NASCAR NEXT GEN: Teams reveal their 2022 challengers – p16

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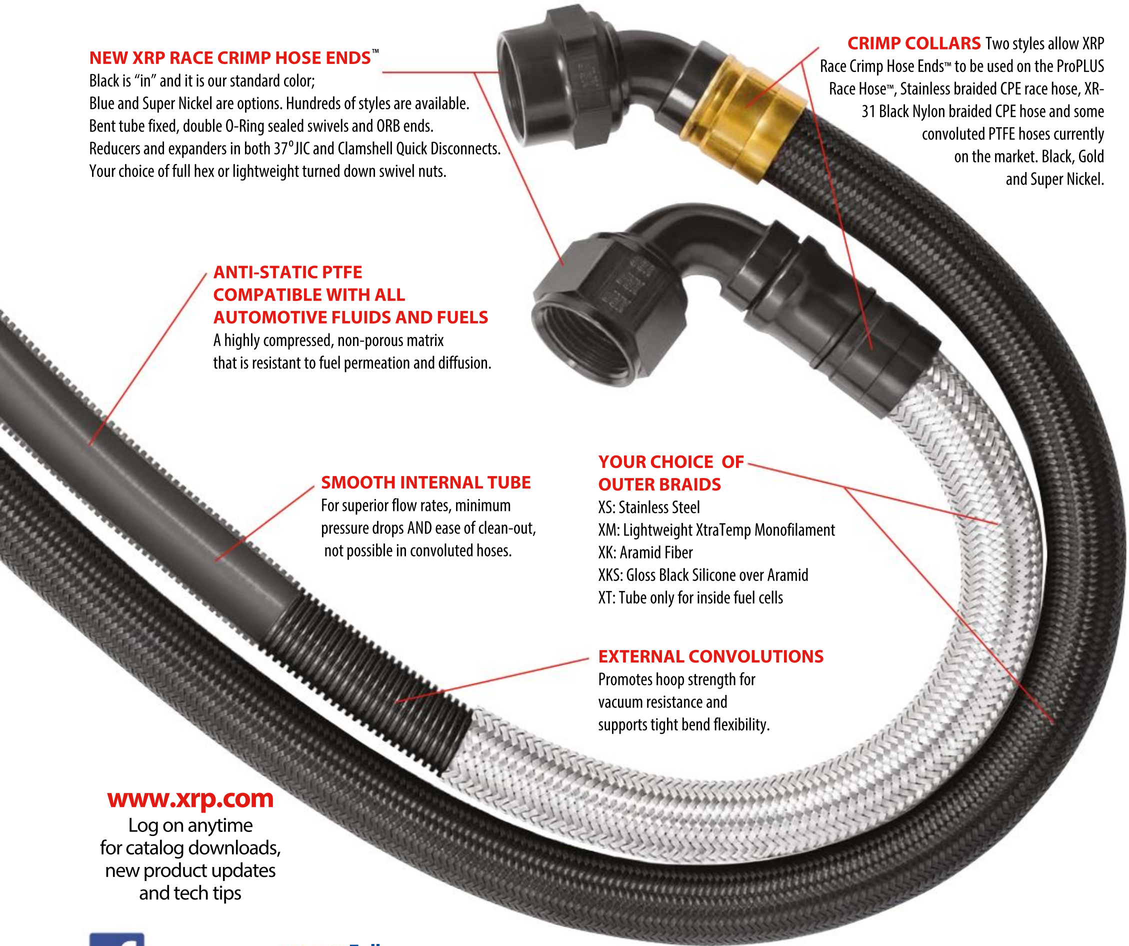

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Strategic thinking

The difference between racing in America and Europe

The first short race of the 2021 IMSA season and, like clockwork, a yellow played a hand in the result at Mid-Ohio. Observers have commented about how a race was stolen, but this is what makes racing in the US so much more challenging than in Europe.

Since I started racing in America in 2007, the rules around the use of the safety car in Sportscars have changed a bit but, in essence, the leader is not guaranteed to retain the lead and the team running the car has to strategise for a win, just like the rest of the field. This is the opposite of European racing and, for some competitors, may seem unfair. However, it does bring equality to everyone competing, re-setting the race in stages and allowing teams an opportunity to recover from incidents.

Call centre

The challenge of the IMSA races lies in knowing what to expect when the safety car is called, and what that means for your car. In a way, the longer the race, the easier some of these calls become because there is time to recover from problems, or incorrect calls. The shorter races is where an incorrect call becomes critical.

As a rule of thumb, if a car goes off, the likelihood of a yellow increases based on the level of damage and risk, and in this scenario there is advantage to be had in stopping before the rest of the field, beating the yellow and forcing others to pit, thereby losing track position to you.

But there are complexities. For example, if you have just stopped, does it make sense to come in, losing track position? If you are a number of laps down, does staying out gain you laps back if the leaders pit? This is where understanding the safety car process is crucial.

Once deployed, the pits are closed and the safety car tries to pick up the leader. But if an incident warrants an immediate neutralisation, it can pick up the first car it encounters. In that instance, it's possible for this car, and any behind it, to end up a lap down to their respective class leaders if they are sandwiched between the safety car ahead and leader behind.

This would be unfair if positions were maintained. So, once the field is bunched up, the following process takes place:

- Any car that has its class leader behind it is allowed to pull to the right, drive past the safety car and catch up to the back of the train (called the wave by).
- Once this re-order is complete, the pits open for each class, in order: Prototypes on the first, GTs on the second and everybody on the third lap.
- Then, should any cars again be between the safety car and their class leader, they can use the pass around to unlap themselves.
- Once complete, IMSA employs the class split, which first allows all DPis to cycle to the front of the field, followed by LMP2 and LMP3 cars.

Richard Dole

Racing in IMSA in the US brings a game of strategy into play that doesn't exist in Europe

So how do teams use the safety car for strategy? Let's take the example of the Daytona 24 hours where the Mazda DPi was three laps down at half way. To get back on the lead lap, we had to do the opposite to the leaders on the same lap as us when the pits opened for DPi under the safety car. That way, after the class-specific stops we were able to take the pass around and then pit as we ended up back behind the leaders, one lap closer to them. With 12 hours remaining, this happened three times and, with five hours to go, we were on the same lap and challenging for the win.

Another example is pre-empting the deployment and pitting beforehand so you keep track position or actually gain spots. This is what happened in Mid-Ohio with the no.31 Cadillac, which sat P2 with one stop to go. A beached GT car on track brought out the safety car, which allowed no.31 to pit before the pits were closed. This lost them track position to our car and the number 10 but, with one stop to go, the rest of the DPis had to pit when their class was open and fuel for longer. It meant 31 could pit again when the Prototype window opened to just top up fuel, their short stop time jumping the other DPis to exit in the lead.

Split second

Of course, it's just as easy to get these decisions wrong. For 31, had the beached GT broken free before the safety car was deployed, they would have had to bank on a yellow being thrown before the end of the race.

In the heat of the moment, you have just seconds to make a decision and, after the event, you are always wiser.

Experience gives engineers and strategists a chance to influence the outcome of a race, and that makes racing in IMSA hugely enjoyable and challenging. Added to that, there is always a chance for any team to have a shot at the win. It's no surprise, then, that the DPi field has been strong and remains attractive to manufacturers.

This isn't to say that one philosophy is right and another wrong. There are reasons why the safety car isn't readily used in European racing to close a field up after an incident, with virtual safety cars deployed instead that retain the gaps between cars as if racing was still under green. This protects the leader, but keeps lapped cars behind with little chance to recover.

I personally prefer the IMSA rules because it makes racing more rewarding, and I highly doubt something similar will be seen in Europe. But there is an opportunity to keep the whole field racing with some thought. And that would make the intensity of racing much more absorbing for fans and competitors alike.

Leena Gade is race engineer at Multimatic Engineering UK

In the heat of the moment you have just seconds to make a decision and, after the event, you are always wiser

Confused.com

From practice to track limits to qualifying to Aston, it's all a bit bewildering

The F1 world never fails to confuse me. The achievement of putting on a meaningful and exciting World Championship under Covid restrictions has been immense. So is the introduction of a team budget cap, something which has never been remotely achievable before.

The organisation of such complicated events is very slick. Impressive also is the rigorous scrutineering and monitoring of increasingly sophisticated racecars that, unchecked, would be cleverly enabled to skirt around the plethora of technical regulations. The whole result is highly professional, and sets a standard for all sports.

But then we have the flip side. Not unreasonably, drivers new to F1, or changing teams, complain of insufficient track time to fully understand their different machines' characteristics, and to click with their engineers, especially when it comes to wringing the last fractions of performance in qualifying. This puts them at a disadvantage to those entrenched in both.

Practice makes…

So please explain to me why, in addition to the FP1 and FP2 sessions each being cut by 30 minutes at every event, at the time of writing the organisers of the British GP just announced they are intending, as part of hosting the first Sprint Race, to reduce free practice to just one 60-minute session prior to qualifying on Friday? Crucially, this sets the starting grid for the Sprint Race afterwards, the results of which award critical World Championship points and determine the grid for the Grand Prix on Sunday.

Given that FP2 on Saturday takes place after the grid positions for the Sprint Race have already been set, with all the attaching ramifications, this acts completely against the drivers' pleas. Teams with the most optimised technical data and simulation capabilities will consequently have an immediate benefit, even with the cost cap.

Not at all what Formula 1 has supposedly signed up to. I suspect, and certainly hope, that this weird attempt at change purely for the sake of change will be re-thought, and re-thought soon, as we all know playing around with things that ain't broke doesn't work.

By all accounts, the biggest boost to F1 recently has come from Netflix's *Drive To Survive* series, so the lessons from this, and the potential for other public communication opportunities, are what should be uppermost in mind.

Confusion needlessly exists, after long-running arguments, concerning track limits. A working group (!) has been set up to finally make a decision. Need it be so hard? I favour no part of the car going beyond a red and white kerb of set dimensions, as used to be the case. This permits limited kerb hopping at chicanes, which can be spectacular. But other people will differ in their opinions. Fair enough.

The first rule, above all else though, surely must be that whatever is defined as the limit should be consistent, at every circuit and at every corner. It should not be for Michael Masi to decide which corners may or may not present an advantage to competitors by running wide. If there is no benefit, drivers wouldn't do it.

XPB

Aston Martin: the money might be there, but the engineering and strategy departments now need to play catch up if the team is going to succeed

Self-regulating limits would be ideal, but in practice this is difficult to achieve. Armco barrier with no run off is the ultimate deterrent, but it would not be safe at higher speed venues. Gravel just gets spread onto the track and grass soon becomes a rut. So perhaps an extremely low-grip surface laid beyond the designated limit and destroying any traction there is the answer?

One has to acknowledge F1 cornering speeds are so fast now, and the cars so aerodynamically sensitive that in-car camera is like watching speeded-up film. Sometimes the white line must be barely visible and the slightest twitch can throw the car off line. Nevertheless, precision is the mark of top drivers, and all drivers have the choice; leave a very small margin as they might if it was Monaco, or risk a penalty.

Gambling strategy

Confusion is not restricted just to the organising bodies either. The folly of F1 teams leaving qualifying runs to the last few minutes, with everyone piling out at the same time, and then complaining about the traffic has me shaking my head in disbelief. Risk of a poor grid slot, or even non-qualifying, by failing to get a clear lap compared to the chance of the track becoming a few thousands of a second faster is high, and frequently catches out these gamblers.

The strategy of getting a banker lap in earlier at least gives the opportunity to run again, even allowing for the desire to save tyres for the race. Perhaps, for some drivers, the added adrenaline rush draws out a fraction more speed? Perhaps.

Confusing also is Aston Martin wasting energy in a spurious attempt to change new aero regulations because they don't suit its car. Thankfully, Mercedes' successes with its own low-rake car seems to have closed this down. Aston Martin really needs to concentrate on getting its engineering and strategy act together. The injection of money seems to have had an adverse effect on an outfit previously renowned for extracting a lot from very little.

Copying Mercedes' 2019 car might have been smart for 2020, but it could also be admitting defeat regarding its own technical capabilities. In contrast to Mercedes, the engineering team hasn't sorted the missing rear downforce issue, hardly instilling confidence regarding its design for the radically different 2022 car.

Lawrence Stroll does not come across as patient with failure. Especially as racing success is now inextricably bound up with Aston Martin's sales of high-end road cars. Hundreds of millions have been invested by Stroll and his pals in this company's revival and its poor performance on track won't encourage the much-needed buyers to whom image matters a great deal. It's tough at the top; even tougher when you're not.

The first rule, above all else though, surely must be that whatever is defined as the limit should be consistent, at every circuit and at every corner

Mad 4 it

BMW says its M4 GT3 car is a step change improvement over the outgoing M6, and will be proven in competition this year before customers take over for 2022

By ANDREW COTTON

It has already developed a reputation as a car to be feared by the opposition

BMW has launched the M4 GT3, a car the Bavarian manufacturer hopes will win major endurance races in customer hands. The all-new challenger is the first to be built under a new rules package created by the FIA to allow for greater freedom of design. However, as the new regulations require BMW to sell 20 of the cars in the first two years in order to retain its homologation, it has been circumspect with the design.

The car replaces the outgoing M6 that was introduced in 2016 and which won the Spa 24 Hours in its first season, and again in 2018. That car had shortcomings, particularly in terms of tyre wear, and it is this feature BMW's development team has worked particularly hard on in order to prepare the M4 GT3 for customer competition.

The base M4 GT3 is derived from the production car, with the chassis and engine being taken from the production line by the race team, and extensive development has taken place, with tests in Almera, Monteblanco and the Nürburgring in the hands of all the company's factory drivers. Consequently, it has already developed a reputation as a car to be feared by the opposition, for a number of reasons.

Waiver saver

The length of the development phase is driven in part by a new set of regulations introduced by the FIA to make its life easier. Under the old regulation set, a manufacturer had to apply for waivers to help it reach the performance balancing windows. These were awarded on a discretionary basis by the GT Commission. The Commission nominally had three categories of car for GT3 racing, including Supercar, Sportscar and Grand Tourer, with more waivers allowed for the latter than the former.

However, with so few rules written in stone, this was not good enough for the manufacturers that wanted more from the category. So, together with the FIA, the manufacturers worked on creating a more predictable set of rules for what they were allowed to do to their cars. The FIA then granted them the opportunity to make any changes they deemed necessary in order to homologate their cars to perform at the required level, placing faith in the performance balancing system.

The one caveat the Commission was able to put in place was the necessity to sell 20 cars within the first two years. That, it hopes, will be enough to discourage anyone from building an expensive prototype that falls outside the boundaries of the performance balancing team and, with GT3 racing spreading ever further around the world, they might yet stand a chance.

The big danger, however, is that the GT3 category will go to Le Mans to replace GTE in 2024. With such temptation placed in front of it, and with the possibility of developing prototypes, the future looks to be on shaky ground.

BMW's M4 GT3 is released to co-incide with the introduction of the new regulations. Others have focused on developing existing models and so are not subject to the same 20 car sales total. BMW has to succeed with this car, both in terms of sales and results, and so looking at the design BMW appears have behaved itself.

June launch

The car was launched at the Nürburgring early in June, with a view to opening up the order books, and is expected to take part in rounds of the NLS (formerly the VLN Series), an SRO-organised event and a Creventic race later in the year to prove itself in competition and to bring the test programme to a close.

Homologation is due to be completed in time for the Daytona 24-hours in January, and BMW is hoping it will be able to compete with customer teams at the American endurance classic, as well as the Bathurst 12-hours in February 2022.

The long gestation of the car has, BMW hopes, played in the favour of the Bavarian manufacturer. It has had time to complete more than 12,000km of testing around Europe in the hands of its factory drivers, and the development team has focused primarily on tyre management.

The outgoing M6 was traditionally hard on tyres, and consequently struggled to be competitive over the hour-long stints required to be completed in modern endurance racing. There is a lot of pressure

'We need to have a GT car, particularly in the GT3 class, that is affordable for the customers, with affordable running costs, that is easy to use and that no one is afraid [to run]'

Achim Klein engineering project leader at BMW on this M4 GT3 programme as the M8 GTE programme has been wound right back to include only the long-distance races in the US. That short-lived project achieved limited success having won the Daytona 24-hours in 2020 but did not win Le Mans, or the World Endurance Championship.

With the Formula E programme also ending, the GT3 programme is the main focus for BMW's racing division for now.

Tyre management

'We need to have a GT car, particularly in the GT3 class, that is affordable for the customers, affordable for the running costs, that is easy to use and that no one is afraid [to run],' says BMW's engineering project leader, Achim Klein, who goes on to highlight that this is a customer racing programme and not for the factory to compete.

'It must not be the car that you can extract lap time over one lap and then struggle to keep the pace over the next 20 laps. All the things we did in the development programme are aimed at this target.

'For tyre degradation over the long stints in endurance racing, it is important not to show the peak lap times, but to have a stable car over a stint.

'Comparing the M6, which we were running at one of our tests, and the M4, what we have seen clearly is that at the moment you cannot extract the one [best] lap out of the car, as you do in qualifying. However, you see over the stint we are lower in tyre degradation and [have better] consistency.

'In the last test, we compared tyres from three different manufacturers that are common in the series where we aim to sell the car. You just put the tyres on the car, and it is just a few anti-roll bar clicks and the car is there.

'The package is robust and useable for customers. You have to do a few ride height adjustments [to adjust for the different tyres], but that was it.'

The GT3 category is starting to become more widely used than ever before and so, if a manufacturer gets its base car right, the market can easily accept the 20 cars required for homologation.

TECH SPEC: BMW M4 GT3

Length:	5020mm
Width:	2040mm
Height:	1308mm (variable, via the adjustable rear wing end plate)
Wheelbase:	2917mm
Weight:	below 1300kg
Transmission:	Xtrac G1337 six-speed transaxle
Suspension:	double wishbone front; multi-link rear
Dampers:	KW Motorsport five-way front and rear
Steering:	Rack and pinion, hydraulic-supported steering
Wheels:	12.5 x 18in front; 13 x 18in rear
Tyres:	30/68-18 front; 31/71-18 rear
Brakes:	six-piston fixed caliper and 390 x 36mm disc front; four-piston fixed caliper and 330 x 32mm disc rear
Engine displacement:	2993cc, four valve, inline, six cylinder
Engine management:	Bosch MS6
Induction system:	twin turbo
Fuel system:	direct injection
Horsepower:	up to 590bhp, depending on BoP
Engine cooling:	Radiator, with air exits through bonnet louvres
Fuel cell:	max. 120 litres, depending on BoP

The new M4 replaces the outgoing M6, a car that was successful but suffered badly from tyre wear. Consequently, this was an area engineers paid a great deal of attention to in the development process

While the class was primarily developed under the SRO banner, which has Pirelli as sole tyre supplier until 2023, IMSA adopted the class to compete in its top WeatherTech series on Michelin tyres. The ACO then started its GT3 class supporting the European Le Mans Series, also on Michelin, but it's the NLS (Nürburgring Endurance Series), where there is open tyre competition, that is a particular focus for the German manufacturers. This year, for the first time, the DTM series will use GT3 cars running on Hankook rubber, while national GT series also use GT3 cars.

Biggest threat

Although the regulations opened up during the design phase of the M4 GT3, Klein says it did not change their design philosophy and that customer racing was its primary concern. 'You need to have a car that is affordable for customers,' he reiterates. 'You also need to build and sell 20 cars, and to do a prototype would be so expensive that you could not sell your car at a reasonable price.'

BMW was aware it needed to radically change the front structure of the car in order to hang the suspension, radiators and front splitter needed to bring it into the performance window. Had the regulations not changed, it would have required a waiver to do the same job, and so the change did not affect plans.

'The main point we were aiming for was the same front end concept as we had on the M6 and M8,' highlights Klein. 'With the wheelarches and cut outs, the radiator package you need [would require you] to cut the whole front end from the chassis. That would have been a waiver under the old regulations, but this was our contribution to the regulation.

'We said if we build a car, it has to look like this. It is not for cheating, but if I cut all the sheet metal that needs to be cut off then I won't have a structure any more.' What's left is two extruded longitudinal beams that create a new support structure.

The change means that the car can make the aerodynamic performance window targets and has improved efficiency over the old M6. 'In the GT3 category, the balance of performance windows are quite easy to fulfil,' says Klein. 'You want to have everyone in the group, so you don't put a very high target there, but you have to do it efficiently.

'With regard to downforce and drag, we made a good step in comparison to the M6, raising the efficiency of the car.'

Production base

The new GT3 car is powered by the S58 3.0-litre, straight-six engine that has been modified for racing purposes and re-branded as the P58. In common motorsport practice, the engine has been lowered in the chassis, with the added bonus that, in doing so, it no longer needs to be tilted slightly. A dry sump has been fitted to make this possible but, other than a change to the exhaust, there are very few other modifications that BMW is admitting to.

'The whole base engine is a carry over,' insists Klein. 'The turbochargers are carry over, the exhaust is only changed because of the routing and the oil system is adapted to the needs of the higher *g* forces, but the rest is fairly standard.

'We added a hydraulic steering pump because the road car has an electric one, and this is belt driven from the front of the engine but, if you had to order a second engine for your car, you get it from the production line.'

Suspension-wise, the factory multi-link set up has been retained, with a double wishbone layout that meets the chassis at more than one point. KW five-way dampers are used on the car, as is the Xtrac gearbox developed for the M8, though modified to be more suitable for customer racing.

Endless testing

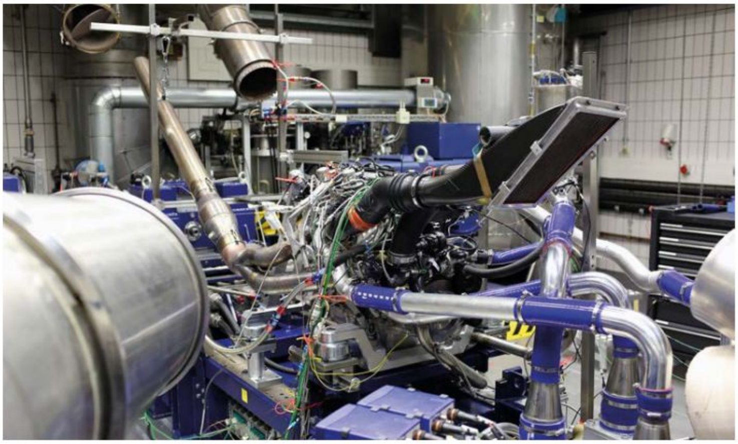
Another area the development team has really focussed on is the braking system. While the discs and calipers do get homologated, the pads do not, although BMW is testing with Endless in order to find the best overall braking package to sell to customers.

'The pitch sensitivity and brakes are key parts,' notes Klein. 'The [GT3] cars are heavy and produce a lot of downforce, which influences the car balance, but you are missing the third element so you have a trade-off between roll and pitch, and you are running heave stiffness with the four dampers, so you need to control your aero.

'The power-to-weight ratio, in combination with steel brakes, puts you into trouble, so brake development is crazy in all GT categories. Carbon discs are not right in customer racing because they are too complex and, if you don't handle them properly, you run into big problems.

The power-to-weight ratio, in combination with the steel brakes, puts you into trouble, so brake development is crazy in all GT categories

Both downforce and drag have been improved over the outgoing M6, making the car more efficient overall, but also with a view to being more manageable in the hands of amateur drivers



3.0-litre, straight-six, P58 engine is said to be a standard production unit, albeit with dry sump oiling and a race exhaust system

expensive to run, so BMW has not made it a compulsory part of the customer package.

Despite being homologated, and with little room for manoeuvre, there are still areas in which race engineers are able to work the set up outside of the traditional suspension settings. The Bosch ABS, for example, is tuneable, with 10 different settings that can be selected according to driver preference and weather conditions.

'The point is we are trying to make the product as robust as possible, along with the engineering support that we send to the series. If the teams are trying something fancy, we have someone there who can say it is worth trying, or we tried it already and it didn't work.

'You can tune it a lot, and you have to be able to if you are building one car for all these different series and these different tyres.'

'With the Endless pads, we made quite a good experience in terms of running and performance, and we have a close collaboration with them in terms of pad development and front-to-rear balance, which is crucial.

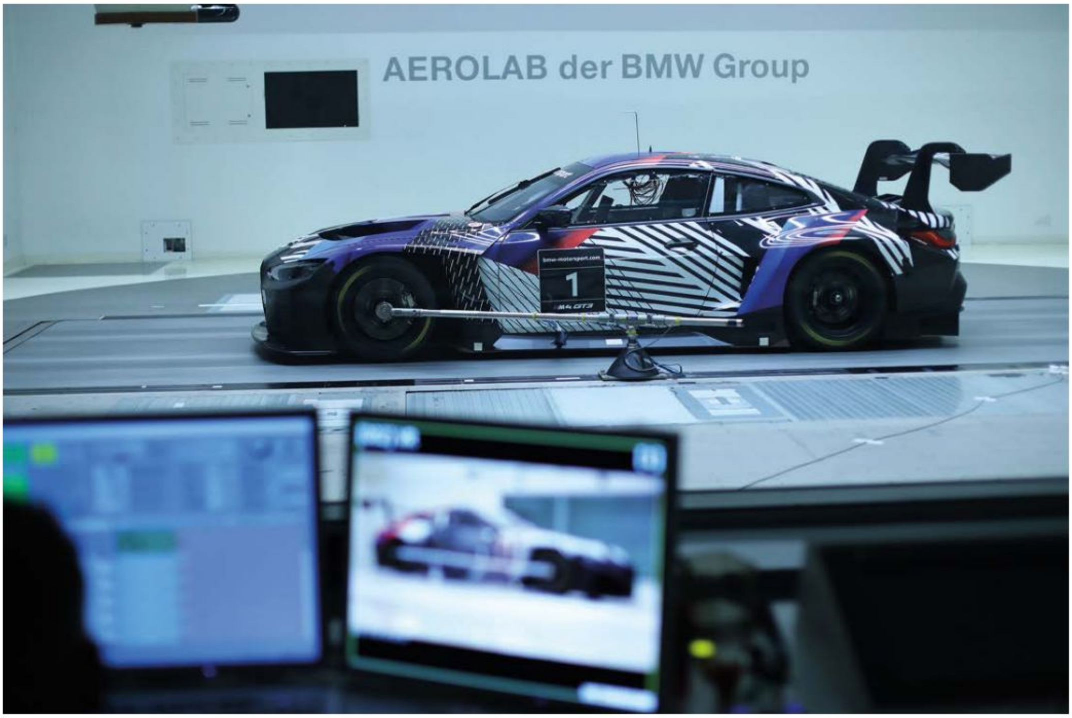
'We are trying to sell the car to customers with the best brakes we can get. If the customer wants to spend less, or finds something better on the market, they are free to do so, but we want to give the best to our customers with our development know how. It is too crucial to say you take the second best.'

Radar love

The car is fitted with the looms and brackets necessary to carry the Bosch-developed radar system that alerts a driver to a passing car, a system that has proven invaluable on the Nordschleife in the dark, as well as in rain and foggy conditions. However, it is

Button moon

One of the side effects of such a long development programme is the BMW engineers have had time to look into the finer details of the car, and have focused on some unusual aspects. For example, the control buttons are colour coded to the alerts on the digital screen in order to make problem solving easier for a driver out on track. Similarly, the team has worked to improve efficiency in the pit, too.



Brakes have seen a huge amount of development and BMW considers them the best package available for the car. They are steel as carbon brakes are felt inappropriate for a customer racecar

We are in the performance window in terms of drag, power and weight… Hopefully they will have problems balancing us

The new car is designed to be a cost-effective, reliable customer racecar that is easy to use, affordable to compete with and does not require a manufacturer-sized team to run

'When the mechanics set up the car, they have a button to zero the sensors. They can then adjust the pit speed limiter, run diagnostic functions of the engine sensors, or zero crank sensors, for example,' says Klein. 'There is a huge menu of functions the mechanic can do that does not require a systems engineer.'

Anger management

'Normally, at the end of the session you hand out a work list to the mechanics and say get on with it. But then, after half an hour, they have a question and you are stuck in the first debrief, then the second, then you go to dinner. By the time you come back, the driver is talking to you, it is 10pm, and the mechanics are angry.

'Waiting for five hours to talk to us, or for the systems engineer, is very inefficient, especially in the customer racing world where you have small teams and people with multiple roles. So, we tried to build the car in a way that the mechanic can do a lot of the work. Now, if I put on the work list to reduce the pit lane speed limit by 1km/h, and zero the sensors for example, the mechanic can do it.

'There is also a guided fire up so, when you start the car, you can check the oil pressure and so on. This was quite a clever idea.'

GT racing is entering a new phase in integrating with the digital world. The SRO European series, for example, comprises one-hour sprint and three-hour endurance events that together make an overall champion. But this year, for the first time, a nominated driver can get out of the real racecar and then go and qualify and race on a simulator. The results of this virtual event will also count towards the overall championship, and BMW has embraced this concept with a surprising development.

'The steering wheel [in the car] is the same as the one you have on the sim' rig,' says Klein. 'You can take the wheel from the car and put it on the sim' rig and you are connected and drive in both worlds. This is developed for the car, and there was a lot of input on the colour of the buttons.'

While delving into this level of detail in the cockpit, it is clear the car has been thought through in more detail than ever before. That's what makes it so dangerous for the competitors on track, and why they are eyeing the new car with something close to trepidation. If the team is able to start thinking about colour-coded buttons, it's almost certainly because it has nailed the overall performance parameters needed to be competitive.

Driveability

'Driveability is the whole story of GT racing,' says Klein. 'If you build a car with the lowest tyre degradation, then you have one of the best cars in the field for GT. Of course, we are trying to do this. We want to build the best car and sell it, we want to have more customers than these 20, so let's see if the customers are willing.

'It is a new car, though, and you have to understand it at the beginning. We have to adapt to this new car, and we have to see how we balance it. We are in the performance window in terms of drag, power and weight, and then we wait to see what happens. Hopefully they will have problems balancing us.'

The performance balancing teams will be keeping a close eye on the car when it races this year, and are expecting to have a tough job bringing it into line with the other cars when it races in customer hands in 2022.

New old Stock

In early May, NASCAR launched its Gen-7 car online. Known as the Next Gen, it is looking to recreate the series' production car values

By ANDREW COTTON

Next Gen Ford Mustang racer bears a striking resemblance to the road car you can buy in Ford showrooms worldwide. That's the whole idea

Photos: Getty Images

After years in the making, countless hours in the computer design phase – that was further elongated by Covid – and more than 1100 hours in the wind tunnel, NASCAR has finally unveiled its Next Gen regulations that will debut at Daytona, 2022. At a ceremony in North Carolina early in May its three competing manufacturers, Toyota, Ford and Chevrolet, unveiled their contenders for the Cup Series under the moniker of 'Stock reborn'.

The Next Gen cars are a complete departure from the Gen-6 cars they replace, with new technology in safety, suspension set-up, body panel materials and aerodynamics, as well as a focus on aesthetics and a reduction in cost, in order to make the category more attractive to a potential fourth manufacturer.

There is also thought given to the future powertrain for the category, with the possibility of hybrid technology being introduced into the new platform as a further carrot on the end of the stick to any manufacturer considering joining in the near future.

Some of the more radical and noticeable changes include the manufacturers styling their own cars, meaning a smaller greenhouse and a shorter rear deck, while aero has also changed considerably, particularly under the floor and in the rear diffuser to improve the racing and reduce the risk of a blow-over.

Product relevance

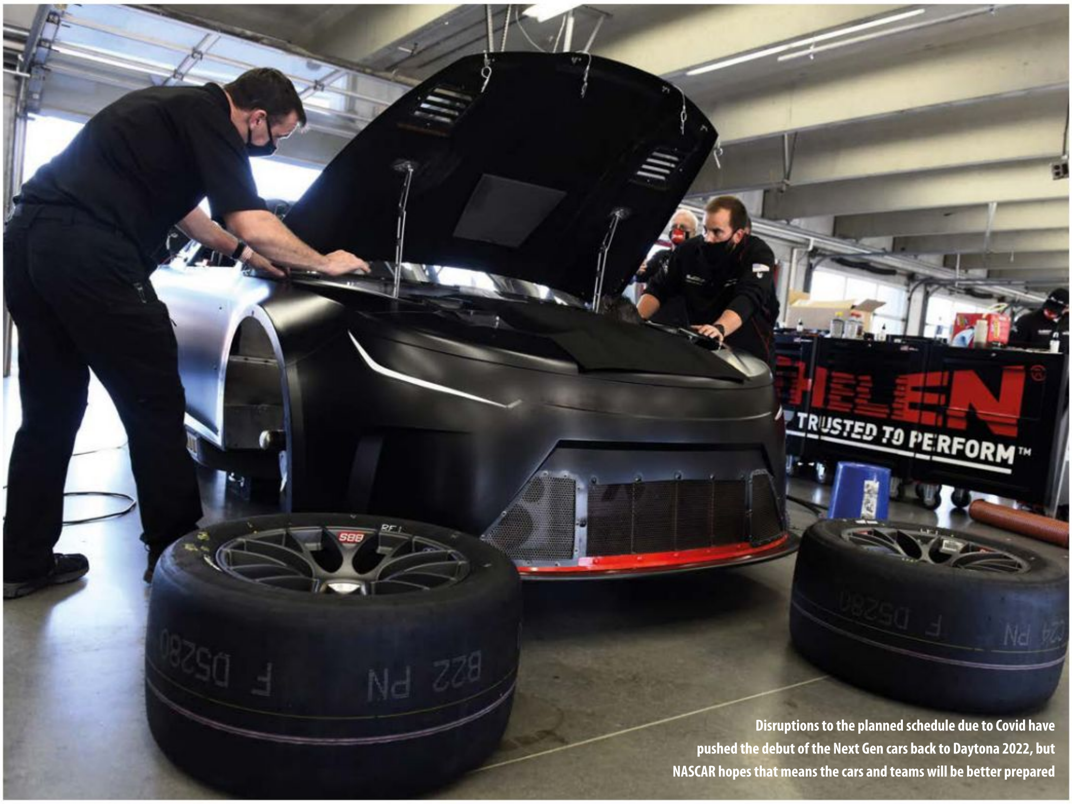
The key point NASCAR was hoping to make with the design of the aerodynamics was that it has put the 'Stock' back into Stock Car racing, thereby making the product more relevant to the OEM production line.

Less noticeable, but with more impact in the competition, will be the reduction in downforce, which will make the cars harder to drive on the road courses.

Manufacturers have been allowed to style their own cars, with consideration given to reducing wheel-to-wheel contact and improving light impact resistance

Downforce has been reduced across the board and new aero devices implemented beneath the cars to improve racing and reduce the risk of blow overs

New technology in safety, suspension set-up, body panel materials and aerodynamics, as well as a focus on aesthetics and a reduction in cost



Disruptions to the planned schedule due to Covid have pushed the debut of the Next Gen cars back to Daytona 2022, but NASCAR hopes that means the cars and teams will be better prepared

Other advances under the skin include softer tyre compounds from single supplier, Goodyear, carbon body parts that aim to better protect the wheels and hopefully reduce the impact of light contact with another car, or the wall, rack and pinion steering, independent rear suspension and a five-speed sequential gearbox.

Key components of the car have been homologated, with sole suppliers including AP Racing (brakes), Hyperco (springs), Öhlins (dampers) and McLaren (ECU), with a view to reducing costs and levelling the playing field.

The ongoing pandemic delayed the new rule set from its originally planned introduction, which would have seen competitors hit the track at Daytona in 2021. Once it became clear the necessary parties could not meet in person for crucial parts of the test programme, including the wind tunnel testing at the Windshear facility for example, the decision was taken to postpone the rules to debut at Daytona, 2022. In doing so, the team relieved the pressure on its own engineers, who would otherwise have faced some all-nighters to process the data and test the parts in time.

However, at the time of that decision, NASCAR was still involved in the computer simulation phase of the design, so the delay was less dramatic than it might have been.

'We were at a point in the project where a lot of what we were doing was largely in the CAD simulation space, so we were able to continue for a while,' said John Probst, NASCAR's senior vice president for racing innovation. 'As some of the key suppliers to the project started getting shut down, we found ourselves in a phase of the project where we were leading into the submissions for the OEMs. And when we do that, it requires the OEMs and NASCAR to be together for the wind tunnel tests and to prepare the cars at the R&D Centre.

'When we got to the point we could no longer co-locate, or even be near each other, [we realised] what was going on.'

Design relevance

This is the third redesign for NASCAR since 2007. The Gen-5, or Car of Tomorrow, was replaced by the sixth generation in 2013.

'The Gen-6 car was really a middle ground where the styling started to come back but the safety features were there, and then this car is a complete re-design,' said NASCAR president, Steve Phelps. 'For us, creating that relevance, creating this thought of we need to put the stock back in Stock Car racing, that's what the styling does. That's what the relevance does, and so that was the important thing for us.

'This has been a long time coming, but we needed to get this right. The cars obviously look fantastic, but also the ability for us to create the testing time necessary, obviously to make sure we get the parts and pieces, get these cars developed, get them on the racetrack and then get the deliveries to the teams is all very important for us to get right.'

There is no doubt the Next Gen cars are a departure from the technology of the old

Aerodynamics has been a key feature of the new regulation set, and the styling departments from the various manufacturers have been allowed to join in the design phase

Next Gen car specs

Length:	193.4in (4912mm)
Width:	78.6in (1971mm)
Height:	50.4in (1280mm)
Wheelbase:	110in (2794mm)
Weight:	c.3300lb (approx. 1497kg)
Spoiler:	TBD
Body:	Composite symmetric body featuring integral flap systems, camera mounts and OEM-specific design elements
Underwing:	Full carbon undertray with stepped centre splitter and rear diffuser
Chassis:	Rectangular steel tube spaceframe with bolt-on front and rear clips and bumpers
Transaxle:	Five-speed sequential manual with ramp and plate differential
Suspension	Double wishbone front and rear; billet aluminium control arms; adjustable coilover dampers
Steering:	Rack and pinion
Wheels:	18 x 12in forged aluminium
Tyres:	Goodyear Eagle
Brakes:	Six-piston monobloc front calipers; four-piston monobloc rear calipers; heavy and light duty disc packages
Front brake discs:	15in
Rear brake discs:	14in
Engine size:	358ci (5.8-litres)
Induction system:	Naturally aspirated
Fuel system:	Fuel injection
Oil system:	Dry sump
Horsepower:	TBD
Engine cooling:	Radiator, with air exits through bonnet louvres
Exhaust:	Split side exit exhaust
Fuel cell:	c.20 gallons
Fuel:	Sunoco Green E15


New composite body shape is symmetrical, unlike previous generations, and was designed in CAD simulation


Cars are lower and wider than Gen-6, but ride 2in higher. Aero details include a carbon undertray and stepped splitter

'The Gen-6 car was really a middle ground where the styling started to come back but the safety features were there, and then this car is a complete re-design'

Steve Phelps, NASCAR president

Steve Phelps

cars, but there are a few points NASCAR wanted to continue. Namely the close, competitive racing for which the category is famous. For that, aerodynamics has been a key feature of the new regulation set, and the styling departments from the various manufacturers have been allowed to join in the design phase.

The cars in general feature a shorter rear deck, a lower roof and are wider, giving them a more aggressive stance than their predecessors. While this gives a completely different baseline from which the teams must work when they start competition next year, the styling change has been warmly welcomed by the manufacturers involved.

'At the very beginning of this journey, when we were trying to draw lines around what we wanted with the Next Gen, one of the things all three OEMs agreed on is more styling relevancy,' says David Wilson, president of TRD. 'We wanted to get away from that big, boxy greenhouse. To do that, we had to accept the challenge that we're going to have cars that aren't as neatly in the aero box we've been used to over the years.'

While the design is individual to each manufacturer, it poses a threat to aero efficiency and challenges the idea of bringing the cars closer together on track. However, all the interested parties were convinced it was a necessary step for the category.

Symmetry in motion

A further change will see a symmetrical car body, removing the skew and tail offset from the centreline teams have previously used to create right-side force. This will bring about a total change in set up and driving style on track.

'One of the things we noticed around our racing is the side force issue, and that was something we really tried to tackle with this new racecar,' says NASCAR's chief of racing development, Steve O'Donnell. 'It is going to be more difficult to drive, especially as you get into the corners, but that's something we're encouraged by. We want to put more of this back in the drivers' hands, so we'll judge what – especially on the intermediate tracks – the drivers are able to do on each and every lap, pulling up on cars and that ability to pass and not be stalled out.'

The new composite body panels will be produced by Five Star Fabricating Inc, which was phased into the Xfinity Series in 2017. NASCAR noticed that Xfinity competitors stood a better chance of continuing their race after mild contact with the wall than the steel-bodied Cup competitors, and so the decision was taken to carry it over.

'You can be dominating at Homestead and have a little brush against the wall with a sheet metal body and you get that little bit of deformation, almost like a soda can or something you'd smash. Occasionally, once you lose the shape, you see that you hurt the car and that can really impact your day, and performance,' says Probst. 'We also see it when cars get together. A lot of times the damage will impact the performance of the car as they move forward, but then also a lot of times you'll see flat tyres result from that.

'With the new car we have tried to inset the tyres a little bit off the body so they're not the first point of contact.'

'In the Cup Series, we're able to use some more advanced materials with respect to the carbon lay-ups. The vendor has demonstrated this through very non-scientific methods of a front-end loader smashing body panels into the parking lot. You can actually see the body panel return to near original shape after some pretty significant hits.'

Chassis development

As with other series, tyres have got bigger too, and are now fitted to 18in wheels (up from 15in). They will carry more load than before, and so tyre development has been a big issue for supplier, Goodyear. The car will run with two inches more ride height and a closed underbody design will reduce the amount of dirty air behind the car in a bid to make the racing closer.

Chassis-wise, the new cars will use rectangular tubing for the spaceframe, a shift from the tubular design of the current cars, while roof flaps will carry over to the new cars. A lower-mounted diffuser flap will further help keep cars on the ground in the event of a 180-degree spin on the faster speedways, after extensive development work between NASCAR and the OEMs.

Currently, organisers anticipate having two rules packages with the new car, a low-downforce, low- drag, high-horsepower version and a high-downforce, lower horsepower package.

An independent rear suspension replaces the traditional solid rear axle, and the Next Gen car will no longer have a track bar for adjustments. Teams will instead tune five-way adjustable dampers, and there will be a travel limiter to retain the higher ride height.

'By having independent rear suspension there's a whole other degree of freedom, different things at the rear that you can't do now,' says Eric Warren, director of NASCAR programmes for GM.

'The Next Gen car really allows us to have both ends of the car. Also, there's some differences in the way the dampers,

Wheel size has increased from the traditional 15 to 18in, changing the way the Goodyear rubber will perform on all types of circuit

'By having independent rear suspension there's a whole other degree of freedom, different things at the rear that you can't do now'

Eric Warren, director of NASCAR programmes for General Motors

One of the minor detail changes for 2022 is the switch to a single, centrally-mounted lug nut to hold the 18 x 12in wheels in place

Eric Warren

springs and suspension attach to the car, and new adjustments to how much load goes into the steering. The number of variables you can change are actually a lot higher than what exists in the current car.'

Global director of Ford Performance, Mark Rushbrook, agrees. 'To be able to have an independent rear suspension, the rack and pinion steering, the driveline, that's all important to us as a manufacturer,' he says. 'To have more relevance to that architecture, and to be able to transfer learning back and forth between road, track and back to the road again.'

The Next Gen car will also feature significantly larger brakes from AP Racing (see news story on p76) and a 20-gallon fuel cell, holding approximately two gallons more than the current model.

In a groundbreaking update, the Next Gen car will also have a sequential five-speed gearshift for the first time, the new 'box replacing the standard H-pattern four speed that has been a NASCAR staple for decades.

A new transaxle is expected to better accommodate the potential for hybrid in later models, although NASCAR has not yet stated a schedule for the introduction of the technology.

Safety advances

Key to the regulations is, of course, safety. NASCAR has worked with the OEMs using LS-Dyna, which is commonly used in crash simulation. 'We went through countless iterations of the car, simulating all the different events we have seen over


It's a new dawn,
It's a new day,
and we're Feeling GOOD.

Suspension sees a step change, with the Next Gen being the first NASCAR to feature independent rear suspension

With five-way adjustable dampers, organisers think teams will have an unprecedented level of tuning

Next Gen car vendors

Aero Tec Laboratories, Inc	Fuel cell bladder
AP Racing Ltd	Brake systems
Bald Spot Sports Energy Management Solutions	Bumper and door foams
BBS of America, Inc	Wheels
Dallara	Radiator ducts
Fibreworks Composites, LLC	Boot lid, bonnet, rocker box, cooling ducts, underwing
Five Star Race Car Bodies	Doors, wings, bumper covers, fuel adapter, quarter panels, rear door crush panel, rear wheel tubs, windows
Goodyear	Tyres
Hyperco	Coil springs
Kirkey Racing Fabrication	Bumpers
Lentus Composites Ltd	Propshaft
McLaren	Digital dash, ECU
Öhlins USA, Inc	Dampers
Pro-Fabrication, Inc	Tailpipes
PWR North America	Oil cooler, radiator
RCR Manufacturing Solutions, LLC	Wheel nuts
Roush Advanced Composites	Greenhouse, brake ducts (upright / rotor), front door crush panels, front wheel exhaust cover, package tray, roof hatch, roof flaps, spoiler base
Roush Yates Manufacturing Solutions	Anti-roll bars, shifter, transaxle mounts, uprights / wheel hubs
Schultz Engineered Products	Fuel adaptor / coupler
Sunoco	Fuel
Technique Chassis, LLC	Chassis: front / centre / rear and body mounts
Thermal Control Products	Fixed window net / driver window net / assemblies
Tilton Engineering, Inc	Bellhousing
Visser Precision, LLC	Control arms front and rear
Woodward Machine Corporation	Steering rack, steering shaft
Xtrac Inc	Clutch shaft, driveshafts, transaxle

the years just to evaluate how the cars performed,' explained Probst. 'When you lean on a lot of our OEMs' experience in that world, as well as the really in-depth database of our own, [we have] over 2,500 events now that we compare the cars to.

'I think from a tool perspective, we are now able to validate as we go, and as all the little bits and pieces validate themselves, there really is an expectation for no surprises out the back end when we finally do the full entire car crash in June.'

Crash course

While Formula 1 crashes commonly occur at lower speeds in cornering, and IndyCar has an exposed driver's head to protect from high-speed objects, NASCAR also has its own most common accident scenarios, including right front corner into the wall, t-bone accidents where a car has spun in the pack and rear-facing blow overs. Diffuser design has been changed to address the latter, with flaps introduced at the rear to help keep the car on the ground, even if it has spun through 180 degrees at high speed, but NASCAR admits is still has more work to do.

'When you look at the new car, it's a balance of stiffness because you don't want the typical intrusion, especially in the centre section of the car. Generally, the main direction of anything that would harm the driver is from an intrusion perspective,' says Probst. 'Certainly, with SAFER barriers and things of that nature, we have tried to as best as possible mitigate the thing that could impact the driver from a crush, or lack of crush perspective.

'This new car implements a lot of front and rear crash structures that have been thought through that process and tested pretty heavily at the clip level. We have taken the car to some of the lab tests that all the OEMs use, and run them at load and at speed into walls.'

The development team says it has focused more on safety and encouraging close racing than setting fastest times, as has been targeted by series such as IndyCar.

After seven years with the Gen-6 cars, the field is proving tighter than ever this year, with 10 different winners emerging from the first 11 races of the 2021 season.

'We'll look at not necessarily speeds, we want to look at the safety aspect for sure,

There really is an expectation for no surprises out the back end when we finally do the full entire car crash in June

John Probst, NASCAR senior vice president for racing innovation

John Probst at the launch of the Next Gen NASCAR in May

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but we're going to look at how many teams can be competitive, the number of different leaders, the number of different winners, the OEMs, are they all going to be able to compete?' says O'Donnell.

Future fuels

Perhaps the biggest revelation of all from NASCAR was its consideration for future powertrain. While it is well known that the series is looking at hybrid, and likely to share the suppliers with its sister company IMSA, NASCAR admitted recently it was also looking at hydrogen as a fuel source possibility.

'It's something that we are having a lot of discussions with our OEM partners about,' confirms Phelps of the introduction of hybrid. 'The Next Gen car will certainly have the opportunity, if we decide to go to some form of electrification in a hybrid vehicle or hybrid engine. I would have said before Covid that we were maybe looking at 2023, [but] it could be 2024. I think, frankly, the opportunity to have a new OEM partner will largely depend on what happens with that hybrid engine.

'We are in collaboration, and I think when you look at our relationship with the OEMs when it comes to alternative powertrains, whether that be hybrid or some form of electric or hydrogen combustion, there is a very aggressive development in the direction of change away from internal combustion engines,' continues Probst. 'We have also been very open that we'd like to see more OEMs come into our sport. We actively engage our current OEMs and potential OEMs all the time on where they want to go with respect to that.'

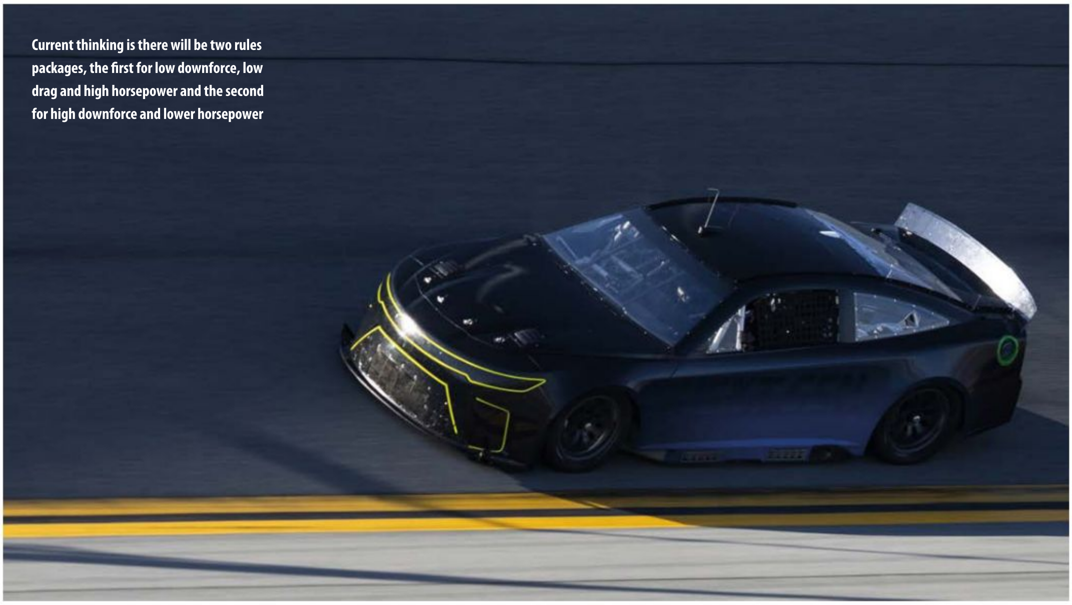
Denny Hamlin (left) and David Wilson, Toyota Racing Development USA president and general manager with the Next Gen Camry

On-track testing will continue this season, with a multi-car test scheduled at Daytona in August, 'roval' and oval track testing in October and then another multi-car test after Phoenix at the end of the season, with scope for more testing prior to the opening round of 2022 at Daytona.

Development will, of course, continue through the 2022 season as more is learned about the cars in true racing conditions that currently have not been simulated, but for now NASCAR has done all it can to tread the line between what the manufacturers and the fans want from their racing.

I think, frankly, the opportunity to have a new OEM partner will largely depend on what happens with that hybrid engine

Steve Phelps, NASCAR president


Current thinking is there will be two rules packages, the first for low downforce, low drag and high horsepower and the second for high downforce and lower horsepower

Storm in a teacup

The introduction of Hypercar has meant the FIA and ACO have compromised every other category in their portfolio and led to total confusion for all on track

By ANDREW COTTON

The introduction of the Hypercar formula to the FIA World Endurance Championship was always predicted to be challenging and, at the opening round of the 2021 season at Spa Francorchamps early in May, so it proved.

The new cars are considerably slower than the old LMP1s by design, with cost at the heart of the regulations designed to encourage competition, and this has led to a compromise for every one of the classes in its portfolio.

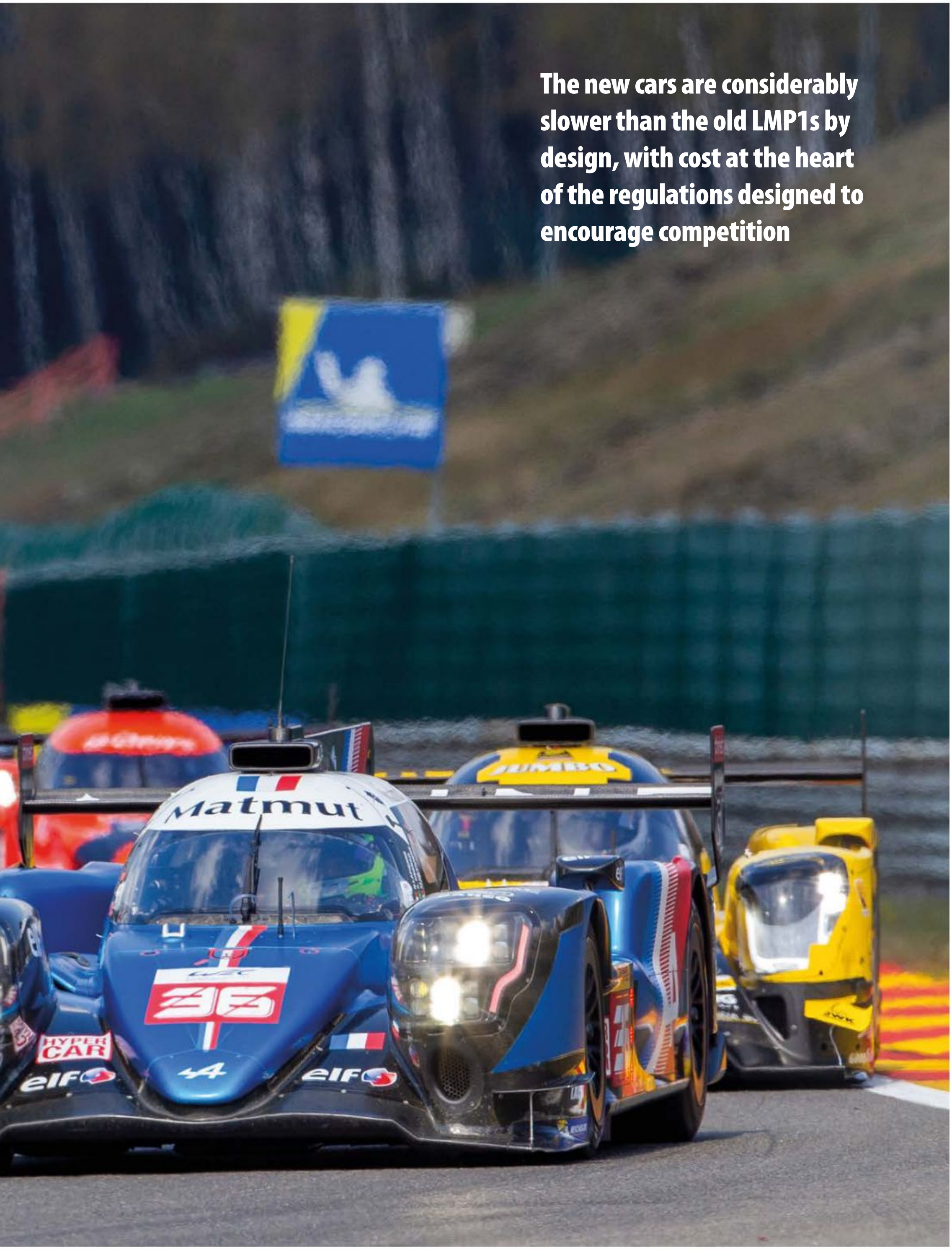
Slow burn

By introducing a slower top class, LMP2 for amateur drivers has had to be performance balanced to slow it down. GTE has remained largely untouched, but is now so close to the performance of the Hypercars at various points of the circuit that overtaking is extremely challenging for all.

As always, the Le Mans circuit is the main focus of the performance balancing and the Hypercars are targeted to complete 12 laps per stint at Le Mans with a race lap time of around 3m30s. This compares with the fastest LMP1 race lap in 2020, held in hot and dry conditions, of 3m19.2s, so around 11 seconds per lap slower.

That is then translated to the other circuits that comprise the FIA WEC calendar, including Spa, Portimao and Monza, prior to Le Mans scheduled to be held in August.

Photos: XPB Images



The new cars are considerably slower than the old LMP1s by design, with cost at the heart of the regulations designed to encourage competition

With such a drop in performance at each of the circuits, the other categories have also had to be slowed in order to allow Hypercars to qualify and race as the top class.

To provide comparative lap times, the fastest LMP2 race lap at Le Mans in 2020 was a 3m27.5s, so it was clear from the start that they had to be slowed significantly. What occurred at Spa, though, was that although the FIA handicapped the LMP2s as much as it dared, they were still far closer to the Toyotas and grandfathered Alpine than the Hypercar manufacturers expected, and definitely closer than was comfortable.

That led to a week of arguments, and a BoP change for the Hypercars ahead of the first race meant under race conditions the Toyotas and Alpines were comfortably ahead of the LMP2 cars, leading many to wonder what the fuss was all about.

Hyper balanced

The Hypercars are built to fit into performance windows of weight, lift / drag and power, and at Spa Toyota was public in its insistence that it had hit the performance targets prescribed by the FIA and ACO. For the LMP2 teams, they had been prescribed a power loss of 50kW (nearly 70bhp), had the maximum weight added to them that the crash test limits would allow (20kg) and the FIA and ACO demanded a slower tyre from sole supplier, Goodyear. They were also mandated to run the low-drag bodykits designed for the Le Mans circuit, although that effect was reduced at Spa due to the high-speed sectors one and three.

These measures, the organisers hoped, would slow the LMP2 cars enough that a gap would remain between its Prototype classes. However, despite being more difficult to drive than before, the LMP2s were still fast enough to trouble the Hypercars in the pre-season test held on the Monday and Tuesday prior to the opening race.

The fact that the teams were focusing more on qualifying simulation than race pace, while Toyota focused almost entirely on race set-up, did not deter the Japanese manufacturer from raising complaints with the governing body. Toyota was angry that the gap between the Hypercar and LMP2 classes was so small that, in certain race conditions, they feared the LMP2 cars could still be faster.

'Our point was that the gap is not big enough between the two categories,' says Toyota's team principal, Pascal Vasselon.

The FIA and ACO, in consultation with Gibson, which powers the Alpine, during a meeting with the Hypercar teams agreed to waive the coefficient for altitude and allow the cars to run at a full 520kW rather than the altitude-adjusted 502kW planned.

'The gap is not what we would like to see,' continues Vasselon. 'It is enough to be on pole, enough to win the race, but there is not enough gap between the two categories. What we are saying is that we will see inversion of lap times [in certain race conditions] and that is not what we expected.'

High-speed advantage

The Hypercars had the advantage on the high-speed sections of Belgian track, namely the Kemmel Straight and the run from Stavelot to the Bus Stop chicane, but in the second sector the LMP2 and GT cars that were fast were able to keep touch with the Toyotas. This does not bode well for the second race, in Portimao mid-June, although Monza and Le Mans are more likely to see the gap in classes the FIA and ACO expected.

If the Hypercars were on full tanks and just starting a second stint on the same tyre, argued Toyota, the LMP2 cars could overtake. This would not look good for the championship and could be difficult for its drivers, should they emerge in traffic, even if the LMP2 car was being lapped.

Indeed, the drivers of cars in other classes were also running into problems with the Prototypes, particularly in the braking zones where there was a clear danger. All were braking at a similar point, making it difficult for the Prototypes to overtake at all in braking zones and creating something of a traffic jam.

'They don't have the speed difference between the cars that you need to make the passes cleanly,' notes Corvette's Oliver Gavin. 'We are all braking at the same place, and you leave the door open for the cars to go past, but they only just manage, inching past you.

> **'They don't have the speed difference between the cars that you need to make the passes cleanly'**
> *Oliver Gavin, driver for Corvette Racing*

The Toyota GR010 was not as reliable as the team would have liked over the Spa week, with hydraulic and electrical gremlins slowing the cars in the pre-season test, while mistakes in the pit made the result closer than might have been expected

With more weight, less power and using the Le Mans aero kit, the LMP2 cars were struggling to pass the GTE cars, especially in braking zones, leading to traffic jams through the twisty second sector and slower lap times as a result

The GR010s looked unwieldy through the corners to the naked eye, and also to drivers in other cars on track. Set-up changes and a BoP adjustment pre-race allowed the Hypercars to pick up speed through the race weekend

Corvette Racing took part in the Spa Francorchamps race to help the FIA and ACO finalise its Balance of Performance for Le Mans in August. The new class stratification between LMP2 and GTE made life challenging for all of the drivers

'The old cars would also not need the whole road but these Hypercars, you can see the body roll, you can see that they are slow, and they then need the whole road on corner exit to carry the speed.

'There is a bottleneck created and everyone is fighting for that same piece of road. At some point you run out of road.'

Heightened tension

For the Hypercar teams, there was never a question that they would win the race if they proved reliable. However, despite multiple 30-hour tests, the Toyotas were not perfectly reliable ahead of the first round of the season. One new car was brought to the pre-season test with the team still chasing electrical and hydraulic gremlins, which only served to heighten the tension and the prospect of an LMP2 car winning the race overall.

The Hypercars could look forward to better tyre wear over a race stint with their rising averages looking more promising than those of the LMP2 cars, and they were scheduled to do at least two stops fewer than the LMP2 cars over the course of a six-hour race. Overall race pace would therefore always play into their favour.

In qualifying, the Toyotas were indeed faster than the LMP2s, by 1.6s, having found a lot of pace for the qualifying session. Toyota maintained it was normal to find four seconds between the first practice session and qualifying, and its drivers confirmed they had not practiced many qualifying runs before the first race.

'The car is so heavy now that when you take 60kg [of fuel] out of it then it makes a big difference,' confirms Toyota driver, Mike Conway.

Although the Toyotas were on the front row as expected, this class stratification issue had not gone away. At Spa in 2019, the gap between the two categories was 6.9s and Toyota had expected a similar gap between the two categories when Hypercar was introduced. After qualifying, Vasselon stated that the gap needed to be at least four seconds to prevent a situation where the LMP2 car could be faster.

'The gap is small, and it is enough to win a race, but for us, the prospect is when the field of LMH has 10-16 cars. With a gap this small, the grid will be completely mixed [and] the cars will be on top of each other,' says Vasselon, adding, 'but we still have time to think about it.'

Hyper vision

The issue for the Hypercar category is that not all the manufacturers have elected to build cars to the same set of regulations. The LMH (Le Mans Hypercar) cars are ground-up designs with the manufacturer homologating its own version for the five-year period. The capability is there to run hybrid power at the front axle, making them four-wheel drive, though not all manufacturers will choose this option. Indeed, those that have yet to commit still have to make the technical decisions whether or not to run four-wheel drive.

At Daytona in 2020, the ACO and IMSA announced there would be a convergence between the LMH cars and the second generation DPi model favoured by the Americans. This rule set, called LMDh, continues to use the base LMP2 chassis, which is homologated including the suspension and gearbox, and fitted with a manufacturer-supplied engine and aero kit.

The second generation cars, due to be introduced in 2023, will be produced by ORECA, Dallara, Multimatic and Ligier, and will also be fitted with a small, spec hybrid system from Bosch and a battery from Williams Advanced Engineering.

Maximum power output from the LMDh cars should be 500kW from the combination of hybrid and ICE, with a minimum weight of 1030kg, and a lift / drag coefficient of 4:1.

The LMDh cars will be designed to have the capability to be as fast as the Hypercars and will have to fit into the same performance window as their more expensive cousins.

That link between LMDh and LMH is critical, because both Audi and Porsche, which have elected to run LMDh cars and make them available for sale to customers, will want the cars to be competitive in the US and in Europe, where they will each be looking to add to their tally of Le Mans wins.

'It is a difficult topic,' admits Vasselon. 'Hypercar has been made slower in several steps. The LMDh cars will be 1030kg and 500kW. If we [LMH manufacturers] increase the engine power [to increase the gap to LMP2], which we could do, we would not be on the rails for convergence with LMDh. We already can make our car faster if they change the parameters, but that will be difficult. Originally, the [LMH] weight was down and the power was at 585kW.'

That references a large number of changes made as the Hypercar concept slowly came together, somewhat derailed in the process by the demands of British manufacturers Aston Martin and McLaren, who ultimately elected not to continue with their programmes anyway and never built a Hypercar.

Once it became clear neither constructor would build a car for the series, the ACO sought to make an agreement with IMSA to take its second generation cars. That would certainly help fill the grid, but the Americans were adamant they would not exceed 500kW engine power in order to keep costs under control and make the engine formula accessible for the majority of manufacturers.

In thrashing out their own rules, the arguments over the power delivered by the hybrid system cost IMSA manufacturers, including Ford, which wanted a high-power hybrid but did not want to build a ground-up LMH car.

With power settled and the Americans sticking to their guns, the Hypercar manufacturers had to agree to change so, instead of building cars to more than 800bhp in order to compete with the Aston Martin Valkyrie, their targets were now considerably less challenging in order to race LMDh cars. They agreed to bring power levels down to align with LMDh, but that led directly to the conflict with LMP2 that will play out this year.

Hyper complicated

Despite the issues in the build up to the Spa event, and the closeness in qualifying, the FIA's plan is to see how the next few races pan out before it decides whether any more changes are required to Hypercar, or any further changes to LMP2, in order to create the desired gap between the classes. Options open to the technical teams include a spec gear ratio and a maximum downforce limit for the LMP2s, as adopted by IMSA, but which heralded a large-scale departure of competitors.

'We did a lot of work in terms of simulation before this event,' said the ACO's director of competition, Thierry Bouvet, ahead of the Spa race. 'We did a new homologation process of Hypercar where we put the car in the wind tunnel. We now have some torque meters that monitor the output of the engine. Weight is another parameter that is important for performance. And finally, we have the option of tyres. For now, that work has been done. Will there be more? Clearly not at this point.'

The reason for allowing the race at Spa to pan out was so the technical teams could see if there was genuinely a need to make a change in order to affect the race result, rather than qualifying, or the inversion of

Changes to refuelling regulations mean the rig must stay attached for a minimum of 35s, even if refuelling is completed earlier

The weather at Spa was dry throughout, leaving the performance balancing teams with plenty of data from all the cars in each of the four categories to work with going forward

Toyota was pushing for a greater lap time gap between itself and the LMP2 cars, despite having the advantage over long runs and in fuel consumption compared to everyone else, including the grandfathered Alpine LMP1 car

United Autosport was the fastest of the LMP2 cars at Spa and, for a few hundred yards at the start, Phil Hanson led the race overall. However, shorter stints and worse tyre wear handed the overall advantage to Hypercars

‘It is also a challenge for the teams to adapt to the new rules because racing is about trying to reach the limits’

Marek Nawarecki, FIA director of sport and touring cars

lap times inferred by Vasselon. ‘There is a difference between the real performance and the race performance of a car, and there is also another difference between the performance factors,’ says the FIA’s director of sport and touring cars, Marek Nawarecki. ‘We are monitoring the first parameters of the performance of each car.

‘That doesn’t mean if they use that performance they will have exactly the same lap time because then there would be no more racing. So, the focus is to make equal the first levels on the first factors of the performance for the different types of cars. That is the goal and, according to what is monitored, that goal is close to the initial objective.’

The problem with balancing performance of multiple classes, and particularly with manufacturers, is they have a tendency to ‘play the game’. There are also different ways to approach a race weekend, with Toyota preferring to focus on long runs to affect the race result, while the LMP2 cars focussed more on qualifying runs with a view to nailing a spot on the front row.

Playing the game

It is widely assumed Toyota arrived at Spa within the performance window set by the FIA, but not with the maximum potential the car may achieve. That is unlikely to be seen before Le Mans 2023, when the full grid will be assembled, including Peugeot, Ferrari and LMDh cars from Porsche and Audi. The FIA and the ACO have to manage expectations before that.

‘It is very diverse and an open kind of technical regulation, and we allowed that for this category,’ says Nawarecki. ‘This allows us to have something very consistent in approach. It also allows us to put all the different cars together, which is not an easy task, but I think that all the technical team worked quite hard to find the correct balance.

‘It is also a challenge for the teams to adapt to the new rules because racing is about trying to reach the limits.’

The different track surfaces, layouts and altitudes are certainly going to play a part in the qualifying sessions for this season, and Peugeot is expected to play the same game as Toyota when it arrives next season.

It would seem then that we have a few years yet of arguments and unusual grid positions ahead but, should they remain reliable, it is more likely than not a Hypercar has enough performance advantage to win the majority of races in 2021.

Hyper confusion

A quick guide to the different categories referred to in this article, and how they stack up against one another.

Hypercar
The overall category designed by the FIA and ACO to replace the old LMP1 class.

Le Mans Hypercar (LMH)
Cars that can compete in the Hypercar category. Ground-up design, with manufacturer involvement in all aspects of the development. Maximum power output: 520kW (500kW at Le Mans) from combination of ICE and hybrid. Weight: 1040kg (Toyota); 1030kg (Glickenhaus). Tyres from Michelin.

LMDh
To be introduced in 2023. Can compete in the Hypercar category in WEC, but main focus is IMSA WeatherTech Sportscar Championship. Base chassis is LMP2 (as described below), OEMs provide engine and aero kit. Spec, low-power hybrid for the rear axle only (from Bosch, Williams). Weight: 1030kg. Power output: 500kW. Tyres from Michelin.

Alpine
LMP1 car formerly run by Rebellion, with ORECA chassis, Gibson GL458 4.5-litre V8 engine, power reduction compared to 2020, and weight increase (930kg). To compete with Le Mans Hypercar.

LMP2
2023 specifications TBA, but base chassis from one of four manufacturers selected by the FIA. Suspension, brakes, clutch, aero kit all homologated by chassis manufacturer. Powered by Gibson GK428 4.2-litre V8 engine. Tyres from Goodyear. In 2021 WEC-spec, minimum weight: 950kg and power: 560bhp (417kW). Le Mans bodykit only (WEC only).

Two steps beyond

Michelin and Goodyear have sliced up the FIA World Endurance Championship and become sole tyre suppliers to individual classes within it, but with very different targets

By ANDREW COTTON

Photo: XPB


JOTA
GOODYEAR
EAGLE
BNI
P2

The FIA has continued its path to reduce competition in the face of cost control measures and in the FIA WEC awarded Michelin the Hypercar tyre deal, while Goodyear was granted the LMP2 sole supplier contract. Naturally, both manufacturers have been tasked with providing tyres that fit the FIA's performance targets and while Michelin has a parameter for Hypercar that is all new, Goodyear has been given the job of coming out of open competition and running tyres significantly slower than in 2020.

The criteria was laid out in the tender and both companies submitted bids, but the manufacturers on which the FIA increasingly relies insisted Michelin be awarded Hypercar, while Goodyear provides tyres for the customer racing LMP2 class.

With both tyre makers secure for three years and an option for a further two, the sands have shifted slightly under the feet of the rule makers as the Hypercars made their debut at Spa early in May and tyre peformance was one of issues.

Michelin's task has not been easy, developing a tyre for a car that, until late on in 2020, did not exist. Under the original tender, tyres developed for the first race would have to suffice for the last race of the 2025 season but, with the deal safely secured, the tyre company now has three defined stages of development, and can enact them when it chooses.

Photo: XPB

Michelin's Hypercar tyre is a cross between a GT construction to handle the weight, and a Prototype compound for performance. Despite the homologation being fixed, it has room to change

'You don't get a one size fits all anywhere, but especially in motorsport'

Matthieu Bonardel, Michelin

Photo: XPB

Alpine ran the ORECA Gibson package previously campaigned by Rebellion and, despite BoP restrictions, asked that the tyres be kept the same. Luckily, the car's characteristics remain similar

Photo: XPB

The Toyota GR010 is heavier, slower and less powerful than the TS050 that it replaces, meaning tyre development for this season was extensive. Michelin took a conservative approach for year one.

The manufacturers on which the FIA increasingly relies insisted Michelin be awarded Hypercar, while Goodyear provides tyres for the customer racing LMP2 class

There is a further complication, though, in that the LMH hybrids are four-wheel drive, while the Glickenhaus that will debut at Portimao in June will be rear-wheel drive, and the tyres on the 007C will be similar to the ones used for LMDh, which will be used in the Hypercar class in the WEC, and the top class in IMSA in the US.

Digital development

'What has been really new in this adventure is the short lead time and a paper describing the specification of the car,' highlights Michelin's Matthieu Bonardel. 'Pretty much all of [our development] was done through digital with simulation. We had the input from machine testing, and then iterations coming back from Toyota and from Glickenhaus. They would go for a test and then come back with new parameters and we had to adapt the tyre to that.

'In the end, we came up with the fact that we are being asked to provide two different types of sizes, one for cars that would be centred, so half and half front and rear axle, which is where one would expect four-wheel drive would be, and another for weight distribution that is more appropriate for rear-wheel drive, so more weight on the back. This made two families of tyres.'

The way in which the tyres work is totally different to those of the LMP1 hybrids. They had around 500bhp from the ICE, and a further 500bhp from the hybrid system delivering power primarily to the front wheels. Under Hypercar regulations, the maximum total power output is 520kW, regardless of whether the power comes from ICE or a combination of ICE and hybrid, at Spa power was able to be delivered to the front axle only above 130km/h.

One size doesn't fit all

'It is more complicated because you don't get a one size fits all anywhere, but especially in motorsport,' says Bonardel. 'You don't have enough downforce where you want it, which is the low-speed tracks, so the tyre slides and wear and heat increases. Then, when you don't want the downforce, like [at] Monza and Le Mans, you get significantly more downforce than you need, which then causes more stress on the tyres.

'In the end, you end up with wishing lower downforce here, and higher downforce there, but no, on the high-speed track it will get too much load.

'People say the cars have less power and are heavier, and it should be easier on the tyre, but it is not. It is 40-50 per cent harder in the rear than with the previous generation because of the weight and downforce and the extra power, and the top speed will not be that different.

'We are reasonably confident we will have things under control at Le Mans. We say we are not going to shoot for five stints this year, but we are confident for two stints. We have to see at the test day if we can go beyond two.

'The reason we are in wait and see mode is because we want real data from real cars on track. Now, we are now dealing with prediction and the regulations are changing.'

The extra weight of the new generation cars and the limitations on cooling due to the single aero package means the tyres must necessarily run hotter, and be designed to do so.

'It is a different load and so the profile has to be adjusted to cope with that load,' confirms Bonardel. 'Then there is significant change in compound to tune them to the front and the rear of the car, and the fact that it shifted in terms of temperature. More weight equals more heat and so, compared to the previous Prototype, we are roughly 20degC hotter.

'For sure, we are moving closer to the territory of the heat of GT with a signature that is closer to a Prototype. Luckily, because we are in both categories, we can combine our knowledge.

'The temperature is dictated by the weight and downforce of the car, and there is not much they can do to change that. The centre of mass and weight of the car is similar, or with slightly higher camber to counter the roll. This is not unusual for GT, but is unusual for a Prototype.'

Changing the tyre through the five-year window means Michelin will be able to adjust first for safety and then, after that, bring in new, more environmentally friendly techniques in the construction of the tyre.

'One of the advantages of being the sole tyre supplier is I can do what I want, with justification,' adds Bonardel. 'If I need to change it, I can. Even if we don't have to change the tyres because there is a performance or safety reason to do so, we still have the plan to change it for next year.

'If I can go five stints at Le Mans then we might reconsider, but it is the plan to change it next year to tune it to more longevity and less wear, and we want it to be a nice place to showcase innovation and anything that is in the spirit of sustainability.

'That could mean using the tyre for more stints, it could mean more resistance to punctures, it could be to facilitate heat up to avoid needing tyre warmers, or it could be to introduce bio-sourced or recycled material. In Moto-e we put bio-sourced and some recycled carbon back, so we are developing some kind of knowledge in race conditions. The ACO and the FIA want us to do that.'

New blood

One of the big changes coming is the introduction of new manufacturers with different cars. Peugeot will join the grid in 2022, and Ferrari in 2023, along with the LMDh cars from Porsche and Audi. Will they receive individually spec'd tyres, or will the two families of tyre technology suffice?

'If they are in the same window of weight and balance then they have the same tyres,' states Bonardel. 'If they have something that is significantly different, then we say we are not going to have the same. This is the reason Glickenhaus has a different tyre. They have a different signature [and] they have a heavier car, it is two-wheel drive.

'The Alpine is grandfathered. They asked that we don't mess up the car, give them the same tyre as when they were Rebellion. But we had to say you remove power and add weight, so it is a different car. Luckily, the different things compensate. Less power is less heat, more weight is more heat, and they put more weight in the front, so they are happy with their car. We said okay, let's not make it difficult.'

'People say the cars have less power and are heavier, and it should be easier on the tyre, but it is not. It is 40-50 per cent harder in the rear than with the previous generation'

Matthieu Bonardel, Michelin

Unfinished business

The tyres for the Glickenhaus 007C are different sizes to anything Michelin has produced before. Like the Hypercar itself, they were developed in CFD first, and are now on track with a heavy development programme.

'The front and rear are brand new, and we have no experience,' confirms Bonardel. 'I am glad Jim [Glickenhaus] was happy with the mileage driven, but we are not. We had one test session where they were limited. Our experience with the new front and new rear, and all the compound, we are much more at ease with the Toyota.

Photo: WEC

Goodyear has been awarded the LMP2 tyre contract for three years, with an option on a further two, and is hoping it can use that time to break into the Hypercar market with its range

Photo: XPB

The United Autosport team dominated LMP2 at Spa, and was a threat to the Hypercars, despite measures to slow the cars in the lower category that included bringing a slower tyre to the class

'They were not able to do long runs from day one. They have to fix electronics and things like that. It is a new car, so I don't even know from a pace standpoint if we are able to do some of the things we would like. The development is not finished with this type of tyre.

'It is very important because the front and rear tyre sizes will be the basis of LMDh. This is why I am taking everything that I can learn from this project because very soon Porsche and Audi will want this tyre, and I will have to make another decision. Is it the same tyre as Glickenhaus? Can I use the same mould, or do I need another one?'

Michelin is aiming to maintain the same technology for all its tyres, and allow the FIA and ACO to balance the performance of the cars using the tools at their disposal.

Total change

The Hypercars are due to lose around 15 seconds per lap at Le Mans, making them slower than the LMP2 cars' lap times in

Mike McGregor (left) led the Goodyear team to develop tyres to fit the FIA's prescribed performance criteria

2020, which led to the inevitable conclusion that the latter would need performance restrictions ahead of the 2021 season.

The FIA and ACO therefore added 20kg to their base weight, the maximum that could be applied without the need for further crash testing, mandated a 50kW reduction in engine performance, a single, low-downforce aero package specifically designed for Le Mans and a slower tyre from Goodyear. In all, these changes were supposed to add up to a 10-second reduction in lap time at Le Mans, leaving still at least five seconds between the Hypercar and LMP2 categories.

For Goodyear, designing a tyre that is supposed to make up two of those seconds at Le Mans required a total change in thinking. Normally, tyres could be compared like for like, but in this scenario it was more a question of bad, or worse?

'What we've done previously is have a rating sheet that we work to where five is our baseline, 10 is better, and zero is worse,' says Goodyear's programme manager, Mike McGregor. 'All of a sudden, when you're doing a tyre performance drop, it's hard then to speak to the drivers to get them to understand how you're trying to write a product, to score it to move forward in that direction.'

'We did the first test in February 2020, targeting a two second drop in lap time compared to the 2019 LMP2 time, just in tyre development'

Mike McGregor, programme manager at Goodyear

Testing times

That was to be the scenario once the tyre manufacturer got to the track, and circuits have been booked and paid for, but the ongoing Covid pandemic means they have simply not been able to get cars and tyres to the circuits as planned.

'We did the first test in February 2020, targeting a two second drop in lap time compared to the 2019 LMP2 time, just in tyre development,' recalls McGregor, 'but then Covid hit. We had 15 tests booked between then and November, which is when we actually had the second test. With lockdown, and the changing schedules, either cars weren't available, or circuits weren't ready.'

The team had multiple back-up plans and had worked hard on simulations but, with a shortened timeframe testing on track, had its work cut out just trying to produce enough tyres for a full LMP2 grid for the entire season. Consequently, tests with cars from multiple teams were conducted, with all of the tyres developed during the lockdown, before a decision on which to use was taken.

'From when we did the first test to November, we had varying levels of performances within the tyres,' says McGregor.

'I think the big thing we noticed at the tests later in the year was how resilient and how good the ORECA is. The aero performance window of that car is phenomenal. We tried varying stiffnesses of the casings, up to 25-30 per cent, which, in terms of putting you in a timeline of Prototype tyres, we haven't run tyres that soft since 2005.

'It was to make the driveability easier for the [amateur] driver, and that little bit harder for the professional driver to really drive it at that limit to extract the ultimate lap time. By doing what we're doing, we've made it better for the drivers. And then literally we were looking at the percentage of grip to then achieve the goal [the FIA was] looking for.'

No-win situation

The final iteration of tyre performed as the FIA had intended, but caused the amateur drivers to complain, both in private and in public. 'With anything that's so well established you put yourself in a very difficult situation because, no matter what you change, people aren't going to like it,' notes McGregor. 'You've had open tyre competition for the last four years, where two manufacturers are pushing to the limit to beat each other. Now though, no matter what you sacrifice, someone's going to come back and go 'well, I don't like it', so it was a no-win situation.'

Having hit the targets set by the FIA, and with the teams pushing for a better product, Goodyear had no option but to take the issue back to the FIA. 'They asked us if we had something between this spec and where we started, and that's when we said yes,' recalls McGregor. 'As a collective group, we'll review and then see what we do moving forward, whether we stick to one or whether they want something else in the portfolio.'

Goodyear, like Michelin, has brought the latest tyre technology to the WEC, including a new wet construction and groove pattern. Previously, the wets had all been hand cut.

'By having hand-grooved tyres, it means you can do a lot of work quicker on developing patterns and understanding them before you then go into modern technology,' explains McGregor. 'So we've been working on the whole moulded wet tyre scenario. The tyres are much more consistent in the wet than what we had previously. And with the slick, the construction is completely new.'

Product integration

While Michelin is thinking in terms of LMDh tyre sizes, Goodyear faces the same conundrum, as the chassis in the LMDh and LMP2 classes are the same. Consequently, assuming the situation remains as it is, both tyre companies will have to produce similar size tyres for their respective categories.

'Only when we get an end goal on the final regulations, relative to when the first car is going to hit the track, can we really start to concentrate on what we are going to do,' says McGregor. 'And without knowing where the calls are going to be from the performance level, it's very hard to say what type of technology we're going to put into work.

'It's completely new sizes for us that we've never done before, so it is a good opportunity for us to start with a blank sheet of paper.'

Photo: Author

Goodyear's new wet construction features moulded tread technology, where previously the grooves were hand cut into the tyres

One of the key development improvements from Goodyear is the integration of the racing programme with the company's production tyres. The transfer of learning from one to the other is vital for the company. Goodyear is OE on Porsche's GT3 R road car, which uses a race tyre designed for the road and the transfer of learning from one to the other is vital.

'We're doing more than two Formula 1 races on one set of tyres and maintaining a level of performance, and that's the technology people are now looking for, both in sustainability and being able to go further on a set of tyres,' highlights McGregor.

Racing accounts for around one per cent of Goodyear's total tyre output in a year, so bringing the racing development into the same arena as product has been a big help.

Both manufacturers are pushing for sustainability, both are trying to reach the FIA performance targets, and both have a lot of learning to do

'One of the reasons for putting this into that in the first place is the impact of the standalone facility is much greater when it's separate to everything else from a mainstream plant,' says McGregor. 'Now we can use machines and equipment that are used in other product and transfer technology across from one to the other.'

Both manufacturers are pushing for sustainability, both are trying to reach the FIA performance targets, and both have a lot of learning to do over the next few years. They may now be sole suppliers, but it does not mean the learning has stopped.

Toyota entered a hydrogen-powered racecar in the Super Taiku 24-hour race at Fuji as it seeks to prove the long-term future of the ICE

By JURGEN STIFTSCHRAUBE

H uncovered

As the motoring world starts to home in on solutions to what will fuel our transport needs in the future, Toyota has opted to create a hydrogen-powered Corolla Sport, which was given its public competition debut by Rookie Racing in the Super Taiku 24-hour race at Fuji at the end of May.

The car, powered by an internal combustion engine using hydrogen fuel, was driven by the company owner, Akiyo Toyoda, whose plan it was to prove the fuel is safe and that, contrary to popular belief in Japan, he would not be blown up in the process.

Fuel cell electrified vehicles, such as Toyota's Mirai, use a fuel cell in which hydrogen chemically reacts with oxygen in the air to produce electricity that powers an electric motor. Hydrogen engines generate power through the combustion of hydrogen using fuel supply and injection systems modified from those used in petrol engines.

Combustion in hydrogen engines occurs at a faster rate than petrol engines – Toyota has calculated it at eight times faster. While this will reduce stint times in a racecar environment, despite using compressed hydrogen in the fuel cell, it means there is power available even from low down the rev range, giving excellent throttle response.

Hidden potential

The plan is that the car, which uses the four-wheel-drive system developed in the GR Yaris and is powered by a 1.7-litre, three cylinder, in-line turbo engine with an intercooler, will be fuelled during races using hydrogen produced at the Fukushima Hydrogen Energy Research Field. Although CO_2 emissions are lower than a standard fossil fuel engine, they are not zero as small amounts of engine oil are burnt during the combustion process, creating NOx emissions at the tailpipe.

'Toyota has hydrogen-related environmental technology cultivated through the Mirai,' said Toyoda. 'It also has safety technology developed through the Yaris WRC. And the GR Yaris has been competing in 24-hour races since its launch.

'Next, I want Rookie Racing, which Toyota has entrusted with development, to take up the challenge of working with hydrogen engines, which represent a hidden potential for motorsports going forwards.

'The reason for competing in a 24-hour endurance race is that simply lasting three or five hours is not enough. You have to have done the preparation to last for the 24 hours.

'On top of that, I'm one of the drivers. Many people in Japan associate hydrogen with explosions so I want to show that it is safe by driving in a race myself.'

Racing heart

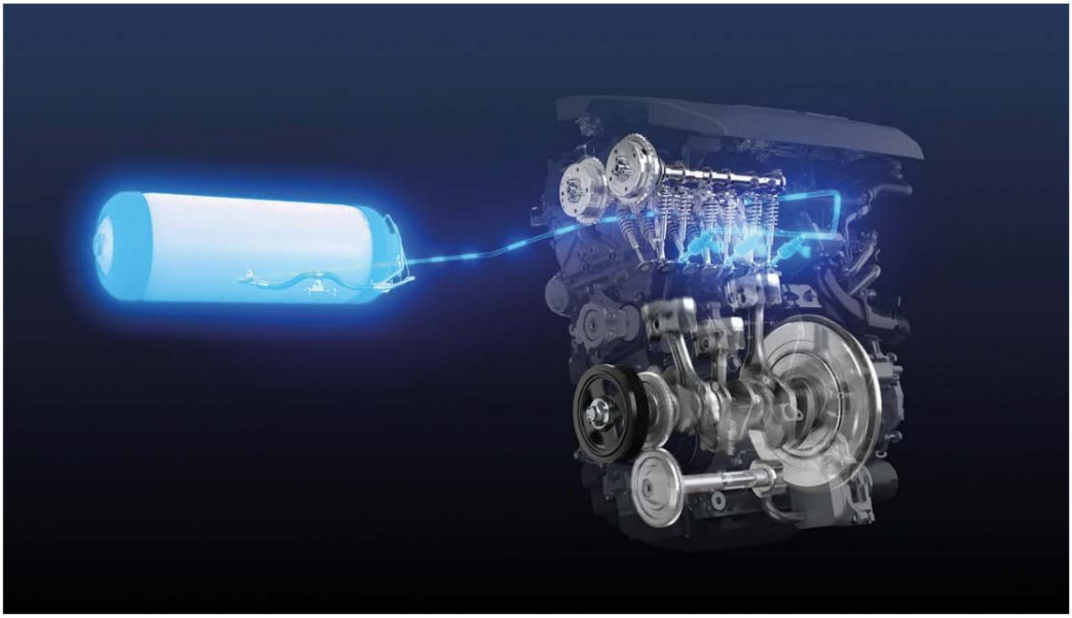
Toyoda is no stranger to racing, having contested the Nürburgring 24 hours multiple times, although success has never found its way to his door. Nevertheless, his experience behind the wheel, and his position as president of the company, mean racing is at the heart of the Toyota operation.

The back story to how the project came about is directly linked to the Covid pandemic. Toyoda was living what he

Although CO_2 emissions are lower than a standard fossil fuel engine, they are not zero

Car has Toyota's four-wheel-drive system and one of the company's 1.7-litre, three-cylinder, turbocharged engines and uses hydrogen fuel from the Hydrogen Energy Research Field in Fukushima

Current hydrogen fuel technology is not emissions zero, but its development is offering a potential alternative mobility pathway for manufacturers like Toyota to explore for the future



Toyota has calculated hydrogen combustion occurs at eight times the rate of regular petrol, which means useable power is available from low down in the rev range, but heat generation is up

describes as an 'evacuee life' at a training centre, where vehicle engineering divisions would bring various cars to him to try out on a dirt course there. Among them was a hydrogen-engine Corolla, and the company's driver, Kamui Kobayashi, was on hand to test the car with the president.

'Thinking, as a member of the automobile industry, that it was important for motorsports to gain citizenship and create a place where everyone could enjoy themselves, even in a carbon-neutral era, I decided we should go with a hydrogen-fuelled engine,' said Toyoda.

It was not a decision the company's engineering division had expected.

'I had been researching hydrogen engines for quite some time, particularly concerning aspects such as bi-fuel engines [engines that can be used by switching between two types of fuel], since around 2016,' said GAZOO Racing company president, Koji Sato. 'However, we weren't getting anywhere in terms of compositing everything into a vehicle. It was only recently that I realised we could use technologies we had on hand to give our efforts some form in the shape of a car. Because hydrogen burns faster than petrol, the response is great.'

'We want to attempt to demonstrate that internal combustion engines can be useful in achieving carbon neutrality'

Akiyo Toyoda, president at Toyota

That car feeling

'At the end of last year, we built a prototype that provided that 'car feeling' car lovers love, such as through sound and vibration, even though we were dealing with environmental technology. I took the car to master driver Morizo [Toyoda] for him to try it out and to casually ask him what he thought. When he said, "Let's race this", my mind flashed back to how careless… let me re-state that… how *challenging* my reactions were.'

Naturally, there are some limitations to the new venture. The high burn rate leads to high pressure and high temperatures, making heat management a particular issue for the team running the developmental racecar. The target, however, for the car in racing conditions is to push the limits, even to breaking point, in order they can then be rolled back slightly for future competition.

'Our bench specs show that output is at the level obtainable by using petrol, so I think performance will be more or less on a par,' said Sato. 'That said, in terms of weight, since the car will be carrying a large number of measuring instruments, I think our first race with the car will lean towards being more of a verification trial for collecting data, rather than one of winning or losing.'

Broader view

This is Toyota hedging its bets as to future technologies. And with the company racing a hybrid in the WRC and the FIA WEC, Toyoda was quick to pour cold water on the all-electric solution, Formula E.

'Above all, when it comes to carbon neutrality, everyone just seems to be talking about BEVs [Battery Electric Vehicles]. Even in motorsport, Formula E is often easily regarded as the racing format of the future. But among 5.5 million people [in the Japanese automobile industry], there are many who have accumulated engine tuning and other know how in racing for a long time.

'We announced our hydrogen engine at this time because we want to attempt to demonstrate that internal combustion engines can be useful in achieving long-term carbon neutrality. And we also want to turn them into a platform that mechanics and private garages, those which support motorsport, can use in the future.'

Once the Covid pandemic subsides and allows racing in Japan to be back under control, the team intends to take its hydrogen-fuelled car to the Nürburgring to race in one of the experimental classes during the 24-hour event in order to prove the technology in Europe, and on one of the most demanding circuits in the world.

This is just the start of what could turn out to be a major racing programme.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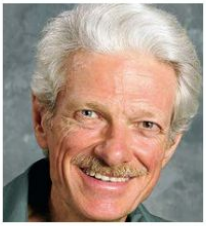
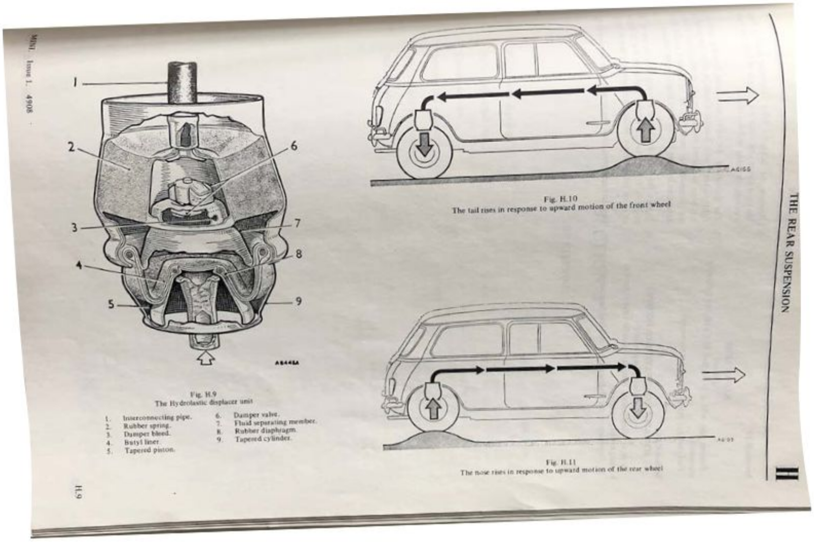


Fluids and solids

On Hydrolastic and live leaf spring suspensions

By MARK ORTIZ



The BMC Hydrolastic suspension was designed to be a much simpler version of the hydraulic suspension on contemporary Citroëns that inspired it. It uses fluid displacement units at each corner, connected anti-synchronously front to rear, and produces a suspension that is soft in pitch and warp and stiff in roll and heave

Q I very much enjoyed your latest newsletter on suspension dynamics and it made me think of the BMC Hydrolastic suspension employed on many of their models from the '60s, such as the Mk II Mini Cooper and Austin / Morris 1100 sedan. These cars had displacer units in place of the Moulton rubber springs (aka donuts) that were plumbed diagonally RF / LR and LF / RR.

The 'Hydro' units were not considered the best for racing and most race Minis (mine included) were converted to dry suspension. But homologation requirements meant earlier racers had to keep the 'Hydro' suspension, so they installed valves inside the car to 'tune' the displacement from one corner to the other, or shut it off completely so most of the suspension was in the tyre carcass.

I was just wonder if you had any thoughts on the BMC Hydrolastic suspension? The MG 1100 had a very comfortable ride for a small road car.

THE CONSULTANT

A Hydrolastic was an anti-synchronous connection of front and rear wheel on the same side. It's essentially equivalent to the torsion bars on Packards, or the coil springs on 2CVs. It produces a suspension that is relatively soft in pitch and warp, and firm in roll and heave.

You could connect diagonally opposite pairs, but you'd want an anti-oppositional connection, an anti-roll / anti-pitch device.

This does bring up one undesirable aspect of warp soft suspension – that it can be a bit problematic for a car that routinely corners on three wheels.

Rough rider

I have said previously that only road irregularities displace the suspension in warp, and therefore making the system soft in this mode can make the car ride bumps better without compromising sprung mass control and camber control. Well, this is true as long as all four wheels are on the ground, but a car can have warp displacement on a perfectly flat road surface if it lifts a wheel.

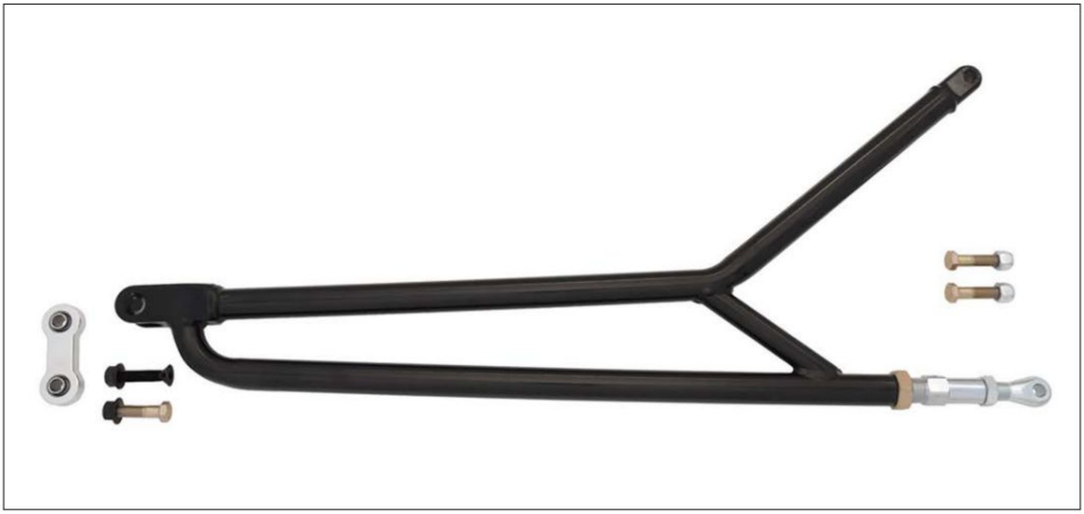
Racing Minis need to be set up to completely unload the inside rear wheel at the limit of adhesion, and generally there will be some daylight under the inside rear tyre when cornering. In fact, almost any engine-over-drive-wheels car with equal size front and rear tyres will need to corner with the inside undriven wheel airborne, or very lightly loaded.

Sudden roller

However, we don't want that wheel to come up very far, and we don't want the car's overall roll resistance to suddenly and drastically decrease as we reach the limit. When the car is extremely warp soft, once it lifts a wheel it can roll a lot more easily by displacing in warp. This sudden extra roll will make the car feel unstable to the driver, and with independent suspension will produce adverse camber change on the driven wheels, which generally will be the ones limiting the car's cornering speed.

Almost any engine-over-drive-wheels car with equal size front and rear tyres will need to corner with the inside undriven wheel airborne

On an oval track car, we aren't trying to cancel driveshaft torque roll… but for a car that has to put power down exiting right turns, we need to try to cancel it



A torque arm will help prevent wheel hop due to spring wrap up on a leaf spring car, but their effectiveness is dependent on the front mounting system and location on the chassis

Q I talked with a guy who races vintage Shelby Mustangs. He told me I must install one of these [shown above] on the rear, saying it was a gamechanger on his car. It's 41in long and easy to package.

I was thinking of making one about 50in long, maybe longer (c of g at 57in), and for the front mounting using either a 'dog bone' toggle link (which I like), a rubber snubber with axial freedom or a 'dirt-style' front mount with variable up / down compliance. The latter (coilover for drive, pull chain with a spring for braking or decel') is I think the ultimate solution as it is de-coupled during braking and acceleration.

THE CONSULTANT

A That's a torque arm, and at 41in a pretty short one for a pavement car. It will definitely prevent wheel hop due to spring wrap up but may, in some cases, create wheel hop due to excessive jacking coefficient. It helps to have the leaf springs as low as you can get them (big lowering blocks or long brackets, and low front eye).

Most people install these right next to the driveshaft, but if you're doing your own frame and floorpan, I suggest offsetting the arm to the right of centre. It should be offset a distance equal to the arm length divided by your ring and pinion ratio, times the ratio of axle centreline height to top leaf height at the axle.

It should also have a one-way link or snubber arrangement at the front end of the arm so it only transmits drive torque and not braking torque. In other words, making it act *only* under power, not acting softer in braking, so make it only able to push up but not pull down. This way you get equal rear wheel loading under power and under braking.

The snubber can be on a drop link, or it can just mount on the end of the arm as on a slapper bar, and bear on a pad on the frame.

The idea is to have an off centre jacking force only when driveshaft torque is present, and have that jacking force offset by the correct amount to cancel driveshaft torque wedge. Braking torque then needs to be reacted symmetrically, probably by just the leaf springs, perhaps with horizontal damper(s) to control wrap up if found necessary.

Power down

On an oval track car, we aren't trying to cancel driveshaft torque roll, and may even want to augment it, but for a car that has to put power down exiting right turns, we need to try to cancel it.

If you can make the arm 50in long, and you have the springs mounting to the axle at about 2/3 of hub height, and if the torque arm snubber has no play so all the propulsion axle torque reacts through the arm and none through the springs, then the arm offset would be 3/2 times 50in (75in) divided by your ring and pinion ratio. For a 4:1 gear, that works out to 18.75in right of centre.

Note that's the offset at the front end of the arm. Where the rest of it is doesn't matter. It can mount to the carrier studs and angle to the right, or be wherever there's room.

If your spring height is around half of your sprung mass c of g height (say, 8in and 16in respectively), and your arm length is a little less than half the wheelbase, you'll have a little more than 100 per cent anti-squat. That's not too bad. With a 41in arm, you'd be around 125 per cent. I generally don't like to see much over 100 per cent for a pavement car.

The action of an offset torque arm will be somewhat imperfect, as the snubber clearance will only be zero at static or at one roll angle, but it probably is still preferable to a torque arm right next to the driveshaft.

CONTACT

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The art of noise (reduction)

As racecars rely ever more heavily on electrical devices, shielding them from interference becomes critical.* Racecar *asks if graphene-based coatings are the answer

By STEWART MITCHELL

A Formula 1 car is an exceptionally harsh and 'noisy' place for a sensor, with many sources of vibration and electromagnetic interference (EMI) present, all of which have the potential to skew sensor readings and make life difficult for efficient performance.

EMI is the interference caused by one electrical or electronic device to another by the electromagnetic fields generated during its operation.

One of the biggest challenges faced in Formula 1 since introducing hybrid powertrains in 2014 has been protecting devices from the EMI produced by the high-voltage electrical circuits related to the energy recovery system (ERS) and, in particular, the motor-generator units (MGUs).

Even just packaging what is essentially very complex machinery that relies on sensitive measuring devices in such a way that they can survive under racing conditions has proven to be a major challenge for the engineers involved.

EMI is a particular issue in sensors with low output signals, such as strain gauges and thermocouples. Sensors such as pressure transducers can have an output voltage of 1-10V, whereas the output of strain gauges and thermocouples will only be a few milli- or microvolts.

In this case, a low signal-to-noise ratio can have a considerable impact on the recorded output of a sensor. This ratio is the level of a particular signal's strength compared to the level of background noise.

For example, a sensor with a 5V output signal and a background level of signal noise of a few microvolts would have a very high signal-to-noise ratio. However, if the sensor output is in the millivolt range, the ratio is much lower, making it much harder to distinguish the signal from the noise.

As a nano-scale transducer, the graphene-based coating is more sensitive, accurate and robust than contemporary piezo units

An ultra-lightweight, ultra-thin EMI / RFI shielding coating has recently been developed by cutting-edge material science firm Advanced Material Development (AMD), potentially changing the game for electronic systems in motorsport

Shielding typically involves enclosing the insulated signal cables in a conductive layer of braided metal wire, or copper tape, that acts as a Faraday cage

While complex signal processing algorithms can help 'clean up' noisy signals, effective circuit design and shielding go a long way to improving sensor performance, reducing the need for such measures.

Where possible, teams keep cable lengths between a sensor and its signal amplifier as short as possible because long cables act as an antenna, picking up electrical and magnetic interference. Twisted cable pairs also help prevent signal noise by reducing induction between the wires.

Traditional methods

The addition of shielding around electrical systems is also imperative. Shielding typically involves enclosing the insulated signal cables in a conductive layer of braided metal wire, or copper tape, that acts as a Faraday cage around the signal-producing system to reduce the impact of electrical or magnetic interference.

Engineers also take installation considerations into account to reduce signal noise. For example, strain gauges are often mechanically *and* electrically attached to the component they measure, resulting in ground loop currents forming that contribute to signal noise.

These occur where a difference in potential develops between the sensor ground and the signal amplifier. However, careful attention to detail regarding earthing the sensor, shielding and signal amplification can prevent this from happening.

Things become a little trickier, though, when dealing with very high voltage systems, such as the powerful electric drive components and energy storage systems that make up a Formula 1 car's ERS.

These produce strong electromagnetic fields that create problems for the sensors used to measure their operation, as well as other sensors nearby.

Fortunately, the frequencies of these fields can be identified and accounted for in the signal processing. But, where powerful fields are present, the only solution is to increase the level of shielding on the sensor circuits as the EMI can otherwise be sufficient to damage the circuitry itself. This traditionally sees various forms of Faraday cage built in metallic cases featuring alloys that reduce the interference.

At lower frequencies, ferrous particles in the cases can achieve high shielding efficiency where solid metal plates would be prohibitively thick. At higher frequencies, aluminium or copper can achieve similar efficiencies.

Engineers use aluminium due to its low density of 2.7g/cm^3 (for weight-sensitive applications) and low cost. While copper is denser than aluminium (8.96g/cm^3), it has a higher electrical conductivity and smaller skin depth, making thinner films more effective. It is also relatively cheap compared to other metals.

Despite these beneficial properties, the weight and size penalty of aluminium and copper alloy systems is huge, making them extremely undesirable in the upper echelons of motorsport. Consequently, innovative non-metallic systems that provide broadband electromagnetic interference (EMI) and radio frequency interference (RFI) shielding in racecars are in high demand.

Coating technology

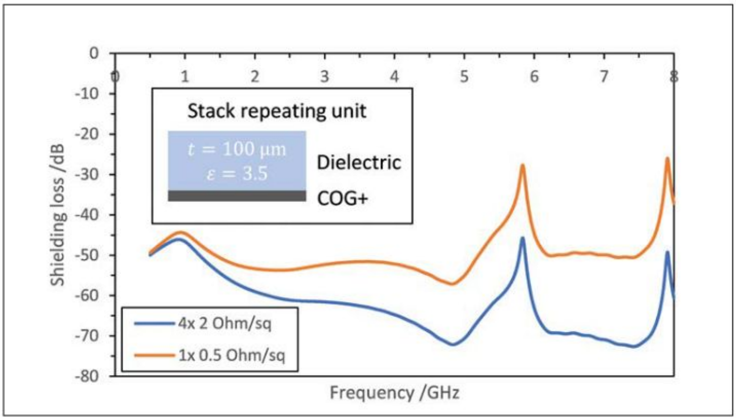
One solution that engineers can apply across numerous substrate materials and in a wide range of environmental conditions is a lightweight, ultra-thin coating that has been recently been developed by cutting-edge material science firm Advanced Material Development (AMD).

'We came up with a method to produce graphene-based coatings, or dispersions, of a range of nanomaterials to dial in specific properties like electrical conductivity or thermal conductivity,' explains AMD's chief science adviser, professor Alan Dalton.

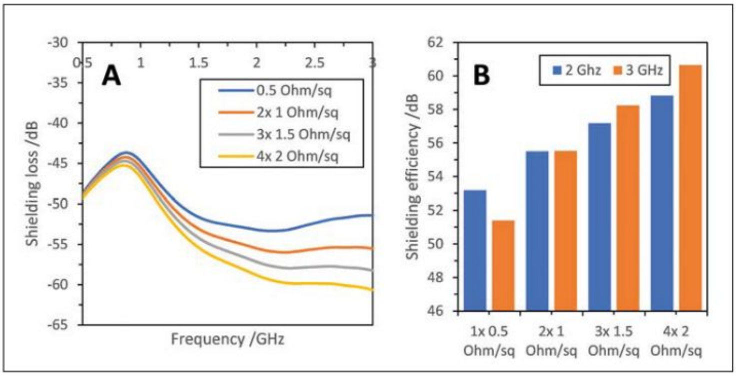
'As a flexible and conformal, graphene-based coating of 20 microns, our solution is currently capable of resisting 50dB of interference across a frequency range from 300MHz to tens of GHz, meeting motorsports sensitive electronics shielding application demands.'

Graphene is unlike any other material in how it interacts with light across the spectrum, particularly infrared and radio frequency. Materials like polymers or metals can be oxidised, or sulphurised, affecting their ability to shield in certain parts of the spectrum, making it hard to dial in properties easily.

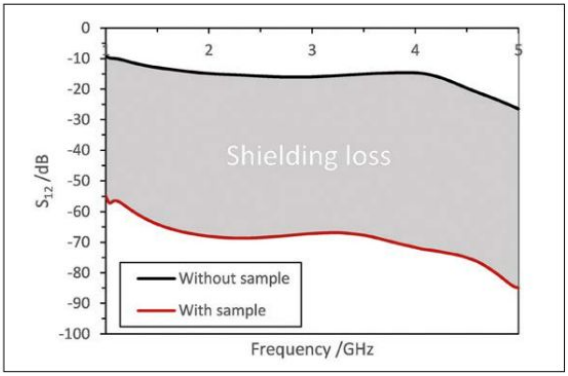
Graphene maintains a consistent performance regardless of the spectral



Shielding loss spectra for two multi-layer stack configurations, showing an increasing benefit at higher frequencies. The spikes are an artefact resulting from the near-field interactions of the conducting sample with the antennae



A: Shielding loss spectra for several multi-layer stack configurations. In each case, the thickness of conductive material is constant. B: Shielding efficiency measured from (A) at 2 and 3GHz, showing increasing effectiveness with number of layers, even though the total conductive material content is fixed



Comparison of transmitted power from antenna 1 to antenna 2 for simulations, with and without a coating sample present. Note the difference in the quantities (calculated in dB), highlighting the shielding loss

'As a graphene-based coating of 20 microns, our solution is currently capable of resisting 50dB of interference across a frequency range from 300MHz to tens of GHz'

Professor Alan Dalton, chief science adviser at Advanced Material Development (AMD)

window, making it ideal for EMI / RFI shielding applications. Currently, no other material features this characteristic. For EMI shielding, using graphene means it is possible to control flow interaction across a broad frequency window.

'There are several different applications where you're playing with the optical-electronic properties of a material,' explains Dalton. 'For EMI shielding, the shielding properties of most metals acting as a Faraday cage is based on their conductivity and electrical mobility.

'The AMD graphene-based coating material has a density of ~2g/cm^3, lower than any metal. Based on our experimental shielding efficiency data, a sheet resistance of 0.12Ohm/sq is required to achieve a shielding efficiency of 50dB. At 250,000S/m conductivity, this corresponds to a coating 33µm thick – a mass coverage of ~66g/m^2.

'It has potential conductivity surpassing 500,000S/m, which is extremely high, almost that of copper or silver, and a significant improvement on other non-metallic solutions. For an aluminium shielding enclosure with a suggested thickness of 0.1mm (100µm), the equivalent mass coverage would be ~270g/m^2. This property enables substantial EMI attenuation on numerous substrate types.'

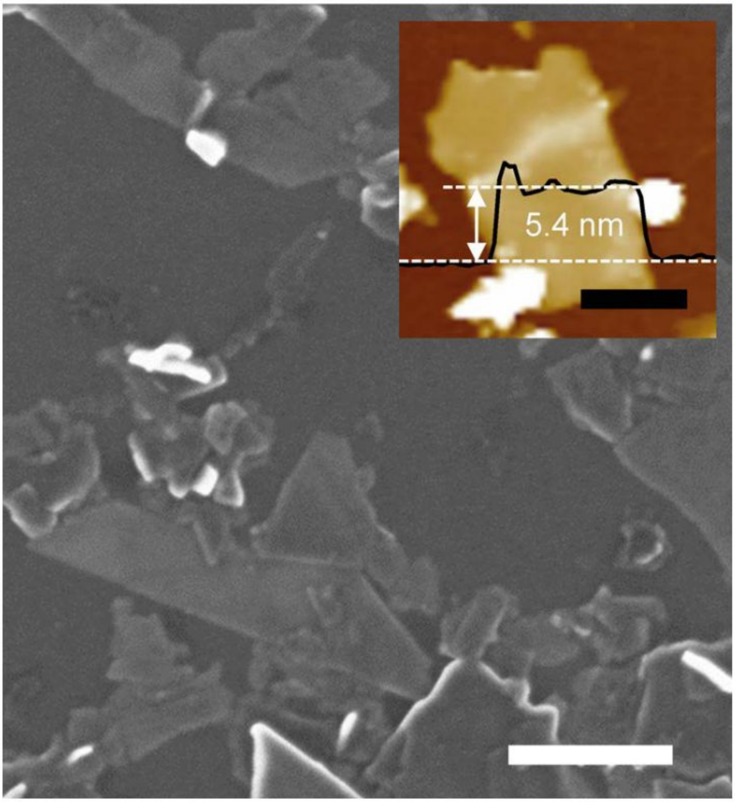
Thermal properties

Traditional silver, copper or nickel-based shielding coatings are deposited down onto the substrate. The component is usually then annealed and sintered at a high temperature. If you do a lot of temperature cycling from below zero up to a couple of hundred degC annealing temperature, eventually cracks will occur, as will delamination of the coating material.

'We can match the thermal properties of the substrate in our solution, so it seamlessly fits with the substrate when it is deposited,' explains Dalton. 'Additionally, regardless of what you do mechanically or thermo-mechanically, it doesn't change its properties, and it remains adhered to the substrate irrespective of temperature.'

For components in or around the internal combustion engine, engineers may use AMD's solution as a polymeric or elastomeric coating as it has a very high threshold before mechanical modification. Meaning if the substrate stretches or contracts, the coating material will not change its conductivity significantly. It maintains its electrical properties and therefore possesses the desired characteristics for EMI shielding.

For high performance and motorsport applications, the most significant advantage is the material's ultra-lightweight and ultra-thin nature. It therefore does not affect the packaging envelope of the electronic components it is shielding, and even



Scanning electron micrograph (scale bar 400nm) and atomic force micrograph (inset, with scale bar 200nm) illustrating the presence of few-layer nanosheets in material processed using the equipment in high-pressure homogeniser apparatus

adds scope for packaging optimisation by removing the need for bulky metal Faraday cages on existing platforms.

'In a coating format, not only can we put this solution down onto a range of planar surfaces, but we can put it onto a range of different corrugated surfaces, including 3D printed items,' highlights Dalton.

'Interestingly, when we tested the shielding capabilities on several other surfaces, we discovered we get better shielding on corrugated and high curvature systems than on planar ones.'

Tailored solution

Another key advantage of AMD's solution is that it works across a huge temperature range and features thermal conductivity. Using a unique production process, AMD can even tailor the heat dissipating capabilities of the coating to a particular environment.

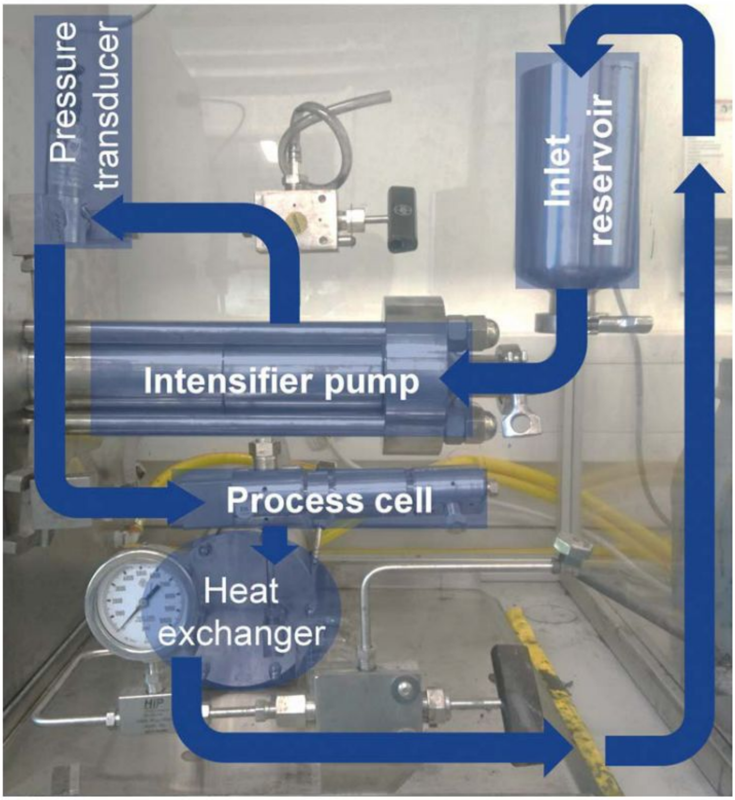
'We can produce a hybrid coating that has the shielding properties of graphene, but the thermal properties of something such as boron nitride, which is an excellent thermal conductor, or molybdenum sulphide, which is an excellent lubricant,' explains Dalton.

'Our graphene-based coatings can have several augmentative functionalities built in, making a multi-functional layer doing lots of different things at once'

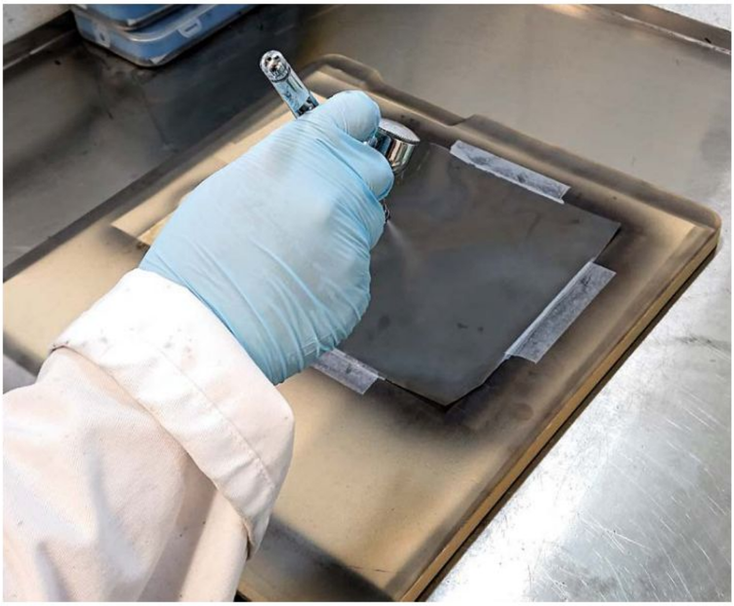
'Our graphene-based coatings can have several augmentative functionalities built in, making a multi-functional layer doing lots of different things at once.

'For Formula 1, teams could have a sensor built into the shielding coating component to monitor structural health. If it begins to fail, it could, through an RFID antenna, wirelessly feed out to the computer that something's going on.'

As a nano-scale transducer, the graphene-based coating is more sensitive, accurate and robust than contemporary piezo units. One of the major advantages it has over



High-pressure apparatus used to delaminate the bulk graphite particles into exfoliated micro and nanoparticles, with overlaid diagram showing the flow through the system



For shielding electrical components in a racecar, AMD believes a spray, or paint deposition is the most applicable coating solution

traditional piezo sensors, or gas sensing using metal oxides, is that the individual platelets have an extraordinarily high surface area, meaning that nearly every atom interacts with its environment.

Suppose there is any change, either mechanically or environmentally, the hyper-sensitive coating will pick it up long before traditional materials like metal oxides or piezo for strain sensing. This kind of sensitivity can provide a lot more detail on the operating environment for the engineers and can prevent terminal failures from occurring.

Manufacturing process

For AMD's graphene-based EMI / RFI shielding coatings, graphite is extracted from the ground and processed using high-pressure liquid jets to delaminate individual graphene sheets from the graphite.

This process forms graphene platelets that are just one atom thick in the z-plane and can be several microns in the x and y planes. AMD then tailors the properties of the coating using a particular optimised particle size selection process.

'During production, we pick out individual platelets from a wide range of shapes and sizes,' explains Dalton. 'We do that because there is a sweet spot in the platelet aspect ratio [average length divided by thickness].'

The graphene is then blended with a proprietary mixture of stabilisers to produce the coating. 'We combine the graphene platelets with the stabilisers and other nano carbons to generate a solution that is an order of magnitude less conductive than bulk metal but, typically, an order of magnitude higher than other non-metal coatings,' continues Dalton.

'Motorsport and, in particular, high-performance hybrid categories require blends that feature several different characteristics in one solution. You want to impart electrical conductivity for shielding, thermal conductivity for heat dissipation and mechanical enhancement, while at the same time being ultra-lightweight, flexible and temperature robust.

'Our graphene coatings provide precisely that, and can be sprayed onto existing equipment, deposited as a coating on most engineered materials, screen printed using a roll-to-roll process or even inkjet printed for high spatial resolution applications. We have made laminate structures by sandwiching our graphene shielding material between layers of thermoplastic to provide built-in EMI / RFI shielding into loaded structures. Because we understand the polymer's mechanics, it's easy to tailor the shape that one requires, while maintaining the shielding properties of the trapped coating.'

The frequency generated by the component being shielded by the AMD graphene-based coating is either reflected or absorbed. Suppose you wanted to dial in a particular window where you wanted to communicate in a small section of the frequency spectrum that would allow transmission and attenuates everything else. For this, AMD can potentially structure the coating material to act as a meta-surface.

'A meta-surface is an artificially crafted structure that derives its properties from internal microstructure, rather than chemical composition,' explains Dalton. 'For this, by engineering the structural element of our coating into a desired geometry, one can tune the optical properties to be active in certain windows of the spectrum over others.'

Filter windows

'We can potentially produce antenna structures in our coating where all of the background radiation is absorbed, but we have a filter that would allow in, say, a 30 or 40MHz window, for instance. We can do that by putting down our graphene nanomaterials and using a lithography stamping process to build structures that provide small filter windows to allow certain signals through.'

The ability to dial in particular windows where systems can talk to each other but absorb interference inherently in the background, like 5G or 4G or other extraneous radiation, is ideal for motorsport applications, given the networks onboard the car, in the pit lane and the mobile devices of thousands of fans in the stands.

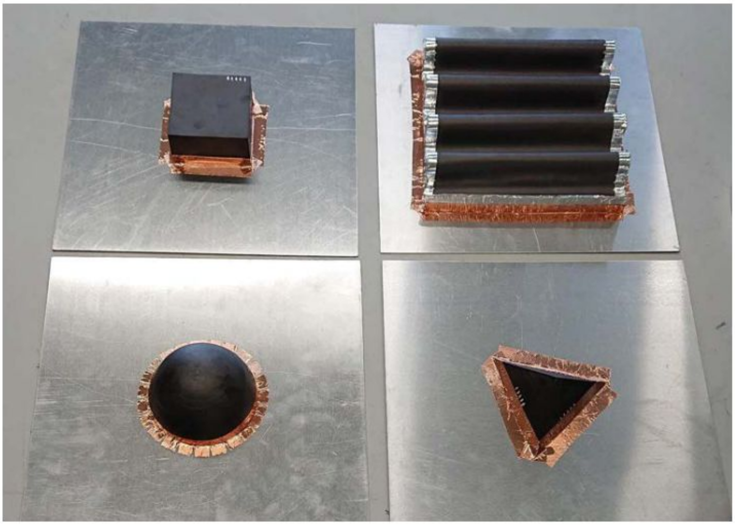
Should an application require shielding in one condition and then modulation of that under a different condition, that is also possible with AMD's coating technology.

'We could have a system where it could modify its transmission of radio frequency energy as a function of mechanical deformation or stress,' says Dalton. 'You could have a simple coating, or a free-standing film, that's protecting a particular component that, if you stretch it by say five or 10 per cent, its transmission in a specific window can change by 80 per cent.

'It might be possible to have a system where using an actuating structure, this transmission window occurs at a particular frequency, and a sensor that you want to communicate with autonomously is locked inside said frequency and can transmit signal in real time.'

This feature is ideal for the conditions inside a racecar as, if you have sensors talking to each other at multiple frequencies and power components producing a lot of radio frequency, it's complex to shield one and let another through. If a race team uses radio frequency to communicate between sensors, you can dial in whatever frequency engineers want based on the antenna design, from a couple of hundred MHz up to two or three GHz.

As a built-in component measuring structural health, engineers could have the coating transmit as it deforms, measuring localised stress and communicating to other systems the mechanical integrity of the part. It could provide engineers with real-time measurement of health in a tiny window unaffected by all the other RF components in the car.



AMD has tested its shielding coating on a range of different surfaces, including corrugated and 3D printed items. Interestingly, the material's shielding capabilities appear to be better on corrugated and high curvature systems than on planar ones

Testing performance

For characteristics within windows relevant to the upper echelons of the motorsport industry (500MHz up to about 10GHz), AMD has so far demonstrated shielding performance of about 50dB with its graphene-based coating solution.

'We've also proved it at higher frequency applications for the same amount of shielding from 10-50GHz, and are about to start testing below 500MHz,' notes Dalton. 'Based on the coating properties, we expect to achieve the same performance of high-level shielding.

'From all the development and testing we have done to date, we have identified that, regardless of where you are in the frequency window, by dialling in a particular conductivity, you can extrapolate specific shielding, as it varies little regardless of where you are in the spectrum.

'We've shown that you can spray it directly onto complicated, corrugated, non-planar structures and achieve high performance across a range of temperature windows seen in motorsport applications. It can be applied as a coating or as a laminate with an adhesive layer on the back if you wish to put it down as a tape. For shielding components in a racecar, we believe a spray deposition or a paint deposition is the most applicable, and our coating lends itself well to that.'

'The next generation of our coatings that are presently being tested will potentially be able to return as much as 90dB of shielding'

As a comparison, traditional nickel or silver-based coatings can be used to shield EMI in the low GHz window, somewhere in the order of 35-60dB if well optimised. However, those coatings are in the region of hundreds of microns thick, and consequently are heavy.

'The next generation of our coatings that are presently being tested will potentially be able to return as much as 90dB of shielding, which is competitive, or better, than traditional metal box components in terms of capability,' notes Dalton.

'It all boils down to the nano-scale physics and our proprietary techniques to make our graphene-based nanoparticles talk to each other in a coating or film.

'Fundamental physics defines why these things are conducting, and how we might optimise connectivity further to produce protective coatings. That's the next six to 12 months in terms of research and development.'

Layer cake

Carbon fibre is a household term these days, but Racecar *charts its development from the McLaren MP4/1 to the latest bio-composites*

By LAWRENCE BUTCHER

Although not exclusively, carbon fibre weaves are usually either unidirectional, with all strips in the same direction, or tows (above), where the fibres are at intersecting angles

Carbon fibre composites have been a part of the racecar constructor's armoury for four decades now, yet still the material retains an air of the exotic. This is likely because its time-consuming manufacturing processes means it hasn't gained widespread adoption in production car applications. This has the potential to change with the arrival of more cost-effective construction methods, but for now, carbon fibre remains the material most associated with racing.

Despite its ubiquity, it is inaccurate to think that carbon (strictly speaking, Carbon Fibre Reinforced Plastic, CFRP) is the only composite used in racing. A composite is simply a combination of two dissimilar materials combined to create something with physical properties different to those of the constituent parts. In the case of CFRP, carbon fibres are encased within a resin matrix, but other fibres such as Aramid and Kevlar are commonplace, and natural fibre-based composites now available on the market have started to see an uptake in motorsport.

There are also metallic composites, and those that incorporate materials such as ceramics, which, where regulations allow, are also applicable to motorsport applications.

Best strengths

However, the logical starting point when addressing composites is CFRP, which first came to prominence with McLaren's MP4/1 Formula 1 car in 1981, the brainchild of engineer John Barnard. Other racers had used carbon fibre before, but Barnard was the first to truly realise its potential. What he recognised is that carbon parts have to be used to the best strengths of the material, rather than simply as replacement for aluminium or steel designs. For example, Gordon Murray worked on a carbon composite chassis for the Brabham BT49 in 1978 but, as even the designer admits, his approach was not the right one.

Where Murray used monolithic carbon as an almost direct replacement for aluminium, Barnard, working with aeronautical engineer John Webb, designed a bespoke chassis tailored to maximise the benefits of carbon construction. The most notable feature of which was the use of an aluminium honeycomb structure, sandwiched between plies of carbon material.

Unable to find a suitable composite partner in the UK, the McLaren MP4 chassis was constructed by Hercules Aerospace in the US. It was groundbreaking in its construction, not just in motorsport but the wider composites industry, which at that time was predominantly aerospace related.

Spread tow fabrics can also be manufactured with different fibres in the two directions… so the mechanical properties can be optimised depending on design requirements

Where it all began. The McLaren MP4 of 1981 was the first racecar to successfully use carbon chassis construction, although it took an aerospace technology company to bring the radical ideas of its designers, John Barnard and John Webb, to life

Never before had such a complex construction been attempted, and many of the processes developed by Barnard and his team are still in use today. Though the first MP4/1 monocoque was the same weight as McLaren's previous aluminium chassis, it was both narrower (making more space for underbody tunnels) and twice as stiff. Ultimately, more refined versions would be 70 per cent stiffer and 25 per cent lighter, a step change in the close-fought world of Formula 1.

By the middle of the 1980s, carbon construction was *de rigueur* in F1 and making inroads into Sportscar racing as well.

CFRP basics

First developed in their modern form at the UK's Royal Aircraft Establishment in the 1960s, carbon fibres are produced by the controlled oxidation, carbonisation and graphitisation of carbon-rich organic precursors in fibre form. The most common precursor is polyacrylonitrile (PAN), although fibres can also be made from pitch or cellulose, and by varying the graphitisation process either high-strength fibres (processed at about 2600degC) or high-modulus fibres (processed at about 3000degC) can be produced, with fibres of varying characteristics in between.

Once surface treatments are applied to the fibres to improve bonding with matrix materials (the resin) the fibres are usually grouped according to the modulus band in which their properties fall. These bands are commonly referred to as high strength (HS), intermediate modulus (IM), high modulus (HM) and ultra-high modulus (UHM).

The filament diameter of most types is about 5-7µm. Generally, fibres are wound into threads and woven into different material types, predominantly either unidirectional strips, with all the fibres orientated in the same direction, or tows, where the fibres are woven at intersecting angles to each other.

One fabric type that has come to prominence in recent years are so called spread tow varieties. Rather than using spun yarns, spread tow materials use thin tapes of individual fibres that are then woven together. This process produces a very low 'crimp' factor (the degree to which each fibre is bent as it passes over another), which produces a fabric that comes close in mechanical performance to cross-plied unidirectional fibres but retains the benefits of a fabric, such as excellent drape and a decreased risk of delaminating.

Using a spread tow instead of a conventional woven fabric, engineers can reduce the weight of the woven reinforcement, yet maintain or improve its mechanical performance. Instead of needing to use two or more plies of unidirectional fibres, the same effect can be achieved with one ply of spread tow, resulting is thinner and lighter parts.

Spread tow fabrics can also be manufactured with different fibres in the two directions, just like unidirectional fibres, so the mechanical properties can be optimised depending on design requirements.

The low crimp factor, where two fibres intersect, also leads to reduced void content (the appearance of pinholes in the surface), compared to traditional fabrics, reducing the quantity of filler material needed to create a smooth surface finish. This makes them particularly favoured for aerodynamically sensitive surfaces. For example, at the start of the 2021 season, Ferrari moved to using a spread tow fabric on the front suspension members of its F1 car, presumably for both aerodynamic and weight benefits, rather than aesthetic reasons.

As Paulo Perello, an R&D composites engineer at Italian specialist YCom explains, 'these spread tow materials are a huge change. In our experience you can have, for example, a T800 fibre in a spread tow that has characteristics higher than a T1000 [in a regular tow] and that is all due to the weaving of the fibre. So it is not just about developing new fibres, you can make use of existing fibres and use them in a different way to make them perform better.'

Construction methods

Carbon components can be assembled using the 'wet lay-up' process, where dry carbon fibre weave is coated with an epoxy resin, in essentially the same manner as glass-reinforced plastics are produced. However, this approach is only valid for non-structural components, and most racecar parts are made using pre-preg materials, so named because they are pre-impregnated with resin, which cures when subject to heat. Consequently, pre-preg materials have to be stored in cool conditions before use.

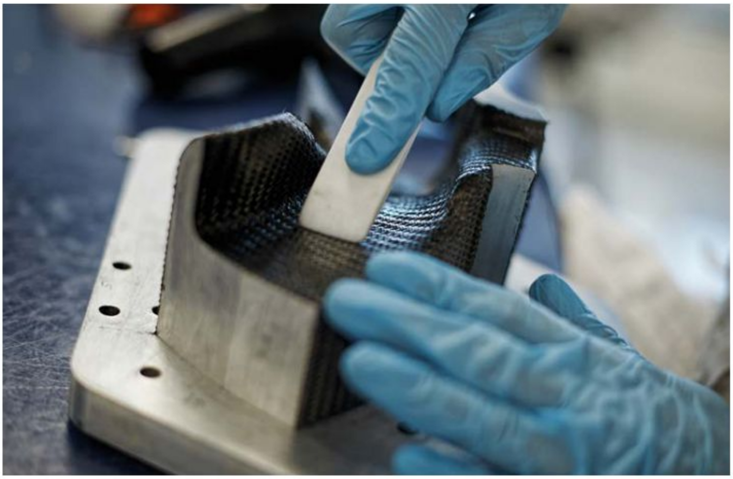
To manufacture a part, individual plies will be cut (generally using CNC cutting machines) and laid into a tool in a specific order before being cured under heat and pressure in an autoclave.

The normal construction for a load-bearing composite component consists of a core material, predominantly aluminium or Nomex honeycomb, sandwiched between plies of pre-preg material. For complicated shapes, high density polyurethane foam is often used, its ease of shaping making it ideal for creating complex geometries.

It is this core material, central to Barnard's pioneering efforts, that is key to the production of light, stiff components. Using just carbon fibre, doubling the number of plies doubles the stiffness, but also doubles the weight. If a core material is used, with plies bonded to either side, a considerable increase in stiffness can be achieved for a minimal weight increase.

During construction, the core material, and the plies encasing it, are joined using a sheet of adhesive formed into a mesh which, when heated in an autoclave, melts forming fillet joints at the interface between carbon and aluminium. The integrity of this bond between honeycomb and carbon material is vital to the overall integrity of a carbon part.

The traditional method of constructing a part from carbon fibre is a lengthy one. Once manufactured, the base fibres must be woven into a fabric and go through a number of treatment processes, including impregnating with resin, before they can be laid into a forming tool and then cured with heat and pressure in an autoclave (right)



If a core material is used, with plies bonded to either side, a considerable increase in stiffness is achieved for a minimal weight increase

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For applications with complex lay ups, construction will often consist of multiple stages, with stacks of plies being subject to a process called debulking. This involves several plies being assembled, before being subject to a vacuum (either via vacuum bagging, where they are sealed in a bag and the air drawn out, or in an autoclave) to consolidate the material, reducing the resin-to-fibre ratio and increasing the strength of a part. This process will be repeated until the entire laminate is complete and then cured.

The main advantage of pre-preg is the distribution of resin throughout the material is well controlled, ensuring consistent mechanical performance once cured. Recent advances in compression moulding of composites, where dry fabric is placed in a two-part mould before resin is injected and the air drawn out, can now produce parts close to the performance of traditional methods.

In the context of motorsport, the high cost of tooling for such processes means they are currently the reserve of high volume mainstream automotive.

Resin types

The type of resin used is dictated by the required mechanical properties of a finished part, and different resin systems will have their own specific curing conditions.

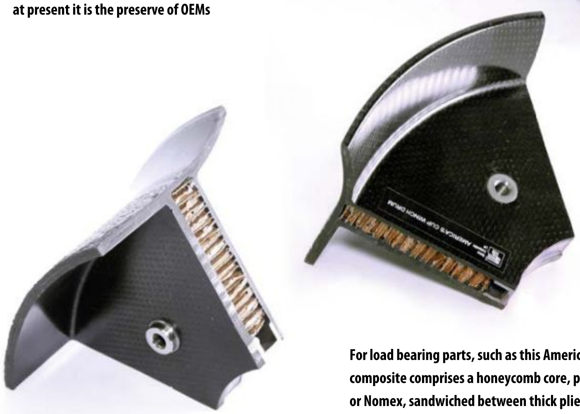
Resins can be broken down into thermoplastic and thermosetting varieties, with the latter being the most widely used in motorsport. Within this subset one finds polyesters, vinylesters and epoxies. Each has its own benefits and disadvantages. Polyester-based resins are relatively low cost, for example, while vinylesters have good toughness and chemical resistance. However, the most commonly found resin systems in pre-preg materials are epoxies.

As Ian Drew, operations director at regular F1 supplier, Retrac Composites, observes, within F1 teams have become very specific in their demands regarding composite manufacturing processes. 'All of the teams are slightly different, and have their own processes and procedures. If you work for six different teams, you have six different KMS (knowledge management systems), cure cycles, material types and inspection methods as they want traceability on all parts. That adds a lot of extra complexity to the manufacturing process.'

There are also an increasing number of high-temperature resins that can be handled in a similar fashion to low-temperature ones. High temperatures have always been the Achilles heel of carbon. Although the fibres themselves can withstand high temperatures, the glass transition temperature of the resins, where they start to lose structural integrity, remained relatively low.

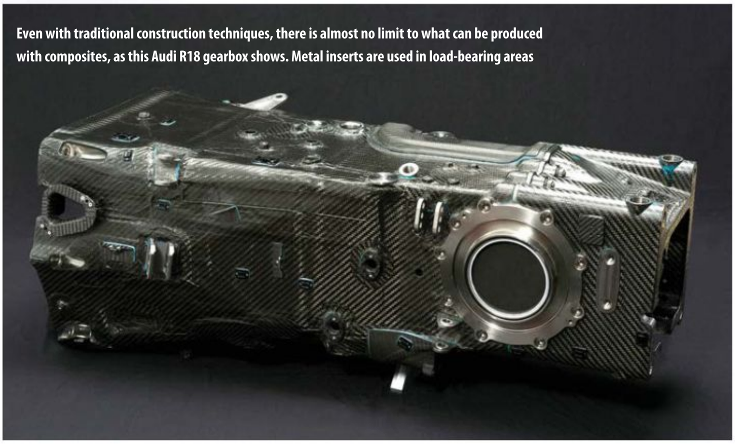
More complex components require multiple production stages, with parts built up in successive layers. Compression moulding is now also being used, but the high cost of tooling means at present it is the preserve of OEMs

Retrac Composites



For load bearing parts, such as this America's Cup winch drum, the composite comprises a honeycomb core, predominantly aluminium or Nomex, sandwiched between thick plies of pre-preg material

Retrac Composites



Even with traditional construction techniques, there is almost no limit to what can be produced with composites, as this Audi R18 gearbox shows. Metal inserts are used in load-bearing areas

Up to a point, thermal barrier coatings can be used to protect composites, and can often be seen on areas such as the inside surfaces of engine covers. But where such coatings offer insufficient protection, high-temperature resins are needed. For temperatures up to around 430degC, cyanate ester-based resins used to be the only viable option, but recent

The type of resin used is dictated by the required mechanical properties of a finished part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developments by material suppliers such as Toray have resulted in both improved temperature-resistant epoxies, good to nearly 200degC, while for very high temperature applications, bismaleimide (BMI) and polyimide resins have been developed.

One particular advantage of these new resins is they are considerably tougher than previous high temperature solutions, which tended to sacrifice durability for heat resistance. An additional benefit, as Drew notes, is the new generation of resins are considerably more user friendly than they used to be, requiring fewer special measure to handle, both from an assembly and health and safety perspective.

An example of carbon Kevlar construction body panels on the Brabham BT62 C. Carbon provides the strength, Kevlar the resilience

The next step in composites is undoubtedly the greater use of plant-based fibres, although bio-based resins are still in development

Blends and fabrics

In some cases, CFRP alone may not provide the required mechanical properties for a given application. For example, a part might require a degree of abrasion or impact resistance, such as a front splitter or side impact structure. In the case of the latter, F1 and LMP1 (now LMH) cars through to LMP3 feature side intrusion panels that employ a material call Zylon, the trade name for a range of thermoset liquid-crystalline polyoxazole, first developed by manufacturer, SRi, in the 1980s and now produced by Japanese firm Toyobo.

Zylon initially saw use in F1 in wheel tethers, an ideal application given its far higher tensile strength than carbon fibres, and its use has since spread to other areas. Available in a variety of forms, from continuous filaments through chopped fibres to spun yarns, it is also maintains its properties up to around 650degC while also having a good degree of elongation before breakage, hence its suitability for intrusion panels.

One of the other more common materials used in areas where impact resistance is needed is Kevlar, which has both excellent toughness and abrasion resistance. There are also a number of hybrid fabrics available, which combine Kevlar and carbon fibres together, harnessing the benefits of both, carbon providing strength and Kevlar the resilience.

Beyond Kevlar, there are a host of other fibres that can be utilised, such as commingled glass and polypropylene filaments which, although heavier than CFRP, provide exceptional impact resistance.

In motorsport, these tend to be most commonly found in applications such as rally car bodywork.

The fabric used in a composite is not the only factor dictating a finished part's properties, the resin has an equally important part to play. For example, the Crestapol 1250LV resin is designed specifically to produce very tough parts and is rated at 575J/m2, twice that of traditional vinyl ester resins. It is also engineered to ensure adhesion between the resin and fibres is as high as possible, which prevents the parts delaminating when subject to stress. However, these more flexible resins may not be suitable where a degree of rigidity is needed from a part, such as large, flat areas of bodywork.

The type of resins used will also be dictated by the type of lay-up systems used. Pre-preg fabrics, for example, are limited to a relatively small selection of resin system. So when it comes to components where properties beyond outright stiffness are required, parts will be made using a resin infusion process (whereby resin is drawn into a dry fabric using a vacuum) as there are a wider range of suitable resins available.

Recent developments

As Retrac's Drew observes, in areas of motorsport such as F1, engineers are relatively conservative when it comes to the selection of composite materials. Having spent many years ascertaining which combinations work most effectively, and nailing down strict process controls, they are understandably reluctant to waste effort trying out new materials that may turn out to be less effective.

This is not to say development has stood still in recent years. Far from it. The complexity of components being created has increased considerably in recent times, with teams demanding far more functionality from composite assemblies. 'We are supplying much more complex bonded assemblies, incorporating things like sensors, strain gauges and pressure taps,' says Drew. 'That means a lot more goes into the manufacturing process.'

Zylon initially saw use in F1 in wheel tethers, an ideal application given its far higher tensile strength than carbon fibres


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Increasingly in the limelight is the use of natural fibres instead of carbon

Looking at the wider picture, there are various other developments ongoing in regard to composites, including the implementation of graphene reinforcement of resins, which has been shown to improve their mechanical properties. There is also work being undertaken on so-called sensing composites, where the conductivity of the carbon fibres themselves are harnessed for applications such as strain gauging.

AM carbon

Another relatively recent development is that of additive manufactured (AM) carbon fibre parts. One of the first common uses of these in racing was brake ducts in F1, which until recently were subject to revisions almost every race, though the low temperature resistance of materials presented their share of challenges.

With the ongoing evolution of materials, such problems are becoming less of an issue, with an increasing number of applications for AM parts beyond prototyping.

AM techniques are also bringing benefits from the perspective of the tooling around which composite parts are constructed. The arrival of dissolvable materials allows for the creation, and subsequent removal, of internal cores in parts with complex geometries. This allows for smooth internal surfaces to be created within aerodynamically sensitive components, improving their performance.

One final area of composite development increasingly in the limelight is the use of natural fibres instead of carbon. These are appealing thanks to their perceived environmental credentials, having a far lower 'carbon' footprint than traditional CFRP. They are yet to match carbon in terms of strength-to-weight characteristics, but they have been used in less sensitive areas such as bodywork on GT cars and the off-road machines found in Extreme E, while McLaren also produced a driver's seat using material from one of the pioneers of bio-composites, BComp.

Undoubtedly, with the growing focus on sustainability in motorsport, their use will increase, though development is still ongoing in regard to bio-based resins, which would further improve the environmental kudos of these new materials.

As Perello notes, efforts towards more sustainable solutions are not limited to just bio-based fibres. Behind the scenes, considerable effort has gone into making consumables with reduced environmental impact, such as resins and filler materials that are water rather than solvent based.

'That is a huge advantage and a step forward. It is technically not that easy for companies to produce solvent-free resins, and it makes tuning the machines that impregnate the fibres harder as well, but it is, I think, one of the nicest developments on the market right now.'

Composite recycling

There is also much work underway on the recycling of composite materials. However, as Perello points out, the nature of the supply chain makes it a complex process.

'You have to make sure that scrap material, or end-of-life components are collected, and the chain of users is quite long, so everyone has to work together. It is something that needs to be investigated further, though, so we are not wasting material.'

After 40 years of development in the intensive environment of top-level motorsport, it is impressive that many of the basic processes and techniques developed with that first MP4/1 remain almost unchanged. However, other elements, such as the properties of materials used and, of equal importance, the understanding of their characteristics and ability to simulate them, have advanced beyond recognition.

The arrival of composites in racing was a step change as significant as that of mid-engine cars in the 1950s, or aerodynamics in the '70s, and it could be argued that no single development since has had such a transformative effect on racecar design.

Honda's carbon exhaust

During the V8 era of F1, Honda developed a carbon-carbon (CC) exhaust system, which saw extensive dyno testing and some limited track use. With no composite resin systems at the time able to withstand exhaust temperatures, Honda decided to experiment with a carbon-carbon material similar to that used for brake discs and pads.

Carbon-carbon describes a composite that uses carbon as a matrix, in essence a synthetic form of charcoal. While by no means weak, CC structures have nowhere near the mechanical properties of regular composites or metallic materials and, with this in mind, Honda's development started with a target durability for the exhaust of 25 laps, aiming to use the parts for qualifying only.

It began by developing the exhaust collector and tailpipes, with the manifold sections still constructed in Inconel, but the ultimate goal was a complete set of CC exhaust pipes, including the primaries. If realised, it could offer a net weight reduction of 39 per cent over the metal equivalents.

Unsurprisingly, development issues were encountered along the way, not least the integrity of the interface between the CC collector and Inconel primaries. This was primarily due to CC's very low coefficient of thermal expansion, and at operating temperatures gaps opened up between the two materials, making it hard for the engine control electronics to maintain a steady air-to-fuel ratio. Honda bandaged this with a gasket material developed to fill the gaps.

Also, the low resistance to oxidation of the CC material at high temperatures meant a surface coating had to be developed to prevent this occurring. Ultimately, the team was able to prevent surface oxidisation and maintain structural integrity for up to three hours at 900degC, which equated to 30 laps at racing speed.

Unfortunately for Honda, regulation changes removed the possibility of running qualifying-only parts, and ultimately the exhausts were never raced. However, the development process proved the concept was feasible and it would be reasonable to expect that, given renewed emphasis on weight saving in the current heavyweight hybrid era, such avenues of investigation may well come to the fore again. If only regulations would permit them.

Leading the charge for sustainability, Porsche entered this Cayman GT4 into the 2020 Nürburgring 24-hours wearing a complete natural fibre composite bodykit

Channel hopping

A window into the possibilities available using advanced simulation channels

By DANNY NOWLAN

One of the great things about what I do is, from time to time, I get really great suggestions from customers for potential articles. In this particular case, the customer (Supashock dampers based in Adelaide, Australia) suggested I write an article about ChassisSim's advanced data logging channels, and how this pertains to racecar design and structural analysis. Given that this, and the use of in-depth data analysis, is a great untold story, I thought it only fitting we discuss the subject in depth.

One of ChassisSim's great strengths is its fully transient nature, combined with a plethora of data channels. If you combine this with the software's full, multi-body vehicle dynamic model you get an excellent snapshot of what the car is doing, which enables you to make some very informed calls on what you are doing with its set-up.

As an example, let's consider suspension geometry and do a force analysis so you can see what you need to take into account. To start, take a look at the simulated lap trace shown in **Figure 1**. Now let's briefly walk through the traces. The first is speed, the second is engine rpm, the third is steer / neutral steer, the fourth is throttle, the fifth is front tyre contact patch lateral forces in kgf, the sixth is the rear tyre contact patch lateral forces in kgf and the seventh trace is the roll centres.

The first immediate take away from this is the lateral forces that are returned. In any structural analysis, one of your most vexing questions is what are the loads and what do you design to? The great thing about a correlated and representative simulation model is you are no longer guessing. As we can see from **Figure 1**, the peak front contact patch lateral force is 514kgf, while the rear peak lateral contact patch lateral force is 606kgf.

Back to basics

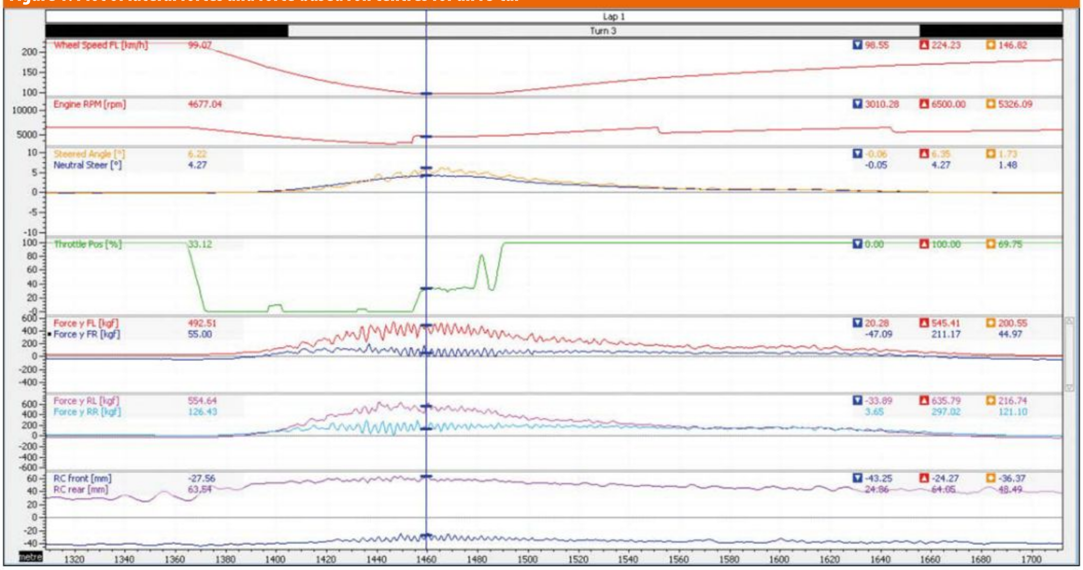
This data has several uses. If you need something quick and simple, you can combine this with the roll centres to determine the loads of your individual elements. The way you accomplish this is by going back to basics. So now let's consider a simple force analysis of a typical double wishbone suspension arm, shown in **Figure 2**.

Going through and doing the appropriate force analysis, we find what is shown in **Equation 1**, below.

$$\begin{aligned}
&\sum F_x = 0\\
&F = F_{21} - F_{34}\cos(\theta)\\
&\sum M_0 = 0\\
&0 = F_{21}\cdot\frac{R}{2} - \frac{3R}{2}F_{34}\cos(\theta)\\
&F_{34}\cos(\theta) = \frac{1}{3}F_{21}\\
&F_{21} = \frac{3}{2}F
\end{aligned} \qquad (1)$$

The significance of **Equation 1** is that you now have the tools at your disposal to figure out the total lateral forces applied to each wishbone elements. All you need to do to correlate this with your suspension is re-do the analysis in **Figure 2** and **Equation 1** and re-apply it to your suspension geometry. You can then cross reference it to the roll centres presented in **Figure 1** and, hey presto, you have your wishbone loads. This simple technique allows you to calculate these load cases with accuracy.

Figure 1: Plot of lateral forces and force-based roll centres for an F3 car



Doing a basic force analysis on suspension wishbones and correlating it with your suspension geometry allows you to calculate loads

Also, the process for the longitudinal forces is nearly identical to their lateral counterparts. The only thing that makes it a bit trickier for independent suspensions is how the pitch centres change when you go from braking to accelerating.

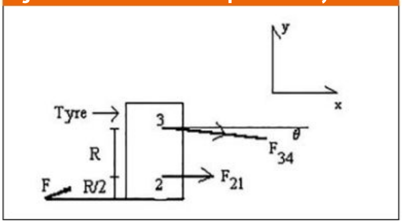
Where you can really make this shine is if you have access to Finite Element Analysis (FEA) software. The applied lateral and longitudinal forces give you the contact patch load forces for the entire lap. Looking at the ride height data both in pitch and roll, you know how the body is moving. You can then do some accurate fatigue analysis testing, not just of the suspension arms but of the chassis. This is where this technique really becomes invaluable.

Spring forces

The other useful thing you can do with the ChassisSim advanced data logging channels is to quantify the spring forces. The software will return all the spring forces zeroed in the air as wheel forces, as illustrated in **Figure 3**.

For a damper manufacturer like Supashock, for instance, this is gold dust on many levels. Since this is at the wheel if

Figure 2: Double wishbone suspension analysis



The great thing about a correlated and representative simulation model is you are no longer guessing

Figure 3: Illustration of spring and anti-roll bar forces for a simulated F3 car

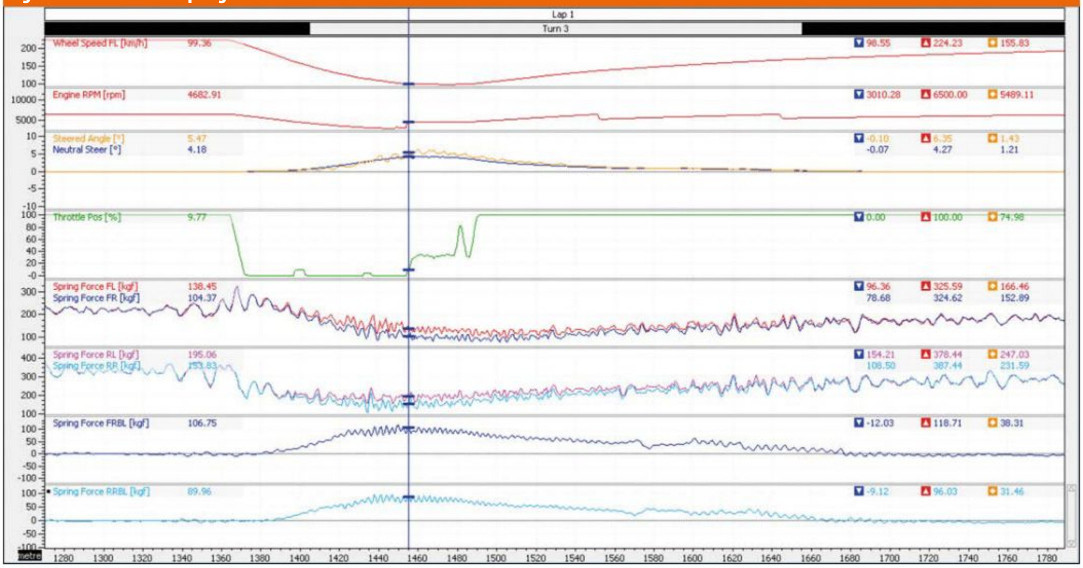
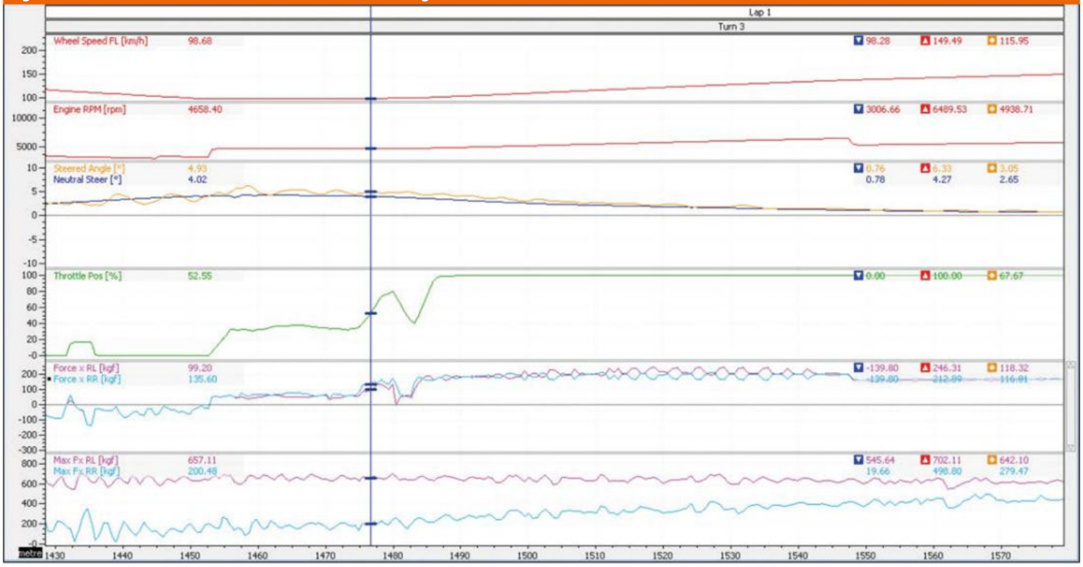


Figure 4: Channels that can be used for differential tuning from a simulated F3 car



you have a pushrod, bell crank suspension, you can work out your pushrod and damper forces in one hit. Also, knowing what the anti-roll bar forces are means you can get a clear picture of the forces going into the anti-roll bar so you can size the bar elements appropriately.

Differential tuning

Another great thing you can do with the advanced simulation channels is differential tuning. This is illustrated in **Figure 4**.

The channels of most interest here are the fifth trace, which shows the applied longitudinal forces at the contact patch, and the sixth, which shows the maximum possible longitudinal forces.

In this low-speed corner, it shows we are caught in a compromise. The locking ratio on this differential is 20 per cent. Right at the mid-corner condition, we have the situation illustrated in **Table 1**.

This tells us in the mid-corner condition we have overlocked the differential, but later on the diff' setting kicks in. The great news is that by looking at this, you get a much better gauge of where your compromises are. This takes an awful lot of guess work out of setting up your diff'.

To illustrate the compromises involved in differential selection, let's review this for a high-speed corner on the same lap. This is illustrated in **Figure 5**.

Table 1: Longitudinal forces through the corner

Forces	Mid-corner	Corner exit
Force x FL (kgf)	107.64	228.05
Force x FR (kgf)	138.83	163.97
Force x max FL (kgf)	662.18	606.23
Force x max FR (kgf)	196.14	276.07

Differential tuning is a complex area of racecar set-up and anything you can do to take the guesswork out of it is advantageous

Another great thing you can do with the advanced simulation channels is differential tuning


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Figure 5: Longitudinal forces through a high-speed corner for a simulated F3 car

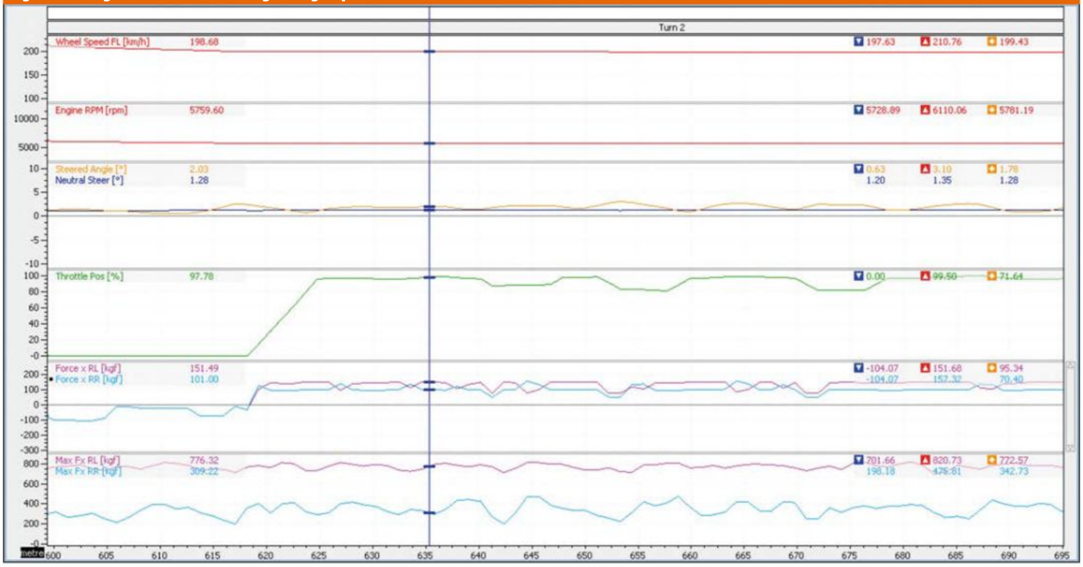
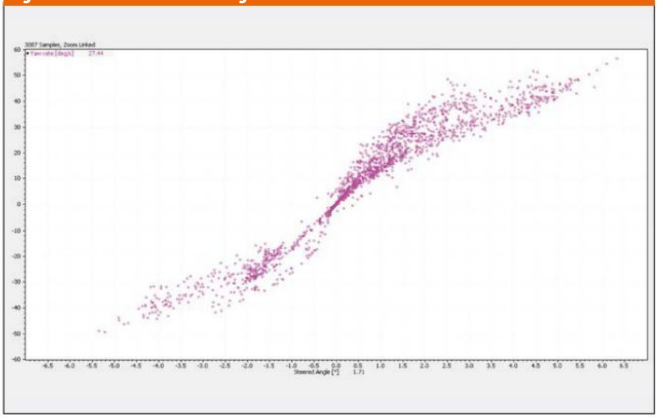


Table 2: Longitudinal forces through a high-speed corner

Forces	Mid-corner
Force x FL (kgf)	151.49
Force x FR (kgf)	101
Force x max FL (kgf)	776.32
Force x max FR (kgf)	309.22

Figure 6: Yaw rate vs steered angle for a simulated F3 car



Here, the situation is very different. This time, the differential setting works very well and just after corner exit the numbers look quite good, as shown in **Table 2**.

What is interesting to note in high-speed corners is that your speed isn't just a function of grip, it's also a function of drag, and minimising drag, and how much engine force you can put down.

Given how distinctly under-powered F3 cars are, you need all the help you can get here. So, in this particular case, we might just have to live with the differential being over locked in low-speed corners. The important thing is these channels give you the numerical tools to quantify all this.

Steering control

Another really interesting thing we can look at is using simulated yaw rate to quantify the control power of the steering. For reasons driven largely by technophobia, most regulatory bodies have seen fit to ban yaw rate sensors. However, if you have a well correlated simulation model, the yaw rate pops out in the wash. That means if you plot yaw rate vs steer angle, you can plot the control power of the vehicle, as in **Figure 6**.

The important thing to note here is the slope of this curve determines the control power. The steeper the slope, the more effective the steering is. So, if you have a driver complaining that the steering isn't responsive, you now have the tools to start exploring it using simulation.

What I have shown here is just the tip of the iceberg. ChassisSim now has over 150 logged channels that cover both chassis and powertrain. In other words, it gives you plenty of options.

In closing, these case studies represent just some of the in-depth analysis you can do with advanced simulation channels. The simulated contact patch loads have a wealth of application to feed structural analysis so you can quantify loads going into the racecar. The returned tyre forces give you key insights into differential tuning and things like steering control power just pop out in the wash.

If you have a driver complaining that the steering isn't responsive, you now have the tools to start exploring it using simulation

FIA seat upgrade

The FIA has delivered an update to the 8855-1999 seat that is used as standard in closed-cockpit racecars. The update is designed to significantly improve the safety of the device.

With support from D2H Advanced Technologies, the new FIA Standard 8855-2021 requires the seat to be much stronger than the original design that is now over 20 years old.

The new seat, which brings it closer to that used in Rallying and Formula 1, offers 60 per cent of the strength of the top tier seat, but at just 15 per cent of the cost, making it affordable for competitors worldwide.

Under the research and development programme undertaken by D2H, the FIA Safety Department conducted quasi-static tests, where forces are applied to critical areas of the seat shell by controlled loading arms, to simulate the stresses of a high-speed impact. Total forces of around two tonnes are measured on core areas of the seat that are crucial to driver safety, including lumbar, centre of the back and head / neck, as well as to the sides including the hips / pelvis region, shoulder and side of the head.

As a result of this extensive development, the new seat has a marginal weight increase over its predecessor and costs around €500 (approx. £430 / $610). The seat is homologated with a 10-year FIA validity, an additional improvement over the five-year lifespan of its predecessor.

The FIA will not withdraw homologation of the 8855-1999 seat as not all cars will be suitable for the modification to the new seat, but those that can are being encouraged to upgrade.

'Proactively improving safety standards in motorsport is absolutely crucial, and it is an area that can benefit enormously from advanced materials understanding and evolving manufacturing techniques,' says Matthew Hicks, D2H engineering director. 'We are delighted to have been able to deliver a lower cost seat that provides such a significant improvement in safety in all conditions within national motorsport around the world.'

Photos: FIA

At 60 per cent of the strength and 15 per cent of the cost, the 8855-2021 seat is very appealing

Multimatic lands VW Group LMDh deal

The Volkswagen Group has teamed up with Multimatic to develop its LMDh platform, which will be shared between Audi and Porsche, while Lamborghini remains a likely third entry from the VAG Group to compete at Le Mans.

Multimatic, which developed the Ford GT and ran the cars in the FIA World Endurance Championship, and with Riley Motorsports developed the LMP2 chassis now underpinning the Mazda DPi car, is one of four chassis manufacturers selected by the FIA to produce cars for the new class that will service both the LMP2 and LMDh categories.

The company, headquartered in Canada but with manufacturing divisions and engineering facilities in North America, Europe and Asia, has been a Porsche Motorsport partner for many years, including providing dampers to the 911 GT3 Cup, while its suspension components were also installed on the 919 Hybrid Evo, the company's Formula E and 991 GTE cars.

'Multimatic is the most obvious and logical solution for us,' said Porsche Motorsport's vice president, Fritz Enzinger. 'We don't have to set up a completely new business relationship with them and can hit the ground running.'

Multimatic's North American base is in Mooresville, North Carolina, as is Penske Racing, which was confirmed as the partner team to run the cars for the factory in the WEC, and in IMSA's United SportsCar series.

'The LMDh concept, and rules convergence between the FIA WEC and IMSA championships is unprecedented, and Multimatic's commitment to the new model is all in,' said Larry Holt, executive vice president, Multimatic Special Vehicle Operations. 'I am equally delighted with the recent Porsche Penske Motorsport announcement as we have enjoyed a long relationship with Roger Penske and his organisation.'

Meanwhile, at VW Group sister company Lamborghini: 'The decision [to race at Le Mans] has to be taken soon, but I don't expect we will be able to race in 2023,' said Giorgio Sanna, Head of Lamborghini Motorsport. 'Even if we take it now, to do a jump like this, not only in terms of development but also structure, it needs the right time.'

One of Lamborghini's preferred options is that the LMDh category be accepted into the European and Asian Le Mans Series, as it will be into IMSA's North American series.

'Why not?' asks Sanna. 'It is an open discussion that I think the manufacturers and promoters will take into consideration.'

IN BRIEF

Formula E and the **FIA** have extended the **Girls on Track** programme for a further six years, and have been joined in the initiative by **ABB**.

Since its inception, the programme has invited young women aged between 8 and 18 to discover for free different aspects of the motorsport industry through activities and workshops.

Following the successful letting of 260,000ft^2 of industrial buildings at **Silverstone Park**, **MEPC** has started work on a further 265,000ft^2 of buildings, the largest of which will offer 90,000ft^2 of accommodation.

'The Phase 3 scheme will provide larger facilities for growing companies, and those attracted to the area because of the skills in advanced engineering,' said MEPC's **Roz Bird**. 'With this latest scheme we again hope to attract a wide range of tenants involved in advanced engineering, manufacturing and industrial processes.'

Nokia has launched a Data Marketplace, a service to facilitate secure sharing of data and AI models, enabling digital transformation and data monetisation for enterprises.

The Nokia Data Marketplace is designed to help communication service providers use data in strategic decision making by providing real-time access to trusted datasets.

Volker Nossek, a central figure in **Audi's** DTM programme between 2004 and 2020, has died after a short illness.

Prior to working for Audi Sport, Nossek was in charge of the ABT Sportsline customer team for Audi Sport.

'For two decades, his life was dedicated to the DTM,' said **Julius Seebach**, managing director of Audi Sport GMBh.

The **MIA's** annual Summer Reception at the House of Lords in London has been postponed to 28 June 2022 due to ongoing uncertainty regarding Covid-based restrictions.

AP only for NASCAR Next Gen

AP Racing has been selected by NASCAR as the sole brake system supplier for the 2022 Next Gen Cup Series.

The UK business has been a major supplier into NASCAR's top racing divisions since 1987, equipping 13 championship-winning cars in the Cup Series alone.

Using patented Radi-CAL caliper design philosophy, combined with its advanced forged aluminium process, the company has delivered high performance four and six-piston monobloc calipers at a price point that suits the objectives of the Next Gen project.

It has also introduced its new direct drive brake disc configuration into the series, ensuring the highest levels of performance and durability.

Teams will be able to use the same front and rear calipers for all circuits, with just two options for discs, for heavy and light duty brake scenarios, further reducing the costs to teams.

The Next Gen cars will also be fitted with AP's pedal box, which benefits from its use of the latest pull-type AP Racing master cylinders, all of which combine to provide control and modulation of the system.

'AP Racing has played an important role in the development and roll out of the NASCAR Next Gen car,' said Josh Hamilton, innovation communications senior manager at NASCAR. 'As sole provider of brake systems, AP Racing has been able to meet and exceed our expectations in development and delivery of brake system parts.'

Calipers, discs and pedal boxes on the new Next Gen cars (see p16) will all be supplied by AP Racing

Murray mint

Gordon Murray, the famed former McLaren and Brabham designer, has announced an investment of a further £300 million into Gordon Murray Design, Gordon Murray Automotive, R&D and talent, along with a new Gordon Murray Electronics division that will put a sharper focus on designing and engineering advanced electric vehicles.

The new headquarters and technology campus will start construction in July, with the first phase opening in 2022.

FS UK is go

The Institution of Mechanical Engineers has confirmed that the UK Formula Student competition will take place at Silverstone on July 21-25, 2021.

Racecar Engineering has linked up with the IMechE, offering the Racecar Engineering Engagement, Outreach and Communications award, 2021 that recognises teams' communication and promotion strategy.

IN BRIEF

Parella Motorsport Holdings, in conjunction with **SCCA Pro Racing**, has appointed **Aaron Coalwell** as the new technical director for the Formula 4 US Championship powered by Honda, and the Formula Regional Americas Championship.

Buddy Frey, who served as technical director for the two series for three seasons, announced his retirement earlier this year.

The **FIA** has signed a long-term partnership with global media group, **Discovery**, to promote its Electric GT Championship, which is planned for 2023.

The FIA is planning six international events across Europe, the Middle East and Asia and plans to expand to the United States in 2024.

No manufacturers have yet announced their participation.

TE Connectivity, a world leader in connectors and sensors, has been ranked among America's best employers for diversity by Forbes, following an independent survey of US workers. The recognition comes as TE continues its efforts to ensure inclusivity and diversity are core to its business, including workplace and community involvement to business partnerships.

HYUNDAI WRC HYBRID

Hyundai Motorsport GmbH / Fabien Dufour

The South Korean maufacturer has started the WRC hybrid test programme for its i20N model that will compete in 2022. The first test took place on gravel in the South of France ahead of a more extensive programme at established venues around Europe and on different terrains

Upwardly mobile

Spanish electric vehicle developer, QEV Technologies, has linked with Dassault Systèmes to take race learning to the road

QEV Tech is on a mission to transform the world for the better through the power of electric mobility. The electric vehicle developer has its roots in racing and knows what it takes to create a winning supercar. It managed the NextEV-NIO team to victory in the inaugural 2014 / '15 Formula E championship, and in 2021 it plans to run a team in the new Extreme E championship.

Away from motor racing, the company shares its expertise with the wider mobility industry and helps global automotive OEMs accelerate their transition to electric technology.

Headquartered in Barcelona, Spain, QEV Tech's vision is also closely linked to its local community's needs. It sees a future where its home city's inhabitants travel around using electric vehicles, a city that bets on sustainable mobility and is united against climate change.

From motorsport, through buses to electric hypercars, QV Technologies aims to be a leader in electric mobility solutions, offering its technological capabilities to help change the world

Through its three business lines – motorsport, electric hypercars and electric buses – QEV Tech partners with leading OEMs to help them develop electric powertrain technology and full e-vehicles, from design concept and prototyping to production.

'The motorsport industry is where we started out,' said Joan Orús, chief operating officer of QEV Tech. 'It's where we have our know-how and it's a great marketing platform for us to branch out and share our expertise more widely.

'Then we have our second line, electric hypercars, offering our services to different manufacturers and working with them to build prototypes from scratch.

'Our third line is the electric bus, where we sell our e-kit platform to manufacturers, or work with them to develop a complete e-bus. We want to apply this technology to help change the world. We want to have clean cities. For us, it's not just about developing the fastest, most expensive cars. We need to focus on lowering costs and bringing greater efficiencies to the wider mobility industry, and we can use our expertise to do that.'

Platform EXPERIENCE

But as QEV Tech scales its entire business and broadens its global reach to keep up with demand, it faces the challenge of increasing complexity. Transitioning from a start up with just a handful of engineers to a team of more than 50, the company needed a platform to bring everyone together, streamline workflows and collaborate on complex designs, while ensuring all involved have access to the most up-to-date product information.

'It was difficult to manage all the information we have across our facilities,' commented Orús. 'With that, and having to monitor all our products and manage all the related data, we were constantly having to contend with changing file names and locations. When you start out as a small company with three people, it's fine. But at the level we are now, it was becoming much more complicated.'

The company already used Dassault Systèmes' design application CATIA, and felt the 3DEXPERIENCE platform could be a good fit for its needs. Working closely with Dassault Systèmes' business partner, Principia, QEV Tech assessed how the platform could deliver the collaboration, simulation, integration and project management capabilities it required. Principia, in turn, listened to the QEV Tech team's requirements and suggested the move to the 3DEXPERIENCE cloud with the CATIA and ENOVIA applications.

QEV Technologies selected the 3DEXPERIENCE platform on the cloud to create an always-on collaborative working environment for its engineers. A single, centralised database allows it to bring together its CAD data, store and securely share information and connect the supply chain to manage complex projects.

'We're not in this industry to create a brand. We want to help others embrace our technology and knowledge, and accelerate the development of electric vehicles,' concluded Orús. 'Our goal at QEV Tech is to work with the big manufacturers and bring our expertise to them. I see the 3DEXPERIENCE platform giving us a good foundation to offer the best experience and integration. Working together, we *can* change the world.'

QEV Technologies
https://ifwe.3ds.com/transportation-mobility

Interview – David Hamblin, managing director at AP Racing

Stop right there

AP Racing started out as a skunkworks project and grew into a globally recognised leader in brake technology

BY ANDREW COTTON

It's important that the regulations do stay open in the top levels, because there's always performance to be found

AP Racing's managing director David Hamblin says that while hybrid powertrains will lead to different brake specifications in production cars, there will always be a case for friction brakes

Andrew Homer

One of the most respected names in brake technology, AP Racing, has cemented its place in motor racing this season by securing some major deals, including component supply in the NASCAR Next Gen (Gen-7) package, the FIA RX2 Championship and extending its support of the British Touring Car Championship.

This is alongside its existing commitment to Formula 1, Super GT and top-level GT racing, open competition on which the brand built its name.

The company started in 1967 and moved to the Midlands of the UK, Coventry, in the early 1990s. It remains on the same site, although the company has expanded dramatically since then with the addition of more buildings and facilities. The most recent is an NVH dyno, which has proven to be an increasingly important part of AP Racing's armoury. It is this sort of investment that helped the company land the NASCAR contract.

However, it is in the OEM department that AP Racing has seen its biggest growth, driven in part by its racing pedigree. As original equipment on the Bugatti Chiron, the crossover is clear to see.

'Probably the biggest change for AP Racing over the last 25 years is the growth of our automotive OEM business,' confirms AP Racing managing director, David Hamblin. 'We started off with niche manufacturers, and that's been growing to the point now where about 40 per cent of our business is road based. And that is through either OEM supply or a growing upgrade market for the road and track days.

'We see the automotive and upgrade areas as very important part of our business growth now, and also in the future.'

Homologated supply

The racing market is finite, with a limited number of series and so many now looking to change to a sole supplier model in a bid to keep costs under control, while also improving the quality and technology for the racing teams. AP Racing is well placed to pitch competitively for such contracts.

'It's a trend I've seen in racing for the past 20 years, but costs, sustainability and so on is driving more what we call homologated series,' says Hamblin. 'At the top echelons of motorsport [brakes] are a competitive part of the car. It's a big performance differentiator.

'But what we are seeing is a trend towards homologated [supply]. That is what we've learned working in the OEM industry over the last 25 years, [and it is] working very well for us because we have industrialisation of supply chains and manufacturing techniques that are better for the medium volume homologated series. That allows us to bring technology to those series in a way that's affordable, and also sustainable, but without watering down the actual content.

'So, whilst the OEM was born out of our racing activities, it's mutually beneficial for both.'

While the lack of diversity and choice for a competitor is frustrating for many teams and drivers, the tide is strongly in favour of series attracting engineering partners to supply the entire grid on the grounds of cost. But is that true? Are brakes really cheaper under such agreements?

'We look at the needs of the series and come up with a solution taking the best technologies, and every series will have a view on what they'd like to pay for that,' explains Hamblin. 'Hopefully, with what we've put in place, we can actually bring technology that potentially was out of reach into the series because of the industrialisation.

Hybridisation

'From a pure technical R&D point of view, we never stopped developing. We are constantly looking at every detail in the braking system.

'With the hybridisation and electrification now in a lot of the top racing series, they're in effect two brake systems on a car. You've got your friction brake and you've got your motor brake. One of the challenges if you haven't got F1 budgets is blending those two together and making braking systems where the driver has confidence.

'That's when you start looking at different materials, different coatings, different tolerancing, stiffness, weight. All those things are in their interest.

'If I look back at what we were doing in 2007, we've moved on. It's important that the regulations do stay open in the top levels, because there's always performance to be found.'

Hybridisation is changing the way brakes are being used in competition. The technology has been commonplace in endurance racing and Formula 1 since 2014, but is now spreading into national series, as well as the production car world, and it is here that AP Racing sees the largest benefit from its racing activities.

Energy capture

'The split between friction brakes and motor braking is going to go towards motor braking,' says Hamblin. 'At the moment, battery technology limits motor technology limits, how much energy you can harness. There is lots going on in the background to try and capture more of that kinetic energy. So we recover more or get your kinetic energy from braking.'

'I see the shift towards more regenerative braking than friction braking [leading to] a reduction in brake emissions.

I see the shift towards more regenerative braking than friction braking [leading to] a reduction in brake emissions

Joe Bennett

AP Racing may have started out in motorsport, but now up to 40 per cent of its market is OEMs and upgrades to road cars for track day performance

Andrew Homer

The company's UK facility includes a semi-automated production line for its continually expanding range of OEM and aftermarket products, but racing is at the heart of the business

And that I think will come potentially through brake disc technology and pad technology in terms of the materials used.

'But fundamentally, friction has traits you can't change. You can't totally change physics. In the automotive section, and certainly from mass transport point of view, I see that friction has been reduced. I think about your day-to-day running to the shop, for example. You can almost imagine a world where 95 per cent of your braking is through regenerative. For sure, the pressure on the European governments is for lower emissions and more sustainability for the environment, which absolutely should be so.'

So could there be a point where regenerative braking is the sole force, and the disc brakes only a back-up solution? Perhaps, although the friction brakes will still need to be capable of stopping the car in case of total motor failure. Using an extreme example, should a car be parked on top of a mountain while the owner is skiing, and then has to be driven down the hill with a battery that will be quickly charged means there will be a total reliance on friction rather than regen' braking, and cars have to be able to cope with scenarios such as that.

But downsizing the brakes can open up packaging solutions, as Nissan tried with its GTR-LM, and Toyota more successfully with its TS Le Mans models.

'I think in general it will drive size down, and when you start driving size down, are there other design opportunities, even packaging opportunities? Absolutely,' says Hamblin.

One of the big drivers for everybody is having zero drag on your brake system

'And will that drive new pad friction pad technologies? Yes, technologies that can reduce even more emissions? Absolutely.'

NVH dyno

Back to the racing world, though, and AP Racing has been highly active in producing new products to service the contracts it has. The facility has grown to include a third building on the Coventry site, including a semi-automated production line that focusses on OEM builds and upgrade kits. The other half is dedicated to research and development, and it is in this part of the facility that the company has its new NVH dyno.

This is designed to detect noise and vibrations in corner and axle brake fixtures, and can recreate brake noise. So popular is AP Racing's dyno that it has run every day since it was first started.

'Being a racing company, we did kind of tweak it a little bit, so we can also run Formula 1 corners on it and do full F1 practice simulation,' says Hamblin. 'It's a very flexible tool that complements the dyno we've had for the last 10 years.

'We have also got a mechatronics department now and one of the things we're investing in is control, so

brake-by-wire, clutch-by-wire or anything else by-wire. We've got in-house capabilities on by-wire now. A lot of things on the car will become controlled by messaging rather than by cable or a hydraulic line.'

Drag reduction

The NVH dyno was key to winning the NASCAR contract, but that was only a part of the pitch. Reducing drag from the braking system was also a central topic.

'One of the big drivers for everybody is having zero drag on your brake system,' explains Hamblin. 'For example, on the speedways, where they don't really use their brakes, we've got lots of tools to give you no drag whatsoever. And the driver accepts the fact that when they're coming hurtling into the pit, they know the pedal might be a bit longer because you've pulled everything back nicely.

'But clearly, on other cars where the driver would like brakes to work more often than once every 40 laps or whatever, it's a challenge. So, we've got a lot of investment in technology and in trying to understand residual drag in a braking system.

'One of the things the NVH dyno, and our other dyno does with the upgrades we got, is to measure that. We can run design experiments and demonstrate and also hit targets the OEMs typically put in now because drag is an enemy to efficiency.'

GT racing

The company has developed a new brake for the GT field, the second generation of the forged brake caliper design that was released in time for the 2020 season, and which is already proving to be popular in the competitive GT3 field. The caliper is lighter, stiffer and can be used for longer, all of which improves sustainability, as well as helping performance.

In GT racing, the brakes are only partly homologated by the manufacturer. Pad choice is free, but that makes it far more complicated for the brake manufacturer.

'From a GT point of view, the brake system is semi-homologated, but as soon as you start changing things like pads, it can put a huge variance in the challenge to ensure the brake system is suitable,' says Hamblin. 'GT cars can be a bit compromised in the amount of air they can get to the brake, so obviously a very efficient cooling package is necessary. That's just not the caliper, that's the disc as well. We have some clever vane technology in the disc, for example, that allows us to cool brakes at a higher rate.'

The company also stays close to universities, and has recruitment drives to gain access to new ways of thinking. 'We've a few grey-haired individuals, but we pride ourselves on bringing a lot of young engineers through who are very enthusiastic, and aren't put off by previous failures. Their dynamism really helps to push us forward as well.

'The next people who are going to be doing this stuff are the Gen Z, so let's get them in and they can tell us what they want.'

We pride ourselves on bringing a lot of young engineers through who are very enthusiastic, and aren't put off by previous failures

GT World Challenge Europe

Brake technology is changing rapidly as both manufacturers and race series become more demanding in their targets, particularly in relation to drag reduction, efficiency and brake emissions

Claret or clarity?

Sometimes one turn of phrase makes sense of everything

Spa-Francorchamps is a place everyone involved in racing enjoys. It throws up a world of challenges for competitors, either in the cockpit through driving or on the pit wall via strategy. It also features one of the most challenging paddocks for an out-of-shape hack, with a steep climb from the bottom of the endurance paddock to the press room on the second floor of the F1 paddock. Conversation always takes a while to get started as you crowd around the coffee machine trying to get your breath back after the climb.

Topics of conversation this year, of course, centred around the balance of performance and performance windows of the Hypercars vs LMP2, but another subject raised its head, and that was what's happening in Formula E? What is it that caused both Audi and BMW to withdraw from the pinnacle of electric racing at a time when their board of directors and engineering departments are pushing the technology in production car development?

At time of writing, Mercedes has yet to commit and, according to sources, there was a mad dash to Monaco to persuade Mercedes to stick with the programme. This, at a time when the FIA pushed the electric GT, announced a promoter and continues its pursuit of all things battery.

It has always been known that there are only three spots on the podium, and that you only need two to make a race. Audi pulling out had nothing to do with its Le Mans ambitions with LMDh as Porsche will do the same thing, yet has stuck with the Formula E project. BMW may be pushing for LMDh, or hydrogen to which it committed a long time ago, but would that be enough of a reason to withdraw from the electric single-seat formula? Is it because it is so expensive that it cannot do both?

'Every category that relies on direct manufacturer involvement is doomed'

This was something to ponder, and we will probably never get to the bottom of it. I always wondered what excuse the manufacturers would use to withdraw from Formula E as they all leaped onto the bandwagon as early as possible with promises of commitment to electric mobility, so how would they reverse that trend? They could not claim to be unsuccessful. They could not say they no longer support electric, and certainly could not say publicly that another race programme was more important, unless that was also electric.

We around the coffee machine in the Spa pressroom never did reach a conclusion and, a week later, in conversation with Stéphane Ratel at the opening round of GT Sprint, he was also unable to put any flesh on the bones.

However, Ratel is nothing if not astute. While he wasn't able to work out why the manufacturers were leaving, he was clear in why he was not interested in promoting the electric GT championship, and offered an opinion on the future of electric racing.

'Electric is about mobility, not about sport,' said the Frenchman. While manufacturers push for high performance (in a straight line) from electric, and are seeking quick lap times on the Nordschleife to prove electric is sporty, there is no electric supercar on the market. Meanwhile, Honda has produced the 'E', a car that is light, has 1970's styling and can do just over 100 miles on a charge. This makes sense, although it is never going to set the world of energetic driving alight.

Ratel also kicked off the interview with another statement borne from years of experience as a racing promoter: 'Every category that relies on direct manufacturer involvement is doomed.' As a starter for 10, that was definitely up there. 'That is a fact of motorsport, and always has been a fact.'

That rather flies in the face of the FIA's stance, where the manufacturer is king, and every rule set, technical working group and decision-making process is led by those that produce production cars in vast quantity. The smaller car makers, racing teams and companies are all pushed to the wings, waiting to put in their opinion, which, according to many, then gets trashed.

Want a calendar that makes financial sense? Don't go to far away countries that involve air transport, they say. No change, it's an important market for the manufacturers. We go, you pay.

Ratel started with a bombshell, and continued in that vein, culminating in, of all things, teleportation.

'You remember the film *The Fly*?' he asked. The one where Jeff Goldblum accidentally gets himself into a teleportation device with a fly leading to a mix of genes. 'Pods, the biggest revolution in human history,' Ratel continued. 'No more roads, no more airports and people and merchandise will be able to move. Even if that happened, you would still have race tracks and cars running on them, and they won't be electric. It will be a V10 screaming and giving you that sensation. That is it.'

Having left the interview I headed for my airbnb, opened a bottle of red, and decided maybe Covid has had more of an effect on my life than I previously thought.

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