced it was taking a sabbatical from motorsport.

Thus Vallelunga was the last ever race for a factory 935, and Moby Dick was subsequently mothballed. 'There were no plans to sell the car to customer teams as long as they would still be competitive with their regular 935s,' says Singer.

And that they were. In 1979, privateer 935s won their class in eight out of nine rounds of the WCM, including overall wins at the Daytona 24 Hours, Mugello, Silverstone, the Nurburgring and at Watkins Glen. Plus, of course, a shock overall victory at Le Mans.

Ground effect 935

Unbeknown to most, though, Porsche had looked at returning to the WCM full time in 1980, with a factory team and an *uber*-Moby Dick, the 935/80. The reason for this late development was that Porsche motorsport boss, Manfred Jantke, was convinced BMW was planning an assault on the 1980 WCM with a pair of works-prepared turbocharged Group 5 M1s. This had Porsche worried since with no other works teams racing in the over 2000cc Division I, BMW could very well score one or two easy world titles in the final years of Group 5, something Porsche was keen to prevent.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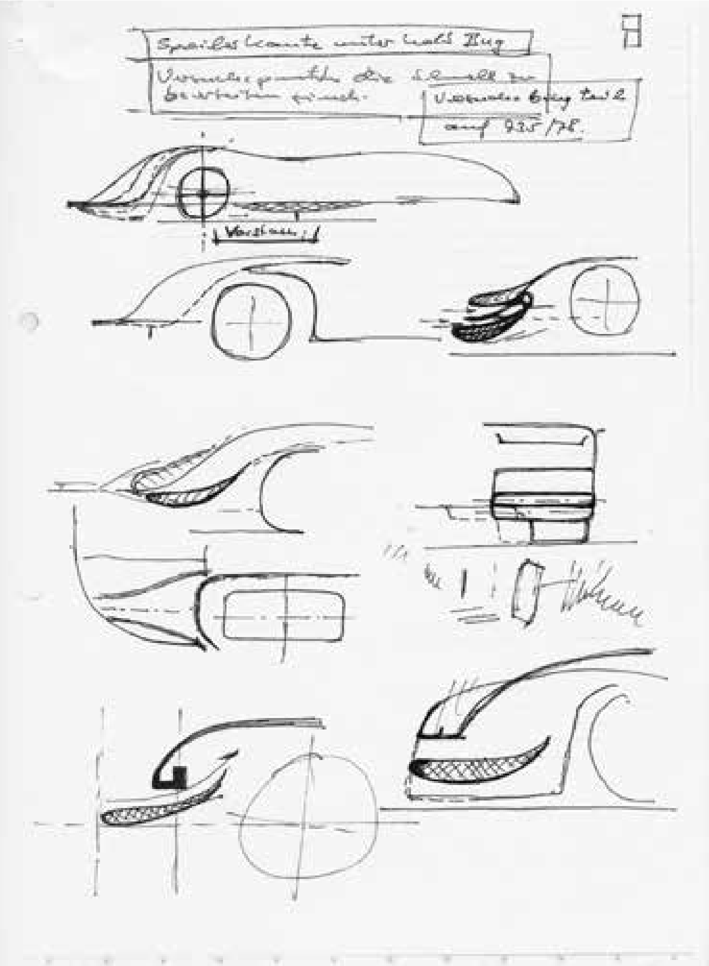
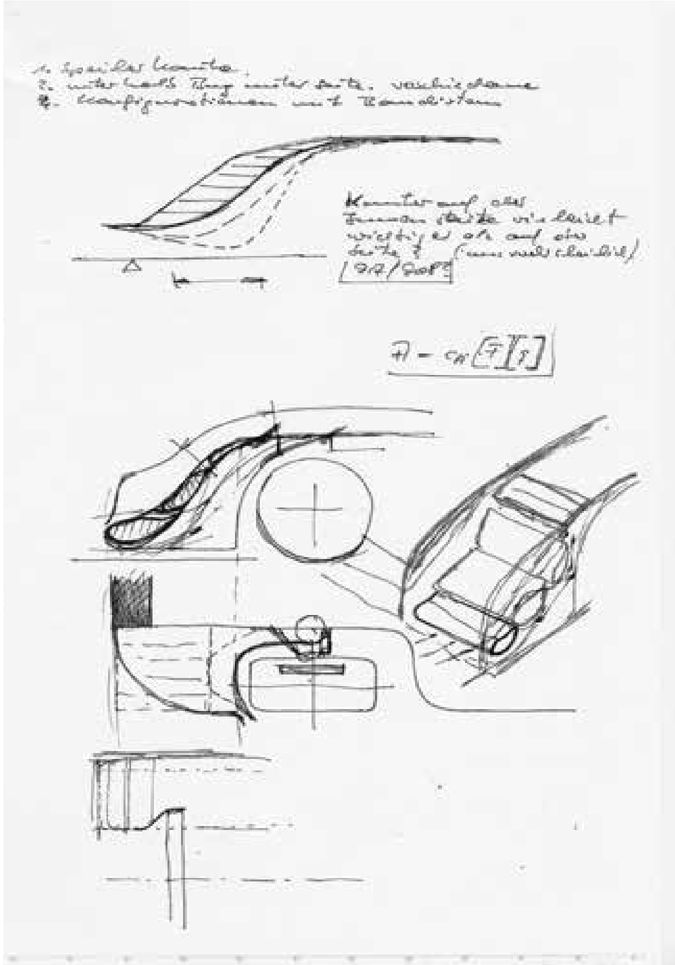




Singer's sketches of some of his radical ideas for the front aerodynamics of the stillborn Porsche 935/80, including an array of separate winglets incorporated into the wheel arches

Jantke thus ordered the motorsport department to make a feasibility study. In the summer of 1979 Norbert Singer had been working on the ultimate development of the 935, starting with the sleek 935/78 from the year before. Formula 1's recent ground effect revolution had Singer thinking along similar lines as Lotus' Colin Chapman, and the 935/80 was to feature rather extreme aerodynamics. A full-width venturi was designed to funnel the air from the front of the car, underneath the full-width flat bottom and to the rear. However, the air would not exit the car from underneath the rear bumper as one would expect. Instead, the wing shape under the car would dramatically curve upwards behind the rear cockpit bulkhead and send the airflow through the top of the car, exiting below the rear windscreen and ahead of the engine. The airflow was then further directed underneath the rear wing, the exact position and shape of which hadn't been decided at the time the project was halted.

The biggest handicap for developing ground effects on the 935 was, of course, the position of the engine. Not only did it sit at the very rear of the car, which would always compromise the ideal airflow, but its boxer architecture also made it wide. Ultimately, the twin-turbo flat-6 would have been shrouded and sealed off from the airflow going underneath the car. But how exactly this would have looked wasn't set in stone. 'When you worked on a new idea, first of all you had to get the overall idea working and then you optimised it,' Singer says. 'Details were worked on later. After that you can check or modify and adapt the concept to the regulations. This was always my way of doing it.'

'You had to get the overall idea working, and then you optimised it'

What might have been

The front of the 935/80 was to receive a similarly radical aerodynamic treatment. Sketches made by Singer show the front wheel arches to be equipped with no fewer than four adjustable winglets, similar to some of the early developments done on the CanAm spec 917/10.

Singer took his ideas to the FKFS wind tunnel in Stuttgart for several days in July of 1979. Equipped with the one-fifth model of Moby Dick, which had a functional internal airflow to the radiators, he started with the race set-up from the 1978 events to set the benchmark figures for drag and front and rear downforce. Over the course of three days, Singer tried some 45 different combinations to the ground effect theme. The rear wing was inclined at different angles and sitting in various positions and heights; the rear fenders were sometimes equipped with small longitudinal gurneys on the inner edges next to the engine cover; the ride height at the rear was changed …

The engine, too, would have received the necessary attention from engine men Hans Mezger and Valentin Schaeffer, with ideally more power extracted from the flat-6 while also needing less fuel than on Moby Dick. For the suspension, too, Singer had some novel ideas, such as a further development of the trailing arms. Alas, the FIA Technical Sub-committee's Paul Frere, didn't like it as he didn't want to open up this area of development any further than the regulations originally intended.

Design and development work on the actual spaceframe chassis hadn't started when it became clear that nothing was happening at BMW. Work on the 935/80 was halted, something which Norbert Singer today says he regrets. 'It was a new attempt at making an even better version of Moby Dick. It's the normal way to further develop a car: the successor should be better, or much better, than the predecessor.'

Thus, Porsche's 1980 return to the WCM and the successor to Moby Dick would only ever exist on paper and in partially developed wind tunnel models. And maybe just as well: for what nickname could this magnificent creature possibly have been given?

NASA's rocket

The NP01 was designed to fill a gap in the market for closed prototypes that can be run on a reasonable budget. *Racecar* was itching to find out more …

By BRETT BECKER

With LMP looks the Elan-built NP01 prototype is sure to appeal to weekend racers who want to live the Le Mans dream for a fraction of a WEC budget

A series-specific racecar is fairly common in motorsports. Such a formula is used in everything from the top levels of the sport on down to the ranks of amateur racing. However, there is a tremendous difference between the 'spec' cars in professional racing and those marketed to amateurs. What typically is available to amateurs on a budget is a scaled-down open-top sports racer with old technology, and limited performance, nothing at all like top-tier cars.

But Elan Motorsports Technologies and the United States' sanctioning body, the National Auto Sport Association (NASA), have decided there's an untapped market between those two paradigms, and the two companies have filled that niche with an affordable, closed-cockpit prototype racecar.

The Elan NP01 – the NP stands for NASA Prototype – debuted at the 2014 Performance Racing Industry show in Indianapolis. How the car was received would determine whether it would be built and whether there would be a series, and to attract early buyers Elan offered the first 10 cars at a discounted price of $59,995.

Those first 10 cars sold within a few months, and delivery of the first finished cars began in the last quarter of 2015. The price has since risen to $65,995 in 2015 and $72,500 for 2016, but when you take a hard look at the car and its specs, the NP01 still represents remarkable value in terms of speed and capability. So far, 23 NP01s have now been sold.

'We thought there was an area of the market that could be tapped because the top entries from Porsche, from Audi, you know the LMP1 cars, they're the cream of the crop, and how many people dream of the opportunity to drive one of those cars?' says NASA director of business development, Jeremy Croiset, who spearheaded the NP01 project with Elan. 'So, the idea was to create a car that would embody that, but still had the NASA core values in its bones – fast and fun and safe, and low cost.'

Elan builds a number of racecars, including the DP02, which runs in IMSA's Cooper Tires Prototype Lites Series, the DP08, a Formula 2000 car, and of course the DeltaWing. Those cars are quite a bit different from the NP01, though, in that their prices were determined after the cars were built and all the costs were added up.

With the NP01, however, Elan was committed to a price point, which presented challenges to the company's engineers. Parts and processes had to be simplified and scrutinised for cost savings.

'From the beginning it was going to be a closed-top car, so that sort of set a lot of things in place,' says senior engineer Robert Lindsey, who oversaw the project for Elan Motorsports Technologies in Braselton, Georgia, along with programme manager Mark Sanderson. 'To start with, I just took the footprint of the Elan DP02 IMSA Lites car, as in track width and wheelbase, and so that gave me an idea how to proceed,' Lindsey adds.

Identical components reduces manufacturing costs, and means racers can carry fewer spares

Chassis concept

Elan used 1018 mild steel for the car's chassis, which arrives at Elan in a box, as a set of pre-cut, pre-bent and pre-notched round and square tubing that it outsources to a local company. Elan then takes those pre-fabbed tubes and welds them together in jigs. The frame is then powder-coated off-site and returned to Elan.

Ease of assembly also comes into play when building the NP01 suspension. For example, Elan made the uprights the same at each corner of the car. The rear uprights are the same as the front and the lefts are the same as the rights. This had two benefits: first, it allows customers to carry just one corner of the car as a working spare. It also increases Elan's economies of scale and simplifies machining processes necessary to fit the uprights to the cars.

The same logic applies to the hub-and-bearing assemblies. They're all the same production-car pieces designed for a road car that weighs some 4000lbs, so in terms of load and duty cycles, the hub assemblies far exceed the demands of the 1450lb NP01.

Economies of scale also came into play with the NP01's control arms. For instance, the rear upper control arms are the same from side to side. The front upper control arms are also the same right and left. But the lowers, front and rear, are different from side to side because of the way the pushrods attach.

Shock value

For shocks and springs, there really was no way to trim expenses without harming the car's performance, so Elan budged a little on costs. Motion Control Suspension provided the shocks, which will be spec'd and set up so they cannot be re-valved by the customer. The springs came from Hyper-Coil. 'People are inclined to tinker with dampers, so we had to get a decently expensive and double-adjustable shock, which helps to eliminate that because you're going to spend your time in the middle of the range anyway, not at one end or the other,' Lindsey says. 'The adjustability removes some of the opportunity for buying your way to the head of the pack. At the end of the day, you just have to know how to set up your car.'

Obviously, identical components reduces manufacturing costs, but it also means racers can carry fewer spares yet still be covered if something gets bent. What's neat is how Elan used similar techniques when specifying the NP01's brakes, wheels and tyres.

StopTech supplies the calipers and discs, which are also the same at each corner. Use of the same caliper at all four corners means the Hawk Performance brake pads are identical. But, obviously, braking needs are different front to

rear, and to create the correct braking balance, the NP01 comes with different size front and rear Wilwood master cylinders and pedals, and a driver-operable brake-balance system.

NASA's long-time sponsor and partner Toyo Tires was involved with the development of the NP01, which uses a 235-40R-17 Toyo Proxes RR, the spec tyre for the series. They mount on to series-specific 17in by 9in OZ wheels.

As far is power is concerned, the NP01 comes with the proven 2.0-litre MZR engine from Mazda. With a 10.8:1 compression ratio, the MZR engine runs on 91 octane fuel and makes 185bhp, and 145lb.ft of torque. The engine arrives as a stock long block from Mazda, and although Elan never pulls the head or rotating assembly, the list of modifications is still somewhat extensive.

Engine mods

Elan adds a proprietary cast-aluminium intake manifold, fuel rail and injectors, dry-sump oiling system and its own water pump pulley and alternator kit. It removes the wet-sump oil pump from the engine and modifies the front cover for engine mounting purposes. It also adds water outlets, machines a keyway into the crankshaft and harmonic balancer, disables the variable valve timing, dials in the cam timing and adds tamper-proof seals to the cam cover, oil pan and crank sensor. The MZR engine uses a Burns Stainless header and an OEM throttle body from Ford, modified to use an idle screw.

'They wanted 185 horsepower,' said Todd Therkildsen, an engine builder at Elan. 'We knew that with a manifold and headers we could get in the high 170s, so we basically played with cam timing to get the number that they had targeted with very little effort and parts. We set them all up the same way. They all have to be within a certain percentage of each other. So far, the three we've run on the dyno have all been pretty much identical.'

Elan also worked with AEM, which is providing its Infinity ECU to control the NP01 engine. The ECU is hardware-locked from AEM, so it is in no way user accessible. The maps are tamper proof to ensure the NASA NP01 series is a true driver's series. The driver keeps tabs on everything using an AiM MXL2 dash.

To put power to the track Elan chose a Sadev 6-speed sequential transaxle, which not only houses the differential, but also the remote reservoir for the engine's dry-sump oiling system. It's a very slick set-up that can handle the power of the MZR, and it saves space in the engine compartment because there is no need to mount an engine oil reservoir.

'It's the same dry-sump system we use in our IMSA Lite, so it's something we buy lots of and we are familiar with,' Lindsey says. 'We're well within the service parameters of this gearbox in terms of torque and rpm. We don't anticipate any longevity issues, and they have probably millions of miles on them because it's an F3 box that they make hundreds of a year.'

On the outside, the body itself consists of a roof panel, nosepiece, sidepods, front fenders and rear quarter panels and the engine cover, which includes the dorsal fin. The car was designed that way to reduce repair costs. For example, rather than replacing an entire front or rear as a result of contact, the owner could replace one corner.

TECH SPEC

Elan NASA NP01

Chassis:
1018 steel-tube frame with integral roll cage structure constructed with TIG and MIG welding; side intrusion-protection panels; force-attenuation nose-box structure and side structures
Dry weight: 1450lb (estimated)
Wheelbase: 102in
Length: 161in
Height: 43.9in
Width: 75.4in

Engine:
Sealed Mazda 2-litre, 4-cylinder MZR with dry sump; 185bhp and 145lb.ft.

Transmission:
6-speed sequential Sadev SL75

Body and Aero:
Centre single-seat enclosed prototype; composite body with easily replaced individual sections to minimise repair costs; functional front splitter; adjustable full-width rear wing

Suspension:
MCS double-adjustable shocks; Hyper-Coil springs

Wheels and tyres:
17-inch x 9-inch OZ Wheels with 235/40/17 Toyo Proxes RR Tyres

Brakes:
StopTech forged-aluminum four-piston brake calipers; Hawk Performance brake pads

Electronics:
AEM Infinity sealed ECU; AiM MXL2 dash

Fuel cell:
11-gallon Pyrotect

Due to stiffness and consistency requirements, the doors, roof and splitter are made from pre-impregnated fibreglass cloth, vacuum-bagged to remove air from the laminate and then heated in an autoclave at Elan's facility. The rest of the components are wet-laid fibreglass.

Suspension philosophy is all about saving costs: the rear uprights are the same as the front, for instance, and corners can be swapped. But dampers are top quality and relatively expensive

The spaceframe, with built in roll cage, is made up of 1018 mild steel which Elan buys in as a kit of pre-cut, pre-bent and pre-notched round and square tubing

Doors, splitter and roof are made from pre-impregnated fibreglass cloth which is vacuum-bagged to remove air from the laminate and then heated in an autoclave at Elan's factory

The Sadev 6-speed Formula 3-spec sequential gearbox is mated to a Mazda 2.0-litre MZR powerplant, which produces close to 200bhp and 145lb.ft of torque

Beneath the car, Elan used marine-grade plywood for the undertray. The wood itself, which extends forward past the fibreglass splitter to add downforce, is treated with a black laminate on the top and bottom.

Rear downforce comes courtesy of an extruded aluminium rear wing. Lindsey points out that they normally use fibreglass or carbon fibre for rear wings, but those materials add tooling and labour costs.

Inside, the car was engineered to accommodate drivers of all sizes. The fibreglass seat is designed to be used with foam-filled seating systems. In addition to harnesses and side nets, the seat insert is one of the few components added by the owner.

It could be said the NP01 follows a common formula, but it's anything but a common car

Which brings us to costs. In addition to low production costs, at least when compared with other closed-cockpit prototypes, the NP01 was also designed to provide owners with low operating costs compared with other cars at this level of performance. 'It is a decent amount of expense up front, but for a lot of guys jumping into this class, it's right along the same lines of what they have been spending,' Croiset says. 'But you don't have the potential costs of frequent engine rebuilds and transmission rebuilds, and the kinds of expenses you get with a car in the 400- to 500-horsepower range. This car is just as fast, but with reduced operating expenses.'

Consider what some racers might spend on a Corvette or a Viper. By the time they add a roll cage, safety equipment, and dial in its performance, it's not difficult to imagine them spending more on cars slower than the NP01.

The next step is the racing, and that's where NASA's new NP class comes in. 'The car is designed to run within NASA and only within NASA,' Croiset says. 'The car was specifically designed not to fit anyone else's particular segment because we wanted something unique to the marketplace that would be run and operated within NASA.'

This year will see the inaugural season for the NP01. It can run at any NASA event nationwide, but there are certain regions of the country that will have more cars than others. Where there is competition, the NP class is the place to race, but drivers can also run the cars in NASA's Super Touring class. Fields will grow in size as the market saturates. In the interim, there will be respectable fields at the NASA Eastern and Western States Championships.

It could be debated that the NP01 follows a fairly common formula, but it's arguably anything but a common car. The NP01 ushers in a new era of NASA racing that holds the promise of close, fast racing at a price previously not possible. 'That was really the whole idea, to make something cool and unique that had never been done before and to try to hit a price point that's attractive to the average Joe,' Croiset says. 'Granted, it's a little above the average Joe market, but as most of us have discovered, you end up spending a lot more than you ever thought you would on your road racing.'

Power house

While his brother's made a career out of driving in the WEC Nelson Hartley has been making stunning racecars and awesome engines

By DR CHARLES CLARKE

Nelson Hartley's Sprint Car might not be quite as refined as the Porsche 919 Hybrid LMP1 his brother Brendon drives in the WEC, but it is still an impressive piece of engineering

It's difficult to write up a New Zealand motorsport story without resorting to cliches and hyperbole about good old-fashioned Kiwi ingenuity. But that's because it's true. Getting on with it and getting the job done in a timely fashion is simply part of the Kiwi DNA. But this is much more than a make do and mend mentality. It's because New Zealand is so far from everywhere, so the first option always considered is: 'Can we make it?', rather than 'Can we buy it in from somewhere and wait for it to arrive?' By making it you control the outcome.

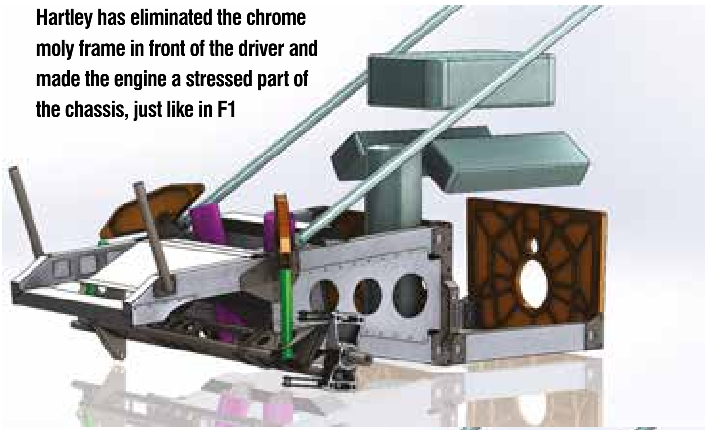
In the case of Nelson Hartley – big brother to Brendon, the 2015 WEC champion for Porsche – there is prodigious output as well. Hartley runs Hartley Engines and Motorsport with his father Bryan (himself a Kiwi motorsport legend) and a very small team of employees.

Nelson Hartley actually makes almost all of the components for his high performance engines, including the pistons in some cases. He is a self-taught SolidWorks and MasterCAM user who uses his models to drive a NZD$400,000 (about £200,000) Centroid 5 Axis machining centre brought in from the USA. There are many anecdotes about the challenges posed by integrating an American milling machine into the Kiwi psyche. Suffice to say there was a steep and entertaining learning curve and that now the machine is producing beautiful components to satiate the colossal appetites of the Sprint Car and Superstock community.

The workshop is a petrolhead's Aladdin's Cave, with all manner of classic engines and components scattered around in various states of disassembly. Classic engines include a custom single overhead cam Ford Kent that Nelson made when he was still at school. Bryan is the local BDA king and legendary Bonneville Mini tuner, so there are various versions of pre- and post Ford based twin cams scattered around the workshop, too.

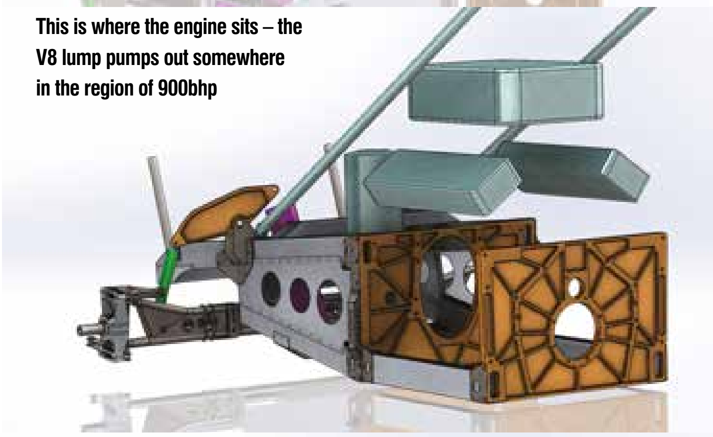
Hartley Engines develops and produces incredibly powerful engines with an attention to detail that would not be out of place in F1 or V8 Supercars. And yet these engines are used in Sprint cars, Superstocks and Sprint boats that compete, mostly in the hands of local weekend warriors,

The front beam from the Hartley Sprint Car – a typically rugged component



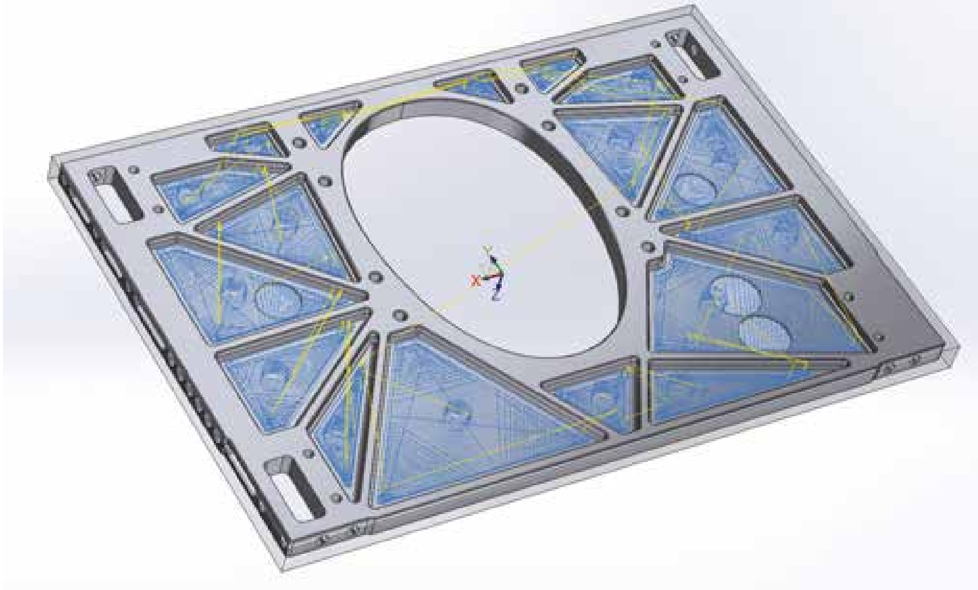
Hartley has eliminated the chrome moly frame in front of the driver and made the engine a stressed part of the chassis, just like in F1

Hartley has fabricated an aluminium glu-lam monocoque box section in front of the engine which holds the front suspension and houses oil reservoirs for the dry sump



This is where the engine sits – the V8 lump pumps out somewhere in the region of 900bhp

Design for the Sprint Car's robust front upright



Tool path showing custom bulkhead. Hartley designs on SolidWorks and uses a Centroid 5 Axis machining centre

rather than rockstar racecar drivers. A recent example is a twin turbo, methanol injected V8 based on the Nissan VK56 engine block producing 1500bhp, where every part is designed, machined and hand crafted, by Nelson and his team. The only standard parts in this engine are the bare block, the bare heads (even these are heavily modified) and the tappet covers; every single other item is bespoke.

'This engine has been quite a big project,' says Hartley. 'About the only pieces we could buy off the shelf were the oil pump and oil filter housing and even then we had to design mounts to fit around the sump and cradle. The turbos were supplied by Steve Murch at MSE Turbos NZ and [race boat maker] Stinger fabricated the exhaust manifolds to fit around their hull and roll cage. We did everything else.' A huge number of hours go into a project like this, from the planning to the manufacture. 'We couldn't be more happy with the results,' says Hartley. 'We would love to show you some pictures of the inside of the engine, because it's just as spectacular as the outside, but at some point we have to look after our intellectual property.'

High achiever

'I would love to do more high-end stuff like this,' he continues. 'Some would argue that we're already there, in that we develop crazy horsepower from relatively small engines. I tend to regard this as high-end output, but it's contained within a low-end casting, in that we are getting significant power from what is essentially a domestic V8 engine.'

There isn't a whole lot of circuit racing in New Zealand that appeals to Hartley from a business standpoint. 'We restore the occasional classic car engine and do a bit of machining for GT and sportscars. Most of that has open rules, so there is not a whole lot to be gained by doing more maths, you just simply make the engine bigger and anybody can do that. On the flip side, everything else is based around one-make series. Where we are strong is extracting the most out of a tight, but slightly open, set of rules. I guess that's why my brother and I were so successful in Formula Ford.'

One of Hartley's creations stripped to its bones: the rough and tumble of both Sprint and Superstock means there's a little more emphasis on beefing up than in some other categories

The three-spring set-up on the rear of the Sprint Car is a Hartley modification to the traditional design. Here the top spring controls the ride height and allows more spring rate on heave

Hartley rebuilds and modifies its own shock absorbers, which is also a big part of its regular business. There's a shock dyno to calibrate damper performance

And then there's Sprint Cars. This is a very American formula – the engines are about 900bhp, they have no gears or clutches – drive is straight from the crankshaft to a truck sized differential and rolling starts are the norm. Both front and rear has live axles. The wheels are various sizes with the largest being on the back right hand corner (as the tracks are counter-clockwise) and they are usually staggered to allow for maximum traction round a 12 to 14 second lap or less – basically it's a suicide mission on an oval dirt track.

Brendon drove Nelson's Sprint Car once and reckoned it was more of an adrenaline rush than a Formula 1 car. And as Nelson puts it: 'Sprint Car racing is the only international, high-end motorsport formula where I can build my own car without the need of NZD$1m (£500,000) and it's available to anyone crazy enough to partake.

The traditional Sprint Car chassis is a birdcage of chrome moly 4130 tubing with very little cross bracing, so that in its basic form, there is considerable chassis flex, under the loads imposed by a 900bhp motor and very large low-pressure ATV type tyres.

Flexing muscle car

This constant flexing over a period of a season makes the tubing work-harden, as the season progresses, so the torsional flexibility decreases over time. So much so that drivers who like the flexibility of the early chassis have been known to make judiciously placed saw cuts in the tubing in order to regain that flexibility.

Hartley, on the other hand, wants more predictability, so he's gone for a stiffer set-up and prefers to condition his kinematics with adjustable and innovative suspension – he rebuilds and modifies his own shock absorbers and has a shock dyno to calibrate the performance, which helps.

The three-spring arrangement on the rear is an attempt to introduce some innovative suspension design into the traditional Sprint Car set-up. The top spring controls the ride height and allows more spring rate on heave (up and down) and less on roll, instead of having massive anti-squat angle changes. 'When we end up on a slick track you have to increase the anti-squat angles using the trailing arms, which can make the turn-in unpredictable,' says Hartley. 'The jury's still out on whether it is a real benefit for a Sprint Car, but it could be useful on other forms of speedway car racing. The concept is quite good and early results are encouraging. You can have some really odd spring rates from the rear of the Sprint Car by

Hartley's engines are beautiful creations and the company is well known for its attention to detail

Above: Hartley Engines is all about big V8s producing big power. One of its Sprint Boat units produces an amazing 1500bhp **Right:** Hartley will make many of its parts in-house – a common trait in NZ motorsport

virtue of the kinematics of the car and the way they lean into the turn.'

The wheels are often massively offset with huge amounts of stagger – anything from 8in to 16in difference in rolling circumference of the rear tyres from side to side. The wheels can be staggered as much as 300mm or 400mm depending on the track. 'On a really heavy track, where there's a lot of grip, the car will be staggered substantially, to discourage the tendency for the car to roll over,' says Hartley. 'Unlike a circuit car, it's very easy to roll a Sprint Car just by tipping it into a turn too aggressively.'

The Sprint Car category hasn't changed much in the last 20 years, unlike F1 or any other open wheel circuit racing category which has changed massively over the same period. 'So our approach to building Sprint Cars is to try and inject some modern innovation, while still working within the rules,' says Hartley. 'There is also a tendency to stick rigidly to the American traditions of Sprint Cars rather than to try and improve things for the better locally. The live front and rear axles are a case in point, this is really antiquated automotive engineering, especially since independent suspensions and active suspension control are standard on many domestic vehicles today.'

In Sprint Cars it doesn't matter whether you buy a Triple X, Maxim or J&J chassis, the engine plate from one will fit on the others and things like the front torsion arms are interchangeable, too. 'It's not so much standardisation, as the fact that everybody copies everybody else,' says Hartley. 'This sort of thing doesn't happen in other formulas – you couldn't put a Dallara upright on a Reynard, for example.'

The same kind of reliance on tradition has meant that some performance parts from the US are lagging behind other markets. 'Parts from Europe or Japan are too expensive, so we make our own,' says Hartley. 'Sometimes it's difficult to get parts from the US, but in general the quality doesn't meet our requirements. For things like oil pumps and fuel pumps and relatively standard components we would buy from America. But in terms of performance parts, they tend not to change the designs, so it's much more cost-effective to develop our own performance parts from scratch.'

Bracecar engineering

The other Sprint Car design departure is that Nelson has abandoned the traditional unstiffened birdcage and introduced significant cross bracing. He has eliminated the chrome moly frame in front of the driver and, with custom-machined bulkheads, has made the engine a stressed part of the chassis as it is in an Formula 1 car, but in this case the other way round. He has also fabricated an aluminium glu-lam monocoque box section (*à la* the Lotus Elise chassis) in front of the engine, holding the front suspension and housing oil reservoirs for the dry sump.

This has been developed in a 'lighten it until it breaks' manner as it's virtually impossible to predict the loadings on this kind of chassis to do any rigorous analysis.

Superstock

Nelson's Superstock engines are also impressive: 'The Nissan VK56 and Toyota 1UZs that we prepare for Superstocks are a different proposition,' says Hartley. 'These engines have a 4-litre capacity with a 10 to 1 compression ratio, which is extremely low, but we are able to get over 500bhp from them running on a single carburettor. This is an impressive amount of power from such a lightly stressed engine.'

The rules dictate retaining the 10 to 1 compression ratio, which is good because it keeps the budgets down. As soon as you increase the compression ratio everything else must be strengthened and reworked so the costs can get out of control very easily.

'It would be nice to have fuel injection on these engines, but the rules dictate the use of carburettors,' says Hartley. 'Our Superstock engines are pretty cool considering Superstock is a full contact motorsport.'

Superstock racing is very popular in New Zealand, but, perhaps like V8 Supercars, the concept doesn't travel very well. Nelson also sells kit sets for most of their lower to medium budget engines. 'There are a lot of people in New Zealand capable of bolting an engine

'It's easy to roll a Sprint Car just by tipping it into a turn too aggressively'

Short oval racing is a popular and relatively low cost form of motorsport in New Zealand, and is also very hands on. Hartley not only sells its engines but also kits of its engine parts so that other racers and teams can build their own powerplants

together, but it's hard for them to compete with what we can do, as far as the maths and design goes,' says Hartley. 'So it's good for everyone if we put a lot of the important parts on the open market. It would be arrogant of us to expect every competitor to buy an engine from us, so we make a lot of our parts available to anybody. It's a win-win. By mass producing things like brackets, pulleys, camshafts, even CNC ported cylinder heads, it keeps the cost down for everybody, keeps more engine builders in business, and the sport prospering as a whole.'

Because the Superstock rules dictate that the engine must be normally aspirated and fed from a four-barrel Holley carburettor, Hartley has designed a special carburettor adapter to connect a four barrel Holley to a custom, flowed inlet manifold for the Nissan VK56 and the Toyota 1UZ V8s.

When Hartley says he makes (or commissions) everything, he means it, including aluminium brake discs, flywheels, camshaft and water-pump pulleys. But he usually manages to incorporate a Mark 2 Ford Cortina cam belt tensioner in there somewhere, as they are still plentiful, economical and they do the job. He has plans to make camshafts and crankshafts when he can make room for a CNC lathe.

'When it comes to pistons, if we could forge our own, we probably would,' says Nelson. 'But as that is well outside the means of most engine builders, we typically send a drawing to Ross pistons in America, or just use blanks and finish machine the top profiles.' There is a big flow bench in the shock absorber dyno room, which again is surrounded by boxes of shock absorbers in various states of repair. This room is at the heart of the testing and recycling part of the business. Shock absorbers are pulled apart and serviceable parts are reused – the rest is scrapped. 'The problem with working in the speedway business is that the budgets are not over the top, but everybody wants the best equipment, so nothing is thrown away if it can be reused,' says Hartley.

The engine dyno is next door. 'We try to organise all the engine dyno work for a particular type of engine into one week. Because dyno testing is so unpleasant with the heat, the noise, the smell and the oil fumes – we try to get it all over and done with at once. So we do 10 or 15 engines in a single week. The neighbours are very good and don't complain too much about the noise.'

Another dimension

Hartley is now making his own 3D printer. He bought one from the US, but it didn't work very well, so rather than shop around until he found one that suited his purposes he decided to make one. In the printer that he bought, all the parts that moved were heavy and all the parts that didn't, were not – so the reverse became the main design criteria.

The prototype is now in production and already printing production parts. The main use for the 3D printer is induction manifolds and trumpets, which need to be made from materials resistant to petroleum liquids. 3D printing is also ideal for the shapes involved.

The overall sizing of the machine is conditioned to accommodate a V8 inlet manifold. And also to be able to print plugs and patterns for casting. The printer has two heads so that he can print the support structure at the same time as the final component.

'Some Nylons can resist 130degC and acetone, methanol, ethanol and gasoline, so I don't have any problems with it melting from temperature or chemical attack,' says Hartley. 'It's also machinable and tapable, so I can machine holes for inserts and if I rough it up, I don't see why I can't put two or three layers of carbon fibre on top, to give it some stiffness. For one or two parts it's way cheaper than modelling it, generating tool paths and machining the final component from solid. Also for testing something on the dyno, it's very much quicker.'

From start to finish

Hartley prefers to be able to start a project and go from start to finish in one operation, rather than get distracted. 'I really like working with large assemblies in SolidWorks and when you see that it all fits together, it's really satisfying,' he says. 'I've developed a series of routines for the 5-axis machine to level things up and to identify the orientation and start-point for the machining, so it's very easy to set up any machining process. It gives feedback in terms of how out of line or level the component is and makes adjustments accordingly. With the motorised beds and fixtures, once an engine block is located it can be machined from either side without doing further set-up. The Centroid 5-axis machine is designed for machining large automotive components.'

Once an engine block has been probed and the required bore size calculated the machine goes through and machines all the cylinders to match. 'Because of the requirement of about 30 of each line of engines per season, I would typically machine 10 at a time and bulk order all the other components, he says. 'Unfortunately these NZD$55,000 (£27,500) motors are going into Superstocks, which will routinely drive into each other, which can write off these expensive engines in seconds.'

Another typical job: a customer has some blank forged pistons and wants a particular profile machined into the top, again because either the component is unavailable or it would take too long to get. In this particular case the job consists of probing the sample piston on the 5-axis machine, using the data to generate a solid model, develop tool paths to the model and then machine the blank piston. 'A couple of hours work. You have to do things fast, because otherwise you don't get paid enough. We're often doing a million-dollar job for $100 budget. And a lot of the time we're doing something that nobody else can do.' It's the Kiwi way.

'It's more cost effective to develop our performance parts from scratch'

Heart and Seoul

Hyundai's new i20 WRC challenger is much more than an interim car to tide the Korean company over until the new 2017 regulations, as *Racecar* discovered

By MARTIN SHARP

The new Hyundai World Rally Car is some 99 per cent different to the outgoing 2015 car

Change is afoot for the top teams in the World Rally Championship, not least because of revised technical regulations coming into force from the beginning of 2017. This has meant that most manufacturers are holding back until next year to launch new cars. Not Hyundai, though, which for various reasons has homologated its new 'NG' Hyundai i20 WRC. The car made its debut on the Monte Carlo Rally in January, winning stages and finishing on the podium.

NG stands for New Generation, a tag which aims to emphasise that the latest i20 production car is far removed from a 'facelift' development; indeed it is an entirely new model with a completely revised floorpan, dimensions and, of course, it features new styling.

Hyundai Motorsport's original intention had been to introduce the NG model as a new World Rally Car during 2015. It was planned that this machine was to be based on the three-door coupe version of the new car, which has largely similar dimensions to those of the five-door derivative. The FIA, however, deemed the NG i20 coupe to be of a different family compared to the five-door, and a delay in the start of i20 coupe production until March 2015 meant the required 25,000 units could not be produced in time, thereby precluding timely homologation of the planned competition version.

It was not certain that the required number of coupes would be built in time for 2016, so the introduction date, and model, was revised to 2016 and the five-door New Generation i20 respectively. Hence the team continued to field its original i20 WRC throughout 2015, using the extra time to develop and hone the specification of its 2016 World Rally Car. Team principal Michel Nandan explains: 'It was close but [we took the decision] because otherwise you compromise all the operation, so we decided to shift back to the five-door because that's easy anyway – a big-big amount of [road] cars – in order to be safe.

'But by doing this, of course, we had to redesign a bit the roll cage and of course all the bodywork package, which meant we had to do some more design and a bit of wind tunnel testing. It [the coupe] could have been possible for the end of last year but it was stupid to do it like that because, with all the suspension links, with the new engine and transmission, it was really too pressing. We said, okay, better to postpone it to Monte Carlo. At least we had no problem with everything and it gave us

Hyundai's new i20 had a fairly successful debut on the Monte Carlo Rally, picking up a well-deserved podium and winning some stages

Hyundai had solid reliability in 2015 but for this year is targeting improvements in traction and the car's weight distribution in an effort to close the gap to Volkswagen's Polo R

more time for development. I think it was quite sensible to do it this way.'

With an entirely new bodyshell, transmission and engine, the new Hyundai is some 99 per cent different to the outgoing 2014/2015 car, with which there had been no major issues during 2015, just the occasional on-event service park technical frustrations – which are not uncommon to all teams.

But while reliability might have been good, the 2015 i20 had reduced engine output and tractive ability compared to its main rival, the VW Polo R WRC. Nandan attributes the main causes of the 2014/2015 car's traction deficit to its weight distribution and centre of gravity height. On average, through 2015 the Korean car took an extra half a second to two-tenths of a second to cover each kilometre compared to the Volkswagen, although on twisty stages, tarmac or gravel, Nandan rates the 'old' i20 WRC's chassis abilities as 'good'.

However, Hyundai i20 WRCs have always had the longest wheelbase of all current World Rally Cars; a straight-line stability asset yet a potential hindrance to nimble handling in twisty sections. At 2525mm the outgoing i20 WRC's wheelbase is 45mm longer than that of the Volkswagen Polo R WRC and Ford Fiesta RS WRC, which share identical wheelbase lengths of 2480mm. Citroen's DS3 has the shortest wheelbase at 2461mm. In contrast, the New Generation i20 WRC's 2570mm wheelbase is 90mm longer than the Ford and Volkswagen, and some 109mm more than its French rival.

But Nandan, a man with a rally car engineering background including working on the triple consecutive manufacturers' WRC title-winning Peugeot 206 WRC, is not overly concerned about the length of the new Hyundai WRC's wheelbase: 'Because the front/rear weight balance is even better than the old car. Yes it affects the handling a bit, particularly in the twisty parts but I don't think it's an issue. So far, the way we did the tests and everything, it's not a big issue.'

The revisions engineered into the latest i20 WRC powertrain itself are also substantial, contributing much to improvements in driveability and power and torque outputs, together with much improved weight balance between front and rear. The new car's centre of gravity height is also reduced.

Body building

Revised specification, lighter steel sheet is used for the production NG body panels to help meet EEC regulations, but the five-door bodyshell is some 10kg to 15kg heavier than the three-door. While the front wheel-arches are the same for the two cars, parts of the rear wheel-arches are formed by the rear doors; overall the five-door 'shell is slightly less stiff than the three-door. This, and a different roofline, convinced the team to develop a new roll cage for the five-door i20 WRC; keeping the cage designed for the three-door was just not the ideal solution.

A year-long, 8000km gravel and tarmac test and development programme of the new WRC was run in parallel with the team's full WRC campaign during 2015, proving the new machine to be quicker, with improved driveability. The NG i20 underwent one test per month on average last year. 'For a young team, to run an intensive test programme alongside a heightened WRC campaign has been quite an achievement,' says Nandan. 'In fact I would say nearly 90 per cent of our engineering people were focused on the new car and we had a dedicated test team for it in 2015. In total, including people from other departments, there were some 30 people dedicated to the new car.'

The new car's engine is entirely new from the ground up; not one part crosses over from the original engine. Compared to the old engine it has lost one millimetre in bore diameter and gained 1.8mm in stroke to have the same 83mm x 73.8mm bore x stroke dimensions as

Hyundai i20 WRCs always had the longest wheelbase of the WRC cars

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The Sadev gearbox has been specifically developed for the NG i20

the Polo WRC. This was simply to enable a more compact unit. In common with the latest Fiesta RS WRC's engine the new Hyundai power unit is machined from solid alloy billet and absolutely on the minimum of the FIA's latest WRC engine weight regulations. The engine is developed in collaboration with Pipo Moteurs, which produces the units for the team. Similar to the final iterations of the outgoing i20 WRC engine Bosch-manufactured fuel injectors are used, in conjunction with a swifter and more powerful Magneti-Marelli ECU than previously used.

The new engine drives through a transversely arranged, six forward ratios, Sadev gearbox which has been specifically developed for the NG i20, rather than the off-the-shelf assembly deployed in the previous car. Revised drop gear arrangements help take mass further toward the rear of the car, as does the more compact transverse engine which is canted rearwards around its crankshaft centreline and mounted as low as allowed by the FIA rules. The shape and size of this new bespoke transmission arrangement, and its mounting and location, have resulted in a much improved position for the steering rack compared to the old car.

Nandan is happy with the potential in the new generation car, while admitting he's sure that the rival team from Hannover (VW) hasn't stood still with the development of the 2016 Polo R WRC, which appeared for this year's Monte Carlo Rally with detail improvements to improve reliability (see Business News P80).

The Hyundai team will be pleased with its performance on the Monte. It an advantage for the rest of the year, too. Because the team started 2016 with a new car with a new homologation it will have the opportunity to deploy three engine jokers, three chassis jokers, and one software modification for its NG i20 WRC cars during the season. This is a unique 2016 freedom for Hyundai.

The new version of the i20 World Rally Car is larger than its predecessor but Hyundai is confident it will perform well

Fast company

Hyundai Motorsport has now proven its immensely flexible capabilities, almost against the odds. Just 12 months after it was officially established in December 2012, the team was 100-strong and had 8000km of testing the first-level i20 under its belt. The first shakedown test of the i20 WRC was in May 2013 and the 2014 specification car first tested in July 2013.

Fourth in 2014 Manufacturers' Championship, with the highlight of a one-two finish in Germany, was just reward for its efforts in such a short time scale. Consolidation came last year with increased car performance and reliability, and having led for much of the rally Hyundai Motorsport's Hayden Paddon scored his first WRC podium with second in Sardinia. There were other good results but Hyundai was pipped by Citroen for second place in the WRC Manufacturers' standings by just six points.

This year the team is contesting the full 14-round World Rally Championship with its new car while also developing and testing the NG i20 WRC for a new homologation under the revised 2017 WRC technical regulations. It is also heavily into significantly expanding its customer department and developing and testing an i20-based R5 for customers, all the while monitoring the FIA's proposed revisions to the R2 rules with a view to offering an R2 rally car in 2017.

By October 2015 the personnel headcount at Hyundai Motorsport at Alzenau in Germany had reached 165 people, and it has grown since. During a notable rally engineering career Hyundai boss Michel Nandan worked for Toyota Team Europe, which employed between 180 and 250 people over the years. He is fully aware of the flexibility limitations implicit to a larger organisation: 'Yes, it starts to be bigger: I have to take care,' he says, with a smile.

TECH SPEC

Engine:
Hyundai Motorsport turbocharged engine with direct injection
Displacement: 1600cc
Bore/stroke: 83/73.8
Power (max.): 300bhp (224kW) at 6000 RPM
Torque (max): 400Nm at 5000 RPM
Air restrictor: 33mm
Engine Control Unit: Magneti Marelli SRG unit
Lubrication: Shell Helix-Ultra
Fuel: FIA approved fuel

Transmission
Type: Four-wheel-drive
Gearbox: Sequential gearbox, six forward gears and one reverse with paddle shift on steering
Differential: Mechanical front and rear
Clutch: Cerametallic twin-disk

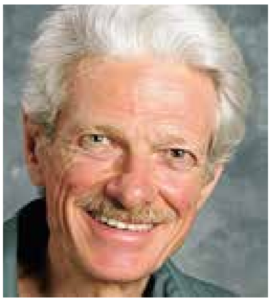
Chassis
Bodywork Structure: FIA-conformant reinforced steel and composite fibre body with welded multi-point roll cage
Length/width: 4035/1820mm
Track width: 1610mm
Wheel base: 2570mm
Fuel tank capacity: 80 litres
Weight: 1200kg minimum / 1360kg with driver and co-driver

Suspension:
Front/rear: MacPherson struts with adjustable dampers
Steering: Hydraulic power-assisted rack and pinion

Braking system:
Ventilated Brembo disc brakes (355mm on tarmac; 300mm on gravel). Air-cooled 4-piston callipers
Handbrake: Hydraulic control

Wheels and tyres:
Wheels: 8x18 inch for tarmac, 7x15 inch for gravel
Tyres: Michelin. **Range:** Pilot Sport for tarmac, A41 for snow/ice tarmac, X-Ice North for ice/snow gravel and Latitude Cross for gravel

Cockpit:
Seats: Sabelt
Belts: Sabelt, multiple fixing points belts with adjustable straps



Strut stuff: getting to grips with MacPherson

Modifying suspension, braking and steering on a BMW CSL

Question

I have a 1973 BMW 3.0 CSL Group 2 racecar with a MacPherson strut front suspension. The geometry of the front suspension is set up with a single lower control arm and a tension rod that attaches to a bolt-on lower steering arm on the bottom of the strut. The rear suspension is a semi-trailing arm set-up with coil-over dampers.

I am in the process of converting the car from a steering box to a rack and pinion steering system that will require a new steering arm to make the geometry work. This is being done to help stabilise the front suspension, especially under braking – the car has a tendency to have significant lateral movements under heavy braking and become very unstable. I attribute this to the compliance in the steering box system, as well as the polyurethane suspension bushings.

I am in the process of solid mounting all the suspension front and rear and removing the urethane bushings. I am also reinforcing the front and rear chassis to try to eliminate as much compliance as possible.

Since I need to make a custom steering arm already, due to the steering rack install, I would like to swap my struts from side to side so that the brake caliper mounts move from the front to the rear. This will make it easier for me to install a brake cooling duct to the front of the strut.

My main question/concern is that the stub axle is not directly in-line with the centre of the strut housing in the side view. It is offset towards the rear in side view by about 0.50in. So when I swap the strut from side to side, this offset will go from being behind the strut centreline to in front of the strut centreline, and I cannot figure out if this will cause any negative steering or geometry effects.

From my research, I know that the critical locations for a MacPherson strut suspension are the upper strut mount and the lower ball joint mount to determine the steering axis and the pivot radius. Assuming that I can design my new steering arm to replicate the location of the lower ball joint, what else do I need to be concerned with when designing the new suspension set-up?

In the side view, what does the linear difference between the lower ball joint and the tie rod ball joint control? If I shorten or lengthen this difference, what effect will it have on steering and scrub? I know I can design the steering arm and upper strut mount to achieve the static caster and camber I desire, but is there anything else I need to be concerned about?

Even when camber velocities are the same, camber accelerations will differ

The consultant

A MacPherson strut system can be thought of as being much like a double A arm system. The lower control arm is entirely the same. It has a control arm plane defined by the inner pivot axis and the ball joint centre of rotation. The front view projected control arm is the line where the control arm plane intersects the y-z (transverse-vertical) axle plane. The side view projected control arm is the line where the control arm plane intersects the x-z wheel plane (the longitudinal-vertical plane containing the contact patch centre).

The system can conveniently be regarded as having an effective upper control arm plane that is perpendicular to the strut axis (not the steering axis) and contains the centre of rotation of the strut's upper pivot. As with the lower control arm, the front view projected control arm is the line where the control arm plane intersects the axle plane and the side view projected control arm is the line where the control arm plane intersects the wheel plane.

As with a double A arm system, the intersection of the front view projected control arms is the front view instant centre and the intersection of the side view projected control arms is the side view instant centre. These are true instantaneous centres of rotation for the upright or spindle and everything rigidly attached to that. In front view, this includes the wheel and the contact patch centre. In side view, ditto, if the wheel rotates with the spindle, as it does with a locked outboard brake.

As with any independent suspension system, geometric resistance to (or encouragement of) roll and pitch arises from jacking (z axis) forces induced by the linkage when ground plane (x or y axis) forces act on the tyre at the contact patch.

The magnitude and direction of these forces depend on two things - the magnitude and direction of the ground plane force and the magnitude and direction of the instantaneous rate of change of x or y displacement at the contact patch with respect to z displacement of the suspension. For example, if the front contact patch's instantaneous rate of x axis displacement with respect to z axis displacement is a tenth of an inch forward per inch of suspension compression (wheel upward with respect to the sprung structure), the system generates a pound of anti-dive force for each ten pounds of rearward ground plane force that the road surface is exerting upon the tyre.

The horizontal distance from the front view instant centre to the contact patch directly determines the instantaneous camber gain or instantaneous camber velocity with respect to z displacement. The horizontal distance from the side view instant centre to the contact patch almost exactly determines the instantaneous caster gain or instantaneous caster velocity, although not quite exactly because caster is not measured in the wheel plane.

If we consider a strut suspension and a double A arm suspension with the front view and side view instant centres in the same locations, the two systems will be identical as regards camber velocity, caster velocity, anti-roll, and anti-dive, at the one point in their travel that we're looking at. However, there will be only one point in the suspension travel where this will be so. Even when the camber velocities are the same, the camber accelerations will differ – and so it is with all the other properties; they change differently as the suspension moves.

Camber changes

The biggest difference is that with the strut design, geometric roll resistance changes much more with ride height, and camber acceleration is positive rather than negative: as the suspension compresses, camber goes toward negative at a decreasing rate, and in some cases may even start to go toward positive near full bump. This means the suspension has little camber recovery in roll when lowered. Consequently, when people make new hardware for the bottom end of the strut, the most common objective is to lower the ball joint. This shortens the front view swing arm length and restores some geometric roll resistance.

This month's Consultant query concerns braking and suspension modifications on a Group 2 BMW 3.0-litre CSL racecar

In any case, an analysis of the suspension's geometry can still be done as per above.

In further correspondence with the questioner, he told me that the suspension is a rear-steer layout (steering linkage behind the axle line) with a lower control arm running roughly transversely and a compliance strut running diagonally forward from the outboard end of the control arm. He was not able to supply a picture of the suspension, and an image search didn't turn one up for me either, but he was able to supply a picture of a car with the fender flares he is using to accommodate the wheels and tyres he describes (not the picture above).

These are not the extremely wide IMSA-style flares some readers may be familiar with. These are more modest, but the front wheels and tyres are at least two inches wider than stock, and the extra width can only be accommodated by widening the track and increasing the front-view steering offset.

Additionally, the racing tyres generate considerably greater forces in braking than those the car was designed for. The questioner is probably correct in supposing that deflection steer is producing the braking instability he describes. Chances are the wheels are toeing out. It is also common to run static toe-out when setting a car up for racing, whereas factory settings for street use generally have some toe-in, partly to compensate for deflection steer in braking.

Racing tyres generate considerably greater forces in braking than those the car was designed for

Taking compliance out of the system will no doubt help. However, even cars with solid bushings or spherical joints have some compliance. If a new steering system is being installed, it would be desirable to have the tie rods oriented in top view so that when the ball joint moves rearward, the wheel does not toe out. This would probably involve having the tie rod roughly parallel to the control arm when the steering is centred, not angled back at the outboard end. Packaging constraints will no doubt limit what is possible.

The questioner describes the spindle pin as being half an inch behind the strut axis in side view, and he would like to reverse the struts, placing it half an inch ahead instead. If the ball joint and the upper strut pivot are not moved, this will decrease trail by about an inch. That's roughly equivalent to a four or five degree reduction in caster. The front wheels will also be about an inch further forward.

Packaging constraints permitting, moving the front wheels forward is good. It makes the car less nose-heavy. This car has a fairly long in-line six engine. The front crossmember passes under the rear two main bearings. The fairly long sump hangs entirely in front of the crossmember. The tops of the strut towers are only slightly forward of the firewall. The layout gives good load paths but arguably would be better suited to front-wheel-drive.

If the struts are reversed, we'd really like to drastically increase caster to get the trail back where it was. Assuming we don't do major surgery to the strut towers, this would involve moving the ball joints forward over an inch. That would also move the wheels forward something like another inch. The wheels would then be something like two inches forward of their previous location. This would be good in terms of vehicle dynamics, provided packaging constraints permit it.

Generally, moving any car's wheels that much will necessitate fender modification. Probably the car wouldn't look different enough from stock to attract attention, but I couldn't guarantee that.

If a complete tubular frame is going to be built, then maybe the upper strut pivots can be moved back with no problem. The weight distribution improvement from moving the front wheels forward an inch or two is not very large – on the order of one percentage point.

Steering shimmy

In some cases, cars with lots of caster and some pin lead will exhibit steering shimmy, often at low speeds. If this goes away at racing speed, it can be lived with if the car goes faster. A hydraulic steering damper can also be helpful. Many German cars have these as factory equipment. In some cases, there won't be any shimmy problem.

The front to rear position of the outer tie rod end with respect to the ball joint controls how fast the steering is, together with the pitch diameter of the pinion gear in the steering rack assembly. Shorter steering arms give faster steering. Scrub radius and front view steering offset are not affected.

How far inboard or outboard the outer tie rod end is with respect to the ball joint controls how much Ackermann effect the system has. Moving the outer tie rod ends in gives more Ackermann. Rack location also affects Ackermann, primarily at large steer angles. Moving the rack rearward increases Ackermann.

We also want to avoid having really large tie rod angularity with respect to the rack, especially at small steer angles, where the system spends most of its time. The straighter the tie rods are with respect to the rack axis, the less load is induced at the rack bushings by tie rod forces.

CONTACT

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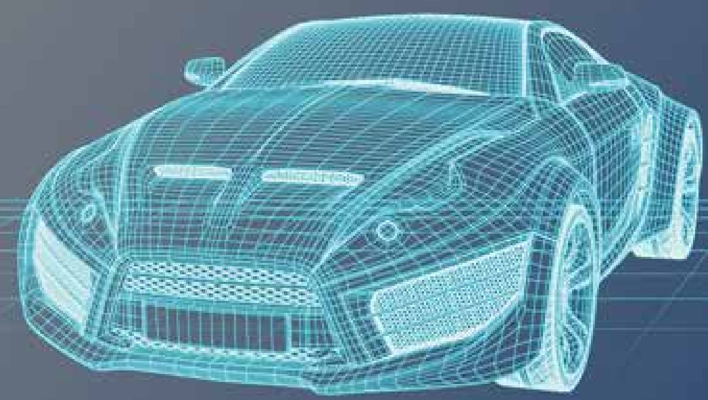

Databytes gives you essential insights to help you to improve your data analysis skills each month, as Cosworth's electronics engineers share tips and tweaks learned from years of experience with data systems

Switch-craft and button pushing

If you thought flicking switches and pushing buttons was easy, then you might want to think again, as our guide to finger controls shows

XPB

Even simple controls like buttons and switches need special attention when it comes to high-end racecars such as this Lotus E23

Buttons are used in many motorsport applications and can allow the driver to make a multitude of changes to the car set-up or power systems. With the introduction of digital processing in control systems, a single button can be used for multiple functions, as the system is able to differentiate between different techniques of engaging a button. For example, a short press might activate strategy A, whereas holding the button for a long time might initiate strategy B.

Switching hour

A mechanical switch, such as the light switches you find on walls, uses a mechanical movement to connect and disconnect a circuit, changing between an *on* state and an *off* state. When a switch that is activated mechanically is pressed and then released, the switch will bounce very slightly on the contact, which produces several on and off states as it repeatedly loses and regains its connection. After several transitions the contacts will settle and a clean signal will be sent. If a system is dependent on the quantity of changes of state, it will be impossible to control as the raw signal produced from the switch **(Figure 1)** will produce multiple on and off states each time the button is pressed.

The idea is exactly the same as a digital switch in a car which outputs a true (on) state or a false (off) state that can be used to control a system. The difference lies within the device which the switch is connected to. Most digital devices now allow de-bouncing to be applied to the raw signal from a switch.

Anti-bounce

De-bouncing is a feature used to counter the mechanical bouncing that causes these accidental state changes. It achieves this by identifying when the switch is bouncing on the contact and outputs a single state change for the group of bounces **(Figure1)**. This means that the button output that is transmitted from the device doesn't change state until the *on* timer is exceeded. The traces in **Figure 1** have been stretched along the time (*x*) axis to make this clearer. The *on* timer could still be as low as 0.1 seconds. This allows the button to be used to control such systems where the number of state changes are counted. Switch de-bouncing is fundamental to the use of mechanical switches in environments that experience high vibration, and misuse, conditions that are usually found on a racecar or bike.

A software package may even offer the ability to ignore multiple button presses from the user that have already been de-bounced **(Figure 2)**. This is particularly useful for buttons on a steering wheel as vibrations in the car can easily cause the driver to press a button multiple times by accident.

Buttons can often be used with more than just two states (on/off). These states are usually activated based on the time the button is depressed, this can then be used to add a secondary function to a button. It is always good practice to keep the primary and secondary button functions related to each other through the same system to avoid any confusion.

For example, the windscreen wiper control system may have two different motor rates for a fast or slow wiping motion. A primary button function, perhaps a simple click, could be assigned to turn the wiper system on and off. Then the secondary function, a button hold, can be assigned to allow the wiper control to alternate between the fast and slow configurations. If the button

Digital devices now allow de-bouncing to be applied to a raw signal

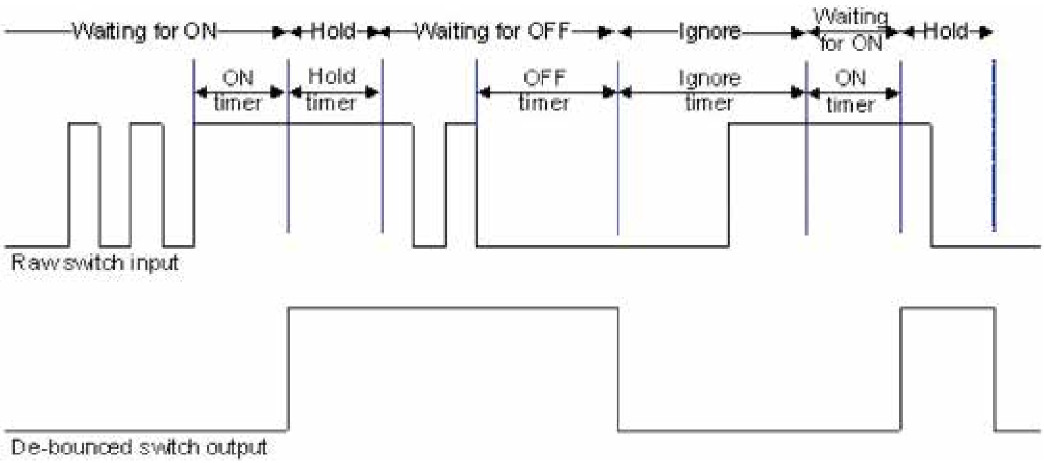

Figure 1: De-bouncing identifies when a switch is bouncing on contact and outputs a single state change for a group of bounces

hold times can be configured, it is also wise to ensure that the hold times can be easily achieved by the driver. It would be impractical to define a *Hold* and *Long Hold* state with only a tenth of a second difference **(Figure 3)**.

Button combinations are another useful tool which can be employed to prevent functions being initiated accidentally. Button combinations are accounted for in most software packages. Should this not be the case, or should you wish to ignore button outputs based on vehicle parameters, logic channels can use a button signal as an input to a function which is also dependent on other inputs values.

For example, you may wish to add a control strategy which prevents the pit limiter from being activated at speeds above 150kph. If the pit limiter is activated on Switch 10 **(Figure 4)** when it is *Held*, you only want to send an *On* (1) signal for the pit limiter when Switch 10 is *Held* AND vehicle speed is less than 150kph **(Figure 5)**.

A logic channel can be used to compare these two statements and output the corresponding *on* or *off* value which can be sent to the pit limiter.

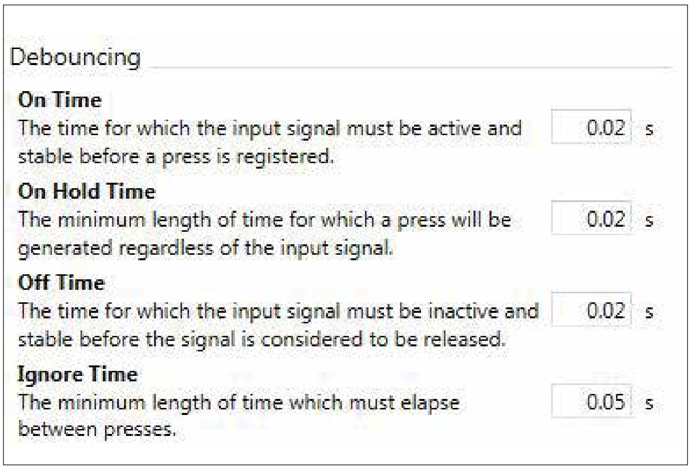

Figure 2: A software package may be able to offer the ability to ignore any multiple button presses from the user if they have already been de-bounced

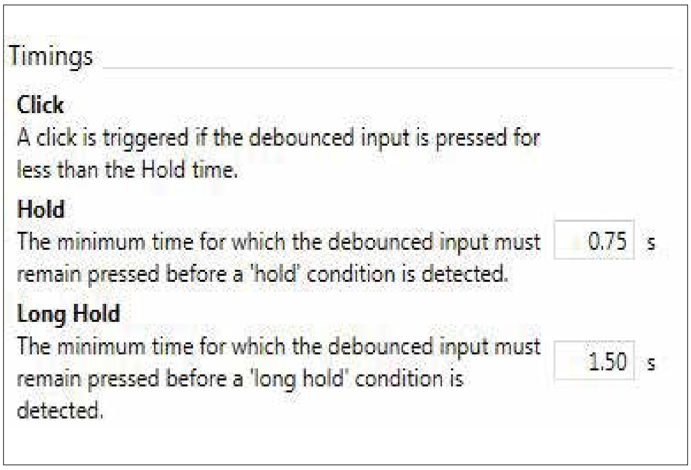

Figure 3: If button hold times can be configured it is wise to ensure that hold times can be achieved by the driver. Hold times of just a 10th of a second are impractical

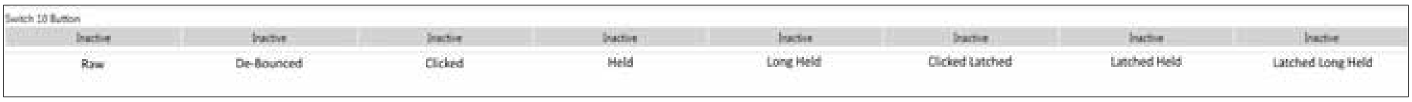

Figure 4: It's possible to add a control strategy which prevents the pit limiter from being activated at speeds above 150kph

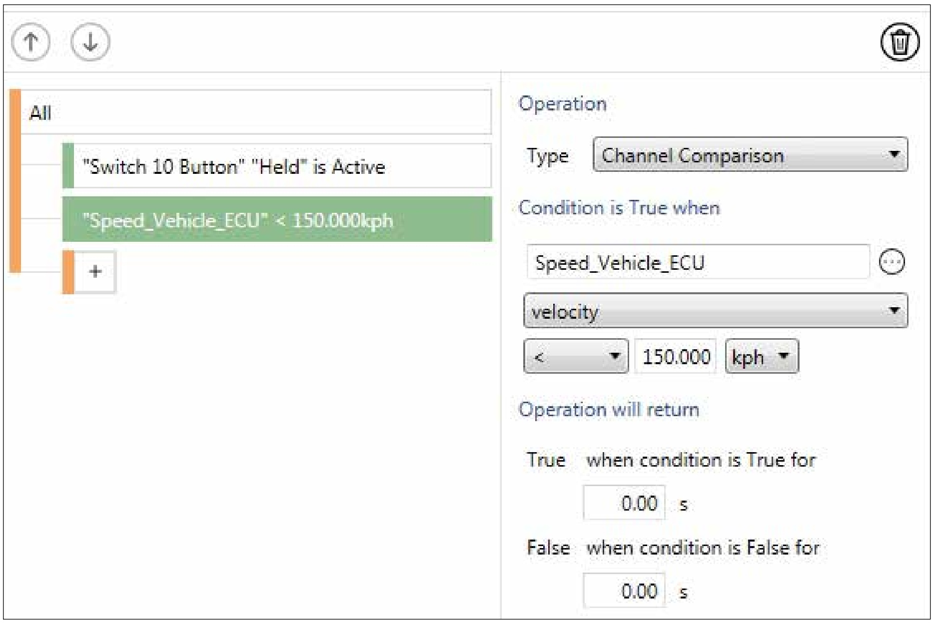

Figure 5: (With Fig 4). A logic channel can be used to compare the two statements and output on or off values

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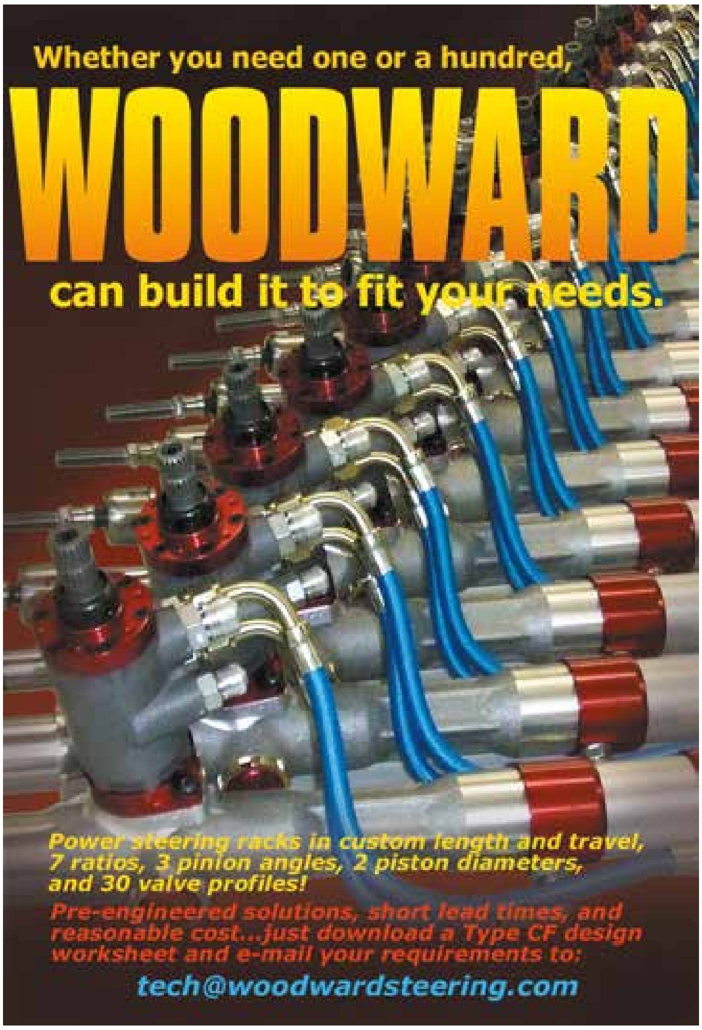
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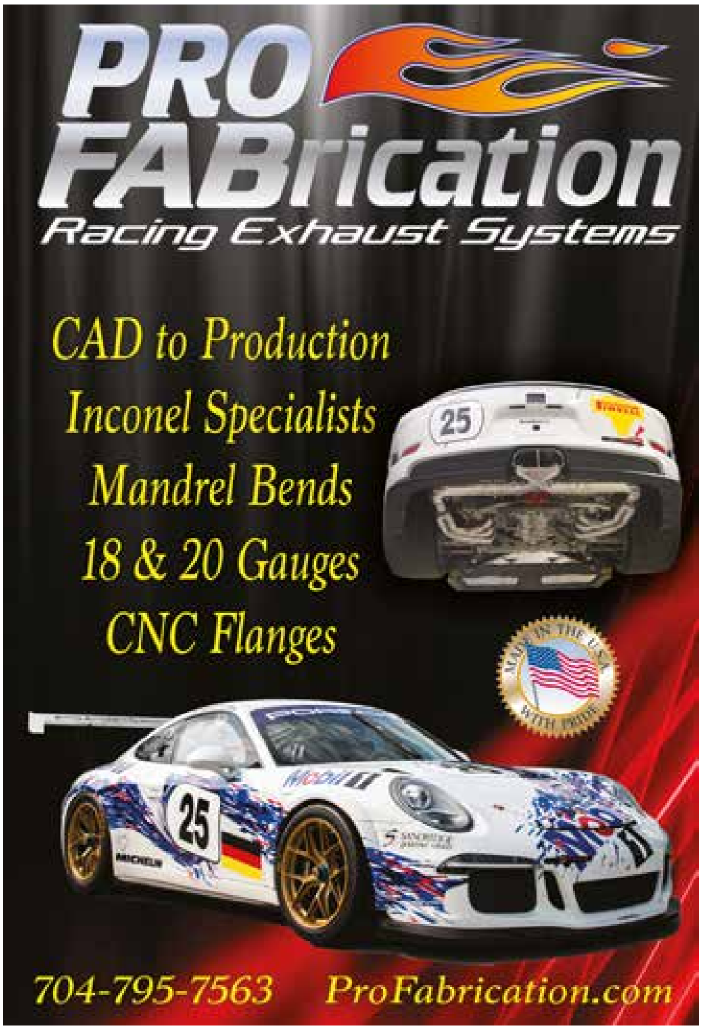
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Aston Martin GT3 racer examined

How would a Vantage GT racecar perform in the wind tunnel?

We start an exciting new mini-series this month with a British GT Championship specification Aston Martin Vantage GT3, kindly provided by Aston Martin Racing. This particular car was being readied for a private client but was to exactly the same specification as the one that Beechdean AMR used to collect first and second places in the 2015 British GT Drivers' Championship.

These lower rear panels are not diffusers in the conventional sense

The key aerodynamic devices that can be seen on the car are controlled by the series technical regulations, which require the homologation of the aerodynamics package as a whole. However, within that there is a degree of adjustability, primarily to the rear wing in this instance, but also to ride heights, too. Let's take a brief tour around the car.

The front quarter view in our lead photo (below) shows the car's splitter with the central section turned upwards to meet the direction of the approaching airflow in this region, as shown by the smoke plume dipping under the splitter. The splitter's underside is shaped into a gently cambered diffuser section across the central three quarters or so of its width. The inlet apertures in the front panel fulfil a variety of functions and connect to various outlets downstream, some of which can be seen in the bonnet. We shall return to this in our next issue when we investigate further how the cooling systems functioned aerodynamically.

A single pair of modest dive planes sits just above the splitter on the front corners. Moving aft down the sides of the car we can see that the sills have been extended to meet the full width of, and blend in to, the wheel arches. And at the rear the car finishes off with a full width, 370mm chord, fairly aggressively angled single element rear wing.

Our second photo (P60, top left) shows the detail of the front wheel arch, and we see that the arch is completely open to the rear, with the rear inner arch shaped to ease the exit of air that finds its way into the arch. The shot of the car's rear (P60 top right) shows that the wing, which has apparently been standard on AMR's GT cars for some time, features a slight twist across its span, with the leading edge raised across the central section (akin to the splitter and also to align with the onset flow) but with a straight trailing edge finished off with a 15mm Gurney. The wing is at roof height but overhangs the rear somewhat, and is assisted by the car's small, standard boot spoiler.

The bottom left picture (P60) shows the car's rear panels and reveals an interesting take on what at first glance looks like a diffuser (with a central cooler above). In fact, the Vantage GT3 does not have a flat floor panel. This apparently to make the car less sensitive to running at the different ride heights mandated in the various GT series that AMR supplies cars for. Thus, the lower rear panels are not diffusers in the conventional sense, and the gill slots take account of the fact that the top of these

Note the smoke plume dipping under the Aston Martin's splitter, the underside of which is shaped into a cambered diffuser section across the central three quarters of its width

The front wheel arches feature large rear-facing vents to aid the exit of air from the arch

The rear wing is slightly twisted across its span which is a feature of Aston Martin GTs

The lower rear section featured slotted pieces – the Aston does not have a flat floor panel

Table 1 – The effects of rear wing angle changes (positive changes to negative coefficients = more downforce)

ΔWing angle	ΔCD	Δ-CL	Δ-CL-front	Δ-CL-rear	Δ%front	Δ-L/D
-1.5deg	-3.6%	-3.9%	+2.7%	-6.6%	+1.06%	-0.3%
+3.0deg	+3.3%	+3.3%	-2.7%	+5.9%	-1.68%	0

The Vantage had a noticeable rearward bias to its downforce as delivered to the tunnel, something that initially seemed curious

panels is open to the front. We shall see later how this feature affected the airflow. The rear mudguards are cut away up to wheel hub height, but are neatly panelled in.

Unfortunately, AMR was not willing to allow us to publish any definitive data, so comparisons with GT cars we have previously tested, which were highlighted in last month's issue, can only be made in vague terms. Suffice to say that the first baseline run on the Aston Martin compared favourably on total downforce and efficiency (-L/D) relative to the most recent GT3 car we have tested (the 2010 Ferrari F430 Scuderia) despite the Aston Martin's lack of a fully panelled floor and conventional diffuser.

However, the car had a noticeable rearward bias to its downforce as delivered to the tunnel, something that initially seemed curious on a car with a static weight split of 55 per cent front, 45 per cent rear. The team remarked that the drivers don't particularly notice a change in balance with speed. Perhaps, then, this is indicative of a set-up that benefits from a proportionate increase in rear grip as speed increases, simplistically suggestive of a car with low speed oversteer (and presumably therefore good turn-in) that is progressively neutralised with increasing speed.

That the car showed a rear downforce bias meant that adjustments to the rear wing would be interesting. Three positions were available and adjusted via the mountings on the underside of the tailgate, and our results are shown in **Table 1** as 'Δ' or 'delta' values, expressed as percentage changes to the aerodynamic parameters.

Wing responses

All the responses were as expected in general terms, drag and overall downforce reducing at the lower wing angle but increasing at the higher angle, and with the anticipated balance shifts. And it is fairly clear that the slightly smaller percentage changes from the bigger positive angle change, which put the wing at its max angle of 16 degrees including the Gurney, indicate the wing's gains in performance at this steepest angle were tailing off. This means the wing was at or near its peak angle prior to stall. The datum wing angle, in between the steepest and shallowest angles run here, was therefore at the upper end of the wing's range, which would account for the rear bias in the car's downforce balance. By way of comparison, the F430 mentioned above recorded an aerodynamic balance in the mid 40s %front with wings angles between five and eight degrees, and would also have shown a greater rear bias and more total downforce with its wing at the angles of the Aston Martin's wing.

Next month: effects of blanking off some of the openings around the front of the Aston.

Racecar's thanks to Aston Martin Racing.

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

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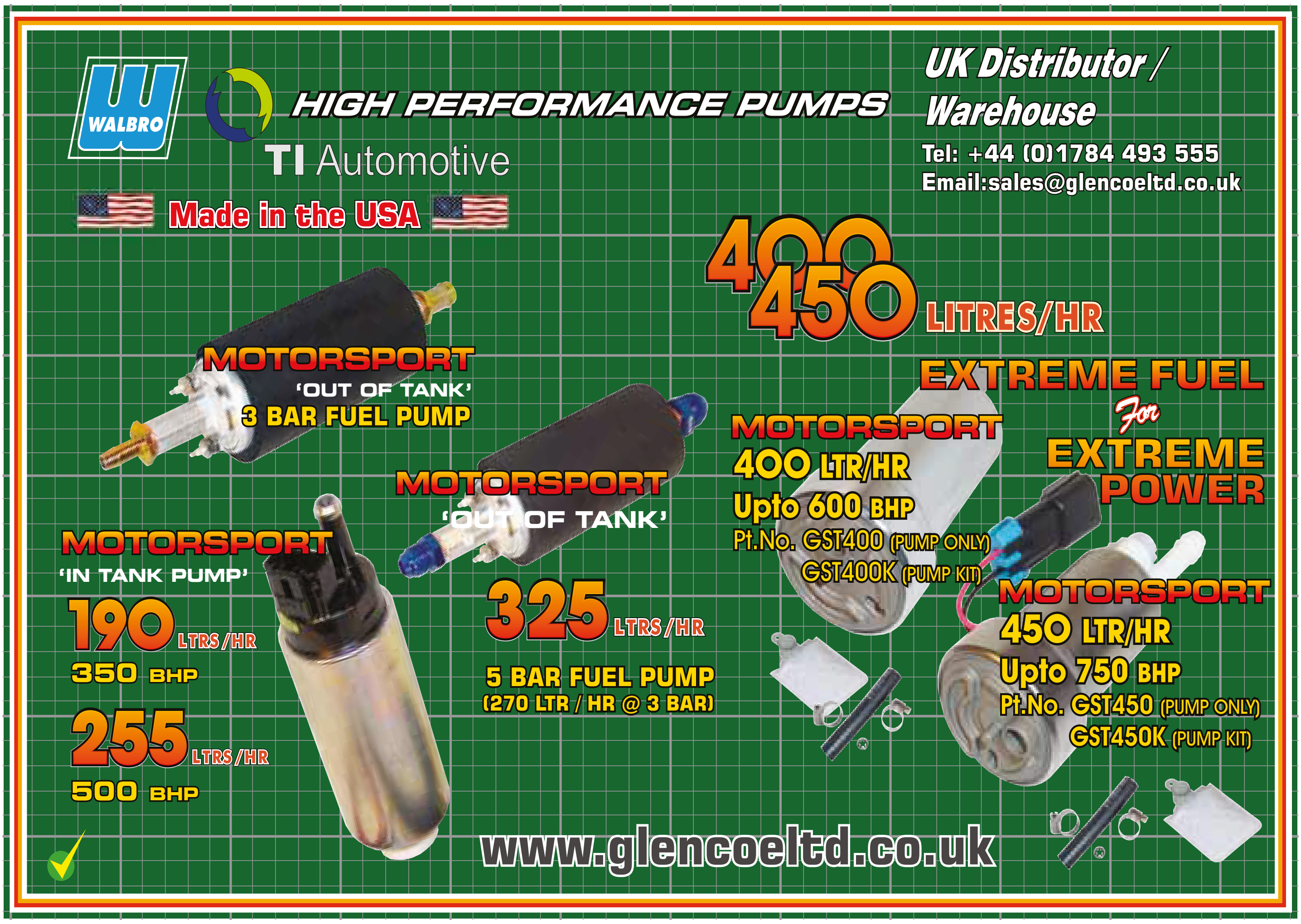
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The grid of the future

Ever wondered what the top motorsport series would look like in 10 years' time? Here's one very carefully considered opinion

By PROFESSOR STEVE SAPSFORD

Motorsport might look very different in the future and autonomous vehicles will surely play their part

Many in the motorsport industry will be familiar with the motorsport technology roadmap, an attempt to map out the future technology requirements for the motorsport industry given the drivers from the regulators, the fans and the requirements of the associated automotive industry. At the MIA Energy Efficient Motorsport Conference, Chris Aylett (CEO MIA), asked me to go a step further, and predict what the grid of the future may look like, across a variety of classes of motorsport.

I was initially asked to look at the potential grid in both five and 10 years' time, but I quickly came to the conclusion that five years hence was too soon for any meaningful changes to be implemented, so I settled on 10 years.

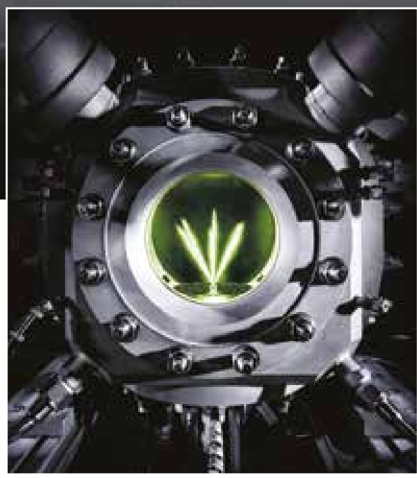
The main purpose of the roadmap is to predict the technologies that will be required in order to help guide investment decisions regarding technology and product development. So, one method of predicting the future should be to draw a line down the roadmap (**Figure 1**) at 2025 and read off what it says. However, I did not force myself to follow this process religiously as this does not take account of disruptive policy changes or technologies – some room for independent thinking and incorporation of new drivers or technologies was allowed. However, please note that this analysis is predicated on the existing dominance of internal combustion-based powertrains, and so most comparisons are drawn from this position.

There are two main routes towards low carbon vehicles **(Figure 2)**; improve overall vehicle efficiency and reduce the amount of carbon in the fuel. For the first of these, the main focus is on downsized, boosted engines combined with hybridisation supervised by intelligent and integrated control systems.

The second method focuses on reducing the amount of carbon in the fuel, either through the use of low carbon electricity or the generation of synthetic fuels. The important point here is that it is not simply a universal move to electric vehicles. When assessing the total environmental impact, one must also take into account that the electricity and its storage (batteries, capacitors etc.) has to come from somewhere. This is a critical consideration when calculating the overall vehicle life-cycle which needs to include the carbon involved in fuel/energy production, vehicle production, through life usage and, eventually, recycling.

In this exercise I have considered four categories of motorsport, all with slightly different drivers, and then tried to determine what I think will be the main features of the propulsion system, transmission and driveline system and the energy recovery/storage. I purposely confined my analysis to the powertrain and only highlight the potential impacts of those systems on the vehicle.

So, to the grid (**Table 1**).



Audi's experimental e-fuels are likely to be developed and proven in the motorsport arena

Formula 1

The powertrain is already highly integrated, so I expect this to continue. There is potential to reduce engine capacities further so it would not be surprising to see 3- or 4-cylinder engines coupled with more powerful electric motors and/or flywheel-based technology

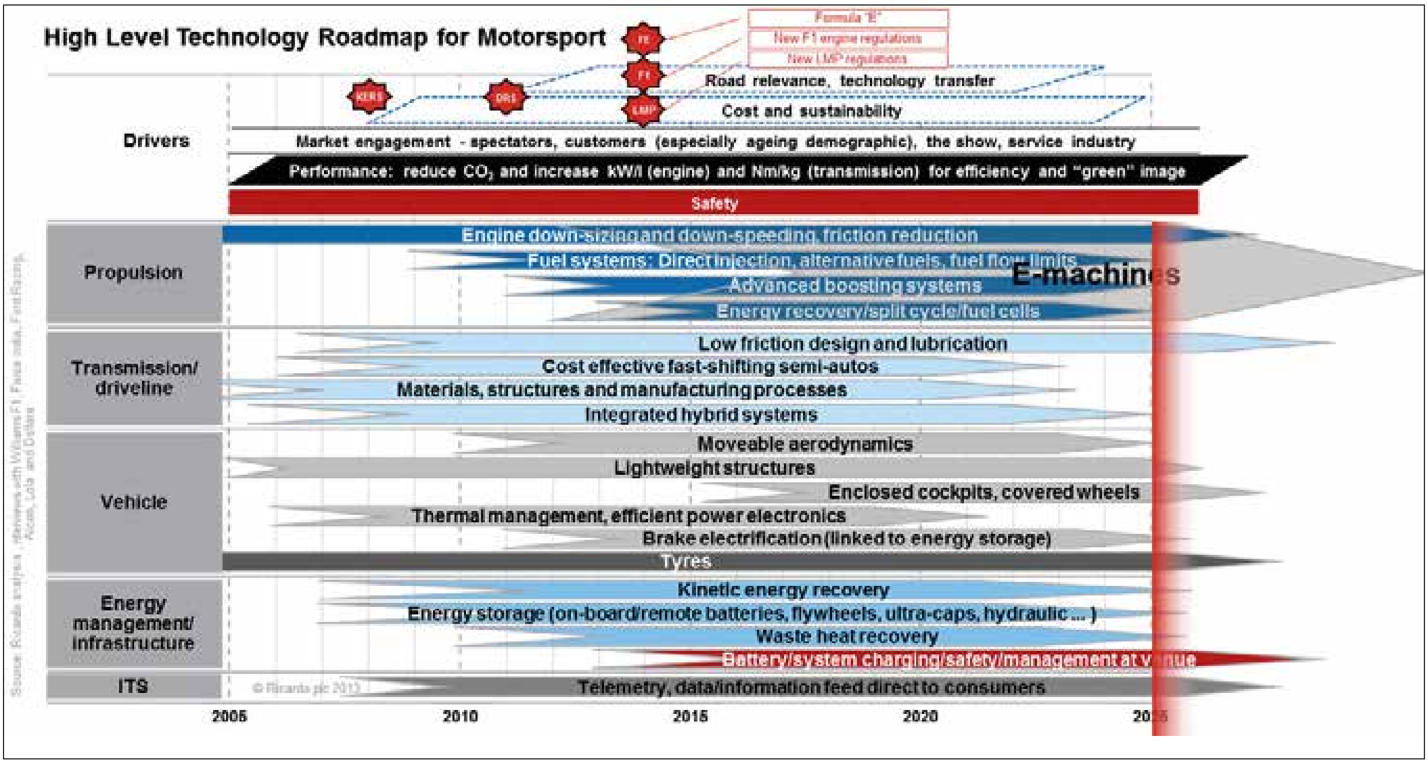
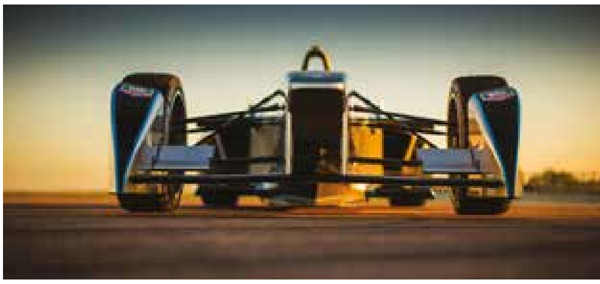


Figure 1: Motorsport Technology Roadmap and potential technologies in 2025. The Roadmap is an attempt to map out the future technology requirements for the motorsport industry

World Touring Cars and other tin-top categories will continue to follow the lead of the road car industry

Split cycle engines could drive thermal efficiencies towards 60 per cent in the less regulated WEC



The main focus for Formula E must be to complete a full race distance on a single charge

for maximum efficiency. Reducing the carbon content of the fuel is one of the main opportunities for reducing CO2. So I am proposing here the use of synthesised fuel from sunlight or other renewable sources of energy. This process basically combines hydrogen generated by electrolysis with sequestrated CO2 to generate methane, methanol and other related fuels. Effectively this means that the CO2 released during the combustion process is mostly replacing CO2 you have already captured from some other process and combined with the hydrogen to generate the fuel, and so on. It should be noted that there are biologically-based processes that achieve the same effect but take the CO2 directly from the atmosphere.

Regarding the transmission and driveline, the focus will be on further light-weighting, perhaps using metal foam-filled gears which are encased in a hardened shell.

There is still substantial energy available to be recovered, but most of that is on the front axle, so I do not think it will be long before energy recovery through regenerative braking will be available through the front wheels, even if we are not allowed to transmit torque through them, for reasons of entertainment.

Waste heat recovery will still feature, although I do expect advances in this area, especially through heat-to-electricity technologies in the exhaust and cooling systems. More intelligent cooling will result in reduced requirements for heat rejection from the vehicle and hence reduced radiator sizes and associated apertures.

World Endurance

With the freest regulations, we may expect to see more diversity in the technologies here. We will continue with similar powertrains but I would expect to see more intense integration of those systems and more aggressive use of disruptive technologies. For example, Ricardo is currently working on split cycle engines, where we use one set of cylinders for compression and another set for combustion, that could drive thermal efficiencies towards 60 per cent. If we imagine operating such an engine under a restricted number of speeds and loads and transmitting this power through a CVT and highly electrified drivetrain, substantial improvements in performance are possible.

Waste heat recovery and cryogenics are a natural part of these split cycle engines and so these technologies would be exploited, too.

World Touring Cars

This is included primarily to force us to think about costs. With the focus on downsized, boosted engines in production cars, it is not surprising that WTCC cars have moved to the same configuration as the base technology has become increasingly available and understood. If we project that model forward, I see a significant move towards 48V architectures for our everyday cars as inevitable, so why would we not expect to exploit this technology in even our more cost-conscious categories in the future? Powertrains will already have integrated starter/generator systems of 10-15kW and (relatively) low cost energy storage, so why not exploit/extend that to provide 'push-to-pass', 'fan boost' etc., and improve the engagement?

Formula E

One of the main purposes of the motorsport technology roadmap was to align drivers from the motorsport sector with those of the

	Formula 1	WEC	WTCC	Formula E
Propulsion	• Fully integrated drivetrain – 3 or 4 cylinder DI and heavily boosted SI engines (Miller-cycle) – Electric motors/flywheels • 100% biofuel or a synthesised fuel (from sunlight)	• Fully integrated drivetrain – Electric motors/flywheels – 3 or 4 cylinder DI and heavily boosted SI **split cycle or 2S engines** • Single (or 3 mode) operating point for max. efficiency	• 3 or 4 cylinder DI and boosted gasoline engines – E or hydraulic boosting • BSG/ISG for electrical systems • 100% biofuel	• Electric motors with no rare earth metals • Liquid nitrogen cooling – Improves performance, efficiency and life (super-conducting e-machines and power electronics) – Boil-off keeps batteries cold
Transmission and driveline	• Lightweight (foam-filled gears) • Even more integrated with propulsion system and chassis • Rear wheel drive	• CVT • eAWD with e-enabled driveline	• eAWD	• eAWD with distributed motors
		It's more about torque control to the wheels through e-enabled drivelines rather than sophisticated transmission systems		
Energy recovery and storage	• Combined kinetic and thermal energy recovery – Re-gen braking on front wheels – Waste heat recovery • E-turbines • Heat-to-electricity systems	• Multiple mode energy stores and system integration • Waste heat recovery – E-turbines – Heat-to-electricity systems (high and low grade heat)	• Moderate, cost effective energy storage – Advanced lead acid battery – Hydraulic supercharging (re-gen through hydraulic pump) and carbon fibre tank	• Race distance on 1 battery – Dynamic charging • Fuel cell-based charging stations (pre-race) – Low carbon H_2
Vehicle	• Intelligent cooling – Reduced radiator size and cooling drag	• Intelligent cooling – Reduced radiator size and cooling drag		• Reduced radiator size and cooling drag

Table 1: The grid of the future for various classes of motorsport

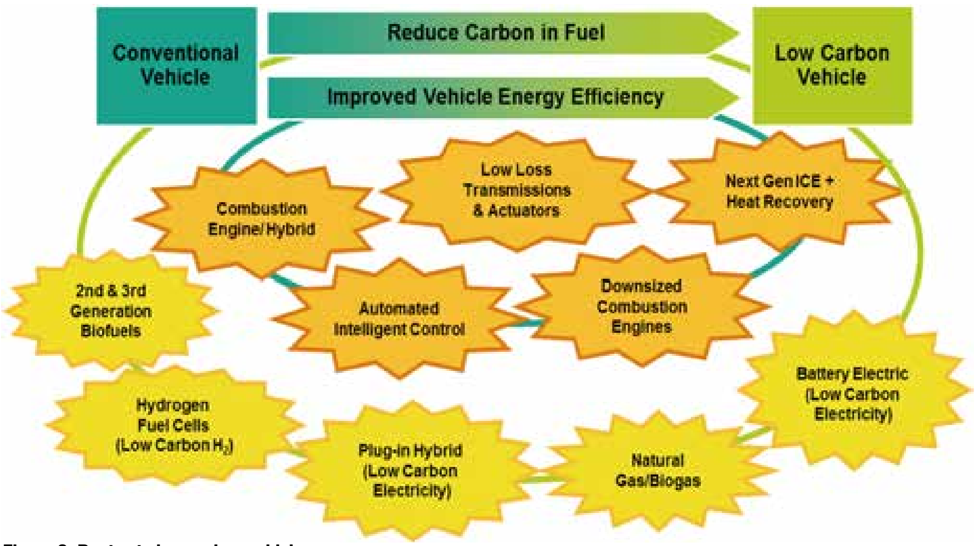


Figure 2: Routes to low carbon vehicles

automotive sector in order to ensure that road-relevant research and development was carried out. This was to encourage/ensure main vehicle OEM involvement in our sport. With the freedoms allowed in FE this season, teams are carrying out internal development programmes on, for example, electric motor design. In the search for ultimate efficiency and performance they are, of course, focusing on rare earth, permanent magnet machines. However, due to costs and security of supply, the automotive industry is focusing its efforts on the development of alternative motor technologies such as induction or synchronous reluctance machines. As a result, I hope that in the near-to-mid-term future, there will be some form of regulation that will encourage accelerated development of these alternative technologies such that these will be common place on the grid in 10 years' time.

That, coupled with the possible exploitation of superconducting materials enabled by a cryogenic cooling system, will enable significant improvements in drivetrain efficiency.

However, the main focus for FE must be to complete a race distance on a single charge. I suspect that this is less than 10 years away, but it is likely to require a combination of advancements in battery technology coupled with some form of dynamic charging. This is also where fuel cells may first appear in motorsport, as the basis of the initial charging system, if they are powered by low carbon hydrogen.

An important feature of the future drivetrain in many of our categories of racing will be the e-enabled driveline. With the increasing electrification of the powertrain generally, it makes sense to use the electric machines and control systems to manage the amount of torque delivered to each individual wheel, thereby creating e-AWD capabilities and reducing the requirement for sophisticated transmission systems.

The one subject we have not yet mentioned is that of autonomous vehicles. I am confident that we will see classes for fully autonomous racing in the not-too-distant future. However, I think some aspects of autonomy could easily stretch into other categories. Here I am thinking particularly of WEC, where we have different classes of vehicle racing on the same track, sometimes under difficult conditions (night, rain etc.). Autonomous driving under yellow flags would be entirely feasible, but inter-class accident prevention may also be possible, and this would provide an excellent platform for develop high speed vehicle-to-vehicle communications.

In this article, I have postulated some potential features of the grid of the future, hopefully with some reasoned arguments. The one thing I can guarantee is that I will be wrong! However, I still firmly believe that we all gain the greatest benefit when motorsport regulations are aligned with the technology roadmaps of the automotive industry. Motorsport is an ideal place to accelerate the development of relevant technologies that can then be used as a great showcase to firstly raise awareness, then enable acceptance, and finally stimulate demand for the cars of the future.

Autonomous driving under yellow flags would be entirely feasible

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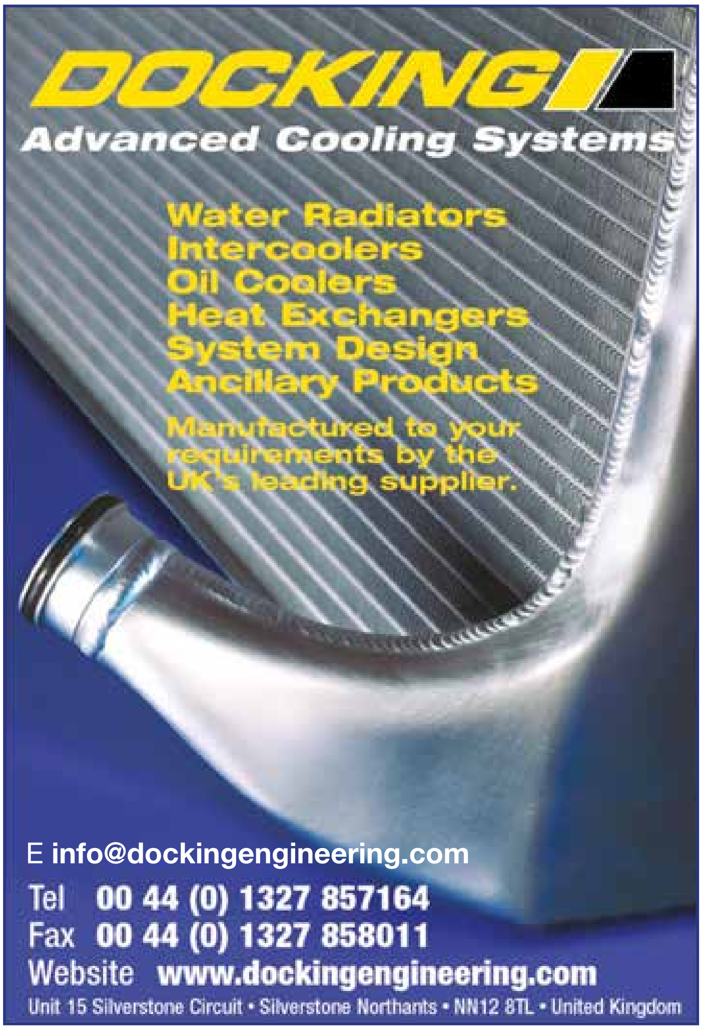
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Stable manners

Race drivers will perform better with a stable car beneath them – but just how do you evaluate and calculate racecar stability?

By DANNY NOWLAN

A Formula 3 car on the edge. With a stable platform a driver is able to push to the limit
XPB

One of the most important jobs for any race/data/performance engineer is to asses and quantify the stability of the racecar. This is absolutely critical, because the stability or otherwise of the racecar will have a critical impact on the driver's confidence and their ability to drive the car to the very limit of its performance envelope.

The focus of this article will be to summarise two important tools that we can use to assess this. The first will be the neutral steer channel. This is a great sanity check that allows you to quickly assess what is going on with the car. The other method I'll discuss is using a tyre model based method of calculating the stability index and tying this in using slip angle data from data or simulation. I realise I've touched upon both these methods before, but it would be a great reference to have them in one article, so you have a quick and easy way to access them.

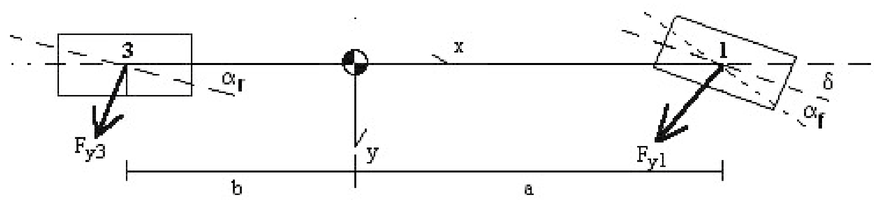


Figure 1: Bicycle formulation of the racecar

The origins of the neutral steer come from the bicycle equations of motion of the racecar. This is presented in **Figure 1.** In this case we have the properties for the slip angles, as seen in **Equation 1** and **Equation 2**.

If the car is neutral then the front and rear slip angles are equal, so equating **Equations 1**

EQUATIONS

EQUATION 1

$$\alpha_{FRONT} = \delta - \frac{a \cdot r + V_y}{V_x}$$

EQUATION 2

$$\alpha_{REAR} = \frac{b \cdot r - V_y}{V_x}$$

The terms of the equations are,

- δ = Steered angle at the tyre (radians)
- r = Yaw rate (radians/sec)
- V_y = Sideways velocity of the car (m/s)
- V_x = Forward velocity of the car (m/s)
- a = Distance of front axle of the car to the c.g (m)
- b = Distance of rear axle of the car to the c.g (m)

EQUATION 3

$$\delta_{NEUTRAL} = \frac{wb \cdot r}{V_x}$$

EQUATION 4

$$a_y = V_x \cdot r$$

$$r \approx \frac{a_y}{V_x}$$

EQUATION 5

$$\delta_{NEUTRAL} = \frac{wb \cdot a_y}{V_x^2} = wb \cdot iR$$

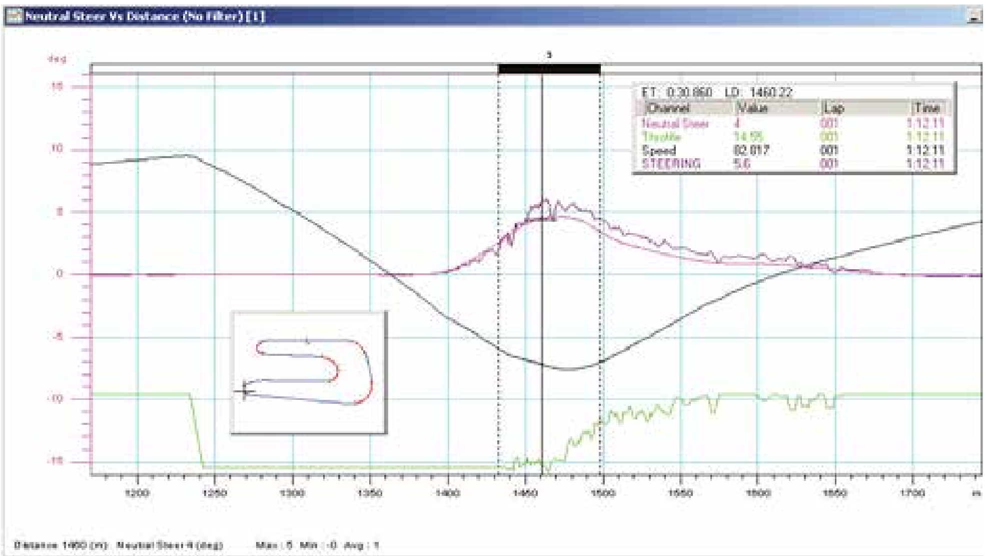


Figure 2: A plot of actual versus neutral steer. The wavy line is actual steering while the smoother line is neutral steer

EQUATIONS

EQUATION 6

$$F_{yf} = fn(\alpha_f) \cdot (Fm_1(L_1) + Fm_2(L_2))$$

$$F_{yr} = fn(\alpha_r) \cdot (Fm_3(L_3) + Fm_4(L_4))$$

To refresh the reader's memory we have,

- F_{yf} = Front lateral force.
- F_{yr} = Rear lateral force.
- $fn(\alpha_f)$ = Normalised slip angle function for the front tyre
- $fn(\alpha_r)$ = Normalised slip angle function for the rear tyre
- $Fm(L_1)$ = Traction circle radius for the left front (N)
- $Fm(L_2)$ = Traction circle radius for the right front (N)
- $Fm(L_3)$ = Traction circle radius for the left rear (N)
- $Fm(L_4)$ = Traction circle radius for the right rear (N)

EQUATION 7

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

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

$$C_T = C_f + C_r$$

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

If the car is being driven at the limit this will give you a succinct picture of racecar stability

to **2** yields this result for the steer angle if the slip angles are equal, see **Equation 3**.

So if you have a yaw rate sensor you now have a very good idea what the steer angle should be if the car is completely neutral. This will be in radians, and to covert this to degrees simply multiply by 180/π. This is approximately 57.2958.

Yaw rate

However, in a lot of cases you won't have a yaw rate sensor, but there is no need to panic because there is an effective work-around. Yaw rate can be approximated by the static assumptions shown in **Equation 4.**

The approximation is entered for yaw rate because we are ignoring transients for the time being. So when this is subbed into **Equation3** we can derive the result seen in **Equation 5.**

Here iR is the inverse corner radius that can be readily derived from data. Again, to convert to degrees simply multiply by 180/π or 57.2958. While this is not perfect in terms of practical application the error is small enough that you can get away with it. In my original article on this I presented a detailed error analysis and I'd refer you to that for more details. The power of this is that you overlay actual steer to neutral to get a quick fire analysis on what the car is doing. This is illustrated in **Figure 2.**

Treading the line

The thing to pay attention to is the middle graph. The wavy line is actual steering, the smooth line is neutral steer. Anything over the line is understeer, anything below the line is oversteer. In this particular case we have oversteer on entry followed by understeer at the mid corner to exit. The principle thing this technique brings to the table is that it is quick, and if the car is being driven to the limit it will give you a very succinct picture of racecar stability.

However, if the car isn't being driven to the limit you need something else, and this is where the stability index comes in.

The stability index is a non dimensionalised measure of the distance from the centre of the tyre forces to the centre of gravity. This is the ultimate measure of racecar stability.

One of the good things about the stability index is that it can be readily calculated from tyre data. Given a tyre model we have the formula sketched out in **Equation 6**. To keep things simple I'm using a 2D tyre model (Traction circle as a function of load) as opposed to a3D tyre model (traction circle as a function of load and temperature). Using this the stability index can be calculated by **Equation 7** – where *a* is this distance from the front axle to the centre of gravity, *b* is the distance from the rear axle to the centre of gravity and *wb* is the wheelbase.

The good news is that getting the information to calculate the stability index is actually really easy. Any validated 2D tyre model (traction circle radius as a function of load only)

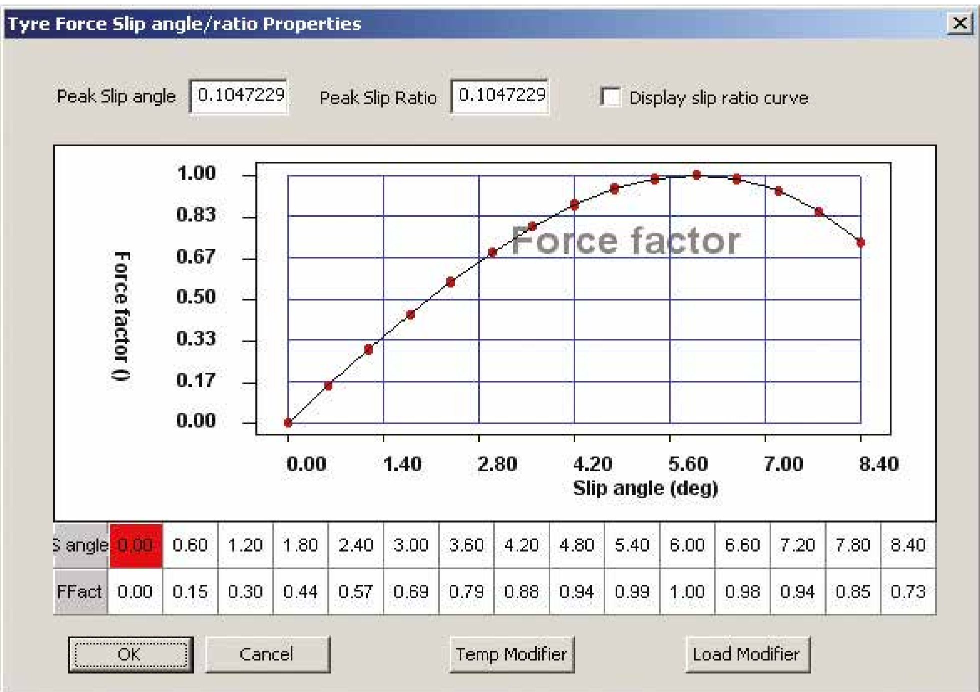


Figure 3: This shows the normalised force curve versus the slip angle. A plot of this is also shown below in Table 3

Table 1 – Typical values for stability index based on a Formula 3 racecar

Item	Description	Value
Fm_1+Fm_2	Sum of traction circle radius for the front	5000 N
Fm_1+Fm_2	Sum of traction circle radius for the rear	7000 N
a	Distance of front axle to the c.g	1.6 m
b	Distance of rear axle to the c.g	1.1 m
wb	Wheel base	2.7

Table 2 – Plot of normalised slip angle derivatives based on Figure 3

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

will do the job. This is where tools such as the ChassisSim tyre force modelling toolbox come into their own because they can work this out from race data. Also, this can be done with a first or second order cut tyre model since all the stability index needs is correlation. Trends are another matter, though.

However, a word to the wise here. The stability index will rise and fall on how good your Force versus slip characteristic is. So, what you need to nail down is this curve (**Figure 3**).

Understeer

Again this is something not to be afraid of. If the tyre rig is good or you are correlating with something like the ChassisSim tyre force modelling toolbox you should be fine. But the reason we need to get it right is because the shape of this curve will have a big impact on the result. We'll see the significance of this shortly.

Let's put this into practice by evaluating some numbers. The first table I'm going to present are some typical F3 numbers that will show the combined traction circle radiuses front and rear. This is shown in **Table 1.**

The next table we are going to discuss is a spread of normalised slip angle derivatives based on **Figure 3**. This is shown in **Table 2**

The derivatives of **Table 2** can be found by evaluating the derivatives of a curve fit of the points in **Figure 3**. So lets consider the case where the car is understeering. Let's say the front slip angle is five degrees and the rear slip angle is four degrees. Using **Equation 4** and the derivatives from **Table 2** then the stability index is **Equation 8.**

Oversteer

Let's now reverse the case and consider the oversteer case, where the front slip angle is four degrees and the rear slip angle is five degrees. Again evaluating **Equation 4** we see **Equation 9.**

While this is a very simplified example, what these stability index numbers tells us is in the

EQUATIONS

EQUATION 8

$$C_f = \frac{\partial C_f}{\partial \alpha_f}\Big|_{\alpha=\alpha_f} \cdot (F_{m1} + F_{m2}) = 4.375 \times 5000 = 21875$$

$$C_r = \frac{\partial C_r}{\partial \alpha_r}\Big|_{\alpha=\alpha_r} \cdot (F_{m3} + F_{m4}) = 7.9567 \times 7000 = 55760$$

$$C_T = C_f + C_r = 77634$$

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

$$= \frac{1.6 \times 21875 - 1.1 \times 55760}{77634 \times 2.7}$$

$$= -0.125$$

EQUATION 9

$$C_f = \frac{\partial C_f}{\partial \alpha_f}\Big|_{\alpha=\alpha_f} \cdot (F_{m1} + F_{m2}) = 7.9567 \times 5000 = 39783.5$$

$$C_r = \frac{\partial C_r}{\partial \alpha_r}\Big|_{\alpha=\alpha_r} \cdot (F_{m3} + F_{m4}) = 4.375 \times 7000 = 30625$$

$$C_T = C_f + C_r = 70408.5$$

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

$$= \frac{1.6 \times 39783.5 - 1.1 \times 30625}{70408.5 \times 2.7}$$

$$= 0.157$$

This is a powerful tool, you would be foolish not to make good use of it

understeer case the total lateral force is acting at a moment arm of 0.335m behind the centre of gravity and in the oversteer the total lateral force is acting 0.4239m in front of the centre of gravity.

Where the full significance of this kicks in is when we combine this with track replay simulation. Track replay simulation is where we take the vehicle inputs and then run the simulation using this. It's something that has been available in ChassisSim for years but it's only recently that the ChassisSim user community is really starting to push this. The big thing this brings to the party is it allows us to look at variables that otherwise would be impossible to log. One of these is slip angles and an example of this is shown in **Figure 4.**

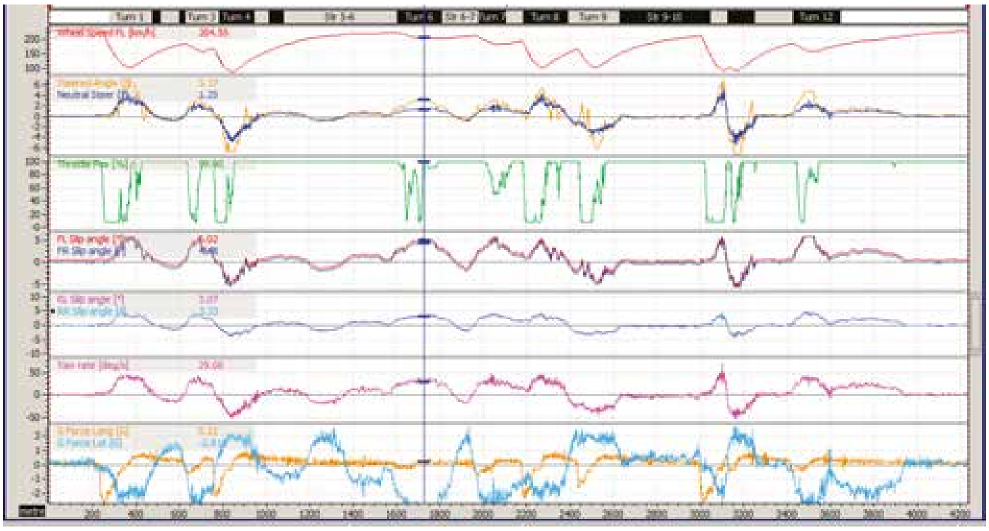


Figure 4: Track replay simulation of a racecar's slip angles. It's important to pay attention to the fourth and fifth traces here

The traces to pay attention to are the fourth and fifth traces. These are the slip angle plots and because this is a track replay it will tell us what the slip angles are. Once you know this you can use the stability index calculation methods we presented above to nail down the stability index and get a true measure of the car's stability. This is a very powerful tool, and you would be foolish not to make good use of it.

Stable environment

In closing, then, we have presented some very powerful and hands-on methods of calculating racecar stability. Overlaying neutral steer to actual steer gives a very quick and hands-on sanity check to see what the car is doing. In particular, if the car is being pushed, you will also get a very good picture of the stability of the car. However, for the ultimate picture, combining our knowledge of what the tyre is doing and utilising this with track replay simulation will allow you to calculate the stability index and get a true measure of what the car is doing. Once you have this you'll be in the strong situation of understanding the stability, or otherwise, of your car and you'll have the information with which to do something about it.

Ferrari spin-off heaps pressure on F1 team as boss says it must perform

Ferrari's recent flotations on the New York and Milan stock exchanges have piled extra pressure on to its Formula 1 team as the organisation steps out from the protection of the Fiat Chrysler umbrella, and its president has now said it needs to return to the very top of the sport.

The Italian sportscar maker has been spun-off from the Fiat Chrysler group and is now owned by Exor SpA, an investment company controlled by the Agnelli family (the name behind Fiat), and Enzo Ferrari's son Piero Ferrari, who's kept a 10 per cent slice of the company his father founded.

Ferrari had a shaky start on its Milan debut in January, beginning its trading at €43/share before slipping to €41.75, then being briefly suspended, before climbing back to €41.90. At the time of writing it had slipped to €36.95.

But at the Milan share issue Ferrari president Sergio Marchionne made it clear that the newly independent company expected great things from its Formula 1 team this year. '[This season] should be the year for us to return to the top,' said Marchionne. 'Our investments have not been lacking.

'We want to present ourselves in Australia as the team to beat. We know that our rivals are strong, but we are not afraid of them as we are the most successful team in the history of Formula 1,' Marchionne added.

Maurizio Arrivabene, Ferrari's team principal, said his president's goals had to be respected. 'The moment we take to the test track, we will understand where we are and whether there is reason to be optimistic,' he said. 'But Marchionne is the president and it is right for him to set the goals. I have to achieve them and I have no problem with that.'

Ferrari made its debut on the New York Stock Exchange in October. At the time of writing the price had plummeted from $54 on issue to $40, though this is also in the context of wider market turmoil.

The sale is intended to raise cash for Fiat Chrysler to ease its high debt level, estimated at €9.2bn, which is a result of the costs of Fiat's takeover of Chrysler and its loss-making businesses in Europe.

While it was still a part of Fiat Chrysler in 2014, Ferrari reported a net revenue of €2.76bn and a net profit of €265m.

Ferrari won three races in 2015, including Singapore (pictured), but its president is looking for much more success this season

Aston Martin says no to F1 tie-up for 2016 but deal still possible

Aston Martin has pulled back from plans for a branding tie-up with the Force India F1 team this season, which would have seen the Silverstone-based team operating under the famed sportscar producer's name, but the deal is not dead, insists Force India.

News of the deal surfaced in the autumn when Force India boss Vijay Mallya revealed that discussions with the British car maker were ongoing, leading to speculation that Aston Martin – a marque usually associated with sportscar racing – was to return to F1, albeit in name only, for the first time since 1959, when it campaigned unsuccessfully with its DBR4.

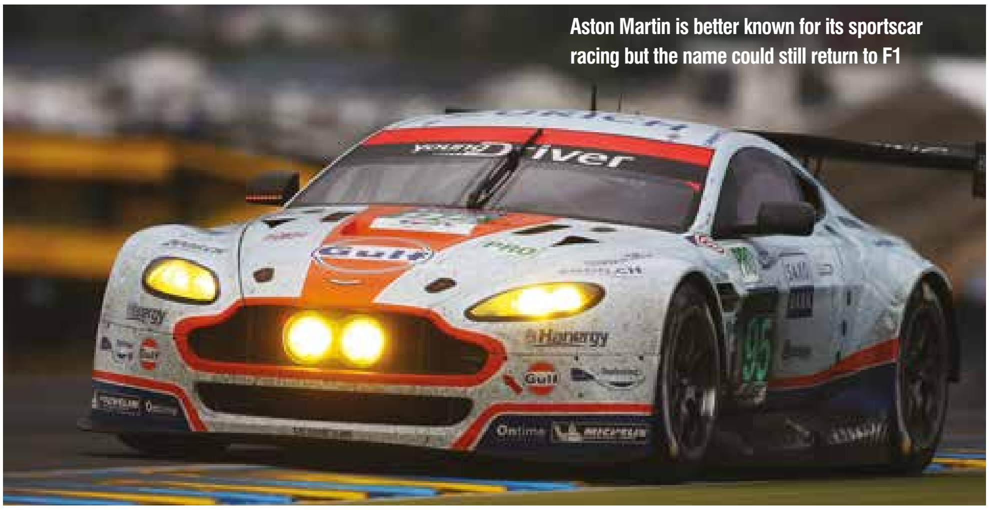
But now Force India's COO, Otmar Szafnauer, has said the deal will not go ahead this year. 'It's a big step, and it's flattering that Aston Martin have been talking to us,' he said at the Autosport International show. 'We're still talking, [but] in the short term, meaning 2016, I don't see that type of re-branding happening. But you never know what the future holds thereafter.'

When asked if the team was disappointed the deal had fallen through, Szafnauer said: 'Our expectations were such that we discussed it and had a good business case to go forward. We did it with the objective of it happening in the short term. If it now happens in the long term, is there disappointment? Probably not. Is short term better? That's what we are still working towards as there is still an opportunity somewhere down the line, maybe even from '17.'

Szafnauer also made it clear that the deal 'definitely' may well still go ahead: 'We're still in communication with them all the time, and definitely it's not dead,' he said.

Force India was not the only team linked to an Aston Martin deal last year, as there was a rumour that Red Bull could use an Aston branded Mercedes power unit – Mercedes Benz has a five per cent stake in Aston Martin. In the end Red Bull stuck with Renault, branded as Tag Heuer.

XPB



Aston Martin is better known for its sportscar racing but the name could still return to F1

Subaru teams up with BMR for British Touring Car campaign

Subaru is to compete in the British Touring Car Championship (BTCC) this season, teaming up with crack tin-top outfit BMR for its first assault on the premier British racing category.

The Japanese manufacturer, which is better known in the motorsport world for its success in the WRC – particularly in the 1990s – will campaign an estate version of its Levorg in the championship. A three-year deal has been signed with BMR, which will enter four cars for Subaru's first ever season in the BTCC.

While the Levorg is a 4wd car on the road BMR will run it in rear-wheel-drive configuration on the track, which it is able to do thanks to a rule change at the end of last season. The car will pack a 2-litre turbocharged Mountune-developed engine. BMR will develop the racecar, with close support from Subaru and Subaru UK.

Paul Tunnicliffe, managing director for Subaru UK and Ireland said: 'We're very excited to have teamed up with BMR for the 2016 championship, the first time a Subaru has competed in BTCC. We were keen to enter our new Levorg Sport Tourer as it offers class leading aerodynamics and handling prowess in standard form. It can be easily developed into rear-wheel-drive to comply with the BTCC regulations so we can't wait to see how it goes against very established competition.'

BMR team boss Warren Scott said: 'I am extremely delighted that BMR are to become a manufacturer team in only our fourth year of competing in the BTCC, I have had aspirations of becoming a race-winning team with factory support from the very beginning and I am immensely proud of the team for giving Subaru the confidence in partnering BMR.'

Carl Faux, chief designer at BMR, said: 'Engineering challenges is what the project presents. A new car, new engine and all the new generation TOCA components requires a methodical approach. Establishing a three-year programme means we can focus on getting the basics right early before developing the package further over the following years.'

The BTCC has welcomed the news. Alan Gow, its series director, said: 'We are delighted to welcome another manufacturer to the BTCC and particularly one with such an incredible motorsport heritage. Subaru is an iconic brand with a huge following and its introduction to the BTCC is certain to excite our many fans around the world.'

Subaru has linked up with BMR to run a rear-wheel-drive version of its Levorg estate model in the British Touring Car Championship

NASCAR could be open to team franchises says sport's boss

NASCAR chairman and CEO Brian France has insisted he is committed to improving the lot of NASCAR teams and has hinted that a franchise system might be put in place.

Team owners in the sport have been pushing for a franchising model, which would give them a bigger stake in NASCAR, since the '90s, but NASCAR has resisted moves in the past. Now, however, France said there could be a change. Speaking on MRN Radio he said: 'I don't have to tell you how important [owners] are as stakeholders. So what we're always trying to do is look at their particular interests and see how to make that work better.'

When asked specifically about a franchising, or 'charter' system – as NASCAR is referring to it – he said: 'It's not so much about [the team owners] demanding it, but this is about being able to structure it with the current revenue streams and current business models that exist, and things that are in play.

'The sponsorship model is different than it was 10 to 15 years ago. Car manufacturers play an always important but different role as the years have progressed and things have to line up in a way that will allow us to restructure in a way that benefits the sport,' he added.

NASCAR is also busy talking to several companies about taking over as the main sponsor of the Sprint Cup when telecoms company Sprint leaves the sport at the end of the 2016 season.

France said: 'Obviously, it's a short list. The opportunity is great and I think we're talking to the right people about where things need to end up. We want to be selective too. It's not just about finding anybody who wants to be a part of what is perhaps the most marquee sponsor [deals] in sports.'

NASCAR Sprint Cup teams could benefit from new 'charter' ownership deal

SEEN: NASCAR Sprint Cup 2016 Ford

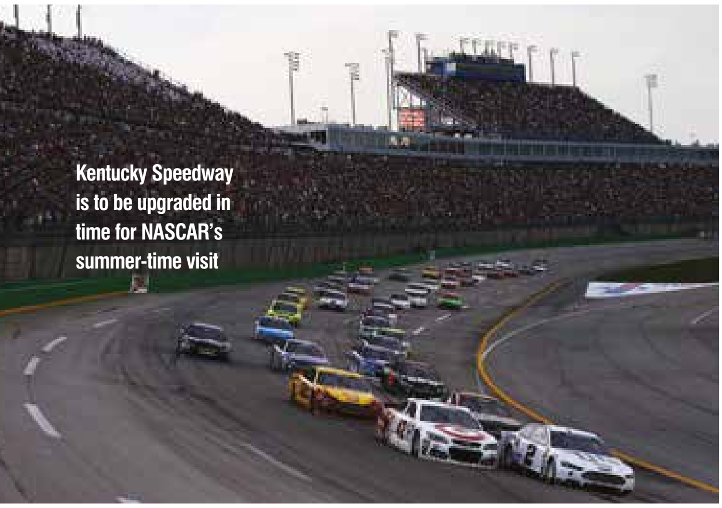
This year's Sprint Cup Ford Fusion is to sport a new look, with changes made to the front of the car so that it more accurately resembles Ford's new production model, which is due to hit the streets in 2017. Ford unveiled its new-look NASCAR challenger at the Detroit Motor Show, soon after the road car it's based on was also shown to the public for the first time. The lower portion of the grille of the new Fusion is now more rounded than on previous models, while the inset area beneath the grille and above the splitter has undergone alterations, too.

'There's no mistaking we're here to win races and championships,' Dave Pericak, global director, Ford Performance, said. 'And we believe the new NASCAR Fusion will be a powerful tool in the hands of our teams and drivers.'

But Pericak was keen to stress that changes were not solely aesthetic: 'Aerodynamics are more important than ever at the speeds these cars run, so we used some of the best wind tunnel and computational fluid dynamics technology available to create this new Fusion. Fortunately, the Ford design team gave us a great car with which to start.'

The new car marks the third body change for the Fusion, Ford's Sprint Cup car since 2006.

Kentucky Speedway NASCAR track to get major overhaul



Kentucky Speedway is to be upgraded in time for NASCAR's summer-time visit

NASCAR venue Kentucky Speedway is to be the subject of a massive renovation project this year which is set to be completed before the three major US stock car series visit the track in July.

Chief among the planned improvements are increases to the banking in Turns 1 and 2, plus the re-paving of the entire tri-oval. Additional SAFER barriers are also to be installed, and work on the project has already begun.

Mark Simendinger, the general manager of Kentucky Speedway, said: 'Modifying Turns 1 and 2 will present an exciting challenge to the drivers while addressing issues of the track surface, [while the] SAFER barriers and drainage will improve safety, which is always our paramount concern.'

The project will be overseen by Steve Swift, the vice president of Operations and Development for Speedway Motorsports Inc., the track's owner. 'We have assembled an excellent team, all of whom are familiar with the demands of speedway construction,' Swift said. 'I am excited about the finished product as we wanted to present a unique challenge to the drivers. This design, with Turns 1 and 2 completely different than 3 and 4, accomplishes that goal. The big winner will be the race fan.'

The 2016 season at Kentucky Speedway begins in July with the return of the NASCAR triple-header weekend.

Ginetta scoops top industry award

UK-based sports and racing car manufacturer Ginetta has picked up the top prize at the prestigious Motorsport Industry Association's (MIA) annual Business Excellence Awards.

Ginetta received the MIA Business of the Year Award, sponsored by Xtrac, for its outstanding business growth and its successful motorsport involvement in 2015.

The Yorkshire-based concern, now in its 58th year, employs 70 people and boasts four single marque championships featuring in excess of 70 cars across their combined grids, while it also produces racecars for open competition.

MIA CEO Chris Aylett said: 'Ginetta Cars is a true British success story, producing innovative and ground-breaking cars, alongside thrilling race championships and extensive support for up and coming drivers. With almost six decades' experience in the management, design and production of cars like the G40, G55 GT4 and GT3, Ginetta crafts many of its components on site in Leeds and is committed to supporting British motorsport.

'Taking an ambassadorial role, Ginetta also operates on a global stage, with presence across Europe, Asia, Australia, the United Arab Emirates and South Africa, as well as North and South America. Indeed, the MIA Business Excellence Award recognises the company's global aspirations with the 2015 debut of the Ginetta-Juno LMP3 in the European and Asian Le Mans Series. We offer our congratulations to the whole Ginetta team, who all thoroughly deserve this award.'

The MIA Business Excellence Awards dinner, in association with Dell, was attended by an audience of over 500 senior executives from the international motorsport business community. First presented in 1995, the MIA Business Excellence Awards recognise excellence at all levels within the motorsport and high performance engineering industry.

Winners in all seven categories were: MIA Service to the Industry Award – Jonathan Lee Recruitment. New Markets Award – Prodrive. Export Achievement Award – Hewland Engineering. Technology and Innovation Award – bf1systems. Teamwork Award – Bentley Motorsport. Business of the Year with annual sales under £5m Award – Base Performance Simulators. Business of the Year with annual sales over £5m Award – Ginetta Cars.

Ginetta Juniors in action at Brands Hatch – the UK sportscar maker has picked up the top MIA award

IN BRIEF

The pain in Spain

It's been widely reported in Spain that the funding provided by Barcelona's city council to help stage the Spanish Grand Prix has been slashed, with its contributions falling from €4m a year to just €2m a year. This comes in the wake of a warning from Ada Colau, the city's new mayor, who in 2015 said: 'In the context of what is happening [in Barcelona], Formula 1 is not the priority.' Her deputy, Gerardo Pisarello, has now confirmed the 50 per cent funding slash. But she also told the Spanish press that the financial commitment was not completely stopped because 'an abrupt withdrawal would have damaging consequences'.

Heading north

NASCAR Sprint Cup operation HScott Motorsports it to relocate to Mooresville, North Carolina, crossing the state line from its current base in Spartanburg, South Carolina. The organisation will set up shop at what was until recently the TriStar Motorsports base, which is a close to 50,000 sq.ft facility – the multi-car NASCAR Xfinity operation having recently moved to Statesville, which is approximately 20 miles north of Mooresville.

Mercedes out of V8S

Australian V8 Supercars squad Erebus has announced it's to ditch its Mercedes E36 AMGs and switch to Walkinshaw Racing-built Holden Commodores this season. Erebus bought out multi-championship winning team Stone Brothers Racing in 2013 in order to run its Mercedes racecars, which were developed with input from the German manufacturer's sporting division. The Mercedes cars won two races, one last year and one in 2014.

Lotus flowers

Classic Team Lotus is set to expand its site in Hethel, Norfolk. The company, which was established by son of Lotus founder Colin Chapman, Clive, in order to preserve and promote the history of the legendary F1 team has gained planning approval to build a new facility which will replace the workshop it currently operates from.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The McLaren race team struggled in 2015 but the road car division has continued to shine

Road car arm upholds pride at McLaren

While the McLaren race team struggled on track and securing and keeping sponsorship in 2015, its road car offshoot enjoyed a hugely successful year, and has now created 250 new skilled jobs at its hi-tech Woking HQ on the back of increased demand for its sportscars.

McLaren Automotive tells us a total of 1654 cars were delivered to customers across 30 markets, and that the demand for its cars, especially the recently-launched Sports Series, has driven the need for a second shift at the McLaren Production Centre and the immediate recruitment of 250 skilled workers. The record year by McLaren Automotive was supported by the launch of no fewer than five new models while its global retailer network grew in 2015 – to 80 retailers covering 30 markets – with 12 new retailers opening, covering important territories such as Seoul (South Korea), Mexico City and Houston.

Further development is planned in 2016, with a focus on controlled and sustainable growth within existing markets rather than significantly increasing the total number of markets covered, McLaren tells us.

Commenting on its 2015 performance, Mike Flewitt, chief executive officer at McLaren Automotive said: '2015 was a year of rapid expansion for McLaren Automotive. When the company was set up in 2010, we set ourselves an ambition to launch one new car every year. In 2015, we launched five! This accelerated development has led to yet another record year, with unprecedented levels of demand for all of our cars, especially the new Sports Series, for which we are currently holding more than six months' worth of orders.'

SEEN: Volkswagen Polo R WRC 2016

The car which Volkswagen hopes will secure its fourth straight World Rally Championship crown is a lightly modified version of the successful 2015 Polo, VW has revealed. The front subframe has been strengthened, as have the rear axle wishbones for the gravel specification of the car. Meanwhile, under the bonnet the pistons in the 318bhp engine have also been the subject of a minor modification, in order to further optimise its reliability. 'We are about to defend our world championship title for the third time in a row,' said outgoing Volkswagen Motorsport director Jost Capito (see *People*, P88). 'The opposition has not been sleeping, and has modified its cars for the new season. So have we, of course. [But] the changes to the Polo R WRC are basically fine-tuning and detailed improvements to make the world championship winning car even better.' The new model started the season with a victory at the opening round, the Monte Carlo rally, in January.

F1 champagne deal goes flat

Formula 1 drivers will no longer be spraying Mumm champagne at the end of a successful grand prix, as it's emerged that the company behind the brand, Pernod Ricard, is saying goodbye to F1. It's been estimated that the company paid around €5m a year for the privilege of soaking F1 podia across the globe, but sources in the drinks industry have said that Formula One Management (FOM) has now decided that's not quite enough, and it's believed that Mumm's predecessor in F1, Moet et Chandon, will now once again supply the celebration bubbly.

Meanwhile, Mumm is to strengthen its ties with Formula E, for which it became the official champagne supplier in October. 'In our mission to continually innovate, excite and push the boundaries, we have chosen to explore a new opportunity – Formula E, electric motor racing – as it is truly ground breaking, has a strong fit with our brand values and is a natural evolution in motor racing,' Pernod Ricard said in a statement.


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INTERVIEW – Rob Jones

The governor

The man who runs UK motorsport speaks candidly about the challenges the MSA faces and its role within the wider industry

By MIKE BRESLIN

'I think there's a symbiotic relationship between the industry and the MSA'

Motorsport is many things to many people, especially in the UK. It's racing, it's rallying, it's hillclimbs, it's production car trials, and so much more. It's not like football, where whether you're playing at Wembley or in the local park, the game is just the same. To oversee UK motorsport's governing body takes a special set of skills, then, and perhaps more importantly a very broad experience.

Rob Jones, the CEO of the Motor Sports Association (MSA), has both the skills and the experience. In motorsport he has done the lot: from marshalling to car prep, from rally co-driving and driving to tin-top racing. There was even a spell as a karting dad – surely one of the most stressful roles in the sport. On top of this Jones is also a successful solicitor, and everyone knows how useful that can be in motorsport. As he says: 'I think it makes for a very good background.'

Jones has been CEO at the MSA for just under two years, having previously filled the post of general secretary. 'My role is really to represent the MSA at all levels and in respect of all disciplines,' he says. 'I'm answerable to a board, and the board expects me to maintain the highest standards for a sport's governing body. My job is to promote the sport, to grow the sport, to ensure that safety is always paramount, and also to make the sport accessible to as many people as possible, particularly at a grassroots level.'

This includes attracting volunteers for marshalling and other vital duties, but Jones admits this is presently something of a concern. 'One of the biggest challenges is the recruitment of volunteers. The thing that keeps me awake at night is the fact that volunteering, and marshalling in particular, does not seem to be as much a part of the social life of younger people as it was in my day. The majority of our marshals are my age [60], rather than younger. And it worries me that we've not got enough new marshals coming through to take their place, because without volunteers, there is no motorsport. This is something we're spending a lot of time on at the moment.'

The industry

Giving up free time might seem a big ask these days but, as Jones points out, marshalling is one of the best ways to get in to motorsport. 'You'll never get closer to the action, you're performing an extremely responsible role. It's a fabulous way into motorsport,' he says.

A lack of marshals obviously has huge implications for motorsport at all levels, and should be a worry for the wider business as much as it is for the MSA, because the industry needs a healthy motorsport scene. 'We are not the industry, but we see the sport as providing its marketplace,' Jones says. 'It's not like that with other sports. With due respect to football, in motorsport people are buying a lot more than a football: the car, the overalls, the belts, the fire extinguisher, the helmet...It never stops! So I think there's a symbiotic relationship between the industry and the MSA.'

The MSA also drives the industry in other respects. Take the decision to embrace FIA Formula 4 in the place of Formula Ford, for example – the UK championship is actually named MSA Formula. 'When the FIA announced it was looking at a generic championship across the globe, we recognised straight away that we've got to be in on this,' Jones says. 'We've finished our first season and I think it's been very good. There were some questions about putting 15-year-olds into single seaters; but we already had 14-year-olds in Ginettas, and we have 13, 14 and 15-years-olds in very fast completely open karts. The fact that the F4 chassis was so safety orientated – the carbon tub is clearly recognised as the safest form of single seater design – is why we felt it was appropriate to reduce the minimum age for single seater racing from 16 to 15. It's our job to promote the sport, and with these 15-year-olds, if they couldn't race in the UK they would go somewhere else.'

The missing link

MSV Formula, along with BRDC F4, has gone some way towards reinvigorating professional single seater racing in the UK, but there's still a massive void left by the demise of British F3, a gap Jones would love to see filled. 'I would really like to see the UK reinstated as the home of Formula 3. The FIA is building a ladder for single seaters and I would be disappointed if the UK is not a part of it, if we don't have a regional F3 championship. I'd like to see the UK once again being the default option for

international drivers looking for the best racing and the best platform to showcase their skills.'

That point about Formula 4 chassis safety above is a reminder of what it says on the back of the ticket: 'Motorsport is dangerous'. It is also rather unpredictable. So it's no surprise to hear that the MSA takes insurance very seriously indeed and has been rather canny in how it's gone about covering the sport in the UK. 'There are 5000 events a year the MSA issues permits for,' Jones says. 'When we issue the permit the cost includes insurance cover for that event, and we have set aside a proportion of those payments to create a fund so that we can increase the excess on the MSA insurance. Currently we cover the first £50,000 of every public liability claim, and we can go up to an annual aggregate of £400,000.'

This means the MSA can go to the market and say it will cover the first £400,000 of a claim, which in turn means it's able to negotiate better deals. So the cost to the clubs is now less, as they don't pay as much for insurance. On top of this the MSA was also able to present the clubs with a rebate of 30 per cent of what they paid for their insurance last year.

Third party

There is one unexpected insurance matter the sport will need to address, though. 'There was a court case in Slovenia regarding a gentleman called Damijan Vnuk,' Jones says. 'He was working on a farm and was knocked off a ladder by a farmer on a tractor. When it first came to court it was realised there was a European ruling that meant everybody in the UK has to have minimum third party insurance for every vehicle. I mean *every* vehicle. We are now lobbying, through the FIA and with the UK Government, to try and make sure that motorsport doesn't suffer as a result of this.'

The above, and examples like it, are reasons why it's useful to have a lawyer at the top of the MSA. But it's not all about the law, there's a fair amount of diplomacy and lobbying involved in Rob Jones' job, too, and the MSA is currently working hard to secure some UK Government funding – the sport receives nothing from government at present. 'We need to show government at national and local level that we have a legitimate role to play in the sporting panoply of the UK,' Jones says. So then: racer, fan, lawyer and diplomat. That's quite a CV.

FIA Formula 4 in the UK is known as MSA Formula. Its first season of racing in 2015 was a great success

RACE MOVES

XPB

Former Formula 1 driver **Ralf Schumacher** has teamed up with long-time Mercedes DTM technical boss **Gerhard Ungar** to run a team in the ADAC Formula 4 Championship in Germany this season. HTP Junior Team Ungar, which won the inaugural German F4 title last year, will now be jointly managed by Schumacher and Ungar.

John Hume, a respected UK drag race engineer and dragster designer, has passed away. Hume was chief engineer for **Sydney Allard** during the period that the Allard Chrysler – Europe's first dragster – and the Allard Dragon were built in the early 1960s.

Former Ferrari sporting director **Luca Baldisserri**, who most recently has been in charge of the Ferrari Driver Academy, has left the Scuderia to mentor F3 frontrunner and now Williams F1 development driver **Lance Stroll**, who was part of the Ferrari academy when he was in karting. It's been reported that **Massimo Rivola** – also a former Ferrari sporting director – is now set to take over the running of the academy.

Ray Snowdon has stepped down from his position as competition director of the Sportscar Vintage Racing Association (SVRA) in the US, a post he has held for the past five years. He now plans to focus on work in other areas of motorsport.

Former drivers **Scott Goodyear** and **Dr Jack Miller** have teamed up with American football star **Adam Vinatieri**, the place kicker with the Indianapolis Colts and a four-time Super Bowl winner, to set up Goodyear, Miller, Vinatieri Motorsports LLC, a team that will initially race in the new US FIA Formula 4 Series. The organisation is based in Westfield, Indiana.

NASCAR Sprint Cup outfit **Joe Gibbs** Racing (JGR) has reshuffled its crew chief line up with **Dave Rogers**, who last year was crew chief on the No.11 JGR Toyota, moving to the No.19 Camry for the 2016 season. **Mike Wheeler,** the crew chief for JGR's No.20 Xfinity Series car in 2015, replaces Rogers on the No.11 Sprint Cup car.

Sebastien Loeb is to return to the World Rally Championship as a team owner this year, with Sebastien Loeb Racing – known for its involvement in sportscars and also in 2016 the WTCC – fielding a car in the Junior WRC. The nine-time World Rally Champion will oversee the operation along with his long-time co-driver **Daniel Elena** and business partner **Dominique Heintz**.

Peter Westbury has died at the age of 77. While Westbury is best known for his exploits as a double British Hillclimb champion, he was also a successful Formula 3 team owner – under the Felday International Racing and Sportscar Team (FIRST) banner – and the constructor of the Felday hillclimb and sports racecars. As a driver Westbury made a single F1 start at the German Grand Prix in 1969.

Michael Bates has taken on the role of senior director of safety and security at Hulman Motorsports, the company behind the Indianapolis Motor Speedway and IndyCar. Bates was previously deputy chief of police for the Indianapolis Metropolitan Police Department (IMPD), heading its Homeland Security Division and playing a leading role in safety and security planning for a number of the city's major sporting events, including the Super Bowl in 2012.

Tim Swietochowski has been appointed head of communications at the Motor Sports Association (MSA), the UK's motorsport governing body. Swietochowski joined the MSA in 2010. Swietochowski's new appointment follows former MSA director of development and communications **Ben Taylor's** move to the MSA's commercial subsidiary, International Motor Sports (IMS), where he is now managing director.

Wolff launches new scheme to attract females into motorsport

Former Williams F1 development driver Susie Wolff has teamed up with the UK governing body, the Motor Sports Association (MSA), in an initiative that aims to attract girls and women in to motorsport.

The Dare To Be Different campaign was launched at Autosport International, where Wolff was quick to point out this was not just about drivers: '[This is] not just on track, but off the track, they will be opened up to all avenues of the sport from engineering to fitness to journalism, we want to create role models; I want to create role models out of the fantastic women who are working in the sport,' she said.

XPB

Former Williams development driver Susie Wolff aims to attract females in to the sport

Dare To Be Different (D2BD) aims to work in two key ways; firstly by creating an expansive online community, and then by bringing young girls together with some of the sports' most inspiring women in a series of special events.

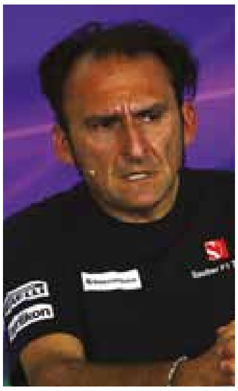
'It's about inspiring women of all ages and backgrounds to break the mould and shatter perceptions,' D2BD explains. 'In the coming months, a fully integrated online community will be formed across an all-new website and other social media channels, bringing together girls and women from all over the UK who share a passion and desire to get involved in motorsport.'

Wolff said: 'This is an ambitious and long-term project that will build an online community of women from all over the world. It will connect them through a shared passion and empower them to become the next wave of role models, whilst also providing access to some of the most successful female names in the sport.'

Dall'Ara replaced by former Red Bull engineer at Sauber

Sauber's head of track engineering, Giampaolo Dall'Ara, is leaving the Swiss Formula 1 team, where he will be replaced by former Red Bull engineer Tim Malyon.

Dall'Ara joined Sauber back in 2000 as a test engineer and then filled a variety of positions before being promoted to head of track engineering in 2009, a post he held until his departure from the Hinwil-based team in January.



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Giampaolo Dall'Ara is leaving Sauber after over 15 years with the Swiss F1 team

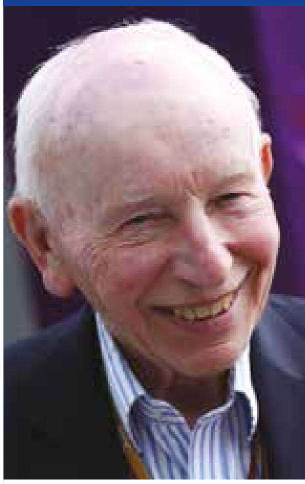
It's been reported in Italy and Germany that Dall'Ara will be joining BMW to help it with its DTM effort. He has worked with the Munich marque in the past, when Sauber was its works F1 team in the second half of the 2000s.

Maylon, Dall'Ara's replacement, previously filled a variety of engineering positions at Red Bull.

Commenting on Dall'Ara's departure a Sauber spokesman said: 'Giampaolo Dall'Ara has decided to leave our company after more than 15 years of service to pursue another challenge. We would like to thank Giampaolo for his dedicated and highly valued collaboration over all these years.

'We wish him all the best for the future. At the same time, we are very pleased to announce Timothy Malyon as our new head of track engineering. Tim has been working for more than 10 years for one of the big F1 teams. We are confident that we can benefit from his long-time experience in order to improve our performance,' the spokesman added.

RACE MOVES – continued



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John Surtees, the 1964 world champion in F1 and also a multiple world champion on motorcycles, has been made a CBE in the UK's New Year's Honours list. The award, which follows an MBE in 1959 and an OBE in 2008, recognises his career as a rider, driver, team owner and racecar constructor, as well as his ongoing involvement in motorsport and charity work through the Henry Surtees Foundation.

Alister McNeill, a respected crew chief and team owner in the US, has died after a battle with cancer. Following a spell working in F1 the New Zealander set up McNeill Motorsports, which became a top team in Formula Atlantic and Super Vee in the 1980s. McNeill sold the business and retired from motorsport in 1990.

Keith Cheetham, who oversaw the BMW Z4s at Triple Eight Racing last year, has now moved to AMDTuning, which has taken over the running of the same pair of Z4s in British GT for 2016, following Triple Eight's withdrawal from the category.

The former Joe Gibbs Racing NASCAR Sprint Cup crew chief **Darian Grubb** is now the vehicle production director at rival organisation Hendrick Motorsports.

Scott Graves has been signed up by Joe Gibbs Racing to be the crew chief on its No.19 NASCAR Xfinity Series Toyota. Graves was previously the crew chief on the 2015 championship-winning Roush Fenway Racing No.60 Ford.

Australian V8 Supercars outfit DJR Team Penske has signed up **Adam De Borre** to engineer the **Scott Pye** racecar in 2016, while **Ben Croke** is the team's new crew chief. De Borre comes to DJR Penske from Prodrive while Croke has spent the past five seasons at Erebus/Stone Brothers Racing.

Mark Fenning has moved from his role as race engineer to **Scott Pye** at the DJR Team Penske V8 Supercars squad (see above), to focus on the team's preparations for the introduction of its new Gen2 car, which is to make its debut when the new formula is introduced next year.

Thierry Cognet, a financial director at Renault, has joined the board of directors at the French car giant's new F1 operation, formed through a buyout of the Lotus team. Before Christmas it was announced that **Jerome Stoll** and **Cyril Abiteboul** have also joined the board.

Experienced sales executive **Brad Gerber** has been named as the National Hot Rod Association's (NHRA) vice president of sales and chief development officer. Gerber will oversee business development and corporate sponsorship deals at the NHRA, the body which runs drag racing in the United States.

Simon Harratt, the former chairman of the BARC South West Centre – a man who will always be associated with the Gurston Down hillclimb venue – has died at the age of 69 after losing his battle with cancer.

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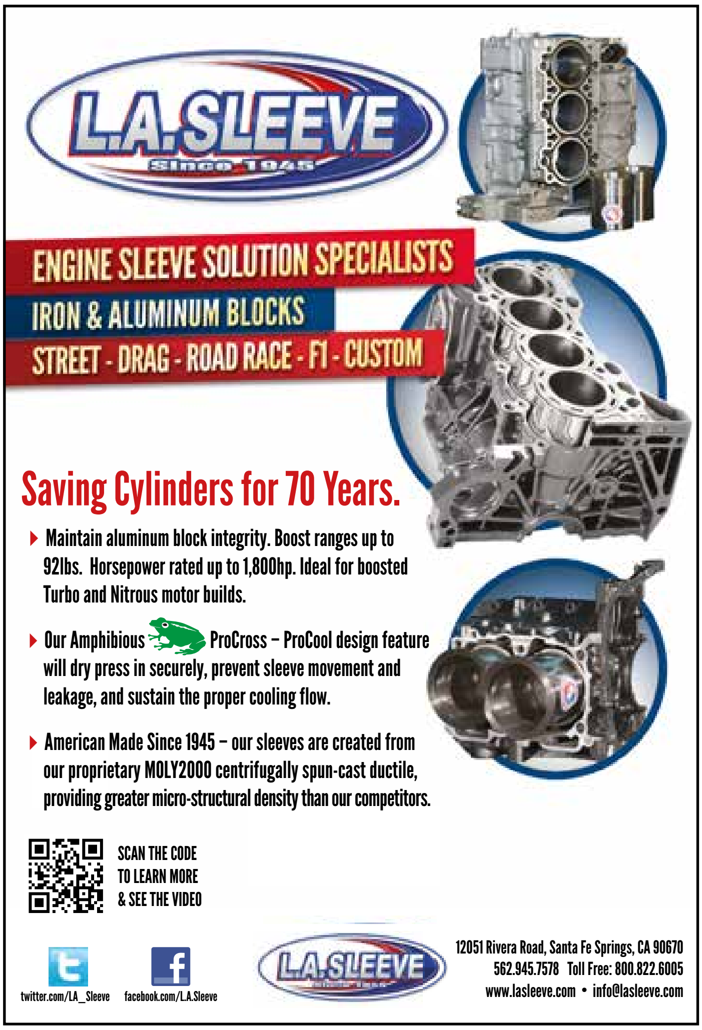
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Capito to quit Volkswagen for chief executive role with McLaren F1 team

Volkswagen's hugely successful motorsport boss, Jost Capito, is to leave the company to take up a role with the struggling McLaren Formula 1 team.

Capito is to be the new chief executive officer at McLaren, although he will remain at VW until his replacement is recruited. The signing of Capito means that Jonathan Neale – who has been acting CEO since Martin Whitmarsh's departure nearly two years ago – will now move on to a new role as chief operating officer at McLaren Technology Group. Eric Boullier, racing director at McLaren, will work closely with Capito. There is no team principal role at McLaren.

Jost Capito is to switch codes from WRC to F1 – leaving Volkswagen to take up the CEO role at McLaren

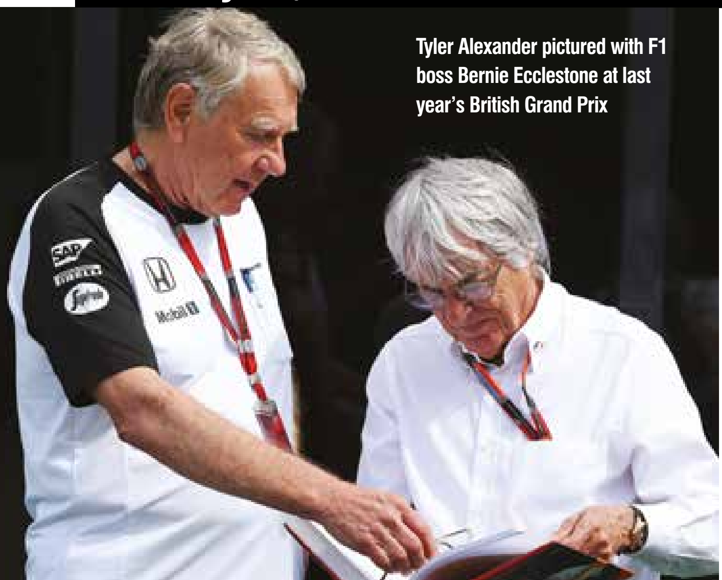
McLaren group CEO Ron Dennis said of Capito's signing: 'I first approached Jost last summer. He is an extremely impressive, competitive and ambitious individual, who comes to us with a very wide range of automotive and motorsport experience, encompassing senior positions at BMW, Porsche, Ford, Sauber and, since 2012, VW, leading the latter company's World Rally Championship team to consecutive world titles in 2013, 2014 and 2015.

'From a motorsport perspective he has experience in not only the World Rally Championship but also sportscars, touring cars, motorcycle racing and Formula 1, about which he is hugely knowledgeable and infectiously passionate,' Dennis said.

Neale says he is now taking on a wider remit within the organisation, and added: 'I am particularly keen to bring to bear my wider industry expertise and experience [mainly with BAE Systems] to drive forward our strategy to grow each of our Group businesses.'

Capito arrived at VW in 2012 and since then the marque has dominated the WRC. He has prior Formula 1 experience with Sauber in the late 1990s.

Obituary – Tyler Alexander



Tyler Alexander pictured with F1 boss Bernie Ecclestone at last year's British Grand Prix

XPB

One of the founding members of the McLaren Formula 1 team, Tyler Alexander, has died at the age of 75. The American teamed up with Bruce McLaren to set up the latter's eponymous organisation in the 1960s and was given a wide ranging role within the operation.

As McLaren put it in a tribute: 'Put simply, Tyler made things happen – quickly and efficiently with his trademark minimum of fuss. There were no definitions or boundaries to his role: he directed the mechanics; he machined spare parts; he arranged accommodation; he paid for last-minute airline tickets; he scrounged favours from a growing list of friends and colleagues.

'He pushed and pulled McLaren's racecars around the world, and, once at the track, made sure they were better engineered and organised than any other team in the pitlane.'

Following his first stint in F1 Alexander worked in his native United States in the late '60s and early '70s with McLaren's successful CanAm and USAC (IndyCar) operations – a profitable business that kept McLaren afloat in the early days. But he then left the organisation in 1982 to work with former McLaren boss Teddy Mayer's IndyCar team – it was through Mayer's brother Tim that he became involved in motorsport in the first place – before returning to F1 with the original Haas (Beatrice Ford) effort in 1985. He also worked in IMSA with BMW.

But Alexander was always at heart a McLaren man and he returned to Woking in 1989, staying there until his retirement at the end of the team's last drivers' world championship winning season in 2008. McLaren Group CEO Ron Dennis said of Alexander: 'Bruce [McLaren] couldn't have asked for a sturdier pair of shoulders upon which to help build the team's reputation.'

Alexander's attitude to life and work was encapsulated in his own words: 'It's not that life is too short; it's that death is too long. So best get on with things,' he said.

Tyler Alexander 1940 – 2016

Ex-Ferrari aero man Tombazis joins Manor

Manor Grand Prix has signed former Ferrari designer Nicholas Tombazis as its chief aerodynamicist.

Tombazis was at the Scuderia for nine years, working as its chief designer before he left the team at the end of 2014 as part of Ferrari's radical restructure. He started his career at Benetton in 1992, as an aerodynamicist, taking up the post of chief aerodynamicist the following year. His first stint at Ferrari followed, and lasted for seven years, before he left for a short spell at McLaren, returning to Maranello in 2006.

In his new role Tombazis will report to Manor technical director John McQuilliam.

Tombazis said of his new employer: 'The team has impressive plans and is investing in all the right areas to achieve its on-track ambitions, so I am very much looking forward to being part of that journey.

'The existing design team is already very strong and I look forward to working with a great group of people to make the most of the opportunities that lie ahead to help us progress through the field over the next few seasons,' Tombazis added.

McQuilliam said: 'I believe this appointment will help to amplify the efforts of a very talented design team that, in recent years, has not had the opportunity to showcase the full extent of their experience and capabilities.

'I am confident that, together with our new Mercedes power unit and Williams gearbox and technical partnership, our new aero structure will provide us with the strength to design and develop consistently competitive racing cars to help steer us towards our long-term ambitions,' McQuilliam added.

Back in the red – but this time Nicholas Tombazis will be with Manor Grand Prix rather than Ferrari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ASI 2016

The motorsport year has officially started with the NEC show – if you didn't go, here's what you missed

By SAM COLLINS

The 2016 season started as it usually does for those in the European motorsport Industry, with a trip to Birmingham's NEC, which plays host to the Autosport International show.

This year there was something of a Williams theme to the event with key figures from its F1 team in attendance, along with a range of cars from its past and a semi-erected motorhome.

As usual there were a range of launches and announcements, and this included the first GT car to ever be built in Poland, the new Gibson GH-20 sports prototype, plus the first real detailed look at the new generation National Hot Rod Stock Cars.

Away from the main show, Jean Todt, the current FIA President, delivered the Motorsport Safety Fund's prestigious Watkins Lecture, covering many issues relating to motorsport safety, and talking about his experiences in the sport. Todt discussed the measures in place to continually improve safety, and spoke of a group of top engineers who are conducting in-depth tests to continue to improve safety of racecars. Todt also spoke about his career as a rally co-driver, his time as the team boss at Ferrari, and his love for the sport.

The British Government was represented by the Secretary of State for Business, Skills and Innovation, Rt Hon Sajid Javid, who praised the international influence and economic importance of the UK motorsport industry. He met with a host of exhibitors and key UK motorsport VIPs.

With the UK motorsport industry worth £9bn and employing close to 50,000 people in 4000 motorsport companies, Javid applauded its importance to the UK economy, and also recognised the key international role it plays.

According to the MIA's Snapshot Business Survey', released at the show, the global success of the UK's motorsport companies continues to grow, as it has done for the past five years. These investments and others when coupled with the fast growing export sales of UK motorsport companies means plenty of jobs are available – some 95 per cent of those who responded to the MIA's survey have well-rewarded skilled vacancies currently available.

Javid said: 'Britain and motorsport have long gone hand-in-hand with success. Our involvement in motorsport, shows the strength of British engineering and innovation in one of the most competitive and demanding environments there is.'

This year's Autosport International show paid tribute to the Williams Formula 1 team with a number of its cars on show and its paddock motorhome set up in the main hall

Autosport Engineering stand awards

Tony Tobias (left) presents Tony Creamer (Mazak) with Best Mantech Stand award

Richard Barnes of SPA Design picks up the award for the Best Overall Stand

Ferrea's Oscar Romano (red shirt) receives the award for Best Small Stand

Centre stage

There was much more than racecars and celebrities at this year's Autosport Engineering Show, held in association with *Racecar Engineering*

Classic Team Lotus showed the first Lotus single seater designed by Colin Chapman, the Lotus 12, and announced the planned restoration of the Lotus 56 turbine car

Chris Aylett, Chairman of the MIA, in conversation with IndyCar's Will Phillips, and the Rt Hon Sajid Javid MP, Secretary of State for Business, Skills and Innovation

The Ginetta G57 is powered by a 6.2-litre Chevrolet engine giving 580bhp – the company claims it will be three seconds faster than an LMP2 around Silverstone

The G57 is based on Ginetta's successful LMP3. The company also picked up the MIA Business of the Year. Company representatives were on hand to discuss the new car

Racecar Engineering was once again proud to be associated with the Autosport Engineering Show. From the moment the Pikes Peak winning PP03 turned up on the stand, to the delight of the audience, it was an instant hit with the marketing and advertising representatives with comments such as 'that's bigger than I thought it was going to be', and, 'it's a bit dirty', greeting its arrival. The magazine extends its thanks to Valet Pro for its provision of car care products, and air fresheners

A NASCAR Sprint Cup Ford appeared in Birmingham – not Birmingham, Alabama but the one in England. Perhaps it got confused on the way to Speedweeks at Daytona Speedway? Either way it was not sporting the latest spec Ford Fusion bodywork

Inlet trumpets have many uses. Tuning, as always, was a big part of the Autosport International Show. Other entertainment included the always popular Indoor Arena, which included a display of a Williams FW08C driven by current driver Felipe Massa

The Pikes Peak winning hillclimber was re-constructed in Latvia and brought to the show, taking pride of place on the ***Racecar Engineering*** stand. It was popular with all, right up until it was driven out of the show on electric power – chased by security

The new Gibson GH-20 sports prototype made its public debut at Autosport International. The FIA CN rules car features a composite chassis and can trace its design roots back to the successful range of British-built Nemesis sports racers

Poland will be represented as a racecar producing nation from this year with the launch of the neat-looking Chevy-powered Arrinera Hussarya tube frame chassis GT4 car

Brian Gush from Bentley Motorsport picked up the MIA's teamwork award from Phil Ward of motorsport and automotive casting specialists Grainger and Worrall

Lawrence Tomlinson of Ginetta picks up the award for Business of the year, presented by Adrian Moore of Xtrac. It was awarded for its many race series and its LMP3 car

Chris Batty of Lestercast presents Aston Martin works driver Darren Turner of Base Performance Simulators with the Business of the Year Annual Sales Under £5m Award

Francisque Savinien of Performance Racing Industry (PRI) presents Stephen Deane of transmission specialist Hewland Engineering with the Export Achievement Award

Helen Briggs, from awards dinner sponsor Dell, presents Dominic Cartwright of motorsport and automotive giant Prodrive with the MIA's New Markets Award

Jon Hourihan, of well-known fluid transfer company Goodridge, presents Jonathan Lee – from Jonathan Lee Recruitment – with the MIA Service to the Industry Award

The award winners. The MIA's Business Excellence Awards Dinner was attended by over 500 senior executives from the international motorsport business community

Steve Sapsford, from global engineering giant Ricardo, presents James Shingleton of motorsport electronics supplier bf1systems with the Technology and Innovation Award

The halls of fame

Sam Collins contemplates the state of the significant international motorsport shows

Racecar gets the red carpet treatment at Autosport Engineering

As the centrepiece of the three day trade show there is the Gala Awards Night, where the show organisers hand out gongs for achievement in a number of categories, such as Racing Car of the Year, and Motorsport Facility of the year. I stopped going to this a few years ago as it appeared to me to be a way of rewarding the companies who spent the most with the show organisers each year, and as it turned out, I was not alone in that opinion.

However, this year the organisers invited me to join the judging panel. This involved me voting on a number of categories, but without having knowledge of how other panellists voted. As a result I went along to the awards and over dinner I found myself defending the judging process. All but perhaps one winner made perfect sense to me. So I will say this here and now – the PMW awards are not rigged based on advertising spend!

The day after the awards I took the chance to have a look around the show itself. Its' not huge but the quality of exhibitors is outstanding, this is partly down to the location of the show in Koln, meaning it attracts exhibitors from France, UK, the low countries and the former Eastern Bloc as well as from Germany. Another reason for the show's popularity is the timing. Running in mid-November, it provides a very neat bookend to the European racing season as minds turn to the following year. So it's no surprise that the likes of Ole Buhl Racing, DC Electronics and Titan choose this event as a place to reveal details of new products.

Out Indy cold

The halls are very quiet at PMW every year, meaning that those in attendance have more time to discuss requirements and capabilities than at other similar events while the exhibitors network, too. 'I got one serious enquiry during the entire show, it was so quiet on our stand, but that enquiry came from a major OEM and has seen us get a multi-million pound purchase order,' one company told me after the show. So it still remains a case of 'the right crowd and no crowding.'

Now, normally at this point I would explain, in the most colourful language that the editor will let me get away with, how much I dislike the town of Indianapolis, especially in December when the temperature is usually so cold I would not be shocked to see petrol freeze in the pumps. As a result I was not disappointed as for the first time in years I skipped the PRI show, and it would be the year when it was warm in Indianapolis (meanwhile, Hell froze over). I'm told the show was vast (as usual) and that it was excellent (as usual).

If PRI acts as the bookend of the North American season and PMW the European, then the Autosport International Show in Birmingham is the other bookend, marking the start of the new season. Getting off the train at Birmingham International station was almost entirely unremarkable – though there was a man dressed as a dog collecting for charity.

Hall marks

The 2016 event (held as always at the NEC) was notable for how empty it felt, at least in terms of stands, something which was especially noticeable in the Engineering show. Large expanses of red carpet and a few totally empty booths told a story. Some exhibitors had relocated into the main show, opting to be there for four days in order to sell to the large UK club racing market, which is very much in attendance over the weekend, while others had simply not turned up.

'We opted to save the money and not to have a stand, we walked the show over two days and made fantastic contacts,' one regular exhibitor told me. 'Its funny because compared to PMW, the engineering show was much smaller and the stands were not such a high calibre, however, the people walking the show were much better!' The chap telling me this went on to explain how much business his company had done just by networking on the MIA Stand, which has clearly become an important hub. Sitting there at one point I noticed that key people, Dallara, Y-Com, Mygale, Riley Tech, ORECA and Ginetta, were all sat in the MIA having discussions. That is almost every top level chassis constructor in the world sitting in one place at the same time, even the FIA struggles to do that (FIA representatives were also present!).

It's a typical sentiment expressed by most who are there. The decline in exhibitors was also evident in the main show and many highlighted that this does not reflect the state of the industry, which does seems to be going through something of a boom period at the moment. But one exhibitor had a theory: 'A few years ago everyone made their orders in November and December but now it's getting later and later. F1 has not really got going yet, where normally they would be about to start testing now, while the rules for other classes have not even been published for 2017, so everyone is sort of waiting.'

It seems overall that, while the size of the two end of season shows is growing, the pre-season event is contracting somewhat. But of all three the event in Birmingham seems the best place to do deals, especially with the help of the MIA, which does not have its big coffee bar/lounge at the other events. So that's conclusive then …

The MIA stand has clearly become an important hub at the ASI show

Clutches
Talking the torque

AP Racing has introduced a new family of twin plate and multiple plate carbon/carbon clutches called PRO Torque.

Designed using its unique Radi-CAL approach, AP claims this new family of products offers all the usual benefits of carbon clutches, but at a lower price point in order to appeal to all sectors of competition. Using a more organic design ethos, the PRO Torque family of products will provide long service life, improve modulation, and they are resistant to high intensity applications, AP says.

With two initial products at launch, the first PRO Torque models cover push-type, twin and triple plate 140mm and 184mm clutches. Further models will be introduced to the range going forward. The smaller push-type clutches incorporate a stainless steel, high-ratio (HiR) pressure plate, with separate fulcrum ring, and a one-piece aluminium cover. Using heavy-duty carbon plates, the clutch offers improved modulation yet proves highly durable in a variety of applications, AP says. The larger version has very similar features but in addition has a very high ratio pressure plate and a 12-bolt one piece cover.

Product options on both include two variants of diaphragm spring, a single cover and pressure plate material, and a stepped flywheel fixing. The smaller models are not suitable for GT applications, due to a restricted wear-in period.

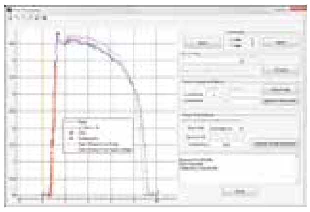
www.apracing.com

Simulation
In a material world

Granta Design has released a new software package that is designed to deliver accurate materials data for simulation.

The new package is based on Granta MI, the leading materials information management system. Developing validated material models for simulation requires analysis of significant volumes of test data to ensure accurate description of the material across the range of relevant conditions.

The MI:Simulation package adds new tools to data and prepare the resulting models for Computer-Aided Engineering, it supports key tasks, such as curve smoothing, averaging, and model fitting. These tasks usually need to be tailored to a user company's specific properties and material types of interest, and to its in-house or preferred analysis methods and models. A sample app is provided to extract tensile test



data from a corporate database, process it, and make the resulting models available for simulation.

The software enables access from directly within CAE environments including Abaqus/CAE, ANSYS Workbench, HyperMesh, and NX. For other systems, integration is still fast and error-free – users can export materials cards from Granta MI, with automatic data transforms and manipulation into the formats read by software such as LS-DYNA, Nastran, PAM-CRASH, PAM-STAMP, Patran, and RADIOSS.

www.grantadesign.com

Heat management
Turbocharger shield

Design Engineering has made its Onyx Series Black Turbo Shield available for smaller turbochargers. The shield is designed to maintain consistent temperature in the turbo to maximise efficiency and minimise lag.

The kit includes the black turbo shield made of premium heat resistant textiles and newly designed stainless steel attachment points, a 2in x 15in (approx 5cm x 38cm) premium roll of DEI black exhaust wrap, two stainless steel locking ties, and a roll of stainless steel locking wire.

www.designengineering.com

Measurement
Taking the temperature

This compact BG Racing pyrometer is easy to use (both for left and right handed users). It records three temperatures per tyre and stores up to 10 sets of memory at any time, and has the ability to calculate the average tyre temperatures for each side of the vehicle, the cross corners and the axles.

An auto lock recording feature is incorporated which means once the highest temperature is seen it is automatically recorded and the user can move to the next location on the tyre. All four brake temperatures can be recorded and stored in the 10 sets memory, but the brake temperature function requires an additional probe.

www.bg-racing.co.uk

Machining
Cutting it with the jet set

Kerf Developments has launched a new range of water jet cutters called the Optima Series.

Kerf says this range of cutters will allow it to provide a cutting solution for a vast array of materials, in scenarios that may demand anything from low volume or prototype parts, through to high volume production.

The process delivers clean cut smooth edges that eliminate secondary hand finishing operations, Kerf claims. The Optima water jet series now enables Kerf customers to process hard materials such as mild stainless and tool steel, aluminium, titanium, brass and copper; whilst brittle materials such as carbon fibre, ceramic, granite, Kevlar and marble are also easy to process, Kerf tells us.

Capability is further enhanced by the option of a three, four or five axis head

www.kerfdevelopments.com

Sensors
Taking it to another level

Gill Sensors and Controls has launched a new liquid level sensor aimed at achieving reliable and accurate tank level measurement. The new GS Level 4223, is said to be the result of 12 years' experience and more than a year of internal development and testing.

The new liquid level sensor will be offered as an alternative to Gill's current R-Series sensor and customised variations, allowing all motorsport customers to benefit from variable length options, fast delivery times, and flexible mounting options.

The sensor is a fit and function replacement for the current SAE 5-bolt sensors. The GS level 4223 also provides the added flexibility of off-the-shelf standard adaptors, suitable for one, two, three and five bolt; along with metric and imperial male thread-mounting options, Gill says.

Using key connection features, provided by Gill, customers can develop their own configurations to suit any flat gasket or off-centre mounting, along with limitless thread adaptions to both male and female forms.

To complement the launch, Gill's level sensor configuration software has been completely overhauled to provide a simple and intuitive way to customise the analogue output settings, minimum level and maximum level, alarm switch level and hysteresis conditions. The software now also offers a new feature to map tanks to give a volumetric output using the simple configuration wizard, or by uploading a CSV file.

The GS level 4223 has passed a full suite of electrical and environmental testing, including automotive EMC and shock vibration to F1 and Rally conditions, to ensure product reliability and robustness, Gill tells us.

Gillsc.com

Transmissions
'Box of tricks for GTs

Hewland has launched a new transmission, the GTT-200, which is optimised for front-engined, RWD GT endurance vehicles.

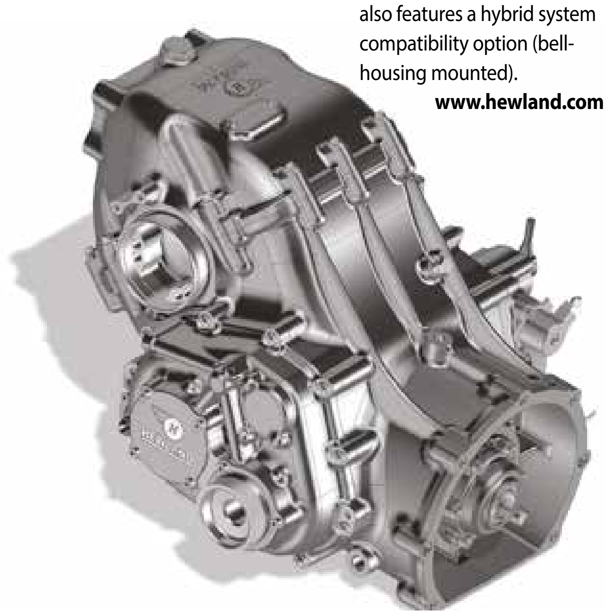
The all-new design offers many of the benefits of Hewland's advanced TLS (LMP) solution in an off-the-shelf package.

It integrates a lightweight magnesium casing, precision ground bevels and a layout designed with weight distribution in mind. The TSI (Torque and Speed Sensing) Differential is Hewland's most advanced differential, combining both torque and speed sensing elements. On-car tuning is achieved through external adjustment, while multiple differential set-up options ensure handling is optimised for all elements of corner approach, turn-in and exit.

The new unit offers externally adjustable negative pre-load giving finer control over vehicle handling characteristics, allowing for improved turn-in and reduced mid-corner understeer, we're told.

The GTT-200 is a 6-Speed transverse transmission with two separate external ancillary drive options. It also features a hybrid system compatibility option (bell-housing mounted).

www.hewland.com



Measurement
Covering all the angles

The B-G Racing Digital Dual Axis Angle Gauge can be used to measure absolute and relative angles to 0.1-degree accuracy in single and dual axis.

It features a large back lit LCD screen, a hold button to freeze the display, a programmable audio buzzer, auto power off function, and V shaped multiple magnetic sides for easy mounting. The digital gauge has low power consumption with a rechargeable battery life of 40 hours. A USB and a mains charger are included in the kit.

www.bg-racing.co.uk

Fuel systems
Handling the pressure

Fuelab has launched its new 58502 Fuel Pressure Regulator for low pressure fuel delivery systems.

The 58502 combines advanced features and increased functionality to provide the ultimate precision instrument for fuel pressure regulation, Fuelab says.

This four outlet port regulator is said to be engineered to deliver extremely high flow rates and a flattened curve for pressure stability. Featuring an anodized billet aluminium body, the regulator uses an aerospace poppet valve design to provide smooth regulating capability and maximized flow.

It operates within a 2-4psi pressure range, and an adjustment mechanism with fine thread pitch allows for precise fuel pressure adjustment. A methanol and E85 compatible soft seat avoids fuel pressure creep. The main seat assembly can be quickly exchanged in case of seat damage such as debris, and can be disassembled for replacement of the o-rings in the soft-seat design. It features dual 10AN inlet ports, and four 6AN outlet ports arranged in-line for cleaner installation, and with port spread that allows for smooth flow when using an 8AN line size.

The regulator is perfect for dual quad carburettor arrangements, as well as single stage and multi-stage nitrous. Compatible with petrol, diesel, methanol and E85 fuels.

www.fuelab.com

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Squeal of fortune

There are some interesting forces at work in the political arena of motor racing. In my rather lowly position, I can't so much as shine a light into the dark corners of the situation, but rather prod a stick into them, and see who squeaks.

Replacing a strong leader is not the work of a moment. Once they have gone, their 'back-room staff' also need to be dealt with, or the old ways continue. At the Volkswagen Group, for example, the departure of Ferdinand Piech as chairman was undoubtedly a blow to the company, but as one commentator noted; everyone in power was put there by Piech himself. Martin Winterkorn succeeded Piech, and then the emissions scandal forced him to fall on his own sword. What's left? Piech's men. Would he come back, I wondered? 'He has never been away,' came the reply from one expert.

The question of what happens to Formula 1 when Bernie Ecclestone relinquishes control is rather surpassed, I suspect, by what happens in the French elections in 2017. With commentators noting that Jean Todt has political ambition, what could happen to him should Nicolas Sarkozy resume his presidency? There are two possible answers to this. One is that he will stay to preside over the situation in which motor racing finds itself; an increasingly one-make sport that enjoys the duality of purpose which is to save money while introducing costly technology. The pursuit of money to sustain such investment has, in the eyes of many, taken over the 'sport' that was previously a competition of speed.

The other option is that Todt will vacate the FIA presidency and go into Sarkozy's new government, thereby creating a power vacuum. Who will step into the FIA breach, or perhaps more pertinently, who will put them there? Will it be a Max Mosley-supported candidate, one that would have a master strategist behind them? Or, would it be a Jean Todt prodigy, one that would continue the work started by the Frenchman?

The two architects are currently locked in an interesting battle. Todt faces a stiff and rather poignant challenge on his road safety campaign from the NCAP organisation, which sees itself as the champion of road safety and sets the standard when it comes to product testing. The Chairman of NCAP happens to be one M Mosley.

Possible candidates for either include David Ward, the former director general of the FIA Foundation and the FIA European Bureau, who challenged Todt for the presidency first time around, but who withdrew from the race in 2013. The other possible candidate is the ACO President Pierre Fillon, the man who has in *Racecar Engineering* admitted that he has political ambition within the FIA. His brother Francois, remember, was the Prime Minister of France under Sarkozy last time around. There are other options, but there is nothing to say that the vote would reflect the needs of the racing community. That is but one job of the president, yet it is what the FIA is most known for in our world.

Given that Ecclestone publicly stated that CVC was long overdue the sale of its shares in Formula 1, and that it would happen before the end of 2015, it would appear that there has been no such sale. There is no contract that legally obliges them to do so, it is more of a stated intent from Ecclestone. However, a destabilisation of the product, either through the lack of published 2017 technical regulations (a return to refuelling, anyone?), or a drop in viewing figures, would be hurting the share sale price. As with most things to do with Formula 1, a lack of clarity is the biggest problem. Or, perhaps there is another game afoot?

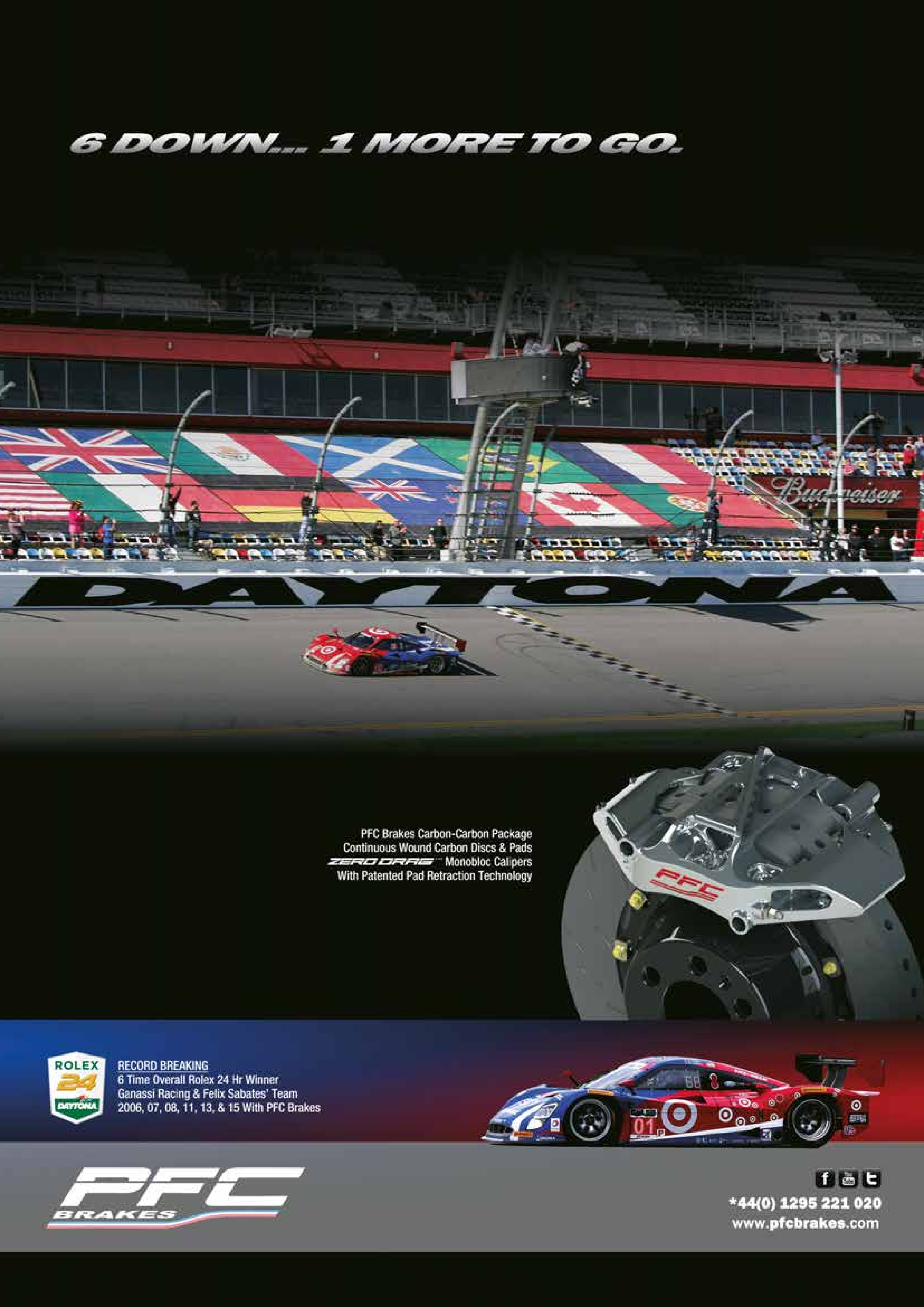
As with most things to do with Formula 1, a lack of clarity is the biggest problem. Or, perhaps there is another game afoot?

On a completely un-related topic, one that arose at the Autosport International show, was; what will happen to hybrid regulations used in the WEC and Formula 1, once the emission scandal reaches some kind of conclusion? The answer to that depends on what the new emissions tests will be. If they are real-world, honest tests that produce figures on which the public can accurately calculate running costs when purchasing a car, the truth will be told. And, according to one engineer, that means the end of powerful hybridisation and battery technology on the grounds of weight, and environmental impact in production.

Should motor racing pursue increased hybridisation, or should it actually reduce the hybrid power to more accurately reflect real world driving? There are two schools of thought – one is that racing should reduce power in order to attract the investment necessary from the respective automotive boards. The other school of thought is that racing is about extremes. No racing car has ever been produced to be 'normal', unless the base model is already extreme.

We will come back to this topic in the not too distant future. Prodding over. Who's squealing?

ANDREW COTTON Editor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