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UK £6.95 / US $16.25
March 2025 / Vol 35 No 3

Inside the world of modern motorsport technology

Racecar engineering™

New generation

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UK club racing embraces low-carbon solution

Porsche overcame a troubled build-up to win the 24 Hours of Daytona for the second successive year

Brandon Badraoui / LAT

Fuelling the future

The political agenda means it is crunch time for Europe's auto makers

In this edition we have taken a close look at fuels, or rather how powertrain development is adapting to new solutions being investigated for racing. Sustainable fuels have reached the level of being used in national motorsport, while the quest to develop hydrogen continues apace. There is also a huge effort being put into increasing motor efficiency, as well as developing software that manufacturers may be able to use in their road cars.

It's interesting to observe (from a great distance, admittedly) how the politicians are thinking, how that affects what happens in motor racing, and the cars we buy. It's also interesting to note that the biggest competitors for our major brands in Europe, from China and the US, are not involved in motorsport over here. Companies such as BYD and Tesla, have the technology to race competitively in a series such as Formula E, but clearly don't see the benefit, or need, to do so. They prefer to just build electric cars.

The EU issue

For the European Union, the discussion has started. At the end of January, the EU opened its formal investigation into its motor manufacturers, which are clearly struggling financially and from a technological standpoint. The car makers have largely sold off the technology and expertise that took a century to acquire, in order to pursue the political electric dream, only to find the cars they produce are not attractive enough to consumers and require massive incentives to meet otherwise unachievable targets.

In racing, Honda's philosophy is to make its Honda Racing Corporation (HRC) division stand alone financially. Normally, when times are hard, the racing programme is the first to go. For Toyota, the only reason its Gazoo Racing department is still running in Cologne is because it remains profitable. Not long ago, the Japanese company employed key figures to slice the financial fat from the bone, if there was any to be cut. At the time, the heads of the TMG Europe were not concerned, as it was making money.

Porsche and Lamborghini, meanwhile, are looking to achieve their goals on track as customer racing is cheaper than factory motorsport. Lamborghini openly stated that it prefers to be represented by a semi-customer team once the car is fully developed. That's the back-up plan for Porsche, too, if the board decides to cut its budget even further.

The question then has to be asked; is there a market for customer teams to run these cars? With the complication of hybrid, the cars are designed for manufacturer racing, or rather to achieve the goals of the manufacturers, rather than the teams. From the teams' perspective, they would far rather drop hybrid systems altogether and just run traditional racecars on sustainable, low CO_2 fuels.

JDC-Miller Motorsports is a customer team racing in the top class of the IMSA Sportscar Championship, but such entries are extremely expensive to run for a privateer, if that's the way sportscar racing will go

This brings us back to the politicians, and the issue they currently face. Do they focus on keeping the European car industry alive, delaying the fines that will come if manufacturers miss their CO_2 targets, or do they follow their own commissioners, lobby groups and environmental organisations that are vocal in wanting them to comply with the targets that have been in place for a long time? If the Chinese car makers can do it, how did the established, successful manufacturers here fail so badly to meet the same goals?

Have we really failed to grasp the concept of electric mobility, with range one issue, recharging another? Or is it that our car industry is producing the wrong cars if the cars from BYD, Kia and Tesla are selling?

Advantage China

According to a report by Forbes, Chinese manufacturers of EVs have a 30 per cent cost advantage over their European counterparts, and the European Union's CO_2 programme is playing right into their hands. As one engineer noted, the citizens of Europe are paying for the destruction of their own car industry, which itself underpins our wealth and manufacturing.

The problem is that if the EU delays the ban on ICE any distance from the 2035 deadline (2030 in the UK), then the innovative programmes currently under way to reduce the impact of carbon emissions will likely die. Hydrogen, for example, as a combustion fuel, or as a fuel cell, will not go ahead, as the weight of the car and the compleity to introduce it, will kill the project.

I therefore maintain my position of advocating lightweight cars, powered by small capacity, efficient engines, together with high fuel cost to encourage consumers to switch from their weighty cars of today. Electric cars should be similarly small capacity, like the Honda e, and hydrogen should be used for heavy-duty applications and long-distance travel. We need to reduce our CO_2 emissions, but we have to do it without killing off the companies that are needed to deliver it.

If the Chinese car makers can do it, how did the established, successful manufacturers [in Europe] fail so badly to meet the same goals?

Old new era

The WRC dropped hybrid systems for 2025 at the second time of asking. Racecar *was at the Monte Carlo Rally to find out how the manufacturers have reacted*

By DANIEL LLOYD

Red Bull Content Pool

The WRC endured a year of ups and downs in 2024 as the short-term technical outlook was decided, but now the cars are up and running without hybrid power

Cars competing for overall victory at the Monte Carlo Rally in January 2025 did so without hybrid electric powertrains. That would be an unremarkable statement had they not operated with hybrids for the last three editions. The 2025 Monte marked the start of a transitional period for the FIA World Rally Championship, following its decision to scrap the 100kW (134bhp) spec system after last season.

From 2027, the WRC will adopt a new set of regulations but, for now, the manufacturers in the top Rally1 class – Toyota, Hyundai and M-Sport – are having to adapt their cars for ICE power only.

How did we get here? Rather fittingly for rally, it has been a long and winding road, with plenty of bumps along the way. The FIA announced in February 2024 that hybrids would be scrapped the following year. That decision was based on findings from an FIA working group panel composed of experienced former rally competitors and technical chiefs. They concluded, as part of their wide-ranging review of the discipline (see *RE* V34N5), that the gap between Rally1 and Rally2 should be reduced to encourage more competition at the sharp end of WRC events. To do this from both cost and performance standpoints, it was deemed necessary to remove the hybrid system, reduce power and aerodynamic performance, and introduce an upgrade kit for Rally2 cars.

Stay of execution

The proposal proved unpopular with the Rally1 manufacturers, who were rather taken by surprise and, after examining the details, were less than enthusiastic. It prompted a review that ended up with the FIA announcing in June that hybrids would stay, and that new rules would come in 2027. All manufacturers pledged their support for this, and returned to working on their seasons.

Then, a separate development arose regarding battery maintenance that sealed the hybrid's fate. It concerned the procedures following a so-called 'shock error' when the battery would disable when subjected to a certain *g* force. This could happen in an accident, or even when landing a jump. Having previously cleared most batteries of their shock errors on site, hybrid system supplier, Compact Dynamics, started taking batteries back to base for a complete rebuild after three such episodes.

All three Rally1 manufacturers were affected to varying degrees, and put their case to the WRC organisers. Among their concerns was they were starting to run low on batteries as the turnaround time for a full factory rebuild was not keeping up with the busy rally schedule. So, in November 2024, the FIA changed tack again and announced hybrids would be abolished after all, but for entirely different reasons to the initial attempt.

'In the end, it was not sustainable for the manufacturers because they needed to change the battery unit many times,' says Xavier Mestelan-Pinon, chief technical and safety officer at the FIA. 'It is not so easy to make a refurbishment. For some, it was impossible. So, for the benefit of the championship, [the decision was made] to remove the hybrid.'

Cause and effects

The Rally1 regulations were introduced in 2022, which was the first season with hybrid power. Therefore, the cars had been designed, developed, packaged and mapped as hybrids from the outset. Although removing a hybrid system is certainly easier than introducing one, with Rally1 being such a competitive class at the top, any trouble adapting to such a fundamental change could have a major impact on results.

For context, the average gap between first and second place in 2024 was 33.8 seconds, while a third of the events were decided by less than 10 seconds. However, meaningful analysis has so far been blurred by the arrival of a new tyre supplier (see box out on p12), on top of the switch to non-hybrid.

The removal of the P3-position hybrid system, consisting of a motor generator unit (MGU) and 3.9kWh Kreisel Electric battery, has impacted vehicle weight, power and cooling arrangements. It has also had a positive effect on team budgets, as teams were no longer spending hundreds of thousands of Euros on required hardware.

To counteract the hybrid system's removal, the FIA reduced the minimum weight of the cars from 1260kg to 1180kg, a reduction of 6.3 per cent. Considering the hybrid system and its mandatory cooling apparatus weighed just under 100kg combined, ballast was required to bring the cars up to the new minimum weight.

For safety reasons, the FIA sought to keep a similar power-to-weight ratio with the lighter, non-hybrid cars, so reduced power output with a 1mm narrower turbo restrictor. Rally1 cars with the pre-mapped electric boost active could exceed 500bhp. The smaller restrictor is understood to be worth around 15bhp, which would take around 150bhp off the top output in total. Still, it's hard to assess whether the power-to-weight ratio has actually been maintained.

'If you take the hybrid power into account, when it was always available, then I would say no,' says Gerard-Jan de Jongh, head of engineering at Hyundai Motorsport. 'I would say it's also a little bit too early to say if that's been achieved. It's different on different surfaces. If you talk about slow, twisty rallies like Greece, power is much less of an issue: it is more about torque.

Lawrence Butcher

The FIA sought to maintain a similar power-to-weight ratio for safety reasons, although how close it is depends on the surface type

Lawrence Butcher

The hybrid cooling systems positioned at the rear of the cars have been removed, bringing the weight distribution forward slightly

There, for sure, having a lighter car will feel like a positive. But on high-speed rallies, where you really need engine power, it will probably be more on the negative side.'

Clearly, the cars are much less complex now without hybrids. For the last three seasons, Rally1 teams had to train engineers and mechanics to safely work on a hybrid system, whereas now they can put more focus on other areas. There is also no longer a need to pre-program three maps for electrical energy recovery and deployment. Teams used these maps across all their cars throughout a season unless a joker (a technical update limited in number) was played.

Disrupted development

However, last year's back and forth over the immediate future of WRC technology only served to disrupt the manufacturers' normal development plans. Therefore, they arrived in Monte Carlo with different stories to tell. Toyota, the reigning teams' champion, rolled out two jokers aimed at addressing

'We've had to re-look at all the development plan we had set out for the next two years, to make sure we aren't developing things for areas of the engine that are no longer going to be used'

Tom Fowler, Toyota Gazoo Racing technical director

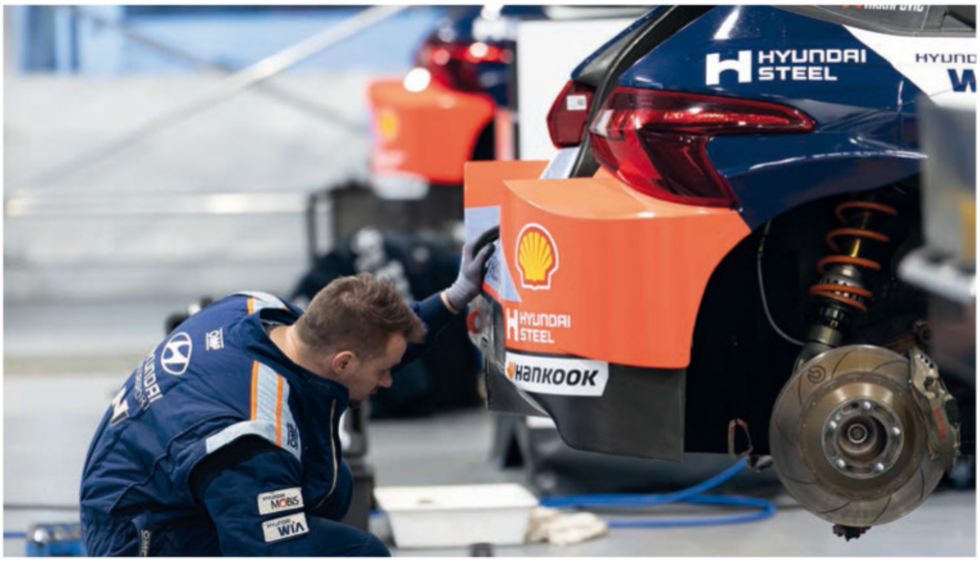
Toyota

Toyota's Tom Fowler says the air restrictor change forced its hand in developments made to the GR Yaris Rally1

Toyota

Operations have become easier as teams no longer have to undergo special training, or worry about hybrid system safety measures

Hyundai



Hyundai is introducing a major suspension upgrade early in the season as it attempts to improve the i20's rear-end grip on gravel

'For safety reasons, I consider it my duty to keep the same power-to-weight ratio… We need to be a little bit conservative. In 2025, we cannot do the same thing as the 1980s'

Xavier Mestelan-Pinon, chief technical and safety officer at the FIA

how the restrictor size reduction impacts the engine's operating range. However, it had also spent several months working on a transmission upgrade that, according to the team's technical director, Tom Fowler, is 'not worth doing' any more because its greatest benefit would have been felt in conjunction with the hybrid.

'We've had to re-look at all the development plan we had set out for the next two years, to make sure we aren't developing things for areas of the engine that are no longer going to be used,' he explains. 'We've already had to adjust our development plan for Monte Carlo. Our new engine for Monte was specifically designed for 35mm rather than 36mm [air restrictor].'

One of the two joker updates for the Toyota GR Yaris Rally1 at the Monte was a new camshaft and exhaust manifold. The other was a replacement set of gear ratios to improve driveability under acceleration without the hybrid there to assist.

'The more you're restricted, the less convenient it is to rev your engine,' Fowler adds. 'The lower rpm window you have to run in, because of the restrictor, then changes items that are tuned relative to revs. Particularly things like the exhaust manifold and camshaft [in terms of] specific timing and tuning to rpm ranges.'

Fowler describes the restrictor diameter reduction as a 'curve ball' for Toyota. It was already planning to introduce an updated engine at Monte Carlo, which it started developing based on the likelihood that hybrids would be canned, but then had to re-think its development when the restrictor change was announced. Toyota's surprise was based on a section of last year's regulations that laid out specifications for privateer, non-hybrid Rally1 cars to compete.

'Everyone assumed, maybe naively, that if the hybrid was removed, this regulation would be implemented as is, but then it wasn't,' says Fowler. 'Why ever that was, it put an implication onto the development programme that was unforeseeable. We had to change the engine plan very quickly, and we reacted to that very well as a team. I don't think anyone else can come to Monte Carlo and say the last jokers they applied were specifically for that restrictor. Whether or not it will bring the benefits that are enough to be successful is another story, but at least we've done it.'

For the FIA, the restrictor was a key ingredient in ensuring the lighter, non-hybrid Rally1 cars would not be what it considered to be dangerously fast.

'They were asking to keep the same restrictor,' says Mestelan-Pinon. 'For safety reasons, I consider it my duty to keep the same power-to-weight ratio. I don't say the cars are not safe, but in the past we had more than 500bhp in these cars. That's very powerful. We need to be a little bit conservative. In 2025, we cannot do the same thing as the 1980s.'

Suspension upgrade

Hyundai arrived in southern France with relatively few changes to the i20 N Rally1 in which Thierry Neuville claimed his maiden WRC drivers' title last year. But that was only because the South Korean manufacturer was planning to unleash a major suspension upgrade at round two in Sweden.

'In 2024, we looked over the whole design of the car,' says de Jongh. 'Two main points to focus on were suspension layout and, as always, weight reduction. We don't need to talk about why weight reduction is necessary, but on the suspension layout, for us it's clear we always had a lack of performance on smooth gravel rallies such as Poland, Finland and Chile. We feel we were lacking compared to the competition, so we made some adjustments to the suspension layout to generate more grip on that surface, especially at the rear end of the car.'

Hyundai started testing the new suspension components towards the end of last summer. De Jongh doesn't want to reveal any mileage figures, but assures thorough running was conducted to prove the parts' durability.

'We were happy with the amount of mileage we were able to accumulate on the parts, on both gravel and tarmac,' he says. 'On tarmac, we had a little bit less mileage, that's why we are delaying the introduction of the upgrade package [until Sweden].'

For the tarmac lanes of Monte Carlo, the Hyundais ran with an updated transmission that the manufacturer took as a joker for reliability reasons, to cover the failure that Esapekka Lappi had in Kenya last year.

Optimisation project

M-Sport claims not to have as deep pockets as its OEM competitors, so the pathway to eventually dropping hybrids was a sensitive issue when it came to developing the Ford Puma Rally1. However, the British team did benefit from running a privateer non-hybrid car for Mārtiņš Sesks in Poland last year, the only Rally1 stable to do so. During those outings, M-Sport established how to optimise gear ratios without the hybrid and applied those learnings to its entire fleet of non-hybrid Pumas for the 2025 rules.

'We homologated some new gear ratios at the end of last year to suit non-hybrid running,' says Tim Jackson, chief engineer of WRC test and development at M-Sport. 'That was something where we had a bit of background knowledge of what we needed to do. Without the hybrid, you ultimately have less output so, effectively, the ratios are slightly shorter to take that into account.'

'There won't be any massive changes… For us, it's more about optimising the package we've got, as opposed to spending huge amounts changing the spec of parts'

Tim Jackson, chief engineer of WRC test and development at M-Sport

On the flipside, M-Sport had to abandon planned improvements to its hybrid system cooling. This was especially galling as the team has a smaller budget this year, although it has continued to look for ways to improve the Puma within its means.

'There won't be any massive changes like [the Hyundai suspension],' says Jackson regarding further updates. 'From their side, that has been in the pipeline for a long time. For us, it's more about optimising the package we've got, as opposed to spending huge amounts changing the spec of parts. There are quite a few optimisation bits that meet the budget we have for this year. So, a lot of areas on the car, but not huge steps in any of them.'

Duct tales

Aside from stating the hybrid componentry must go, the 2025 regulations also dictate teams must close off any openings on the rear bumper, except the exhaust outlet. These openings formed the back end of the hybrid cooling system, enabling ducted air to escape. On the other hand, manufacturers may leave open the air entry ducts in the front that served other functions, in addition to cooling the battery and electric motor.

'The basis is that all the exits have to be closed, but the inlets can be kept,' confirms Fowler. 'It's appreciated those are used for

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The Ford's hybrid boost was mapped as a two-stage pedal, with the extra power only coming in at the top end of the press. This saved it needing any big engine changes for 2025, the M-Sport team instead placing its attention on optimising the gear ratios

Monte Carlo winner, Toyota, updated its suspension in 2024 and was developing transmission upgrades for this year, until the hybrid system rule change was confirmed

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cooling other things. It just depends on how you did your other cooling systems. One way to do it is to have a system that is fully ducted from entry to exit, though some systems are only ducted after the point of the cooling function, and then the air is left to do its own job afterwards.

'In our case, we tend to go down the more fully ducted route, because it's more efficient. So, in closing the rear bumper, we had to make sure the changes made to the other systems wouldn't be negative on the cooling performance. This, in the end, was relatively straightforward.'

One of Toyota's priorities was to ensure it could maintain the level of rear brake and transmission cooling it had when it used the hybrid cooling system to help cover those parts. Hyundai, meanwhile, is looking at re-directing some of the disused hybrid cooling ducts to regulate the rear brakes.

'To be honest, the updates came so late in the year that we are still trying to assess what is the best solution for us,' admits de Jongh. 'If we are re-using these ducts to cool other components, or if we close them off completely.'

On the other hand, M-Sport has not been significantly impacted in this area. 'From our side, the [hybrid system] coolers weren't integrated with any other coolers from a ducting point of view,' says Jackson. 'We gain with reducing the inertia because we haven't got the coolers hanging out the back of the car any more. And then, it's a case of blanking off the air ducts, which [delivered] the cooling air to the rest of the car's cooling circuits. We're fully independent.'

Although the hybrid power pack was fixed in position for all cars, some individuality was permitted in the system's

'To be honest, the updates came so late in the year that we are still trying to assess what is the best solution for us'

Gerard-Jan de Jongh, head of engineering at Hyundai Motorsport

cooling layout. It had to be in the rear section of the car, but Toyota and M-Sport had their radiators closer to the bumper, whereas Hyundai's was set further forward. This meant losing 10kg of coolers, pumps and lines had a slightly different effect on the weight distribution of each car, though the general trend has been forward and down.

On the aerodynamics side, blanking off the exits creates smoother surfaces that one might expect to bring a small reduction in drag. Fowler reports that Toyota found a 'very, very small improvement', while Jackson determines the difference to be negligible: 'When we ran the CFD trying to evaluate different designs for that, they surprisingly don't have as big an effect as you would think, from a drag side of things,' he says. 'They do have an effect on the downwards airflow but, honestly, not a huge difference. I'd be surprised if the driver would feel it, based on the numbers we've got.'

Percentage game

Reducing the minimum weight by less than the weight of the combined hybrid power and cooling system means ballast must be used. Simple maths suggests up to 20kg of it would be required, based on the cars shedding almost 100kg but only needing to be 80kg lighter by regulation.

However, it's not that straightforward, as Fowler explains: 'The amount of ballast added to the car won't be equal to the difference between what was taken out, and the new weight,' he says. 'The hybrid car was one of the most difficult to get on the weight for quite some time. You had to make decisions about the level of risk of lightweighting certain components. In rally, the underfloor protection is tuned depending on the car weight you want, versus the level of protection you need from the conditions you have. Previously, it was very hard to meet the minimum weight, so you had to take a lot of risk in how much protection you had. Now, it's relatively easy to meet the minimum weight, so you can afford to be a bit safer in your protection. That means your ballast [amount] drops down.'

What does this wiggle room, which didn't exist with a fixed hybrid system, mean in terms of fine tuning a car's weight distribution? And could it become a quiet battleground to manage the weight of components so the amount of ballast can be adjusted in pursuit of the ideal balance?

'You've got a little bit of flexibility,' reckons Jackson. 'In terms of making other components lighter, everybody has been doing that from the start. I'd be surprised if someone suddenly had that emphasis, as a result of removing the hybrid. The target is always to make a component as light as you would feel comfortable with, knowing you could use the weight you're saving as ballast somewhere else.'

When it was a hybrid category, Rally1 stood further apart from the rest of the sport technologically. Now, it is ostensibly more accessible to Rally2 drivers wanting to test themselves in the top division, or competitors adapting to a new car.

'Some people are speaking to us for some events, as you can maybe imagine,' says Jackson. 'It is less daunting, definitely. It is one less obstacle for a driver coming in. Adrien [Formaux] has said that going to Hyundai, and Josh [McErlean] has said that coming to us. It is much easier for them to learn the car, because it's one less element they need to be concerned about.

'It should make the step up from Rally2 to Rally1 much simpler. Yes, you have more aero and engine output you need to learn to handle, but not having the hybrid there, psychologically, is a massive thing that should make it easier to transition.'

Driver perspective

But what about the end user of the non-hybrid Rally1 car? Several drivers in Monte Carlo said they could feel some difference compared with the more powerful, but heavier, hybrid car. They were missing the hybrid's contribution at launch and when exiting low-speed corners on the tarmac. Reigning world champion, Thierry Neuville, noted his Hyundai felt lighter on the rear and the suspension suddenly felt stiffer when going through compressions, which required changes to the set-up.

'The hybrid was mainly supporting out of corners for one and a half, two seconds,' says

'Previously, it was very hard to meet the minimum weight, so you had to take a lot of risk in how much protection you had. Now, it's relatively easy to meet the minimum weight, so you can afford to be a bit safer in your protection'

Tom Fowler

the Belgian, who tested a non-hybrid car in competitive conditions at Rallye La Nucía in Spain towards the end of last year. 'Those are the little moments where you feel the power is down, and you would like to have that push. I think it will be more visible on tarmac than snow or gravel; we couldn't use it often [on those surfaces] because it would spin the wheels and destroy the tyre. Overall, it is not a massive difference. If we would have kept the same turbo restrictor, I think the cars would have been the same speed as before.'

The impact of the WRC's return to non-hybrid cars will be properly felt as the 2025 season plays out on different surfaces. There will also be new rallies to contend with, in the Canary Islands, Paraguay and Saudi Arabia. With only two seasons to run the cars in this form, adapting quickly to the new package will be key to determining who comes out on top in the short term.

Enter Hankook

Aside from the removal of hybrids, the onset of a new tyre manufacturer was the talk of the service park in southern France. Hankook was awarded the tender to supply the WRC from 2025 until 2027, replacing Pirelli after four years. The topic of tyres was especially pertinent at the Monte Carlo Rally because of the event's notoriously variable conditions. Tarmac stages with mud and ice patches made selecting the right rubber extremely difficult, especially for drivers competing on Hankooks for the first time.

Hankook is not new to rally, for it also supplies the ERC4 class of the FIA European Rally Championship and has worked with Rally2 cars in the British national series. Its WRC tyres were originally developed for Rally2 car performance, but new structures and compounds across the full range, from tarmac to snow, were developed to accommodate the more demanding Rally1 vehicles.

'In particular, the Dynapro product used in gravel competitions required substantial modifications, as changes to the structure and compound alone were insufficient to manage the power of Rally1 cars,' says Roy Cha, team leader of Hankook's WRC tyre development team. 'To address this, a new pattern, R213W, was explicitly developed for Rally1 vehicles by redesigning the existing pattern.'

Hankook's priority in year one is to bring durable tyres that foster driver confidence and safety. Two manufacturers suggested there was still work to do regarding durability on gravel, but equally

Toyota

Lighter, non-hybrid cars put less demand on the tyres, but also allow the drivers to be more aggressive; Hankook reckons the result is a slight net gain in safety margin

acknowledged that Hankook is facing a steep learning curve. The South Korean company started live testing in February 2024 and conducted trials in eight countries, covering approximately 2000km.

'To ensure fair evaluation opportunities, we consulted with the FIA for each test,' adds Cha. 'Each Rally1 manufacturer participated in tyre evaluations with nearly equal mileage shares, ranging from approximately 500 to 700km.'

For the love of rallying

Stellantis Motorsport has scoured its parts catalogues to prepare a budget-friendly, entry-level FR6 racer

By LAWRENCE BUTCHER

The idea of a 'budget' racecar is something of a misnomer. Racing is an expensive occupation, full stop. However, there *has* to be an entry point to the competitive ladder, and organising bodies at a national level have always tried to create a route in for young drivers.

In France, the latest such initiative is the FR6 class (see sidebar on p18), intended as a jumping-off point for aspiring rally drivers. Theoretically, the FIA's 'rally pyramid' already has such a class, Rally5, though with the base price of a Rally5 car being around €60,000 (approx. US$61,660) it cannot be considered accessible to all. FR6 is therefore positioned at a lower price point, around 40 per cent less. Peugeot is the first manufacturer to build a car for the class, the 208 Racing.

Stellantis Motorsport, the department responsible for Peugeot's parent company's racing activities, has already made a success of the 208 platform in customer racing. It has sold some 850 units across the Rally4 and R2 variants since its launch in 2012, as well as nearly 100 of the 208 T16 R5 car. According to Stellantis, the new Racing model draws on lessons learned from these projects, while incorporating a far higher proportion of road car components to keep costs in check.

With a base price of €38,900 (approx. $40,000), that's around €46,000 ($47,300) with tax, the 208 Racing can still hardly be called cheap but, with inflation accounted for, the cost does look competitive compared to similar machinery built to the FIA's R1 regulations. For example, the Ford Fiesta R1 launched at €45,990 plus tax in 2019, while the Suzuki Swift Sport Hybrid R1 was introduced to the Italian market at €35,664 ahead of the 2021 season.

Pyramid selling

'We consider the FIA pyramid as definitely a good thing, as it is a worldwide regulation and is useful for the drivers and manufacturers,' says Didier Clément, customer racing manager at Stellantis Motorsport. 'But you must consider that the lowest step of the pyramid is Rally5, and that is already very expensive for drivers.

Peugeot has a rich history in rallying and is keen to support entry-level growth

TECH SPEC: Peugeot 208 Racing

Chassis	Bodyshell reinforced by welded 'cage
Engine	Peugeot EB2 PureTech
Cylinders	3
Displacement	1199cc
Bore / stroke	75 x 90.48mm
Max. power	145bhp at 4500rpm
Max. torque	240Nm at 1750rpm
Electronics	Marelli ECU
Suspension	MacPherson strut
Dampers	Peugeot Sport
Brakes	Front: 302mm ventilated discs Rear: 290mm discs
Handbrake	Manual command
Wheels	Steel 7 x 17in
Tyre	205/45 ZR17 road tyres
Transmission	Front-wheel drive
Gearbox	B4 manual, six-speed plus reverse
Clutch	Single disc
Differential	Mechanical open
Length	4055mm
Width	1745mm
Wheelbase	2540mm
Fuel tank	45 litres
Fuel	E85 super ethanol
Weight	1050kg minimum
Price	€38,900+VAT

Not just the car, but running costs, tyres etc. They are also already very fast cars, so we decided we needed a lower step for young drivers, and also some older drivers.'

Stellantis set out to create a 'proper' rally car, one which used as many standard components as possible, although Clément is at pains to point out that 'it is not just a standard car fitted with a rollcage and some fire extinguishers.'

In overview, the 208 Racing takes the base production platform, along with its 1.2-litre, PureTech, turbocharged three-cylinder engine, and adds a mixture of uprated standard components and bespoke racing parts, making full use of the entire Stellantis group's parts catalogue. The result weighs in at 1050kg with 145bhp making for brisk, if not heart-stopping performance.

'We have only used specific [racing] parts where it is absolutely necessary,' reinforces Clément. For example, though the standard 208 brakes would not be up to the challenge of rallying, the electric version of the car, which is considerably heavier, has a more robust brake package that the team was able to utilise. This was also the case for some of the suspension members, such as the wishbones, with the beefier EV versions ideally suited to rallying. However, the dampers and springs are racing units, albeit non-adjustable ones. The intent is to place the driver front and centre, rather than their chequebook-acquired engineering talent.

'The production suspension is too soft in the spring and damper for the rally car,' adds Clément, 'but, we were able to keep all of the production parts except for those.

'To keep the price below the limit, the damper we chose uses a very simple valving, but with a rate suited to the rally car. You are not able to adjust the ride height or the spring; that's expensive and it is unnecessary to unbalance the car.'

Safety checks

There were some areas where Stellantis determined that costs could not be cut, safety being the obvious one. 'Safety is an important matter and, because of that, the rollcage is from the Rally4 car,' continues Clément. When your child wants to drive a rally car, you want them to be safe.'

The fire suppression system also meets the same standards, with three automatically triggered systems in the cockpit, including a 360-degree nozzle.

Another area in which it was deemed false economy to shave cost was the electronics, with the 208 Racing featuring a motorsport ECU and bespoke wiring harness to ensure reliability. This approach meant the standard dash could be replaced with a digital display, and a circuit breaker panel and centre console with switchgear added for the crew. The system also allows for data logging, a vital element given the target market is customers who might be early in their driving development.

Notably, the decision was taken for the FR6 class to use standard road tyres. 'There are several reasons for that,' explains Clément. 'Firstly, standard tyres are really cheap. You can find 17-inch road tyres for €90-100 (approx. $100), compared to €400 each for Rally4 [tyres]. We also have just a single tyre for all conditions.

'It is also the case that with racing tyres, the car can react quite aggressively. We want this car to be gentler [and] easier to drive for young and inexperienced drivers.

'The final thing is that at the start of every stage, racing tyres need to be warmed up. We have seen so many times – even with experienced drivers – mistakes on cold tyres.

Peugeot's 208 has consistently sold around 200,000 units in Europe each year for the last decade, making it a popular and recognisable platform on which to develop a rally car to the new FR6 regulations

'It is not just a standard car fitted with a rollcage and some fire extinguishers'

Didier Clément, customer racing manager at Stellantis Motorsport

The standard tyres will give grip immediately. Therefore, we decided that for this type of car, a standard tyre is technically the best choice.'

The only downside being that, for now, the 208 Racing will be limited to tarmac stages, as the road tyres would not have the durability needed to last on gravel.

The engine remains almost entirely stock, though for the transmission Stellantis again turned to its parts catalogue. One of the advantages of the use of 'modular' platforms in road cars is that parts can be shared across a variety of model lines, and in the case of the six-speed manual transmission in the 208 Racing, some of the upgraded internals from a light commercial version could be swapped in. 'We mixed a variety of standard parts to make a suitable unit,' says Clément.

Ever since the arrival of the R5 regulations (now Rally2) over a decade ago, there has been a trend within the sport towards using road car-based parts to keep costs under control. The FR6 rules and the 208 Racing are a natural result of this approach, with the experience from previous

For now, the 208 Racing will be limited to tarmac stages, as the road tyres would not have the durability needed to last on gravel

Stellantis Motorsport projects helping in its development. However, as Clément highlights, 'it is really difficult to strike the balance. It is so easy to put money into the brakes, the suspension, everything, but then you have a car that is 70, 80 or 90,000 Euros. Then it makes no sense.

'To produce a proper rally car with so many standard parts was really challenging. Engineers always like to do lighter, faster, stronger, but to keep the price below the limit, we had to discuss every single part and chose the right path, finding the balance between cost, efficiency and safety.'

Running costs

Of course, the cost of a competition car is far more than just its sticker price, with reduced running expenditure a key target for both the FR6 regulations and Stellantis with its 208 Racing. Fortunately, early testing showed the road car-sourced components were up to the task. 'For example, during the start of development of the car, we didn't change the gearbox once,' notes Clément. 'The engine was very reliable, and we already know it well from the Rally4 car. The only components that need to be changed regularly are the brake pads.'

The 1.2-litre, turbocharged, three-cylinder engine is essentially stock, though use has been made of Stellantis' parts catalogue in combining uprated standard components from light commercial models in the attached transmission

A six-speed manual gearbox will keep drivers busy and adds to the motorsport 'feel' of the car

It is hard to save costs by using production parts when it comes to electronics. Stellantis chose to fit a race-ready ECU and motorsport wiring harness for reliability, replacing the stock dash with a digital display and circuit breaker panel

Orders for the 208 Racing opened in October 2024 and deliveries are scheduled to begin in February 2025

The use of road tyres also helps beyond their initial purchase cost, as they are far more durable than dedicated racing rubber.

'In September 2024, the car was used as the zero car on a tarmac rally and ran the same set of tyres the entire event,' recalls Clément. 'Following which, those same tyres were used for track testing.'

Several experienced drivers were drafted in to try the car and give feedback, including Léo Rossel, Alexandre Bengué, Teddy and Jimmy Clairet, Jordan Berfa and five-time French rally champion Yoann Bonato.

The concept has so far proved popular and, with the 208 currently the only FR6 car available, customers are already lining up. But what of markets outside France?

According to Clément, there have already been discussions with the FIA about extending the vehicle's reach: 'We believe many drivers will be attracted by this car, and we have already had some contact with the FIA. Hopefully, in the future we will see this become a complete set of regulations.'

For now, Stellantis will focus on the French tarmac rally market, though a circuit-specific version of the 208 Racing is planned, which will be very similar to the rally car but with a lower, stiffer suspension set-up.

It is encouraging to see a manufacturer such as Stellantis investing in the lowest rungs of national motorsport and, for Clément, the case for cars such as the 208 Racing is a no brainer. 'From my side, it makes sense,' he says. 'Rallying is all of the time too expensive, and that is the reason why we want to give more access for young drivers. But we also have had some customers already buy the car who are 50 or 60 years old and just want to have fun, without any worries about tyres or running the car. It's about the pleasure of rallying.'

FR6 explained

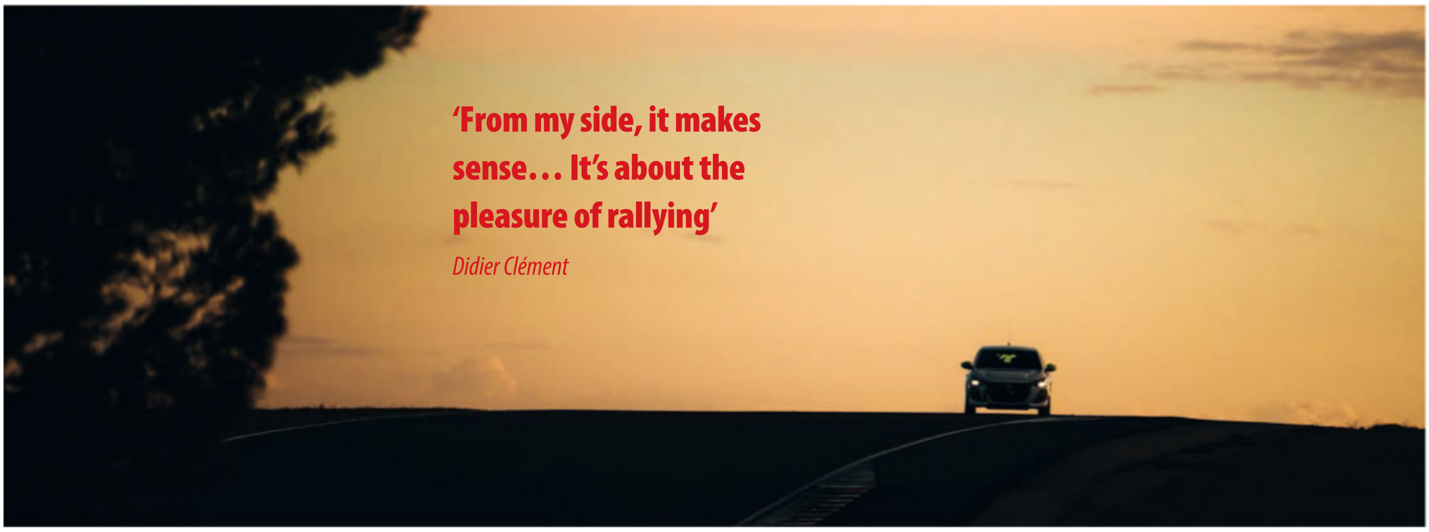
FR6 is the latest initiative by the Fédération Française du Sport Automobile (FFSA), France's national motorsport governing body, to help facilitate amateur rallying by providing a class populated with easy to drive and easy to maintain cars. Key to this is the use of mainly standard production parts and road tyres, but combined with motorsport electronics and high levels of competitor safety, thanks to safety 'cages built to the same standards as found in FIA Rally4.

Currently, Peugeot is the only manufacturer with a car built to FR6 requirements, though the class is open for other manufacturers to join.

For 2025, the FR6 Trophy will be contested across six regional zones, covering all corners of France, and drivers will be expected to compete in six rallies in their respective zones, with the best five results counted. There will then be a final bringing together of the top five drivers from each zone.

There are two categories of winner, one for under 25s and one for older drivers. The prize for younger drivers is a seat in a Rally4 car at four rounds of the Stellantis Motorsport Rally Cup France in 2026. For older racers, spoils are a seat for a round of the French Rally Championship.

Clément is hopeful that the class will prove popular and provide an ideal start for aspiring drivers without big budgets behind them. 'They will not have to worry about the car, they don't need an engineer on site to set up dampers, worry about tyre temperatures, or anything like that,' he claims. 'They just drive the car and will compete in identical machinery, so it will not be a question of knowledge, or money that determines the winner.'



'From my side, it makes sense… It's about the pleasure of rallying'
Didier Clément

Use of road tyres means the 208 Racing is limited to competing on tarmac stages for now, and a circuit version is also in development, which will feature a lower, stiffer suspension set-up

Lola has returned to international motorsport with a Formula E programme in association with Yamaha, and has big plans for the future

By ANDREW COTTON

One direction

Lola may have made its name, and its previous fortune, with traditional ICE racecars, but the new Lola is a very different animal, with a clear focus on new computer and AI technologies

Lola was once a pillar of chassis manufacturing, both in the United States on the IndyCar scene and in global sportscar racing, as well as international single-seat formulae, the British company sought to return to Formula 1 in 2010, but the plan didn't pay off. Lola Cars International was liquidated in 2012 and many of its assets sold to local companies in the UK, including to Multimatic, which also recruited staff from the company.

The business was mothballed for more than a decade before it was bought by Till Bechtolsheimer, a keen historic racer and occasional Daytona 24 Hours participant, in 2022. That purchase secured the name and the intellectual property for the cars, but Lola as a revived entity needed a new direction. Initially, there was talk of creating a feeder series for the FIA Formula E World Championship but, eventually, the company found its feet in the main event.

From supplying successful, low-cost chassis to customers in IndyCar and sports prototypes, Lola entered its latest era as a manufacturer team, with a commitment to race in Formula E, in association with Japanese firm, Yamaha.

It's just the start of a brand-new chapter for Lola that may one day bring it back to its former hunting ground at Le Mans, but with a very different outlook compared to the original company.

'The focus of the FIA is to match what is happening with road cars, which is software-defined vehicles'

Mark Preston, motorsport director at Lola Cars

The move to electric racing was only part of Lola's decision to enter Formula E. The opportunity to work on the hardware, increase efficiency of motors and batteries, and align itself to the global automotive industry are key drivers for the new-look organisation.

New talent

One of Lola's biggest assets was its staff. The company, along with Reynard, and others in the United Kingdom, was for many years a hotbed of new talent, and this will continue under Bechtolsheimer's ownership. However, while before the company employed designers, fabricators and model makers, along with trackside staff, this time around it will focus on new computer and AI technologies. This, Lola hopes, will give it strength in depth, while the company's size gives it the agility to move with the times as the automotive industry struggles to find a clear path forward.

This is a new direction for Lola, and the move away from the traditional motorsport mould is highlighted by the sale of its wind tunnel, once the jewel in the crown of the company, and which was installed at great expense under one of former owner Martin Birrane's other companies (see sidebar on p23).

For Lola, the decision to move away from aerodynamic work is a torch beam onto its own future plans. 'This is not the same Lola as we were 10 or 12 years ago,' says Lola Cars motorsport director, Mark Preston. 'Back then, it was pretty much do a chassis, put in a V8 and a data logger onto it and go racing. Nowadays, it's more software driven, with aero being reduced in a lot of ways because of Balance of Performance, and quite rightly so, I believe. The focus of the FIA is to match what is happening with road cars, which is software-defined vehicles.'

Software focus

That focus on software, and efficient electric motors, is where Lola has set its long-term goals. Formula E allows more control of the electric powertrain than almost any other series, outside of F1 and the LMH regulations in sportscars. 'There is a lot of performance left in the hybrid system that we are able to unlock in the formula car, which is to get into the MGU and VCU,' says Preston. 'That's why the LMH rules are [also] quite interesting for us, because the learnings can be not just the VCUs: we can get deeper into the electrified part of the powertrain.'

One of the key regulations in Formula E is that the front MGU is homologated and supplied by the FIA from a single designated supplier, but the rear is open to a manufacturer's specification. The only rule is that the rear MGU and its control unit are homologated by the manufacturer once per homologation cycle. This affords a manufacturer the freedom to select its own partner and develop the hardware, as well as the software.

Partnering with Yamaha has given Lola access to the manufacturer's resources and knowledge of roadgoing EV powertrains, while the Japanese engineers benefit from involvement with the world's most advanced electric racing series

'The LMH rules are [also] quite interesting for us, because the learnings can be not just the VCUs: we can get deeper into the electrified part of the powertrain'

Mark Preston

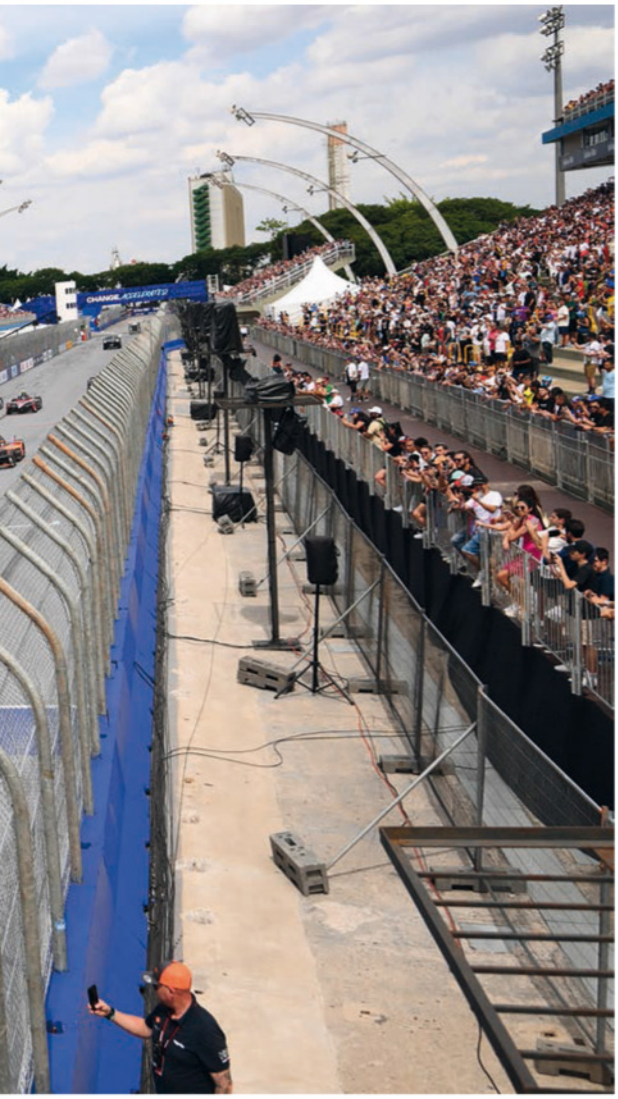
That access to both hardware and software development is what makes Formula E and LMH exciting for Lola, but also for Yamaha. The Japanese brand is one of seven to enter the electric series in the 2024-'25 season, alongside the likes of Porsche, Jaguar, Nissan and Stellantis. It's clear to see what the manufacturers are getting from their electric racing programmes.

In sportscar racing, under the LMH rule set, battery development is allowed, which makes it more interesting for a company that is developing its own hardware. However, Formula E has a spec battery, which has limited appeal, although there is still plenty to interest a manufacturer, says Preston.

'Yamaha has a lot of knowledge of electrified powertrains from their roadgoing work, so it has been very much a collaboration. They have been bringing expertise of, let's say, inverters, and have products they sell already in motorbikes, and other things, but racing is pushing everything to another level.

'They are writing the energy management software, for example, with support from the engineers in our team. We are modularising the project. They have been doing some modelling for us on other aspects of the car where they have brought in expertise from a different division, which is quite cool, because then you have very deep knowledge of these certain areas, which we can then apply to racing.'

Yamaha engineers from the company's battery department have been reverse engineering the Formula E battery to



understand how it works, and to improve cooling strategies in different climates, integrating control systems and maximising performance both in terms of regeneration and deployment. It's clear to see what the Japanese get out of the deal, while Lola has access to intensive manufacturer development and resource.

Hydrogen future

Lola has committed to Formula E until 2030, taking it through the current Gen 3 Evo era, which has just started, and into the Gen 4 regulations. It has done so hoping that Yamaha will stay the distance, though that has not been confirmed at time of writing.

While the commitment to entirely electric racing is secure, the British company has its eyes set on a different goal for 2029. It is planning to develop its knowledge of electric powertrains to consider a 24 Hours of Le Mans programme under the hydrogen rule set, using fuel cell technology.

There is no guarantee it will do so, or that it will find the necessary funding, but it is a definite target. 'I'm a big fan of the idea of strategic intent,' says Preston, who was seen roaming the Le Mans paddock last year.

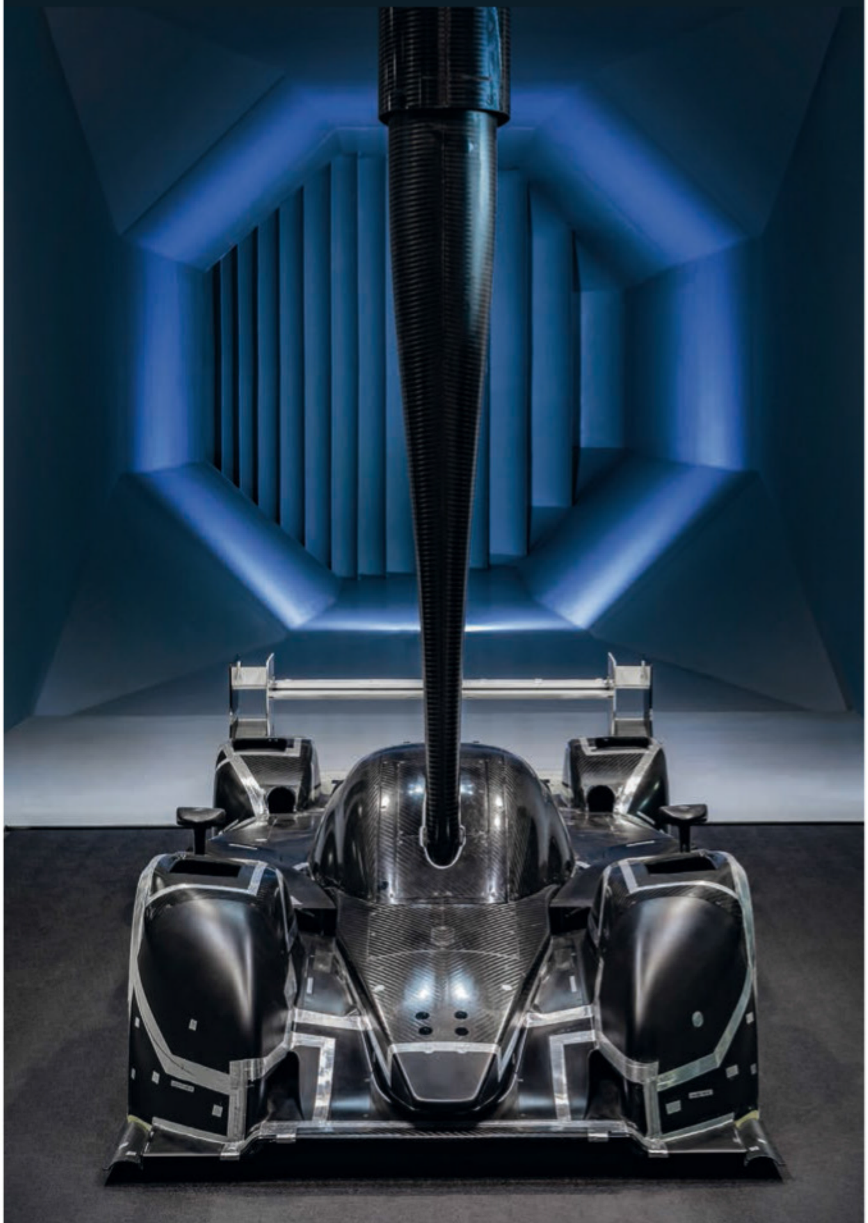
For sale: one tunnel, very windy…

The Lola wind tunnel, owned by the Peer Group property investment firm, was designed, built and continually developed by Lola Cars International. Lola acquired the tunnel from British Aerospace, relocating and redesigning it to create an advanced motorsport and automotive aerodynamic testing facility. That opened in 1998, and provided valuable data for its teams, Formula 1 and automotive OEMs.

The key differentiator for the tunnel, compared to others at the time, was the airflow quality, underpinned by extremely low and consistent turbulence levels. It was also of modular design, meaning it could relatively easily be dismantled and relocated.

One reason for selling the wind tunnel is that, at 50 per cent scale capacity, it is the wrong size for Formula 1 teams, which normally us tunnels scaled to 60 per cent. It has also been rivalled by the opening of the nearby Catesby railway tunnel facility, which allows for private, full-scale testing in controlled conditions. F1's restrictions on wind tunnel testing and resource also contributed to the decision to sell up. Teams are limited in how many tests they can do during a set period, based on where they sit in the championship. This ostensibly frees up wind tunnel testing capacity for other clients.

'There's quite a lot of wind tunnel capacity out there because of the Formula 1 rules,' says Lola Cars motorsport director, Mark Preston. 'Because Formula 1 is only allowed to use their own tunnels for a certain amount of time, there is actually quite a lot of resource available in the UK.'



At 50 per cent scale, the Lola wind tunnel is not attractive for F1 teams, but remains a state-of-the-art facility

'Whether or not we end up with a hydrogen powertrain, let's see, but as a strategic intent it matches our strategy. It makes it easier for the engineers too, because we can say we're doing a software formula, and that we can use it in a Le Mans car. |You can take out the fuel tank and put in a fuel cell, which is just another energy source; just another module with its own control system. If you think about the fuel cell, you build the model of the vehicle so you could theoretically take out the Formula E battery and put in a fuel cell. The Formula E car is four-wheel drive, and so would the hydrogen Le Mans car be to get the regen', so there are a lot of parallels.'

That is not to say Lola wouldn't come with a hydrogen-fuelled internal combustion engine, but it believes more in the future of fuel cell technology than burning hydrogen as a combustible fuel, and the link between Formula E and LMH is closer than one might think.

Production drive

However, the current main drive of the company is to link it to the production car world, and for that the software element of cars is key. Lola always established itself as a haven for young talent in all areas of racecar design and operation and, in this respect, it will stay true to its roots. The UK government announced in January that it will open the door for AI technology to be developed heavily, and Lola plans to be at the forefront of this technological revolution.

'Whether or not we end up with a hydrogen powertrain, let's see, but as a strategic intent it matches our strategy. It makes it easier for the engineers too'

Mark Preston

'Our current discussions are around what is the future of motorsport,' says Preston, 'and what is the future of automotive? Where is all the resource going at the moment? The buzzwords are AI, and software-defined vehicles. Lola traditionally wasn't in this area, but this is becoming the go-to thing in motorsport and road cars now.

'As we know, motorsport should lead road cars, and so it cannot really be leading in areas that are irrelevant to road cars. I'm not saying aerodynamics is irrelevant, but certainly what is more relevant at the moment, and why there is the emphasis on Formula E powertrains, is because that's where the development is in road cars.'

For now, though, Lola is still finding its feet in racing. To smooth out its return to the track, it hired Peter McCool, an experienced designer and former technical chief of the Aguri Formula E team, to help steer its engineering direction. Abt Sportsline, a stalwart Formula E outfit that won the 2017-'18 title with Audi, also came on board to provide its proven race expertise and event personnel, though there is still a bedding-in process that needs to be sorted. Even down to radio calls and strategy decisions, it's a time of learning for all.

'We are just making sure we are using resource as efficiently as we can,' says Preston. 'That's a constant discussion, whether or not we are using everyone's strengths and weaknesses the right way around.'

Lola's long-awaited racing return came at the São Paulo E-Prix in December 2024 where its young driver, Zane Maloney, finished two places outside the points. Although the project is currently in its debut season, the ambition of today's Lola is clear: to align with the automotive industry and develop relevant technology in the racing environment.

Production ambition

Yamaha announced in October 2024 that it will develop the e-axle for the new Caterham sports coupé that is aimed to be completed in mid-2025. Project V was initially unveiled by Caterham at the Goodwood Festival of Speed in the summer of 2023, and later at the Tokyo Auto Salon the following January. Yamaha will supply a trial model of its e-axle for the prototype, and will provide the technology and expertise in terms of vehicle motion control.

Lola recruited 2016-'17 Formula E champion Lucas di Grassi (pictured testing the Lola-Yamaha T001) for its eagerly awaited return to racing, as well as FIA Formula 2 race winner Zane Maloney

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Duda Bairros

Mitsubishi contested the series with its Lancer from 2006-2010, but has been tempted back under the new SUV era

Pit Stop Films_Disclosure

Toyota's new Stock Car is based on the Corolla Cross, an SUV version of the Japanese company's hugely popular saloon

Market forces

Brazil's premier tin-top series recently unveiled this surprising new racecar, after 45 years running with saloon models

Brazil's top series is undergoing major change this year with the adoption of SUV-style cars that could rival GT3 lap times

By DANIEL LLOYD

Love them or loathe them, sport utility vehicles (SUVs) are becoming increasingly prevalent on our roads. In global terms, almost half of new cars sold are SUVs, from crossover city cars to luxury 4x4s, according to the International Energy Agency, while a 2023 report from the International Council on Clean Transportation think tank stated that SUVs made up 47 per cent of all new car sales in the European Union in 2022. That's a figure nine times greater than in 2001.

It therefore seems a case of when, not if, motorsport is swept along with this powerful tide. Manufacturer boards need to see a resemblance to their passenger vehicles, or at least a vague company 'design language', to greenlight a race programme. This has made the arrival of SUV-style racecars inevitable in various motorsport disciplines.

Some series have already explored SUVs. Examples include the Jaguar I-Pace eTrophy, a short-lived support race to Formula E, that folded in 2020, and the NASCAR EV Prototype, built to a generic crossover style, potentially foreshadowing what American stock car racing might one day look like.

However, when it comes to SUV adoption in motorsport, South America is currently leading the push. This year, both the TC2000 touring car series in Argentina and the Brazilian Stock Car Pro Series will change

Victor Eleuterio

their ways by introducing new, bespoke racecar platforms with clear SUV design cues. This article will focus on the latter which, despite still flying under the radar, is the better known of the two overseas thanks to its driver line up. The Pro Series, or Stock Car, contains many of Brazil's well-known international stars of the early 21st century, including Rubens Barrichello, Felipe Massa, Nelson Piquet jnr and Daniel Serra.

Significant shift

The series has been loyal to the saloon car for the last 45 years, so its impending switch to SUV styling is significant, driven by the direction of the domestic road car market.

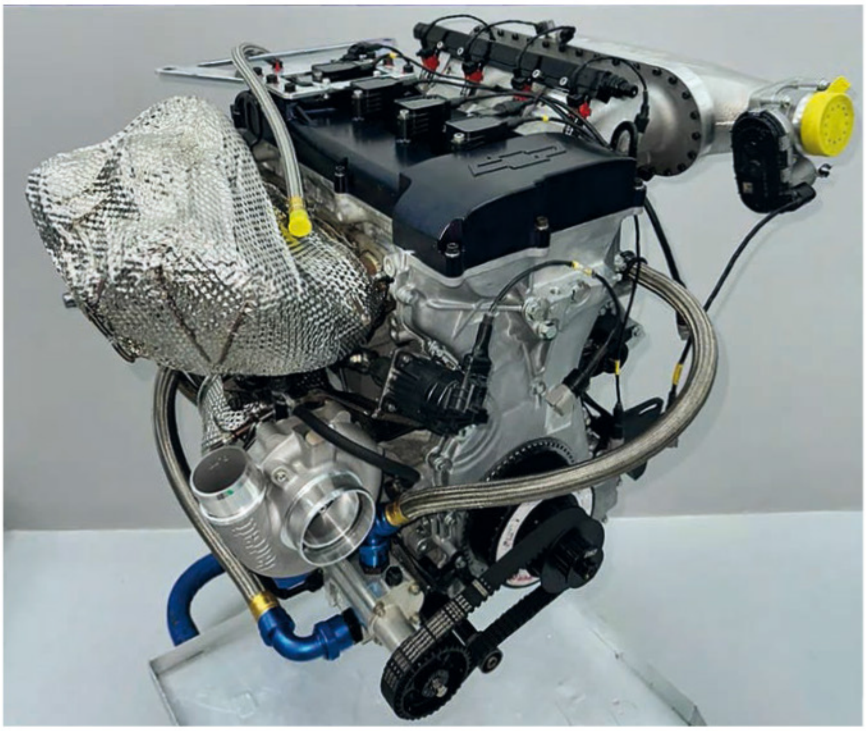
When it comes to SUV adoption in motorsport, South America is currently leading the push

'Today, the preference is for SUVs, which have evolved significantly in terms of design, comfort and vehicle dynamics,' says Paula Saiani, product marketing director at General Motors South America. 'Currently, around 40 per cent of passenger car sales are concentrated in this type of vehicle, a percentage twice as high as five years ago.'

GM is one of three road car manufacturers buying into the Pro Series' new SUV rule set. Its Chevrolet brand will go up against Toyota and Mitsubishi, which has been tempted back after 14 seasons away. Chevrolet is running the Tracker, while Toyota is entering the Corolla Cross and Mitsubishi the Eclipse.

The common platform on which all of these cars will be based is the Audace SNG01. It has been developed by Audace Tech, the in-house engineering arm of Veloci Group, a holding company that also counts Stock Car Pro Series promoter, Vicar, among its assets. Veloci purchased Vicar in 2020 and its director, telecommunications executive Lincoln Oliveira, became CEO of the Pro Series promotional body late last year.

The SNG01's makers predict lap times will fall by four to five seconds, based on a 120kg weight saving and improved aerodynamics



Audace Tech

The 2.1-litre, four-cylinder engine is around 55kg lighter than its V8 predecessor and based on a Cosworth racing unit (albeit re-badged). Audace's engineers have spent three years re-working and developing it into its current form

Audace and Vicar set some overarching goals for the new Pro Series car. These included making it faster, lighter, safer and more technologically advanced than its predecessor, the Giaffone JL-G09, which was introduced 16 years ago and updated in 2020. Audace consequently replaced the naturally aspirated, 6.8-litre V8 with a more efficient, 2.1-litre turbo producing up to 520bhp in race trim. The SNG01's makers predict lap times will fall by four to five seconds, based on a 120kg weight saving and improved aerodynamics. Not your average SUV, then.

Built from scratch

'We started the project in 2021,' says Enzo Bortoleto, CEO of Audace Tech. 'Vicar was bought during Covid. We did the first year of Covid and tried to get everything working. In 2021, we looked at [the car] and decided to do some development. Then, from 2022 onwards, we started really developing it, with an engineering team designing the chassis and parts.

'We built this car from scratch. Obviously, we have the carry-over parts, for example the gearbox. We did our own ratios, but Xtrac had already developed it. But the suspension system, rocker design, everything was developed by us, including the chassis.'

The first test for the SNG01 prototype took place in mid-2022. At that point, Audace was working to the brief of a saloon body shape. However, as discussions moved along with the manufacturers, the SUV style took precedence the following year. This gave enough time for Audace to conduct CFD tests and produce the new bodywork.

The basis of the SNG01 is a steel tube frame chassis onto which Chevrolet, Mitsubishi and Toyota attach their SUV bodywork. Audace contracted steel industry giant, ArcelorMittal, to develop a particular grade called DP980R that would bring improvements in strength and safety. Audace sent tube samples to the Brazilian Institute for Technological Research (IPT), which compared it with the standard 4130 racecar chassis grade.

'We have a much stronger tube with better welding,' says José Avallone, lead chassis and suspension engineer for the SNG01. Avallone was an F1 designer for Jordan in the 1990s before returning to Brazil to start his own team. 'It is much better than 4130. It took a long time, more than one year, to develop, but we are happy with the result.'

Duda Bairros

Enzo Bortoleto (centre) is the young face of Stock Car's in-house constructor and technology firm, Audace Tech. His father, Lincoln Oliveira, runs Stock Car

Shock absorbers

The SNG01 chassis weighs around 150kg, as part of a 1200kg total car weight with driver. Although Avallone and his colleagues considered ways to make the chassis lighter, they felt it was not possible without compromising safety. For driver protection, Audace fitted a composite shock absorber to the chassis on each side of the cockpit to dissipate energy from an impact. There are also steel absorbers at the front and rear, thinner than the chassis, which ArcelorMittal also developed.

'They have a huge lab in France where they tested the materials and design, to bring something much safer than we have now,' says Avallone. 'They helped us a lot, providing a lot of technicians and testing.'

'Most cars normally use aluminium,' adds Bortoleto, 'but, as a steel company, they did it in steel. They matched the same properties of the aluminium [being only] 0.5kg heavier. It was interesting from a cost / benefit analysis side. We quoted, and aluminium was 10 times more expensive than steel.'

The SNG01 measures 5146mm long and 1960mm wide, with a 2750mm wheelbase. The wheelbase is a smidge under that of the JL-G09, but the new car is 80mm wider.

'Initially, we would have liked to have a longer car,' notes Avallone, 'but, after a lot of discussions, because the road car is more like this, we kept it the same.'

Power to weight

The switch from V8 power to a turbocharged, 2.1-litre, inline four has transformed the Pro Series car. Despite being much smaller, the new engine has a comparable output and achieves just over double the amount of power per cylinder. It has made the Pro Series vehicle more efficient, and more adaptable in terms of weight distribution.

Like its predecessor, the SNG01 has the engine in the front, but now the power unit is around 55kg lighter. With less mass exerted on the front axle, tyre life and cornering attributes are set to improve. It has also enabled Audace's engineers to move the weight distribution rearwards in pursuit of an even balance, having previously been biased towards the front. For instance, the alternator has been placed by the transmission at the rear. The new packaging freedoms have additionally allowed for the car's c of g to be lowered slightly.

Audace Tech

ArcelorMittal, one of the world's largest steel companies, developed a special grade steel for the SNG01 chassis that is said to be stronger than traditional 4130. The company also developed front and rear shock-absorbing structures

'For packaging everything in the car, it was much easier because the engine is smaller,' says Avallone. 'The weight distribution is much better now than before, because we can play with it more. We are still testing the car to find the best balance, but we can shift weight from front to rear to get it where we want.'

The engine is far from an off-the-shelf installation, as Audace has carried out an array of modifications. Its origins lie in a Cosworth racing unit, but many parts have been tailored to the Pro Series' wants and needs. The participating manufacturers are allowed to add their own badges to the spec engine, even though Audace developed it.

'We used the baseline of the engine, but we developed other components and structures,' says Rafael Cardoso, consultant on the SNG01 engine programme and director of Motorcar Racing, a Brazilian endurance race team. 'We made the engine block and cylinder heads with CNC and did other parts [such as] the crankshaft and dry sump oil system. It's a complete development for racing.

'We worked on the development of the Stock Car engine for three years. Today, we have a good engine with a long life and good power.'

That power has been pushed on the dyno to more than 550bhp, according to Audace's engineers, but teams won't be able to utilise all of that capability to ensure it lasts.

Push-to-pass

During races, the car will have a standard output of around 470bhp and a maximum torque of 580Nm between 4000 and 6800rpm, though power can be increased by a 50bhp boost from the push-to-pass system. This was a feature of the JL-G09 (which ran at a similar base level and up to 550bhp in push-to-pass mode) and has been retained into the SUV era, though now an e-gate is used to electronically control the boost pressure within the Garrett G-series turbocharger. This task is carried out by the new FuelTech FT700 control unit.

'It manages the electronics, engine, turbocharger control and gearbox, and we have 5G transmission to the teams,' highlights Cardoso. 'It's a VCU, not an ECU. It is a big change in the electronics, because the old car used a Bosch ECU [developed] many years ago. Now, we have an evolution with a new concept.'

Made in Brazil

The FuelTech control unit is one of several instances where Audace has championed Brazilian engineering companies. Some of the SNG01's components were outsourced to overseas suppliers, such as the dampers from Penske Racing, gearbox from Xtrac and brake calipers from AP Racing, but local talent was used wherever possible.

'[FuelTech] put a lot of effort into developing what we wanted,' says Bortoleto. 'It was very nice to do this development with them. We are discussing [whether] to have engine fuel maps for the driver's strategy. The idea is that we want to do some: for example, they can move [between] three maps: economic, medium and aggressive.'

Another example of Brazilian input is the bodywork, manufactured by Magna Compósitos. The company from northern Santa Catarina state incorporated a range of materials including Kevlar, aramid fibre, carbon fibre and glass fibre. The wheels have also been developed in Brazil by Mangels, as have the ventilated brake discs from Hipper Freios and the pads from Cobreq.

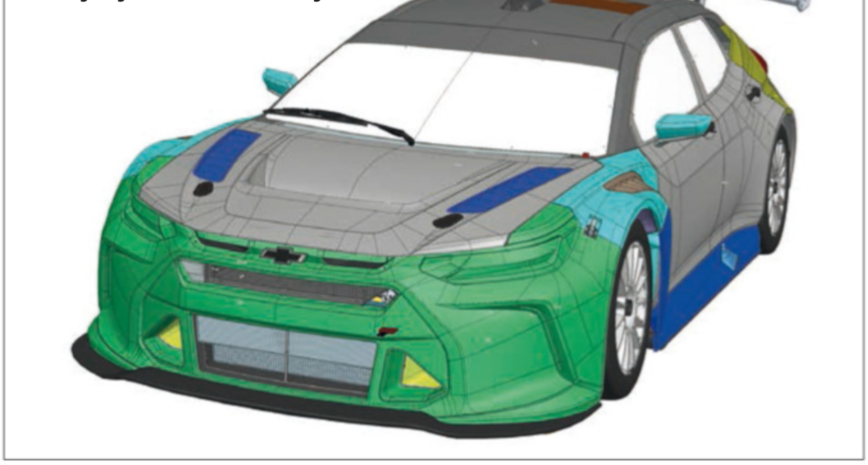
The SNG01 puts its power to the road through Xtrac's P1529, a transverse transaxle gearbox that is popular in GT3. Audace initially tested its prototype car with a Hewland unit but opted for the current transmission early in the process.

All cars run on Hankook Ventus slick radial tyres with a 300mm (11.8in) section width and 457mm (18in) inner rim diameter. These have been retained from last year.

In the first season of the SUV platform, drivers will steer using a hydraulic system from Woodward. The original plan was to use electronically-assisted steering, but that was

During races, the car will have a standard output of around 470bhp and a maximum torque of 580Nm between 4000 and 6800rpm, though power can be increased by a 50bhp boost from the push-to-pass system

Several CFD studies were undertaken to ensure the manufacturers' SUV designs were respected without giving one an inherent advantage



Audace Tech

delayed due to some issues that were found during the testing phase of the car.

'We have a parallel project for an electrical one,' confirms Avallone. 'Maybe in two or three years we are going to electric. For safety, and to make it more reliable, we decided to go for something we had more data with; we have some GT3 cars with the same unit. We didn't have too much time to play around, so we will start hydraulic and look ahead for electronic.'

Aero improvements

The prospect of considerably quicker lap times will no doubt excite the teams. Pole position for the 2024 season finale at Interlagos was a 1m39.326s lap from Guilherme Salas, driving for the KTF team, which Bortoleto also leads. Based on observations Audace made during testing at the same track, the SNG01 might be knocking on the door of last year's FIA World Endurance Championship LMGT3 pole time of 1m34.413.

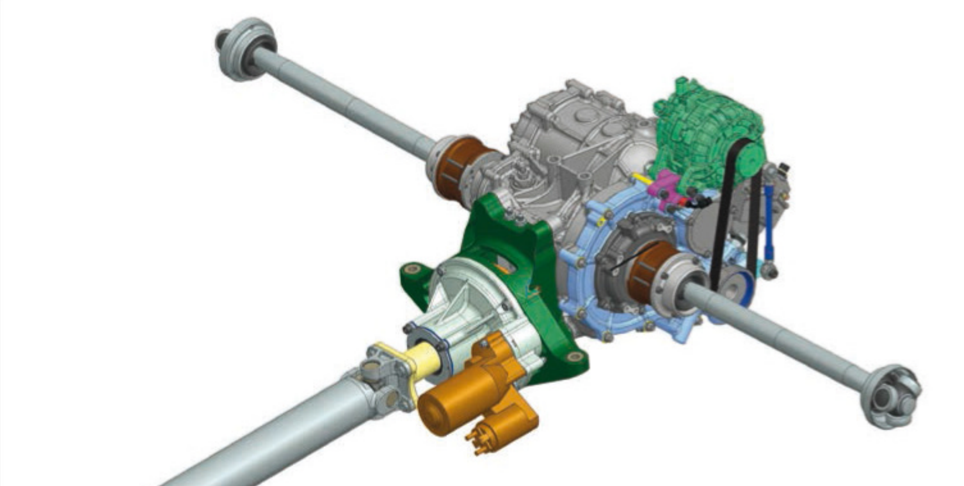
An improved aerodynamics package has been a key contributor to the quicker lap times. Audace studied the aero extensively using CFD, analysing the accumulated data with two different companies. There is also the fact that a drag reduction system (DRS) has been added, without the push-to-pass boost being scrapped.

'This car can generate four times more downforce than the previous car,' says Avallone. 'I think aerodynamics and weight are key to the performance. The previous car had a flat-bottom style, but now we have a splitter at the front and a big diffuser at the rear. The central floor layout generates downforce. Also, the rear wing has two flaps for the DRS system that helps to generate overtakes during the race.'

The CFD work included ensuring one manufacturer's bodywork style would not give it an advantage over the others. With the JL-G09, the Pro Series balanced the dimensions of each manufacturer's diffuser, splitter and Gurney.

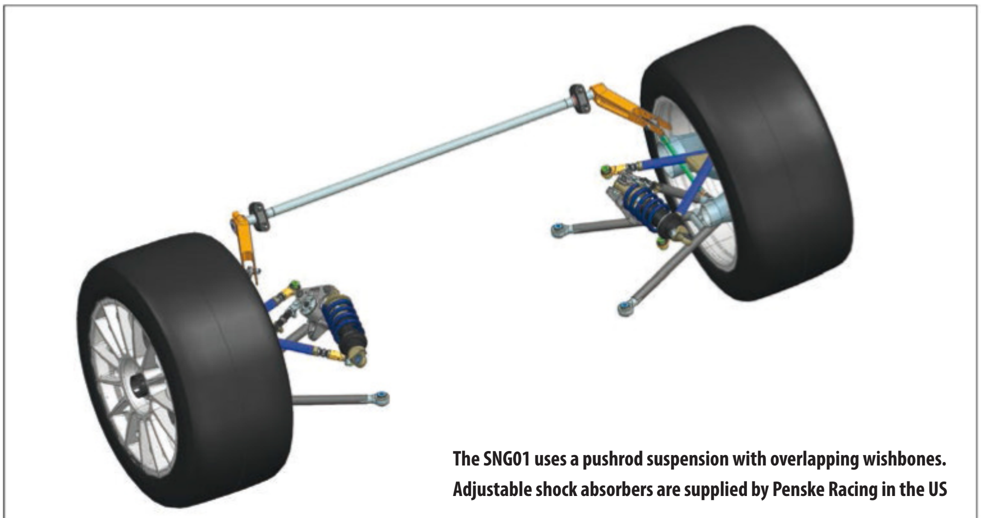
'We have to equalise all the bodywork because we have three manufacturers, and we have to balance the performance of all three,' explains Avallone. 'CFD helped us a lot here. When we put the model in CFD, the back end of the car had a lot of influence on downforce and drag. We realised that we had to study this area quite a lot. Changing the rear windscreen angle by two to three degrees made a lot of difference in the aerodynamic performance of the car.'

The result, Audace hopes, is a field of cars that have equal performance but appear different enough to please the manufacturers and fans. Of course, they can't look too much like SUVs due to their low ride height, which is necessary to get the underfloor working, but the stout back section, complete with token rear door handles, and boxier profile is enough to get the message across.



Audace Tech

The SNG01 transaxle, including the Xtrac six-speed, semi-automatic, sequential gearbox, Audace bellhousing and Dana propshaft



Audace Tech

The SNG01 uses a pushrod suspension with overlapping wishbones. Adjustable shock absorbers are supplied by Penske Racing in the US

'The idea with the new Stock Car is to not only be in Brazil. It could go worldwide. We can talk to manufacturers and have the same platform, and then we can develop the bodywork for them'

Enzo Bortoleto, CEO at Audace Tech

'Being honest, when we use the word SUV, we start thinking very badly about it,' says Bortoleto, 'but when you look at it, the car doesn't look like an SUV. It is very low.'

International vision

The concept of the common platform also plays into the hands of other manufacturers, as Bortoleto explains: 'The idea is that it's the easiest and cheapest way for an OEM to go racing at a premier national level. Any car brand could come tomorrow.'

The SNG01 will appear in the Stock Car Pro Series, but those responsible for its development believe it could also venture beyond Brazil. The designer of the outgoing vehicle platform previously said this with the JL-G09, though it didn't materialise. Platform-based racing is an attractive concept for manufacturers, because it enables them to compete much more cheaply than if they developed a full racecar themselves. Audace hopes the model it has developed for this approach can be exported overseas.

'The idea with the new Stock Car is to not only be in Brazil,' says Bortoleto. 'It could go worldwide. We can talk to manufacturers and have the same platform, and then we can develop the bodywork for them. All of them would be fighting for a championship without spending $10 million on engineering, but on marketing.

'At the end of the day, the brands really need marketing to sell their cars. All the money in engineering they must use to have better cars for us to drive on the roads.'

According to Bortoleto, the SNG01 costs around €300,000 (approx. $312,000) while Audace expects it to be easier to work on, potentially reducing running costs.

Hybrid future?

If the Pro Series is following road car trends and manufacturer desires in relation to body style, it would surely not shy away from electrification. That is proving to be the case, as Audace has designed the SNG01 with the potential to accept a mild hybrid system.

'We are already looking for 2026 or 2027 to have a hybrid solution,' reveals Bortoleto. 'It won't be anything high voltage but, at the end of the day, we need to help Toyota, Chevrolet and Mitsubishi to sell hybrid cars.

'What is hybrid about? It is about having instant power. Nothing is better than the push-to-pass, though instead of being a power boost on the turbo, it's an electric engine. This can help them to sell the hybrid solutions on their road cars. That is our mindset.'

> **'We are already looking for 2026 or 2027 to have a hybrid solution'**
>
> *Enzo Bortoleto, CEO at Audace Tech*

This concept will undoubtedly sound familiar to British readers, for the BTCC already tried it with a low-voltage hybrid system from Cosworth in 2022. The unit delivered an on-demand power boost working in conjunction with the turbo, but only lasted three seasons before being dropped for this year.

'We are studying to have something like specific motors on both rear wheels,' says Bortoleto, 'or something that regenerates the battery from the car. The idea is to have 10-15bhp, which helps a bit, and is quite simple to do. The first idea, electric engines on each wheel, is already being developed by FuelTech on electric cars. We would have more power, but also more weight, so we are studying that.'

'Initially, when we started the design, we had to look for this [hybrid option],' adds Avallone. 'We have a space in the car where we could put a battery pack. Then, in the near future, I would say in three or four years, we can go hybrid.'

New era

Unusually, the Pro Series employs an American-style draft system to determine which car each of the teams will run. After the 2024 season finale, the three manufacturers lined up and selected their representatives. Chevrolet had first pick due to its unbroken participation since the first season in 1979 and selected last year's champion, TMG Racing. The draft ensures the grid isn't dominated by a single manufacturer, as the 15 teams are distributed evenly between Chevrolet, Mitsubishi and Toyota. Some teams will be involved with different manufacturers, such as the KTF squad, which is running a Mitsubishi and also assisting the new Car Racing outfit with its Toyota.

In recent months, Audace has been busy assembling more than 60 chassis for the 2025 season, which will have just over 30 entries. The task was streamlined by using advanced robotics in a partnership with Brazilian industrial manufacturer, ESPAS.

'By adopting these modern processes, AudaceTech and ESPAS achieved a production rate four times faster than the hand-crafted methods used for the previous Stock Car chassis,' notes Avallone.

In January 2025, the teams will head to Audace's headquarters in western São Paulo to finalise the builds and get to grips with the new features. Audace has tested the car extensively, racking up around 15,000km.

'Each team will be led by our engineers and a mechanic, and we are going to pass them all the manuals and take out any doubts they have,' says Bortoleto. 'It means they get to understand the car better. We have some testing in March and April, probably one car per team, and then we have the championship starting in May.'

When the Stock Car Pro Series field lines up for the opening race at Interlagos, it will be the start of a new era for Brazilian motorsport. Time will tell if it also marks the dawn of a wider movement towards SUV adoption in global racing.

Fan experience

The Pro Series is big in Brazil, a country well known for its ardent support of local heroes. To satisfy the live audience's hunger for information, Vicar and Audace Tech are implementing 5G connectivity to each Pro Series round. This will not only assist with communications between each car and the pit wall / race control, but also the fan experience through the series' official mobile app. Each car carries a 5G router, which exchanges signals with a receiver at the track. The system runs on Qualcomm Snapdragon 5, providing rapid transmission of a wide range of data.

'Per car, we have three cameras, one looking forward, one backward and one 360-degrees inside the cockpit,' explains Enzo Bortoleto, CEO of Audace Tech. 'You can see all the drivers and listen in to their radios instantly. For example, you can choose Felipe Massa and which camera to follow him on. All the data from the car is being put together through an API [application programming interface].'

The system could also help officials to monitor races. Rafael Cardoso, Audace's engine lead, even suggests it would be possible to replace drive-through penalties with power reductions transmitted to the FuelTech control unit through the 5G network.

The use of a private 5G network could also help overcome problems with mobile data reception for the large crowds that show up to Pro Series races.

'At Interlagos, for example, we have six or seven antennas around the track,' explains Bortoleto. 'Each car has an antenna on top with a 5G sim card in it. Inside, we have the 5G router, cameras and sensors. The antenna connects to a private network, the idea is to have a protected system. We want to use this 5G connection with ultra-low latency and high troubleshooting. We can send high volumes of data over the internet and connect very fast.'

Propelling the push to enhance event connectivity is the fact Pro Series owner and CEO, Lincoln Oliveira, is the head of America Net, one of Brazil's biggest telecommunications firms.

Stock Car Pro Series

Vicar and Audace want to enhance the Pro Series event experience for fans, teams and officials alike

Liquid launch

The FIA and ACO have laid the groundwork for the future of hydrogen technology in racing, but there are still details to finalise

By ANDREW COTTON

The H24EVO has still not yet reached the level of performance required to make the technology viable [to race at Le Mans]

The latest iteration of the H24EVO is a dramatically different design to its predecessors. A canopy over the driver compartment retains a visual link to the current Hypercar field, but under that it has been changed to a single-seater layout. More significantly, the hydrogen is stored onboard as a liquid, rather than a gas

The Automobile Club de l'Ouest (ACO) took the covers off one of the most important cars it has ever produced at a ceremony in Paris near the end of January. The H24EVO is the latest development of the ACO's hydrogen fuel cell car that it has used as a rolling test bed for the technology, as the organisation targets the introduction of hydrogen at the 2028 24 Hours of Le Mans.

The ACO has long planned for the technology to race against the current LMH and LMDh cars, originally scheduling its arrival for 2024. Covid scuppered that initial timeframe and, by the time the project was fired back up, the use of hydrogen as a combustion fuel had become a hot topic.

Under the regulations that may not become a fully-fledged class until 2029, both hydrogen fuel cell and hydrogen-fuelled ICE will race against each other for overall victory in the FIA World Endurance Championship, which includes the famous event in northern France.

There have been developments since the start of the ACO-supported Mission H24 programme in 2018. It started with the LMPH2G, which featured a stack of 230 cells that generated power to run two electric motors at each rear wheel. Excess electrical energy from the fuel cell and regenerative braking was re-directed to a KERS system, boosting the base 250kW power output to 480kW. It was replaced in 2021 by the H24, which had a battery capable of recovering more braking energy, and sported two motors that delivered more power. It also took the demonstration aspect further, completing a handful of Le Mans Cup races.

However, the latest generation H24EVO has not yet reached the level of performance required to make the technology viable, which is to complete 10-lap stints of the 8.5-mile Circuit de la Sarthe at full prototype racing speed, with similar refuelling times to the current petrol-powered cars.

Gas to liquid

While this latest iteration of the car has not achieved those lofty goals, it still represents the future by switching to liquid hydrogen storage. Originally planned and announced at Le Mans last year with 7.8kg of high-pressure gas storage, the change to liquid has led to a major redesign. The work includes a new, centrally-located fuel tank, different delivery mechanism to the power source and alternate refuelling strategies. The target storage amount is 11-14kg which would permit a stint of around 40 minutes.

Another key change is that the car is now a single seater, departing from the two-seat layout of previous hydrogen demonstrators and the WEC's Hypercar field.

Maintaining pressure and temperature within a cell housing the [fuel] tank, as well as the refuelling pipes and the delivery of the fuel to the power source, will be a subject for development

The H24EVO features a canopy over the cockpit to reduce drag and retain visual links to Hypercar, but the single-seat design is a novelty, and the first since the monoposto LMP cars of the 1990s.

The liquid fuel storage tank is now more traditionally located, behind the driver rather than in the car's sidepods as the gas versions were. The revised, more protected position is due to the fact liquid hydrogen must be stored at 20K (-253degC), so needs to be isolated from any hot parts of the car, and human interference. Maintaining pressure and temperature within a cell housing the tank, as well as the refuelling pipes and the delivery of the fuel to the power source, will be a subject for ongoing development.

Switching to liquid storage for the new car aligns with the FIA's announcement last February that it would focus its hydrogen efforts on that method.

The H24EVO continues to feature a fuel cell design that will be adopted by the ACO in its future Hypercar class. However, the regulations will also cater for ICEs that use liquid hydrogen as a combustible fuel. The FIA and ACO are working to ensure the three solutions (fuel cell, combustion and petrol hybrid) perform at similar levels to avoid undue interference from the Balance of Performance process.

Latest rubber

As well as moving to a liquid storage tank, the H24EVO also features expected upgrades, including the latest tyre from Michelin, made with a greater amount of renewable material. Making the size of the tyre on the EVO different to those on existing Hypercars was primarily an aerodynamic decision, but also an ecological one, as it further reduces the amount of rubber used in each tyre.

However, the organisers are concerned that the load exerted on the new tyres could be too high, so are considering different suspension solutions to protect the tyre.

The evolution of Mission H24

Since 2018, the ACO and FIA have pushed the idea of hydrogen technology and presented it to the world in a racecar format. The first iteration was called the LMPH2G and featured a hydrogen fuel cell design fitted to an ADESS LMP3 chassis.

Developed by the team at GreenGT, based in Magny-Cours, France, it was first unveiled as a concept car and then demonstrated at race tracks around Europe.

Following this public debut, the ACO went further with the project, launching the H24 prototype which boasted a higher power output from two electric motors instead of four. Symbio, became a partner on the fuel cell system, while Plastic Omnium (now called OPmobility) supplied the tanks that housed the 8.6kg of hydrogen carried onboard at 700bar. The fuel cell stack produced a constant 250kW and the car had a peak output of 550kW.

The H24 tipped the scales at approximately 1450kg, but the new H24EVO undercuts it by 150kg. Part of the weight saving comes from using a single, rear-mounted motor. A new

'We want to test some tyres in anticipation for what we want [to run] at Le Mans, so we want a new tyre, a different size, with more renewable materials inside,' says the ACO's consultant on hydrogen regulations, Bernard Niclot. 'You always push the limit.

'In the future, I would like us to introduce some progress in terms of the suspension, but it won't be an active system. The problem is that hydrogen cars are heavier than the Hypercars. We can play with the aero, but the tyres are heavily loaded and so we could face some durability topics.

'I think with the work that is done by Michelin – they have made some good progress and have a good understanding of what the tyre can do – so we are confident, but we can also improve the durability using the suspension.'

Blending in

The target for this generation of the H24 is to lap Le Mans as quickly as a current generation LM GT3 car, go as far on a stint and refuel in a similar time. 'The first target is to improve the performance of the car, and put real racing components in the car so we can reach the level [we require],' says Niclot. 'That is not [going to happen] in 2028, but it is a good step forwards and it is important to make a demonstration of better performance.' Development in the fuel cell itself has also meant greater power density, so more power from the same stored energy. The car also carries a high voltage battery with the latest racing technology.

'The power density will be increased, so you will have more power with the same volume and mass of the fuel cell,' says Niclot. 'The battery will be a better one, a higher level racing battery with the best technology inside, like Formula E and Formula 1.'

With the previous gas storage plan, the increase in pressure from empty tank to full brought a large temperature change that engineers were struggling to control. The pit stop refuelling time also looked likely to be two minutes or more, which has now been addressed with the liquid solution.

That is not to say the decision has come without consequence. Other than the incredibly low temperature the fuel must be stored at, the move to liquid hydrogen has necessitated a major change in the hardware delivering the fuel to the power source.

The decision to switch was taken late in 2024. A technical working group, including representatives from Ferrari, BMW, Toyota and Hyundai, as well as the ACO, looked at the engineering solutions required to introduce hydrogen to racing, and the system on the H24EVO is one of the outcomes from that group.

Series specific

It's interesting to note that the FIA has introduced parameters that will allow it to accept hydrogen as a fuel, leaving individual series wishing to go down that route to finalise the details according to their needs. It points towards the FIA expecting more series to use the fuel in future, in addition to the WEC and Extreme H.

One of the areas where individual series can make changes is in the amount of fuel carried onboard. 'Another example is the dormancy time,' says Niclot. 'When the tank is heated, the hydrogen starts to evaporate and then you increase the pressure in the tank, and you don't want to go above a certain value of pressure. Then you want to [reduce the pressure from] the tank, and this is the boil-off.

'The time between the moment you fill the tank and the moment you start to release hydrogen into the air is what we call the dormancy time. Again, the FIA wants to define a minimum dormancy time, and then we can increase this request because

Symbio stack produces up to 300kW and is helped by a 3.4kWh Fortescue Zero battery that recovers braking energy. Top speed has risen by 40km/h as the motor output has increased to 650kW.

Car design is set to be frozen in the spring and a static model will be displayed at the 24 Hours of Le Mans in June. Looking even further ahead, the first track test has been projected for April 2026.

The first two evolutions of the car were the catchily-titled LMPH2G from 2018 (left) and the updated H24 that was introduced in 2021 (below). Both were fuel cell cars using gas, but liquid storage has been introduced to the programme from 2025

of specifics related to things such as the starting procedure. It is a parameter we can then fix in the regulations.

'In WEC, for example, we want to have only one system of refuelling, but the FIA does not say you need a unique refuelling system.'

Complex system

Naturally, the refuelling system is one area that the FIA and ACO have closely examined together. Although the time to fill the tank has reduced dramatically, there is still the need to transfer a cold liquid to a cold tank without evaporation. 'Liquid hydrogen is cryogenic, so you have to maintain the temperature inside the tank,' explains Niclot. 'The problems of boil-off is a clear question we didn't have with gas hydrogen. Then you have to manage the safety, with more complex system of valves and redundancy.' This is in reference to maintaining the integrity of the tank as it fills.

'Second, you have to realise that liquid hydrogen is at 20K, below the temperature that you liquify oxygen or nitrogen. So, it is even more important that we are sure we don't have a cold part of the system in contact with air. You must have the tank protected in an envelope to avoid such a possibility.

'For this, you need to be more accurate in the way you install and package the tank in the car. It is not unfeasible. With technology, once you understand these problems you can solve them, but you have this added complexity. Then there is more complexity in the way you refill the car too, because we have to manage this cryogenic hydrogen,

The H24EVO might not achieve all the ACO and FIA expect, or hope, to see in the next five years, but it is still a significant car in that it visually and physically represents the latest thinking for the regulations

which is more difficult [to handle] than the gas hydrogen we had before.

'We have some process in the procedure where we use helium to create a barrier between hydrogen and the outside. Helium has the property that it liquifies at an even lower temperature than hydrogen, so it is the only chemical component we can use as a gas in contact with the hydrogen liquid. It is an inert gas, but this is something that you don't need for gas hydrogen.'

Keeping the tank isolated in the car will require a protective layer, and some advanced heat shielding, and the pressure within the tank has to be kept within limits, which is not an easy task.

Weight watching

Thoughts then turn towards the weight of the car, and crash testing it. Niclot was hopeful that a manufacturer building a bespoke fuel tank specific for racing would be able to save significant weight, but maintaining tank strength in the event of an accident made any weight saving minimal. 'We know we could reduce the weight of the tank but, even with high level fibres you still have a minimum weight, and this was quite heavy,' he says. 'Even with some studies to reduce the weight, it did not change much. It is always good to reduce weight in racecars, but in the tank itself we could improve, but not by much.'

Despite going to liquid storage, the overall car weight of 1300kg is unchanged compared with the previous gas version, so it is still heavier than a GT car, but many believe that number to be optimistic. Any crash testing will therefore need to be adapted to suit. For reference, Hypercars currently run at a maximum of 1080kg under normal circumstances, while the GT cars are around 200kg heavier. One engineer estimated that the current Hypercars would have to carry 400kg of ballast to be a comparable weight.

In its current guise, the H24EVO might not achieve all the ACO and FIA expect, or hope, to see in the next five years, but it is still a significant car in that it visually and physically represents the latest thinking for the regulations. 'The target remains at 10 laps [at Le Mans], and to have representative performance,' concludes Niclot. 'We want to show that this technology can compete with petrol cars and have the same level of performance.

'I think in motorsport it is always the way that [no matter how much] you try to slow down the cars, they are faster than we imagined. That's been the same story for the last 50 years. I am not nervous [about the performance potential of the H24EVO], and I hope for a good result from the hydrogen car.'

The change from gas to liquid storage has added another layer of complexity to an already challenging project, but the ACO remains confident the technology and expertise exists to solve the issues, and that motorsport is the platform to showcase it

Green grass roots

Fastest Mini in the World is just one club-level category that has embraced sustainable fuels. However, proposed new MSUK regulations mean others may need to join it in 2026

Sustainable fuel is a major topic in the upper levels of motorsport, but what's happening at club level? **Racecar** ***investigates***

By MIKE BRESLIN

While the person in the street might say that motorsport has nothing to do with sustainability, the person in the pit lane knows better. From the use of hybrids in Formula 1 to electric power in Formula E, our sport has been championing environmentally friendly technology for many years. The next big move in this space will be F1's switch to 100 per cent sustainable fuels in 2026.

Formula 1 is by no means alone in moving to lower carbon fuels, with the FIA World Endurance and FIA World Rally Championship both already there, as well as some series on a national level. In the United Kingdom, for instance, the British Touring Car Championship (BTCC) will adopt 100 per cent sustainable fuel from the start of this season at the expense of hybrid systems. Fuels with less sustainable material content have also been implemented: FIA British Formula 4 has used a 20 per cent mixture for the last three seasons, and all cars at last year's Goodwood Revival meeting ran on fuels with at least a 70 per cent share.

That's just the start, though, as the sport's national governing body, Motorsport UK (MSUK), has put out a proposal that all competition vehicles that use specialised racing fuel will have to switch to a product with at least 50 per cent sustainable content from 2026. At time of writing, draft regulations to that effect have gone out to consultation, but it's highly likely the proposal will happen for, as MSUK technical director, Ian Smith, says: 'It's quite clear that from the point of view of national motorsport, the primary route for us to demonstrate we're being proactive in terms of our carbon footprint is sustainable fuels.'

Sustainable race fuels, whether e-fuels or biofuels, can have a chemical structure that is almost identical to the fossil equivalent and are refined using similar processes

Before we go into the use of such fuels on the UK club scene, it's worth taking a brief look at what makes a fuel sustainable in the first place.

Special brew

'To make a sustainable fuel we need two elements, carbon and hydrogen,' says David Richardson, new business director at Coryton, which supplies sustainable fuels to a growing number of championships and competitors. 'The hydrogen element is always in the environment naturally, but the carbon element, that's where the magic comes into play.'

Generally speaking, there are two types of sustainable fuels: e-fuels (also called synthetic) and biofuels. 'Simply put, e-fuel is using renewable energy to power a process that captures carbon and produces hydrogen,' explains Richardson. 'To capture

the carbon, you can either have, effectively, a big vacuum cleaner that scrubs the carbon out of the various gases that are in the environment, or you can connect them to industry. So, things such as concrete manufacturing, which is hugely carbon intensive, and the steel industry.

'The next thing you need to do is create your hydrogen, and for that you use a process that has been around for hundreds of years, which is electrolysis,' Richardson adds. 'All you really need there is plentiful amounts of de-salinised water.'

However, such processes also need a very generous energy supply. 'They are really energy-intensive,' concurs Richardson. 'Figures that you hear can range anywhere from seven to 20 units in vs one unit of energy out. Not very efficient. However, the point is that those types of technologies are well suited to locations where you do have plenty of renewable energy.'

This is why some of the more high-profile projects are located in countries such as Chile, where there is an excess of wind power, or in Saudi Arabia with solar.

'The great thing about biofuels is that Mother Nature has done all the heavy lifting'

David Richardson, new business director at Coryton

Using the surplus energy in such areas to make a fuel means it is not being wasted. In a sense, the fuel acts as a 'battery', as the energy can be stored within it – liquid is a very dense storage medium – while it is then also easily transported.

Flower power

When it comes to biofuel, there are two different types. 'First generation' biofuels are derived from crops grown specifically for the purpose, which is unsustainable because of the impact it has on food production. 'Second generation' biofuels, on the other hand, are produced from biomass sourced from organic waste and by-products of activities such as food production and timber processing.

'The great thing about biofuels is that Mother Nature has done all the heavy lifting,' says Richardson. 'In our case, we use waste plant matter that would otherwise go to a landfill, or would be composting and creating methane, which is another bad greenhouse gas. What we're doing is we're converting it into a form of alcohol [usually ethanol, but also methanol]… You're effectively creating a non-fossil crude product, and that's good, because you can keep and utilise all of your existing infrastructure, including the refineries and the petrochemical industry.'

At these refineries, this non-fossil crude product goes through a 'downstream' process that's pretty much the same as that used to produce petrol, although there are far fewer sustainable chemistries available, so it is more complicated. Eventually, the manufacturer is left with something that can be almost indistinguishable from a fossil fuel.

'We're talking about a liquid hydrocarbon that is just derived from a different source, as opposed to one derived from fossil sources,' says Smith. 'Their chemical structure and

Racecars with modern engines can use most currently available sustainable fuels without any significant modifications. This Radical SR3 ran on Coryton's Sustain Super 80 at Oulton Park last season

'If [the government says] 100 per cent sustainable fuel from day one for everybody, it'll fail because the supply chain will not be able to meet the demand'

Ian Smith, Motorsport UK technical director

their behavioural characteristics are very similar. In theory, the sustainable fuel that the BTCC is going to use in 2025 [Carless Hiperflo ECO102 R100] and the 80 per cent fossil fuel the series used in 2024, have very little difference in the chemical structure. And to be honest, the change is no different to if they were running 100 per cent fossil fuel supplied by Total [sic] and they were switching to 100 per cent fossil fuel supplied by Shell.'

Circular carbon

However, there is a big 'but…' to all this, because if this fuel, however sustainable its production may be, is to be burnt in an ICE, then surely CO_2 goes straight back into the environment?

'To be very clear, if you put carbon through combustion, you're going to get CO_2 out of the tailpipe,' says Richardson. 'The point is, the CO_2 we've released from the tailpipe, we are recovering it. It's circular carbon. It comes out of the tailpipe, goes into the atmosphere, is absorbed by bio, or through an e-fuel route, and is converted into a liquid. Combustion burns it to CO_2, and it just goes around in a circle.'

One of the main issues with this is governments have generally focused solely on emissions at the tailpipe – which explains the fixation with EVs – so, while sustainable fuels can potentially contribute to net zero, they are rarely recognised as doing so. There is now a great deal of lobbying taking place for this to be put right.

MSUK is one of the parties pushing for such a change. It sees sustainable fuel as just one part of its environmental approach (see box out on p42), and is working hard for it to be used in national and club level motorsport. This comes on the back of some high-profile adoptions, notably in BTCC, which has helped raise the profile of these fuels and facilitate their wider use.

'The BTCC have acted as the leaders in this space,' says Smith, 'and the effort they've put in supports the broader picture because they've also taken the time to work through

All cars in the British Touring Car Championship will use Carless Hiperflo ECO102 R100 sustainable fuel from this season. The fuel was tested successfully in Daryl DeLeon's Cupra (pictured) in some races last year

re-testing a cross section of homologated fire extinguishers to ensure they still meet the FIA test when extinguishing a sustainable fuel fire rather than a fossil fuel fire. There was always going to be a very low risk in that space.'

MSUK is currently working towards mandating the use of sustainable fuels in some categories from 2026, specifically those running control, specialised race fuels, or those that allow their use. This covers a wide spectrum of motorsport disciplines, including hillclimbing and karting. These fuels will have to contain a minimum of 50 per cent sustainable content, with a road map to 100 per cent fossil-free racing fuels by 2030. However, there will be no changes for those categories using regular pump petrol, so these regulations will only affect about 10 per cent of the series that MSUK oversees.

'If we were to say *everybody* has to use a sustainable fuel from January 2026, we would price a load of people out of the sport,' says Smith. 'We started with the specialist racing fuel for practical reasons. For the most part, if the way the vehicle is engineered and configured means you need to use a specialist fuel, you're already operating well in excess of what you would pay on the high street for your fuel.

'The other thing is, the majority of the companies supplying sustainable fuel to the UK need to build their supply and build their capacity,' Smith adds. 'They deserve a lot of credit because they're advocating this technology, in spite of the fact that government legislation doesn't support it and doesn't inspire confidence to invest in the industry. What they've said is, if you go for 100 per cent sustainable fuel from day one for everybody, it'll fail because the supply chain will not be able to meet the demand. Their argument is that a phased approach would allow the supply chain to realistically build its capacity and resilience.'

Drop-in fuels

When it comes to using these fuels, for most modern vehicles even 100 per cent sustainable should not cause much of an issue, to the extent that some of these products are referred to as 'drop-in'.

'A modern car that's running an electronic control unit and lambda [sensor] will figure it out, as long as the operating

Whatever's in the tank, spectators will still enjoy the action at historic events. Advanced fuels could also hold the key to ensuring these older cars stick around

All cars racing at Goodwood's major motorsport events now use sustainable content fuel. The transition started at the 2023 Revival, in the Fordwater Trophy for Porsche 911s, where some top drivers helped to deliver the message

'If you're talking about a specialist racing fuel, there's no such thing as a drop-in, even with fossil [fuel]'

Ian Smith

conditions within the ECU have not been fixed and it's open band, and you've got knock sensors,' says Richardson. 'The engine will look after itself and, by and large, they can use anything they like.'

Dave Beecroft, who is currently developing the Chevron TOCA Junior car, which uses a standard Mazda four-cylinder engine, confirms this. 'We use the same Carless fuel as the [BTCC] touring cars, and it's been no problem,' he says. 'In fact, it's been very good.'

Where the challenges come along are with more specialised race fuels, but then that's always been the case. 'If you're talking about a specialist racing fuel, there's no such thing as a drop-in, even with fossil, because you're chasing that higher octane, and all of the things that go with it,' confirms Smith.

'Even if you just switch from one supplier to another, you're going to put your engine on the dyno to make sure the mapping is calibrated for the different fuel. None of that really changes when you start to introduce a sustainable fuel, because it's still a liquid hydrocarbon, just derived from a sustainable source rather than a dinosaur.'

All this means is that when a sustainable racing fuel is introduced, there is a need to work with the engine builders. This is something that Anders Hildebrand, the managing director at fuel producer and importer, Anglo American Oil Company, has experience of, having produced and supplied much of the fuel that has been used at Goodwood for its recent switch to sustainable. Indeed, for the Gordon Spice Trophy at the 2024 Members' Meeting, open to a wide variety of Group 1 touring cars, Anglo American provided every engine builder involved with a sample of fuel to test.

Historic headache

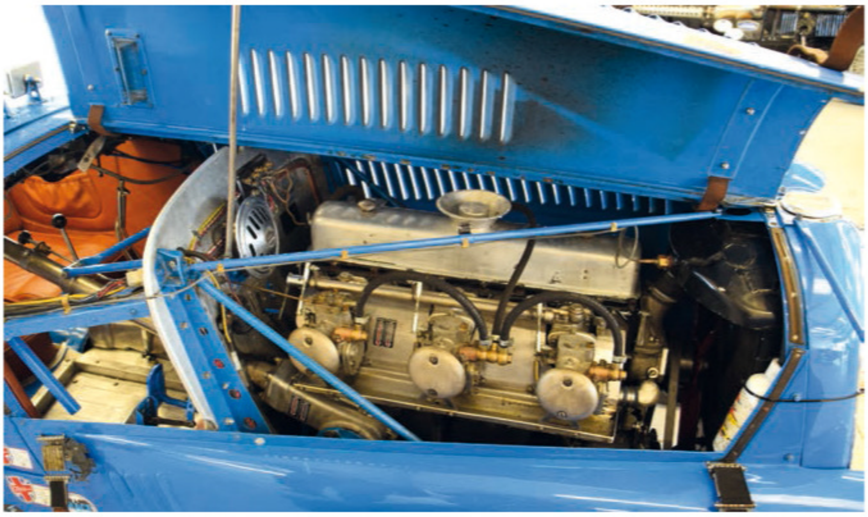
Historic racecars, like those used at Goodwood and other such events around the world, as well as in many UK club racing categories, will often not have fuel injection, ECUs or knock and lambda sensors, so require a more careful approach.

'With a carburetted car, there's not a huge amount you can do when it comes to mapping, because there is no such thing, but there are some changes you can make with the carbs,' notes Richardson. 'We often say to people, if you're running very high load, and you have very high compression, the one thing you might look at is having an optimum operating condition under load, even if under idle conditions it may sound like a bag of nails. It's just because of the way the chemistries behave with carburettors, and you can't change the characteristics under different load conditions of how it atomises that fuel.

'You can change the floats in a carb, you can change needle heights, or you can change jets,' Richardson adds. 'By and large, that's about as much as you can do in terms of adjusting the conditions. Then you've got your timing, and you have to match that with all three of those elements.'

Making sure that combination is right is critical, not least because of the exorbitant cost of rebuilding many of the engines used in historics. 'People have blown cylinders, or there's been catastrophic events when they have not understood, fundamentally, how some of these fuels change ever so slightly, compared to fuels they traditionally used,' says Richardson.

One of the key changes is that these fuels can be denser. 'With the historic vehicles, if you have the wrong density of fuel, if it's too dense, the float sits too high in the float chamber,' notes Hildebrand, 'so you won't get enough fuel in the chamber for the car to run properly.'



Unlike modern engines, sustainable fuel needs to be tested on historic powerplants, such as this 3.6-litre Delahaye unit, before it is used in races. Sometimes higher density mixes can cause carburettor and fuel system issues

Percentage game

It's important to note here that sustainable fuels currently used in club level and historic racing will not normally be 100 per cent sustainable. Instead, most contain a proportion of sustainable components, and for good reason.

'I'm happy to make ratios up to 70 per cent made from sustainable components,' says Hildebrand. 'If you go above that, you start to struggle with octane, useability etc. We can just chuck in lots of ethanol, but that will mean you have a fuel with a very high oxygen content and you specifically have to tune the engine for that fuel. You can set it up so it runs fine on a mix like that, but for the historic market you don't want too much ethanol because it's going to eventually eat everything. Ethanol absorbs moisture, it becomes acidic. It starts to pit the fuel system, it can perish fuel lines and other components. It's fine in modern racecars, they can cope with that.'

[A] small hike in performance comes at a cost… price is possibly the biggest barrier facing the wide acceptance of sustainable fuel at club level

Competitors will clearly need to take a certain amount of care when it comes to the use of some of these fuels, and not just with the tuning of their cars. 'How the racers treat the fuel is also important,' continues Hildebrand, 'because when you have higher levels of oxygenates they're not as stable as lower oxygenated race fuels. So, one thing teams have to do is not leave the fuel in the tanks for a couple of months and then go racing hoping it will be the same, because it deteriorates faster in an open environment. In the drum, it's not a problem, but when you have it in the tanks it can be. It can affect the materials, especially when you start to go to higher levels of sustainable components.'

All that said, *Racecar* has spoken to several club racers who have already switched to sustainable content fuel, and most had few issues to report. Some have even seen performance hikes. Nigel Death, the race director for the Fastest Mini in the World competition, an event for highly modified cars (see *RE* V34N12), uses Coryton Sustain 50 and comments:

Current thinking

Not so long ago, EVs looked to be the future for club motorsport sustainability, but now the spark seems to have fizzled out, most recently with the BRSCC Formula Foundation E electric series (see *RE* V33N2) failing to get off the ground. Steve Wills, the head of Formula Foundation car builder, RSR Technology, notes, 'it's not commercially viable as things stand.'

Motorsport UK, for its part, sees EVs as just part of the mix. 'We're saying, let's take a proportionate approach,' says Ian Smith, MSUK's technical director. 'We're not going to advocate that we electrify the sport in its entirety because that's just not practical; it would require a huge amount of investment in infrastructure for starters. However, if you're interested in competing in a sprint or a hillclimb event in an [electric] road car, there's no reason why you shouldn't be able to do so.

'The important thing is we're not wedded to one particular technology,' Smith adds. 'Our strategic view is that there's space for lots of different propulsion technologies in order to realise net zero.'

The Formula Foundation E series has, so far, failed to launch, but MSUK is still keen to encourage the development of some level of grass roots electric motorsport

'We have evidence to show it makes a difference. We tested it on the dyno and it delivers a 3bhp benefit.'

But that small hike in performance comes at a cost, literally, for the price is possibly the biggest barrier facing the wide acceptance of sustainable fuel at club level right now. 'These components are more expensive, and so the racers will have to get their heads around why they should pay more,' says Hildebrand. 'The cost will only go down when there are more players on the market. As it is now, there are lots of start-up companies; they need to make a profit and, for them to get to that level, the volume needs to increase dramatically.

'If you don't rush it, take it step by step, the cost will not be too bad because, with more sustainable chemicals becoming available, we can make fuels more cost effectively.'

UK motorsport's future looks set to include an increasing element of sustainable fuels but, at the present time, cost and availability remain the biggest barriers to their large-scale adoption

Interestingly, these new sustainable chemicals might not necessarily be developed with fuels in mind. 'What is going to drive the ability to make sustainable race fuels is not really if we have more sustainable components in pump fuels, because they will not have high octane components,' says Hildebrand. 'It will actually be the chemicals where products are being made. For example, oils used in the cosmetic industry. If people now tell us, actually, we want to have sustainable components instead of components made from crude oil, that's where we're going to see specialised components coming through, which we can then use in race fuels.'

Eventually, this should drive costs down, but for now Richardson says sustainable fuels for high performance applications are around 30 to 50 per cent more expensive than fossil race fuels, though he does not believe that is too much of a barrier to most competitors.

Smith agrees: '[Those affected by the proposed new regulations] are already operating in a way that predisposes you to accept you're paying more than the high street for your fuel. It's a performance component of your racing vehicle… [There] is a cross section of competitors who are more likely to have the means, and are therefore more likely to have the capacity to adopt this technology in the first instance.

'Also, we're not removing the option to use a super unleaded that you can buy on the high street,' Smith adds. 'People might argue, 'oh, my engine requires 102 octane, or x amount of oxygen content.' Well, of course it does, because that's how you've configured it, or how you've mapped it. There are no unsolvable reasons why it couldn't run on super unleaded.'

Big picture

One interesting point with all this is that club racing, as an activity, produces very little carbon when compared to motorsport's big draws, such as the British Grand Prix, which last year attracted 164,000 people on race day, most driving their own cars. The important thing, though, is that the sport needs to be *seen* to be doing something.

'There are lots of reasons why it is in our interest to be proactive about this, not least of which is, if we wait until we're told to do it, we won't have the luxury of a phased approach, or the opportunity to give people time to transition,' says Smith. 'It's also brilliant to see a steady trickle of people who are outside that first phase of the regulations asking, "Can we use the sustainable fuel anyway?"'

'I think it's very positive,' concludes Hildebrand. 'We are having customers buying our fuels with sustainable components and using that to attract sponsors, and also to justify racing. They are doing everything they can to be as sustainable as possible.'

Smith says there are currently no plans for all of UK motorsport to switch to sustainable fuels, but he does see the proposed regulations as 'the start of a journey' in that direction. With no sign that the internal combustion engine is going to disappear from racing – or roads for that matter – any time soon, surely this is a journey well worth taking.

While club motorsport generates plenty of CO_2, this is dwarfed by the amount emitted from the tailpipes of regular road cars transporting spectators to flagship race meetings such as the British Grand Prix at Silverstone

'If we wait until we're told to do it, we won't have the luxury of a phased approach, or the opportunity to give people time to transition'

Ian Smith

Go with the flow

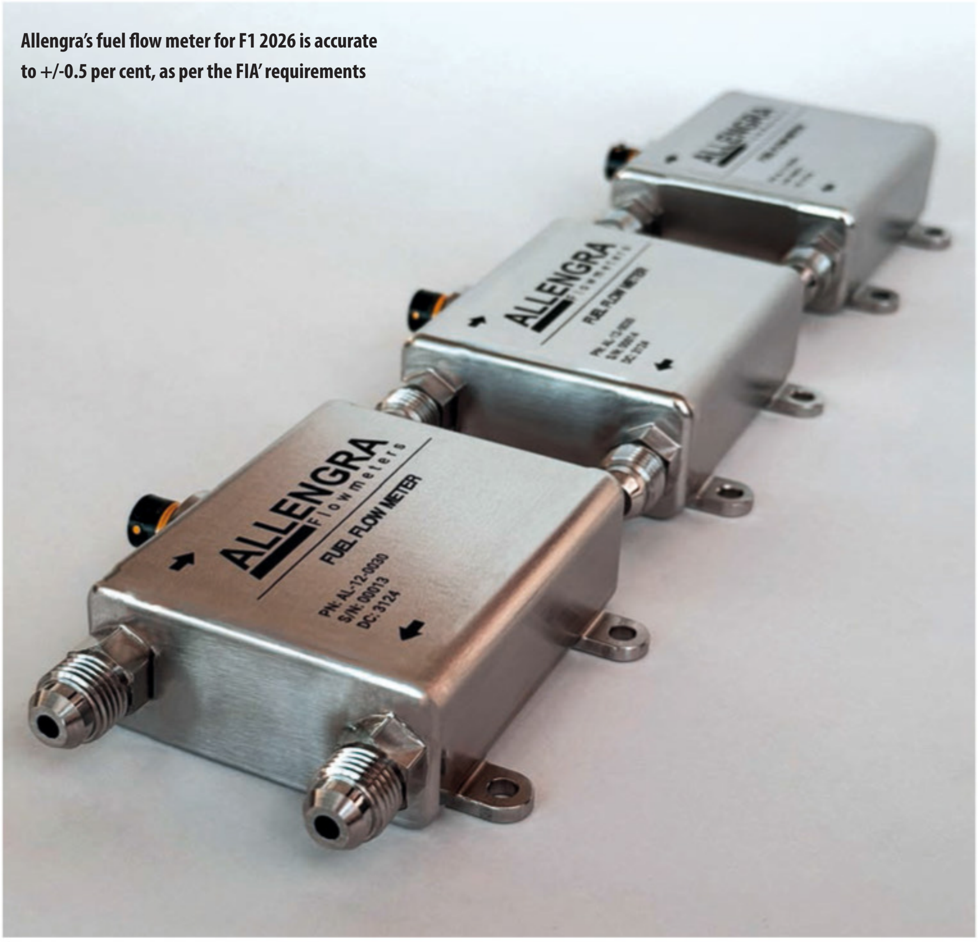
Formula 1 is introducing a new fuel flow meter supplier in 2026 for the championship's progression to 100 per cent sustainable fuels

By DANIEL LLOYD

Fuel flow meters have become essential hardware in modern Formula 1. Their purpose is to monitor how quickly fuel is passed from the tank to the engine. Too fast and the car might gain a power advantage the organisers would deem unfair; too slow and the engine won't make the most of the available fuel, hampering its efficiency.

Such meters were introduced with the arrival of the compact, turbocharged, 1.6-litre V6 hybrid powertrains in 2014, as a way of regulating how the teams feed their internal combustion engines. The maximum fuel flow rate was set at 100kg/h and that remained in place for just over a decade. However, change is afoot next year, when the fuel flow rate formula will be adjusted to coincide with the arrival of new technical regulations.

From 2026, F1 will ramp up its green messaging by introducing fuel made entirely of 'advanced sustainable' components, developed by each of the fuel companies that supply the different power unit manufacturers. The 100 per cent sustainable content fuel replaces the current E10 blend that contains 10 per cent renewable ethanol. The shift is not only bringing changes in the way the fuel flow rate is formulated, but also ushering in a new fuel flow meter supplier.



Allengra's fuel flow meter for F1 2026 is accurate to +/-0.5 per cent, as per the FIA' requirements

Allengra

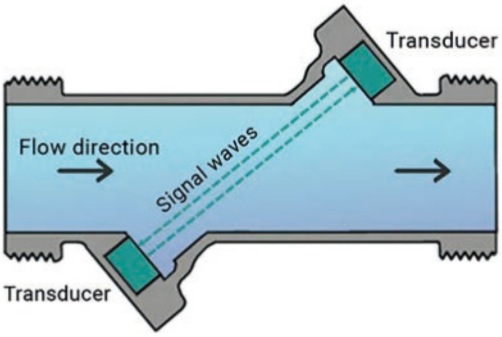
Tender process

In advance of the new regulations, F1's sanctioning body, the FIA, launched a tender to identify a company that would build and provide the same fuel flow meter to all teams from 2026 to 2030. Candidates had to fulfil several criteria in their applications, covering wide remits such as technical, commercial and sustainability (see box out on p52).

The FIA gathered the pitches from multiple applicants and determined that FIM World Superbike Championship supplier, Allengra, would be awarded the contract. It will be the first time this ambitious company, with its operations spread between Germany and Romania, has held F1's single supply contract for the fuel flow equipment. Gill Instruments manned the post initially before being replaced by fellow British company Sentronics in 2018. Sentronics had its tenure

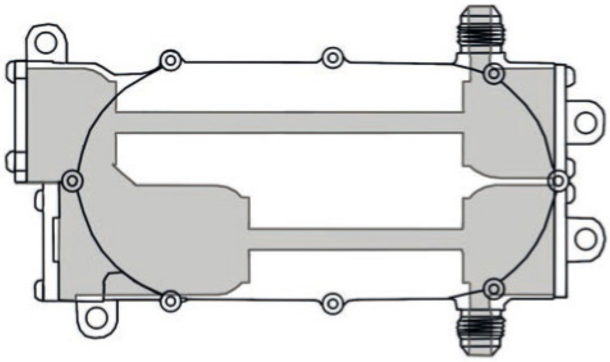
From 2026, instead of the FIA giving each car a maximum fuel mass flow rate, it will impose a maximum fuel energy flow rate

Allengra



Allengra's fuel flow meter features two ultrasonic transducers set either side of a fuel channel. A signal is bounced between the two

Allengra



A signal is then swept through the meter by the flow of fuel and the time of flight principle used to measure how long it takes for the signal to traverse the device

extended after a fresh tender process in 2022, taking it through the current ground effect era.

If Allengra is an unfamiliar name to some in motorsport, that is because it only started exploring the sector relatively recently. Founded 20 years ago by Raul Junker, it initially focused on developing ultrasonic flow meters for the heating industry, before pursuing other industrial avenues and diversifying into vehicles. Having its meter achieve FIA homologation paved the way for Allengra to shoot for the coveted F1 supplier position.

'We had OEM products for gas boilers and heat pumps,' says Niels Junker, commercial director at Allengra and son of the founder. 'From there, we went into coffee machines, clean tech and other industrial applications. Only in 2020 did we start looking into motorsport, because the tender was coming up for the fuel flow meter in Formula 1.'

In fact, Allengra bid for the FIA's 2023-2025 fuel flow meter supply contract, but lost out to Sentronics, which provided one sensor for the F1 teams to manage and a second, encrypted device for FIA monitoring.

After missing out first time around, Allengra tried again when the 2026-2030 tender applications opened with an improved pitch that won over the FIA's auditors. It made its fuel flow meter – now a single device, rather than two – more compact, satisfying the FIA's weight saving target.

Feeling ultrasonic

Allengra's F1 fuel flow meter uses ultrasonic metering (see **table 1**). In this method, two ultrasonic transducers are set on either side of a channel in the middle of the flow meter, through which the fuel is passed. The transducers emit a signal that bounces between them, across the fuel current.

'We measure in the domain of picoseconds. It's 10^{-12}. That is really short. Light travels 30cm in one picosecond'

Niels Junker, commercial director at Allengra

This signal is swept along by the flow of the fuel and the 'time of flight' principle is used to measure how long it takes for those carried signal waves to travel the length of the device.

'Once the signal flies together with the direction of the flow, the signal gets accelerated,' explains Junker. 'We measure the time of flight, and then we measure against the stream where it gets decelerated, so you have a time difference.

'You need plausibility tests because there may be electrical interference. We measure in the domain of picoseconds. It's 10^{-12}. That is really short. Light travels 30cm in one picosecond. At this level, at the limit of physics, you can have many influences, and you need to correct for them. That's why we have a very high measurement frequency. If I measure with 6kHz [6000 times per second] maybe I have some measurements that are failures, but those would be corrected through the other measurements. A lot of software goes into that, which we have from all the industrial domains we integrate to make it a reliable measurement.'

Table 1: Allengra 2026 F1 fuel flow meter spec sheet

Measurement method	Ultrasonic transducers
Measurement range	+/- 5-8000ml/min to +/-480l/h
Accuracy	+/- 0.5 per cent of measured value
Repeatability	+/- 0.25 per cent
Response time	<1ms
Temperature measurement	Two platinum chip resistors
Pressure measurement	Monolithic pressure sensor
Pressure accuracy	+/- 0.1bar
Compatibility	All types of petrol blend, including e-fuels
Fuel operating temperature	0-90degC
Fuel operating pressure	-.01 to 10barG
Supply voltage	5.5-24V DC
Current consumption	<130mA at 12V, <220mA at 5.5V
CAN standard	ISO 11898-2
Message format	2.0A (11-bit identifier)
Baud rate	1/2/4Mbit/s
Connections	2 x 6AN male
Pressure loss	200mBar at 100kg/h
Weight	390g
Dimensions	98.5 x 31 x 106mm
Wetted materials	AISI304, AISI316L, PEEK, FKM

As F1 pushes towards its 2030 net zero target, fuels used by the racecars will comprise significantly more sustainable materials from 2026

Ultrasonic metering in this way is capable of measuring fuel flow extremely quickly and accurately. It has to be, as the FIA demands the 2026 fuel flow meter have an accuracy of ±0.5 per cent. Allengra is confident its device meets that criterion.

'What they expect from us is to measure precisely and [ensure that] measurements are repeatable at the same level,' adds Junker. 'For example, if I test on a rig, every lap should show the same consumption. And there should be reliability, of course, [withstanding] vibrations and crashes up to many *gs*.'

The sensor also needs to function in rising temperatures. Fuel in an F1 car is not allowed to be colder than 10degC, or 10degC below the ambient temperature, but it becomes hotter over the course of a race.

'Our sensor also needs to work up to 80 or 90degC, so we can guarantee it doesn't have an impact on performance up to that. It doesn't mean that, if you go over that, it will be destroyed, but it will probably not have the same precision you would get at a normal temperature. We would be able to see if somebody tried to manipulate it by heating up the sensor and putting it inside.'

Tamper proof

F1 is returning to a single fuel flow meter in each car from 2026, having used a pair of sensors since 2020. The move to two devices was made in response to the controversy surrounding Ferrari's power advantage over its rivals during the 2019 season. The extent to which the Italian manufacturer's power unit was stronger than the others prompted an investigation that led to a settlement between Ferrari, which always denied any wrongdoing, and the FIA.

'As we've had some challenges with the possibility for teams to tamper with the signal, and experience of teams trying to basically play around with that measurement, that's why we decided to introduce a second device that is encrypted and private to us,' says Martin Baerschneider, F1 powertrain engineer at the FIA. '[It was done] to better police and monitor the first solution, though fitting a second one was an afterthought.

'Basically, we are trying to rectify that situation by going back to one device, but still giving us the functionality of being able to police with a private channel.'

For this reason, the anti-tampering mechanisms of the fuel flow meter have been bolstered ahead of the regulatory shift.

'There is already an anti-tampering mechanism in place for the current fuel flow meter,' adds Baerschneider. 'A similar approach is now happening on the FIA channel. A number of anti-aliasing features are in place to ensure the flow measurement frequency is bearable. It's a very high frequency, above 4.5kHz. If you have a constant frequency that you check, that gives teams the opportunity to tamper with the signal. If that signal is variable, it gives [teams] less opportunity.

'On top of that, we now have a pressure delta we check as well, between the inlet and the outlet of the fuel. This gives us another source of cross checking. That is also a private signal to the FIA, it's a new feature [for 2026].'

The FIA hopes the change to how fuel usage is governed will help promote competition between fuel suppliers

Weight saving

Reverting to a single fuel flow meter aligned with the FIA's target of reducing the weight of F1 cars. The 2026 breed will be 76kg lighter than this year, when the minimum weight will rise to 800kg for just one season to accommodate new driver cooling equipment. The prevailing thought was that if the functionality of two meters could be replicated in one, it would be an easy win for overall weight saving.

'We're now having two measurements in one single device, from two independent channels,' says Baerschneider. 'It means the weight of the total solution is now under 400g. We're saving over 250g compared to the current solution, so it's a big step forward.

'We will still be able to have two separate measurements, one for the teams to control fuel flow, and one for us to police. On the latter, we will have a second, independent channel that will be private and encrypted, just for us to verify the measurement the teams are receiving is correct.'

While the method of measurement is not radically different to what came before Allengra's tenure in F1, the way in which a car's fuel usage is governed will change.

Instead of the FIA giving each car a maximum fuel mass flow rate (which is measured in kg/h under the current regulations) as it has done since 2014, from 2026 it will instead implement a maximum fuel energy flow rate measured in MJ/h.

The standard ECU from McLaren Applied will then convert the fuel mass flow registered by the Allengra meter into a fuel energy rate using the energy density and lower heating value (LHV) of the fuel in the equation. The LVH is the amount of heat released when a certain amount of fuel is burned.

The energy flow limit from 2026 will be 3000MJ/h above 10,500rpm. This translates to just over 20 per cent lower than the current maximum fuel flow rate. Below 10,500rpm, the fuel energy rate is calculated by multiplying the rpm by 0.27 and adding 165 to the total number.

'The total solution is now under 400g. We're saving over 250g compared to the current solution, so it's a big step forward'

Martin Baerschneider, F1 powertrain engineer at the FIA

Increased competition

The change to how fuel usage is governed stems from the introduction of fuels containing more sustainable components. It also aims to promote competition between the different fuel suppliers, and will examine the environmental credentials of each fuel.

'There is clearly some level of correlation between energy and mass flow if you use a single, specific fuel,' says Baerschneider. 'However, what we wanted to achieve for 2026 is that those fuels can really become a performance differentiator. The LHV of a specific fuel type is, essentially, the conversion factor from energy density to mass flow. So, the better your fuel, the higher the energy density you get from it [and] the better the power of the engine will be. We will take the specifics of a fuel that is being tested by an independent test house, and use our calibration as a conversion factor between energy flow and mass flow.

The idea is to develop those sustainable fuels, and for the teams and power unit manufacturers to profit from having an efficient fuel'

Martin Baerschneider

Table 2: Fuels developed for the 2026 regulations must adhere to the following properties, as laid out in version 10 of the technical regulations (FIA)

Property	Units	Min	Max	Test Method
RON		95.0(1)	102.0(1)	ISO 5164/ ASTM D2699
Sensitivity (RON-MON)			15.0(1)	ISO 5164/ ASTM D2699 ISO 5163/ ASTM D2700
LHV	MJ/kg	38.0	41.0	GC
Density (at 15°C)	kg/m³	720.0	785.0	ISO 12185/ ASTM D4052
Methanol (2)	% v/v		3.0	EN 1601 or EN 13132 or EN ISO 22854
Oxygen	wt%	6.70	7.10	Elemental Analysis
Nitrogen	mg/kg		500	ASTM D 5762
Benzene	wt%		1	GCMS
DVPE	kPa	45	68	EN130161
Lead	mg/l		5	ASTM D 3237 or ICPOES
Manganese	mg/l		2	ASTM D 3831 or ICPOES
Metals (excluding alkali metals)	mg/l		5	ICPOES
Oxidation Stability	minutes	360		ASTM D 525
Sulphur	mg/kg		10	EN ISO 20846
Electrical conductivity	pS/m	200		ASTM D 2624
Distillation Characteristics:				
At E70°C	% v/v	20.0	52.0	ISO 3405/ ASTM D86
At E100°C	% v/v	40.0	80.0	ISO 3405/ ASTM D86
At E150°C	% v/v	75.0		ISO 3405/ ASTM D86
Final Boiling Point	°C		210	ISO 3405
Distillation Residue	%v/v		2	ISO 3405

A correction factor of 0.2 for MON and RON shall be subtracted for the calculation of the final result in accordance with EN 228: 2012
A stabilising agent must be added

'The fuel flow meter still, technically, measures fuel mass flow, but the limit allowable will be correlated to the energy you are allowed via this conversion factor. The idea is to develop those sustainable fuels, and for the teams and power unit manufacturers to profit from having an efficient fuel.'

'Not all molecules have the same energy,' adds Pierre-Olivier Calendini, fuel research centre director at Aramco, which is supplying Aston Martin from 2026. 'Depending on the molecules we are using, the energy per kilo is different. To allow for that, we can use different solutions to really open the competition. So they have proposed to move to energy [flow rate from fuel mass flow].'

It is worth noting here that F1 will continue to not have a fuel mass limit in 2026. When the hybrid V6 era started in 2014, cars had to start each race with no more than 100kg in the tank. This was incrementally increased up to 110kg before being quietly dropped ahead of the 2022 season. As a result, cars rarely started races at the fuel limit, teams preferring to enhance lap times and tyre life by under fuelling for the start and managing the amount onboard through engine control. This approach will be maintained into the next rules cycle.

Key combatants

The fuel manufacturers in F1 are currently Shell, which supplies the Ferrari-powered cars, Petronas (Mercedes), BP (Renault) and ExxonMobil (Red Bull Powertrains). One more will be added to that list in 2026, though, when Honda returns to the championship in an official capacity with Aston Martin, bringing with it the current FIA Formula 2 and Formula 3 fuel supplier, Aramco.

Additionally, Renault will leave and its factory team, Alpine, will become a Mercedes customer, while newcomer Cadillac will start as a Ferrari customer before introducing a new power unit before the end of the decade. General Motors' recent establishment of a dedicated F1 powertrain company, GM Performance Power Units, underlined that. Meanwhile, Sauber will leave Ferrari's custom in 2026, once it transitions into the Audi factory team, and will use BP fuel.

The various suppliers are currently working out the final compositions of their 2026 fuel solutions. As of mid-January, Allengra had only received samples from some of the suppliers, and those it had received were not the finished product. Aramco, for example, expects to finalise its fuel by mid-autumn, ready for next year's pre-season test.

'It's an iterative process,' says Calendini. 'We plan to freeze the 2026 fuels at the end of Q3. Because once the fuel is fixed, we need to ensure we have all the chemicals and components required to be able to manufacture the fuel at the end of the year, and to start shipping it in December.

'I don't yet know the 2026 calendar. We assume it will be similar [to 2025], so that is why we need to fix everything around October / November, with certification, settings etc.'

The race to synthetics

The shift to regulating fuel flow in terms of energy, rather than mass, could give the different fuel suppliers an opportunity to shout about their technologies and production methods. It could also foster a race to bring synthetic components into the fuels. The types of sustainable material that can be used from 2026 are listed in **table 2**. That raises the question of how much variation could there be in the content of future F1 sustainable fuels?

'It's difficult to answer that because it's very difficult to know the knowledge of the others on sustainable components,' says Calendini. 'We do not think that someone will come with a very specific component. The competition will be much more about how you are setting and fine tuning your fuel. Most of the components are available on the market at the beginning of 2026. For us, the target is to use [a synthetic] component from Neom, once our production plant there will be ready, [but] it will not be for 2026.'

Allengra feels it has a device that can handle the variety of fuels that is set to come. The company has worked with sustainable fuel already in the aviation industry; the flow meter used for its unsuccessful F1 contract bid, for example, has been used with aviation fuels for helicopters.

'The sensor needs to be capable of handling sustainable fuels,' states Junker. 'Our sensor is completely stainless steel so, for the fuel manufacturers, it is easier to develop fuels without any restriction, at least from the flow metering side.

'The ultrasonic principle works with liquids and gases. The only thing you need to calibrate it for specifically would be the fuel, because every fuel has a different


All teams were given the option to try the new fuel flow meter at the 2024 post-season test, but only four took up the offer

density and, by that, a different way of behaving. The speed of sound is also different in every fuel. There are fuels that are similar, but you see a difference because we want to measure precisely, with +/- 0.5 per cent accuracy. To do this, you need to calibrate it very precisely.'

Validation testing

Testing of the Allengra fuel flow meter with the 2026 fuels will continue this year, although constant development of the blends makes it a challenging task.

'We do validation testing on the communication side of the sensor,' explains Junker, 'so the teams can integrate it into the ECU and read it out. Also for the FIA to have access to the sensor. These are the first tests. Then you have endurance tests, which are tests on track with the car. At the same time, once the first 2026 spec fuels come out, we will have material tests of the sensor where it's submerged in the fuel. You have fuel running through, but it's also in the fuel tank. So, you need to be on the outside and inside to be compatible with the fuel. We use stainless steel for everything, but the connector is a different material.'

The 2026 fuel flow meter was installed on four of last year's F1 cars for an official test held shortly after the 2024 season finale in Abu Dhabi. All 10 teams were given the chance to install the device, with a large chunk of the cost covered, but only four took up the offer. The Allengra device was run in the Mercedes W15, Williams FW46, Sauber C44 and the title-winning McLaren MCL38. Three of those cars were Mercedes-powered, though Baerschneider is quick to dismiss this as anything more than coincidental.

'There is obviously resource needed to make that work,' he explains. 'The form factor, size and mounting are different. To allow for that, teams will have to adapt the installation, they will potentially have to make loom changes, and will have to change the hydraulic, fuel-in / fuel-out connections, so there is cost and labour involved. We offered an FIA project to exclude that activity from the budget cap, but not all the teams had the time and resource to do so, though four teams decided to do it for that test.'

'The only thing you need to calibrate [the fuel flow meter] for specifically would be the fuel, because every fuel has a different density and, by that, a different way of behaving'

Niels Junker

Positive feedback

The feedback from the Abu Dhabi session was positive, at least from a reliability perspective, although it was difficult to make too many conclusions because the cars were using the 2024-grade fuel with a lower proportion of sustainable content. The Allengra meter was installed where the FIA control meter currently sits, while the team sensor from Sentronics was left in place. This meant the cars had one Sentronics and one Allengra meter in their fuel tanks simultaneously, but no data was shared between the suppliers, and the teams were not privy to the FIA and Allengra's findings on the 2026 device. Any data gathered was purely for the benefit of the organisers and the new supplier.

Considering the test occurred during Sentronics' supply contract period, special dispensation was agreed to run the Allengra unit on track as early as 2024. That backdrop also means further track testing is unlikely before the next generation of cars hits the track in a year's time. Static rig testing will hold the key in the interim, and the first samples of the future fuel were sent to Allengra towards the end of last year.

'The fuel that is mandated for the test was the race fuel teams ran during the season,' confirms Baerschneider. 'The fuel flow meters were calibrated to that specific fuel. Clearly, the move to advanced sustainable fuels in 2026 is going to be a challenge for everyone. Not just for Allengra, but for a lot of other suppliers. Our fuel is more aggressive on the hardware, so there are challenges [not only for] the connectors, but also the internals and hoses [which are] outside of Allengra's remit.

'That compatibility testing is now starting effectively. I think the next chance to [track test] is when the 2026 cars are starting to come together. They will mostly be in full-car dyno testing. We will be able to achieve a bit more testing on that, on top of the testing that's happening at Allengra.'

As a new supplier enters during a time of regulatory overhaul, the target remains the same: regulate fuel flow and beat the teams who are always looking for an advantage.

Commercial and sustainable

Every time the FIA launches a tender for a spec component, it issues a document with the various criteria it wants the winning bid to meet. Aside from being technically sound, offering strong accuracy, repeatability and compatibility with different fuels, the 2026 fuel flow meter needed to satisfy commercial and sustainability requirements.

Unlike the 2023-'25 tender, when candidates were invited to state their products' prices, this time the FIA declared the unit should cost no more than €3000 ($3087) per unit, or €1500 per year if being leased. It also mandated the service fee after 100 hours of running time should not exceed €500.

In setting the tender requirements, the FIA also put a strong emphasis on sustainability. For example, it increased its requirement for the tender winner to have an FIA Environmental Accreditation rating of three stars, rather than two as before.

'We have been pushing for the sustainability aspect,' says Baerschneider. 'This new 2026 fuel flow meter offers a five-year product life, which is impressive [note - the FIA's requirement is three years minimum]. It has a low service requirement and the materials used in the product are recyclable. I think just increasing the overall life of it, and the recyclability, helps our sustainability push. On top of the weight and footprint, it was another big criterion for choosing that product in 2026.

'We also looked at the business risks of each company, and legal aspects, too. All the offers we received were strong.'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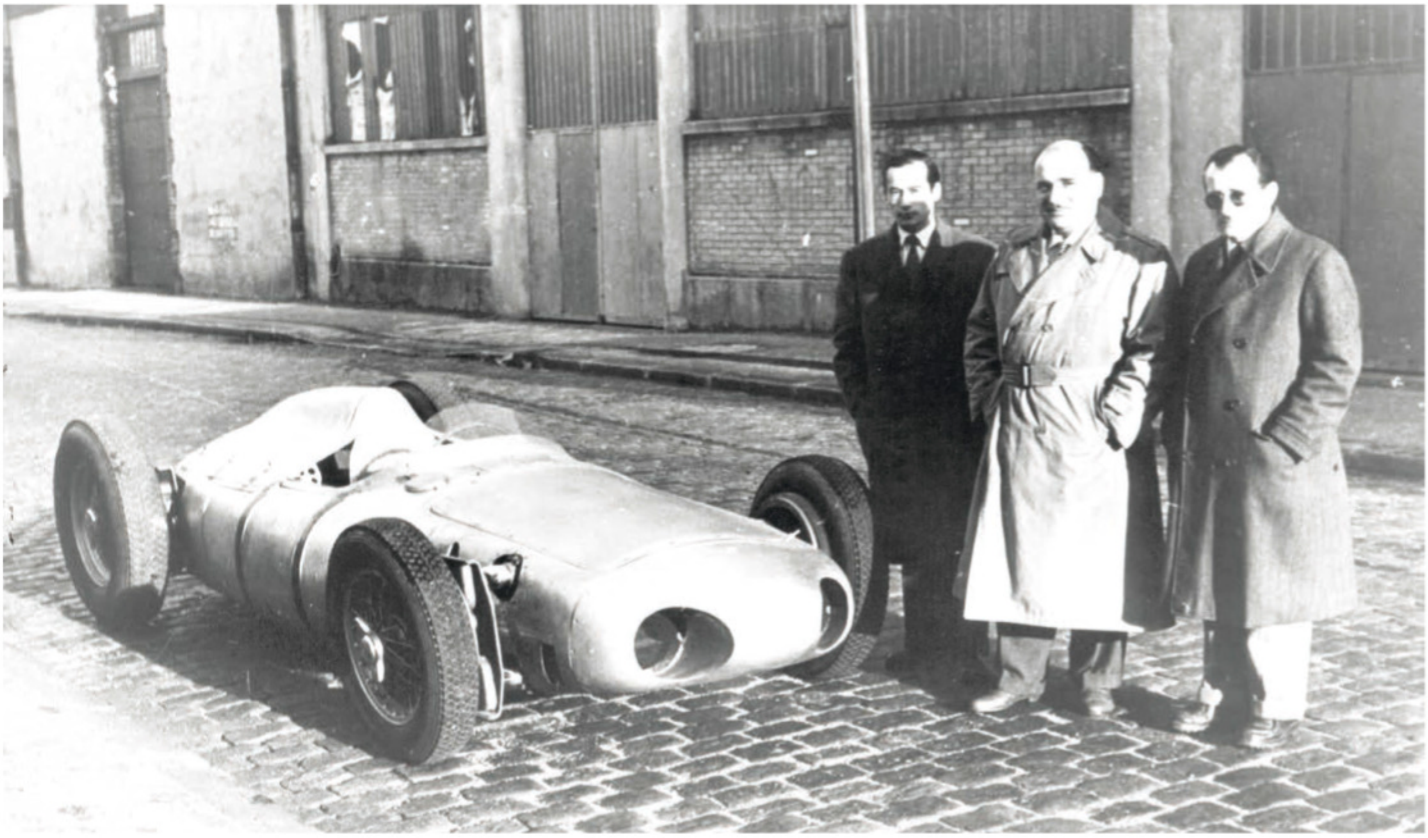
The lion that didn't roar

In the early 1950s, the racing world was rocked by news of a new French grand prix car full of advanced features, but the story of the Sacha-Gordine reads like one of its creator's films

By KARL LUDVIGSEN



In 1953, all motorsport was agog at the sight of the ultra-low, mid-engined, Sacha-Gordine racer. Left to right are its creators, Nari Edward Perkins, Sacha Gordine and Cesare Vigna

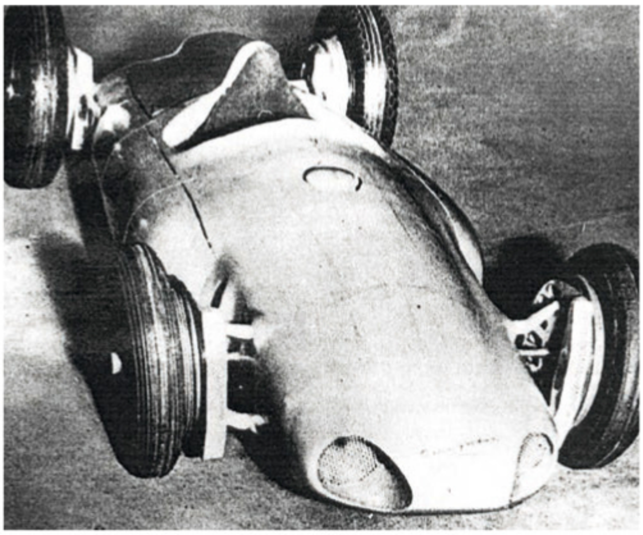
In 1944, Prince Sacha Alexandre Gordine Gregorieff was on a roll. He was 34 and had found his metier in motion picture production. His first produced film, *Adventure is Just Around the Corner*, was aptly named, leading the way for more film releases by Sacha Gordine, as the jovial man of Russian extraction styled himself.

Russia's St. Petersburg was Gordine's most likely city of birth on 27 February 1910, though the aristocratic family moved west to Paris in 1917 in the shadow of the Russian Revolution. In the 1920s, young Sacha became passionate about motoring, on four wheels and two. At the first running of the Bol d'Or 24-hour motorcycle race, Gordine's mind started whirring. His trajectory from the world of cinema to motorsport will be familiar to some as the path recently trodden by Jim Glickenhaus, a film producer who oversaw the creation of an LMH car that finished third at Le Mans in 2022.

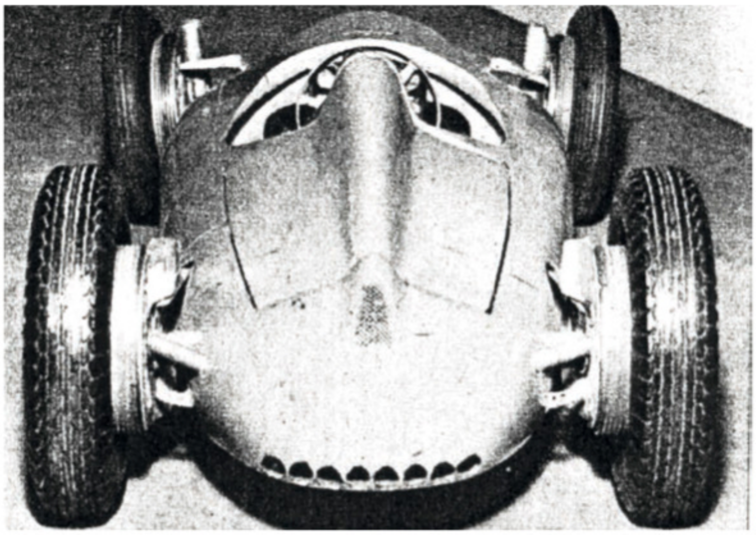
A century before Glickenhaus' podium finish, Gordine observed that the Bol d'Or was open to small cars as well as bikes, which prompted him to make the bold decision to become a car builder. His concept was a three-wheeler with the front wheels doing the steering, as well as the driving from a JAP motorcycle single-cylinder engine. Naming it the 'Sacha', Gordine found customers for his racy cyclecar.

'I competed in several Bols d'Or,' he related. 'At the time, I had built around 10 cars. There was also a single-track vehicle, a 'monotrace'. That was fantastic! Its support wheels were from a children's car! I presented it for scrutineering at the Montlhéry Bol d'Or. It was accepted but, after three or four hours of the race, I was already around 30 laps in the lead! I was disqualified for dangerous driving.'

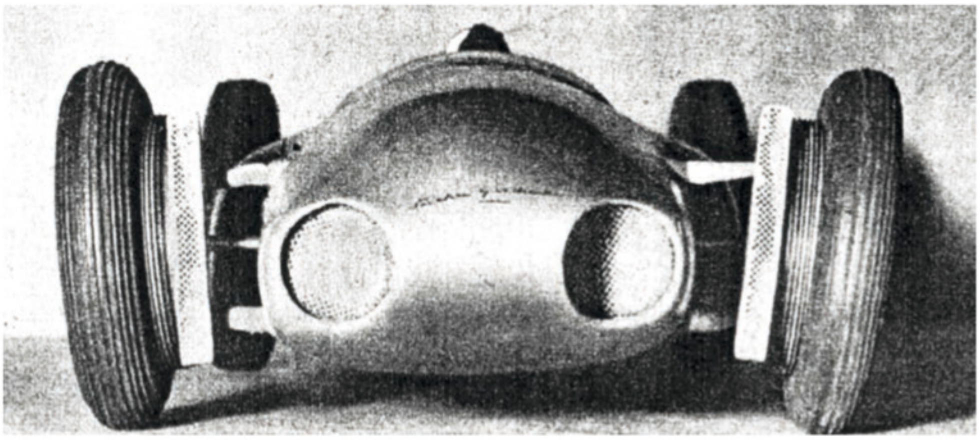
Gordine was soon ready to scratch his itch for four-wheeled motor racing. He had no pushback from his wife Régine, a keen driver who had competed in the 1950s in the Monte Carlo Rally, Tour de France, Le Mans and the Mille Miglia before she met Gordine.



The first manifestation of the Sacha-Gordine racer was this scale model. One of the highlights was the huge air scoops fitted to all four large-diameter brakes



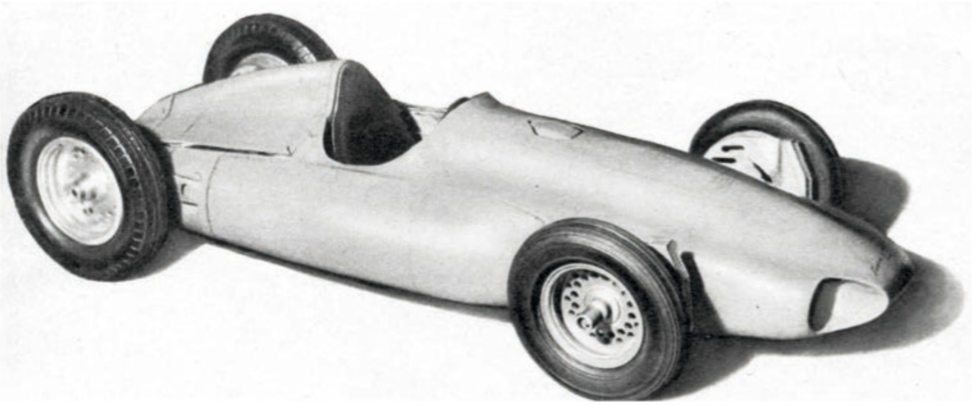
The de Dion axle connecting the Sacha-Gordine's rear wheels is shown by the model, as was a plan to provide for ventilation from the engine and transaxle bay



A low frontal view of the proposed Sacha-Gordine emphasised its record-breaking for the time brake sizes, and the unusual paired inlets in the nose for cooling air. The camber on the front wheels is over emphasised in the model

'Disappointed by Gordini, disappointed by Ferrari, Sacha Gordine decided to build his own car in order, he explained, no longer to be constantly dependent on others'

François Jolly, motorsport writer



A sleeker, more refined model suggested further evolution of the Sacha-Gordine's design. Wheels are undefined at this stage

Poring over the model here are its designers, principal engineer Vigna on the right and Perkins on the left

Indeed, in 1954, Régine contested the Monte Carlo Rally while pregnant with their son, Sacha Gordine jnr.

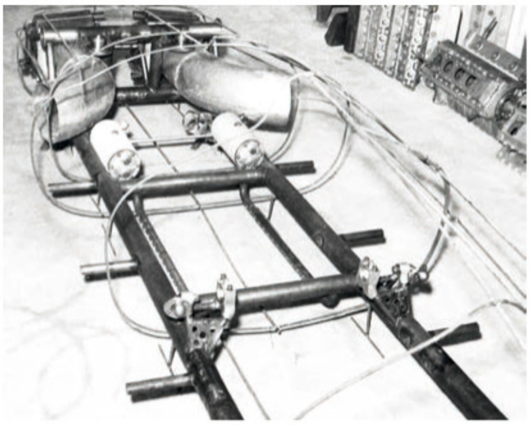
For the 1950 season, Gordine decided to raise his racing game. He turned to the most prolific French maker of sports and racecars, Amédée Gordini, famed for the 150 successes of his cars, starting with victory in the 1934 Bol d'Or. Heavily backed by French car maker Simca, Gordini fielded racecars in Formulas 1 and 2 and also built sports racers, such as the Gordini TMM, which used a formula car as its basis and placed the driver in the middle of its envelope body. Gordine enjoyed this handy racer in the Bol d'Or, Le Mans and the Paris 12 Hours at Montlhéry, where he won his class. His enthusiasm for racing on the Nürburgring aimed him at an event there on 20 August 1950, the Rheinland-Pfalz Preis. There he could compete against cars of similar capacity over six laps of the demanding German circuit.

He asked Gordini to prepare his 1.1-litre Gordini TMM for the event but, viewing his client as just a wealthy amateur, the constructor prioritised the preparation of his official team's cars and, consequently unable to participate in practice, Gordine was refused entry to the race. His disappointment was profound, and he resolved to look to another marque. Ferrari was a candidate but Luigi Chinetti, in charge of Ferrari sales in France and the United States, did not accommodate him.

'The decision of this man of action was quickly taken,' reported the author François Jolly. 'Disappointed by Gordini, disappointed by Ferrari, Sacha Gordine decided to build his own car in order, he explained, no longer to be constantly dependent on others.'

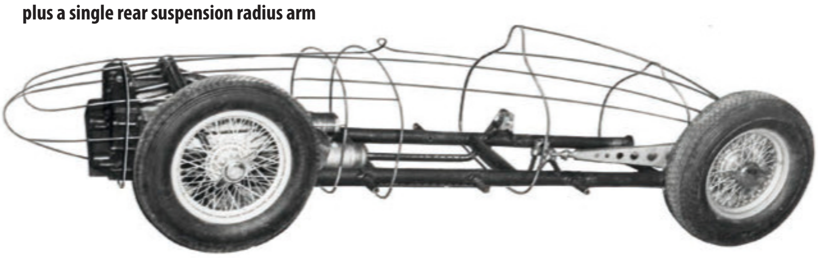
Italian connection

'Gordine's first venture consisted of equipping a chassis with a Ford engine,' continued Jolly, 'but a chance meeting with Italian engineer [Cesare] Vigna, cousin of the head of Alfa Romeo's technical services, Dr Alessio, will change the course of destiny.'

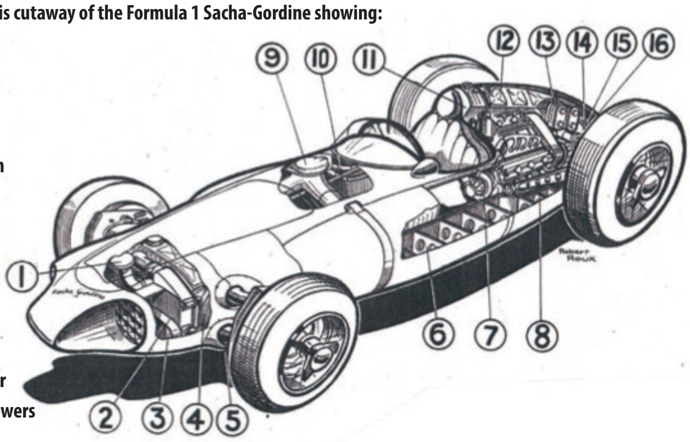


This picture shows the simple, ladder-type frame, but also the large ducted outlets for warm air from the twin radiators

A side perspective outlined the body shape of the future Sacha-Gordine in relation to its frame, plus a single rear suspension radius arm

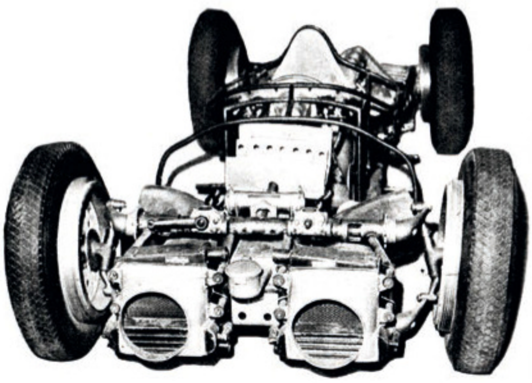


Robert Roux essayed this cutaway of the Formula 1 Sacha-Gordine showing:
1) oil filler
2) left oil radiator
3) left glycol radiator
4) glycol reserve tank
5) lower suspension arm
6) fuel-tank baffles
7) left coolant pump
8) left radius arm
9) fuel filler
10) steering shaft
11) glycol header tank
12) special fuel reservoir
13) two-stage Roots blowers
14) de Dion rear axle
15) transaxle
16) Glaenzer halfshaft



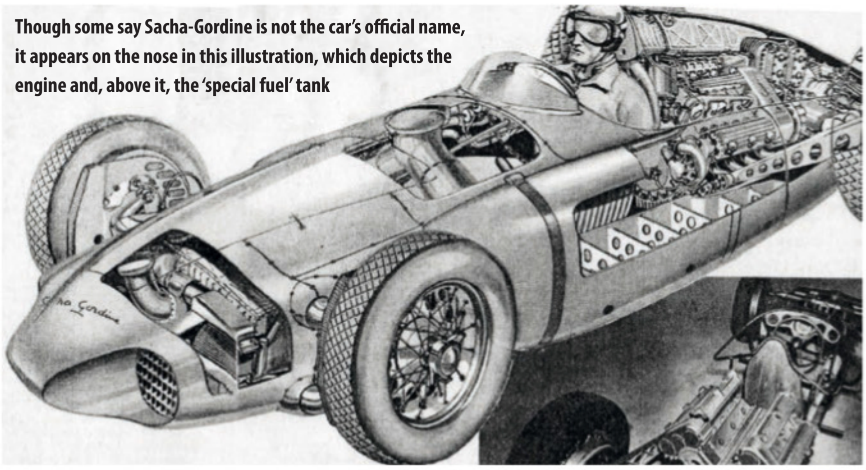
‘We wanted to do our best with everything using logic and reason. Our car is the application of studies conducted up to today in thermodynamics and alloys’

Sacha Gordine



Elements of the two-speed steering and torsion bars can be seen here

Though some say Sacha-Gordine is not the car’s official name, it appears on the nose in this illustration, which depicts the engine and, above it, the ‘special fuel’ tank



Born in 1920 to an Italian engineer, Cesare Luigi Vigna studied at the Freiburg Polytechnic. This qualified him to be employed by the Porsche organisation in the late 1930s when its demand for engineers was nearing a peak. The end of hostilities found Vigna at Italy’s Alfa Romeo but, when his ideas for a ‘revolutionary project’ were dismissed, he emigrated to France and worked for Gordini, where he met Gordine.

‘The engineer’s son,’ Jolly continued, ‘certain of the value of his work… crossed paths with the sportsman’s son, who was burning to inflict a repudiation on the manufacturers who did not believe in him.’

Vigna left Gordini to work for Gordine, taking several of Gordini’s collaborators with him, including close friend, Albert Alain.

‘We don’t claim to be omniscient,’ explained Gordine, ‘we had to overcome scepticism from many people… We started with a screwdriver. We gradually grew. ‘Vigna realised a dream here,’ he added, ‘designing an entire car. After having worked under the direction of others, he was able to reveal what he had carried inside for nearly 15 years.

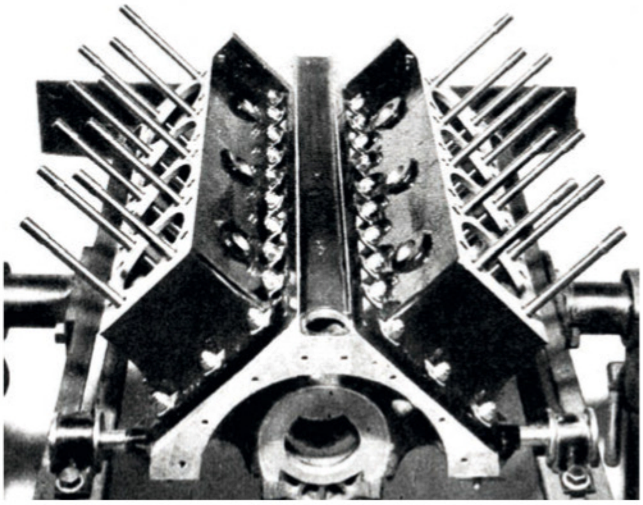
‘We wanted to do our best with everything using logic and reason. Our car is the application of studies conducted up to today in thermodynamics and alloys. All the cast parts, which is most of them as they are made from the latest alloys, are x-rayed to check for porosity or the early signs of breakage – which, incidentally, is part of the production cost.’

Vigna’s vision

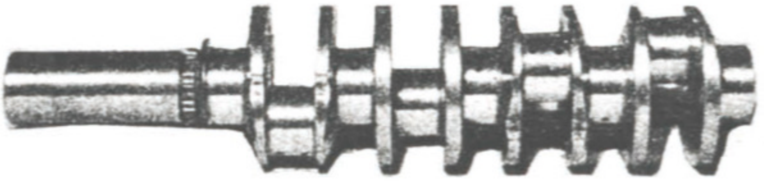
Whether or not the end result resembled the ‘revolutionary project’ he had proposed at Alfa Romeo, Vigna’s vision of the ideal racecar was impressive. His first effort had adapted existing components, including engines, but this was judged not competitive enough, so a more radical design was presented to Gordine towards the end of 1950. Vigna was joined by Naris Edward Perkins, a British engineer who brought novel concepts of carburetion and combustion. Gordine was well enough acquainted with technology to appreciate that what he was being shown was worth pursuing.

The two engineers settled down to draw the 2000 blueprints needed to build a Sacha-Gordine, as the press had dubbed the cars.

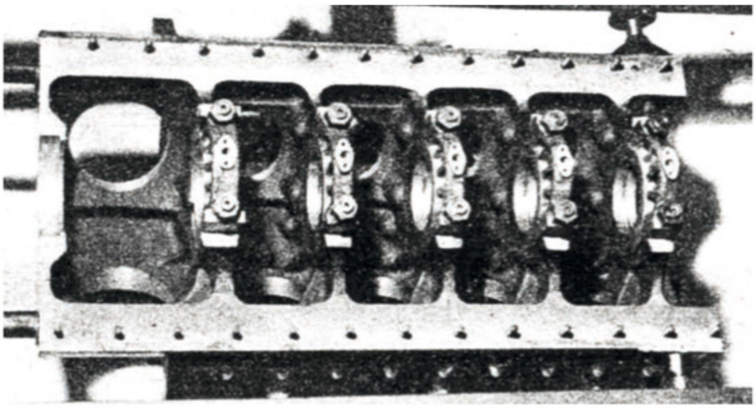
‘It’s a perfect collaboration,’ confirmed Vigna. ‘During the day I oversee what is happening. I check the machining. Perkins designs what we have updated overnight. Because we work at night, our best solutions have been found at half past two



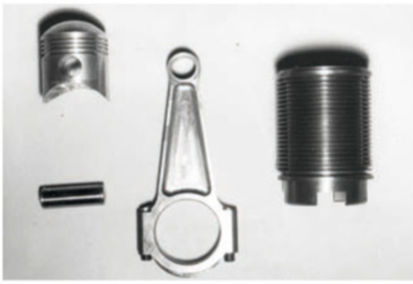
Bolts at the base of the V8's coolant jackets are chiefly for sealing because the long studs extend into the crankcase to hold the cylinder heads down



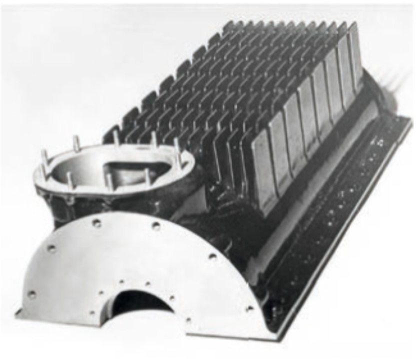
At the long end of the fully machined Sacha-Gordine crankshaft was an attachment for the bevel gears and shafts that drove the engine's four overhead camshafts



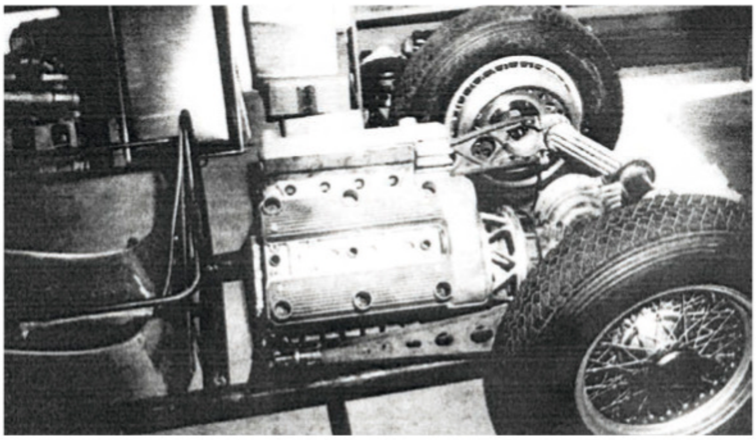
Each of the V8's five main bearing caps carried a fitting that allowed for lubricant to be fed to the engine's Vandervell thin-wall bearings



Piston, connecting rod, gudgeon pin and cylinder sleeve of the Sacha-Gordine V8. Its use of finned cylinders in a liquid-cooled engine is unusual



The attributes of a porcupine were attributed to the V8's artfully cast sump section of the crankcase. The open port at the rear housed the lubrication system's two pumps



A single finned magnesium casting covered each head of the V8. Unfinished here, they lack their spark plug apertures. The radius rod on the far side shows its cast inner stiffening ribs

in the morning in front of a very strong cup of coffee! We have worked for 54 nights in succession!'

A company to fund the work was duly registered as the Société des Automobiles Gordine (SAG) with Régine Gordine as president. Sacha, the cinema impresario, found quarters for his engineers in an immense private residence in Paris. When castings and fabrications started to arrive, they were directed to a small workshop at Neuilly-sur-Seine thought to have been used previously by Bugatti.

Funds rapidly began to flow from Gordine's accounts. Bruited about was the sum of 250 million Francs for the project (some £255,000, or US$715,000 at the time). Gordine relied on his proven skills as a raiser of funds for filming to bring in the cash.

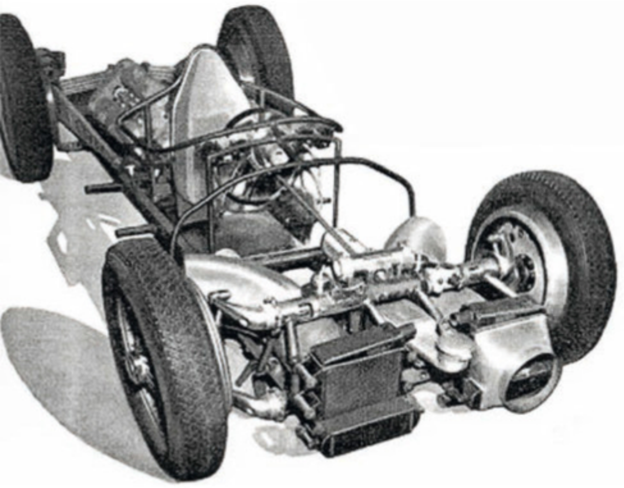
A wild card, however, was the decisive role of the racing rule maker, the FIA. At the time of SAG's creation, the rules for Formula 1 cars specified 4.5-litre engines unblown and 1.5-litre supercharged. The dominant Alfa Romeos made the latter the choice for Vigna and Gordine, for the rule would still be in place through 1953. They were sure to be competing long before then.

Adaptable by design

However, in October 1951, when the SAG racecar was still largely on the drawing boards, the FIA gave notice that new rules would take effect in the 1954 season. Thereafter, supercharged cars were allowed a paltry 750cc and naturally-aspirated racers 2.5-litres. This obliged the Sacha-Gordine planners to adopt a new stance: their design would be adaptable. The first racer would be an unblown 2.0-litre to compete in the Formula 2 of that capacity, already in force.

Why the team of engineers chose to reveal their plans to the public in mid-January of 1952 is not clear. We know they had plans to race the new Sacha-Gordine in Formula 2 from at Pau in April of that year, so may have judged it propitious to reveal their plans three months in advance. They did so with a fabulous avalanche of photos and data about their coming racecar. Exclusive source of information was the respected *L'Automobile* magazine, with photos by René Pari, spread more widely by the Agence Intercontinentale. The introductory remarks by the periodical's Fernand Bucchianeri included the following: 'Although the model and the chassis of the Sacha-Gordine are finished and its parts are being assembled, it is impossible for us to report on its performance yet…

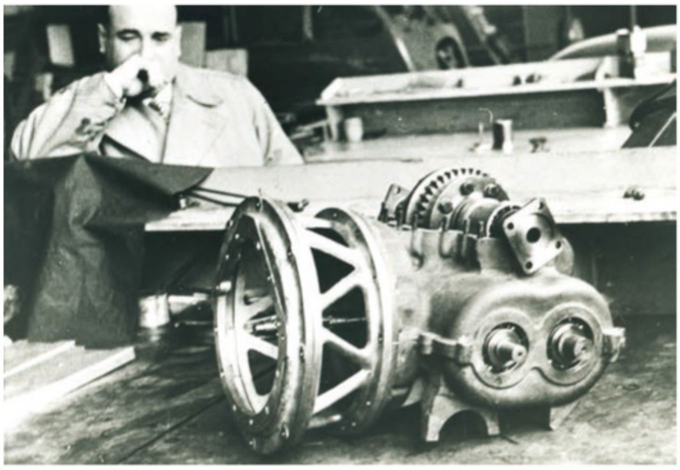
'To tell the truth,' added Bucchianeri, 'this racing car was born of a human rivalry. Its engineer belonged to a major Italian firm for a long time. An emigrant, the engineer recreated… and improved on his own account what he had already invented.



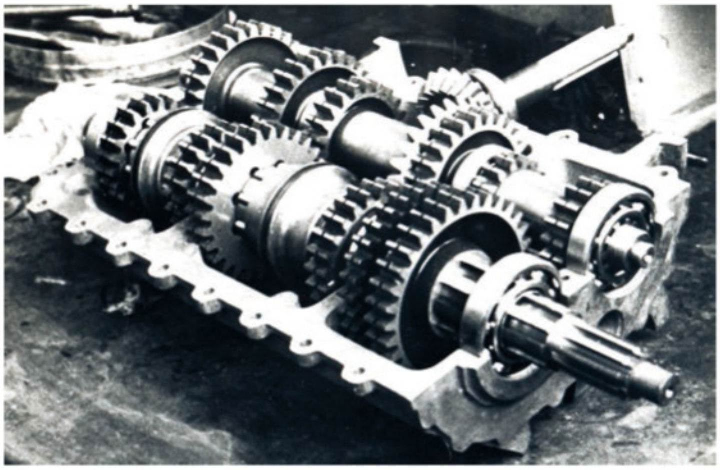
Combined with its lavish use of magnesium castings and its novel cooling system, the new French entry was instantly recognisable as a forward step

Still lacking its brake internals, this assembly shows the car's dual cores for oil and glycol, its oil filler and some of its suspension elements

An unmachined magnesium housing gives an overall view of the transaxle design, with its detachable final drive cover and lateral guide for the de Dion axle



In front of a musing Sacha Gordine is his namesake transaxle, complete with the ventilated housing for its twin-disc clutch. The cover of its final drive gearing is removed here



At top, the bevel drive from clutch to transaxle is visible, as are the sliding plungers that engage and release ratios on the five-speed mainshaft

Who would complain about this rivalry? And what nation, in the world of invention, has the right to claim paternity of the marvel on which it prides itself?'

For the writer, *L'Automobile* chose Jean Bernardet, a respected motor racing reporter for French sporting paper, *L'Equipe*. Having built some small racecars himself, the multi-lingual Bernardet was well equipped to assess what he was shown. Some of the following is based on his reporting.

The SAG had nailed its sail to the prevailing rules with its design of a 1.5-litre car powered by a two-stage supercharged V8. Closest to its configuration was the Type 360 Cisitalia racer designed by Porsche for Carlo Dusio. It followed that mid-engined, 1948 design in having fuel tanks on both flanks, filled from the cowl and carrying 300 litres. Where it did not follow the Cisitalia was in its ladder-type frame, comprising two large diameter longitudinals in chrome-molybdenum steel, joined by five crosspieces. A tubular superstructure supported the bodywork and fuel tanks.

Vigna also made his Sacha-Gordine far lower than the Cisitalia, achieving a reduced frontal area and an enhanced degree of lateral stability. Combined with its lavish use of magnesium castings and its novel cooling system, the new French entry was instantly recognisable as a forward step. Its engine cooling used ethylene glycol, with a boiling point of 197degC allowing high temperature operation by two coolant pumps delivering 200 litres per minute. Twin apertures in the nose led to individual radiators whose efflux was ducted to vents behind the wheels. Half covering the cores for water cooling were those for oil cooling, between which was the filler for the lubricant.

Where the Cisitalia relied on a flat 12, the Sacha-Gordine used a 90-degree V8. In its original boosted version, its dimensions were 61 x 64mm for 1496cc. For the 2.0-litre Formula 2 variant, the bore was enlarged to 70mm for 1970cc. This was possible because its V8 was based on a magnesium crankcase to which two four-cylinder groups were attached by long through bolts, composed of housings that carried individual wet cylinders of nickel-chrome steel, sealed directly against the crankcase. Facing the coolant were fine circular fins that left a thickness of 2.5mm at the bottoms of the cylinders' grooves.

Cut off at the crank centreline, the crankcase had five two-bolt main bearing caps carrying Vandervell bearings of 62mm for the mains and 58mm for the pins of the steel alloy crankshaft, whose throws and counterbalances were at 90-degree intervals. Fins on the magnesium sump provided additional oil cooling.

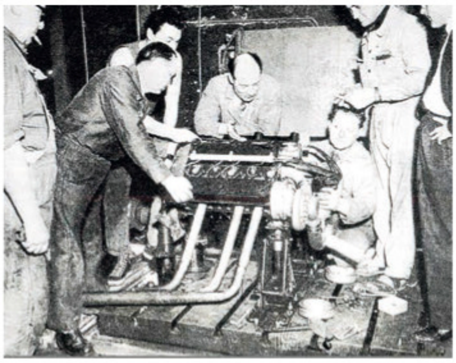
Machined all over, connecting rods were of unusual design, with shanks that widened steadily from small to big ends. Domed, full-skirted, forged pistons carried four rings.

At all valid opportunities, gasket-free sealing was obtained by matching finely finished surfaces.

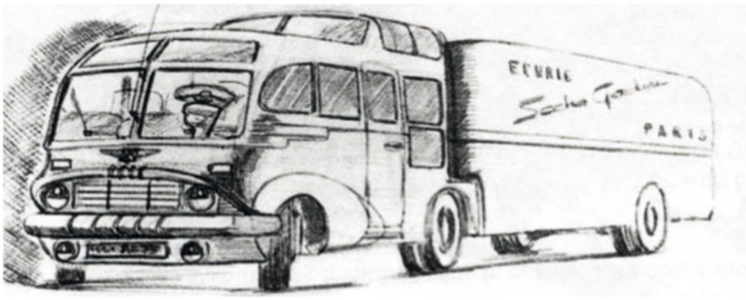
Dry sump lubrication

At its rear, or clutch end, the V8's sump carried the twin pumps needed by the dry-sump lubrication system. Circulating through both engine and transaxle, the system included several filters.

Also at the clutch end were the shafts and bevel gears that drove the overhead camshafts, two for each bank. Veed at a 90-degree angle, two valves per cylinder measured 44mm for the inlets, 42 for the exhausts. Both had hollow 8mm stems, the exhausts being sodium cooled. Valve guides and seats were of a bronze alloy. Between the valve heads, the aperture for

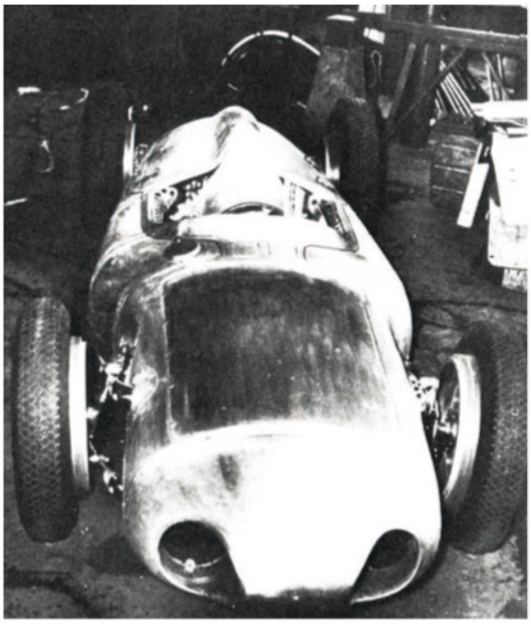


Evidence that the 2.0-litre Formula 2 V8 was run on test is shown here. However, its full pipeworks and four twin-throat carburettors were not yet fitted



This sketch depicts a well-designed transport rig for 'Ecurie Sacha Gordine Paris.' In the event, no such transporter was ever required

The completed Sacha-Gordine Formula 2 car displays its intricate steering mechanism, wheel-carrying king pins and huge brake scoops



Seen at Levallois-Perret, the nearly finished Formula 2 Sacha-Gordine shows a wider disposition of its twin air entries

Design and build work was also under way at the same time on a proposed sports model… and a civilian version. Le Mans was the objective

ignition was only 5mm, this being the access port for sparks from an 18mm plug, fired by a Vertex-Scintilla magneto. 50mm diameter tappets delivered 10mm lift from the cam lobes and were closed by three concentric coil springs with a peak pressure of 189lb.

Fed by four twin-throat carburettors, output of the 2.0-litre Sacha-Gordine V8 was 191bhp at 8000rpm on conventional fuels. Also under development, said the engineers, was a fuel developed in wartime by Nazi scientists (though thought likely to have been nitrous oxide) which, in combination with a proposed compression ratio of 20 or 22:1, would have tested the skills of the finest combustion chamber designer.

A vented magnesium casting joined engine to a transaxle while housing a twin-disc clutch. This drove a speed-reducing bevel gear pair that turned the input shaft of a ZF limited slip differential-equipped transverse gearbox, its twin shafts carried by eight bearings on two bulkheads and the ends of the cast aluminium housing. The straight-toothed gear pairs were engaged by rings of sliding plungers, with motorcycle-style actuation going up and down the five ratios in sequence. A gear on the driven shaft engaged the final drive on a shaft above the transaxle centre, which could be easily accessed via a magnesium cover to change the final drive ratio.

The rear of the transaxle's housing carried a vertical groove in which slid a guide pivoted from the centre of the car's cast magnesium de Dion axle. Similarly cast radius arms pivoted from the frame to the rear wheel hubs, while a rotating cuff helped the guiding tube avoid acting like an anti-roll bar. Lever arms joined the de Dion tube to torsion bars alongside the frame members. Although not specified in detail, dampers front and rear were a synthesis of friction and hydraulic elements.

Porsche plus

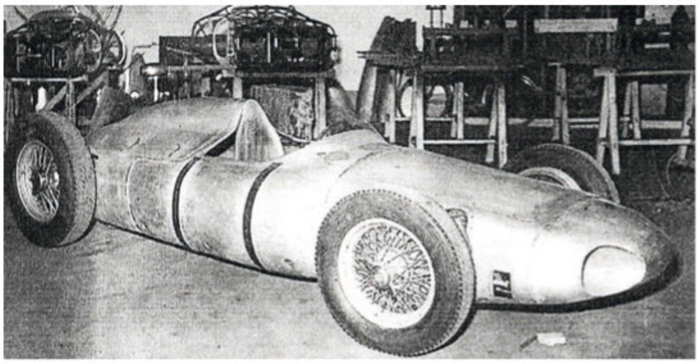
While most descriptions simply identified the Sacha-Gordine's front suspension as 'Porsche-type', there was more to it. The similarity lay in the use of upper and lower trailing arms sprung by torsion bars within lateral tubes. However, the tubes were further apart than Porsche's design, offering greater lateral stability, while the trailing arms were shorter and stiffer. Each wheel pair was joined by a strut serving as the king pin, around which its wheel carrier rotated. Steering, which featured a choice of ratios to suit different tracks, used a rack that operated a pair of central links steering the wheels through a pair of pivoted arms and longer links. The aim of the design was to preserve geometric precision through the full steering arc.

New records were set by the SAG racer's close-finned brake drums, whose diameters were 16in in front and 14in at the rear. Backing plates were huge scoops to collect cooling air. The Sacha-Gordine's hydraulic braking system used two master cylinders, each to its own axle. These actuated four brake shoes per wheel.

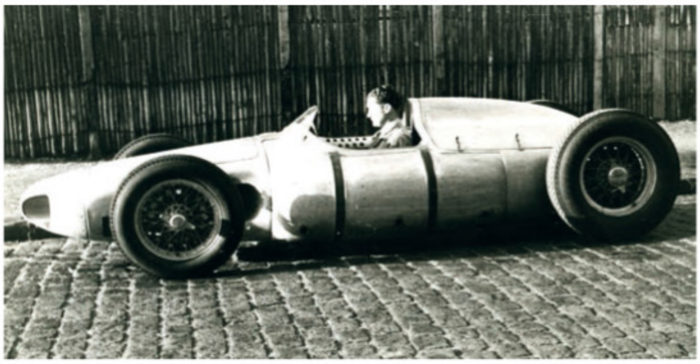
Dunlop tyres rode on wire wheels, 5.50 x 17in front and 7.50 x 17in rear, with plans to upgrade to 18in.

Wheelbase was 2580mm, front track 1350mm and rear track 1320mm, while dry weight was 680kg (1500lb). Not light, but in touch with potential rivals.

Design and build work was also under way at the same time on a proposed sports model that would carry its fuel in a central tube and use most of the Formula 2 car's running gear and powertrain. Italy's Giovanni Michelotti was already preparing striking designs for bodywork and a civilian version. Le Mans was the objective.



Against a background of unfinished frames at Levallois, the almost completed Sacha-Gordine made a good impression when journalists visited the SAG factory in January 1953



One Sacha-Gordine reached an advanced stage. The disparate size of its tyres on 17in rims is evident, as is its ultra-low profile body

Feeling the pinch of the small Neuilly quarters, the SAG outsourced fabrication of the transaxle to Pont-à-Mousson, and the many magnesium castings to an Italian supplier. During 1952, a move was made to 154 Rue Danton in Levallois-Perret, close to Notre-Dame. Machine tools were purchased so almost everything could be manufactured and machined on site and, by the end of 1952, the SAG employed 15 people.

The doors of Levallois were opened to the press in January 1953, now with the hope of entries at Pau that year. While there were certainly cars under construction, whether the racing version had been tested is a matter for conjecture. Some say the Formula 2 car was driven at Montlhéry by French star, Jean Behra, while others thought André Simon a potential team driver.

'If an entry had indeed been made for the Pau GP in May 1953, the SAG did not appear there,' wrote journalist Pierre Haverland. 'It did not take part in any other race, in any test session. We did not hear anything more about it. This vast project disappeared as suddenly as it had been born.'

Write off

The truth was that Gordine was at the mercy of the tax authorities. The financial support of a Swiss banker friend, Mr Foufounis, was insufficient to cover a debt of 90 million francs. Accordingly, Gordine wrote off the whole project, breaking up the SAG in June 1953. Most of the machine tools were sold to compensate the privileged creditors, and what was not saleable was stored aboard a 600m², three-level barge Gordine had bought to store assets of the cinema world on which he continued to depend.

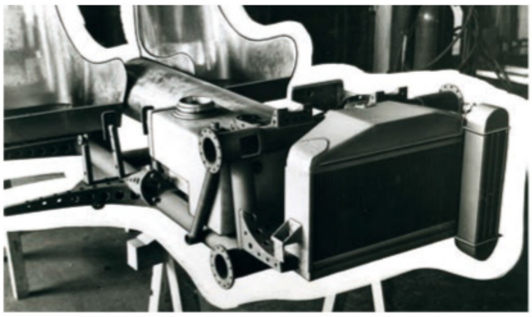
Moored along the Seine near Asnières Bridge, this became the resting place for the finished car and the two in-progress builds, plus half a dozen engines and the wooden foundry patterns for their main castings. The finished car was on display for years to SNCF users taking the train from Gare Saint-Lazare to Versailles, before Gordine finally donated it to the French branch of oil company Shell, only to later disappear without trace.

'All that remains of the superb Sacha-Gordine racing cars consists of a small technical file, plans, a few articles, a handful of photos, one or two machine tools… and piles of invoices'

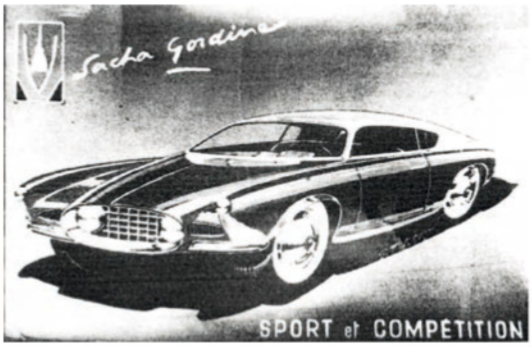
François Jolly

When obliged to move the barge to a quieter part of the Seine, the remaining cars, parts, models and tools were stolen.

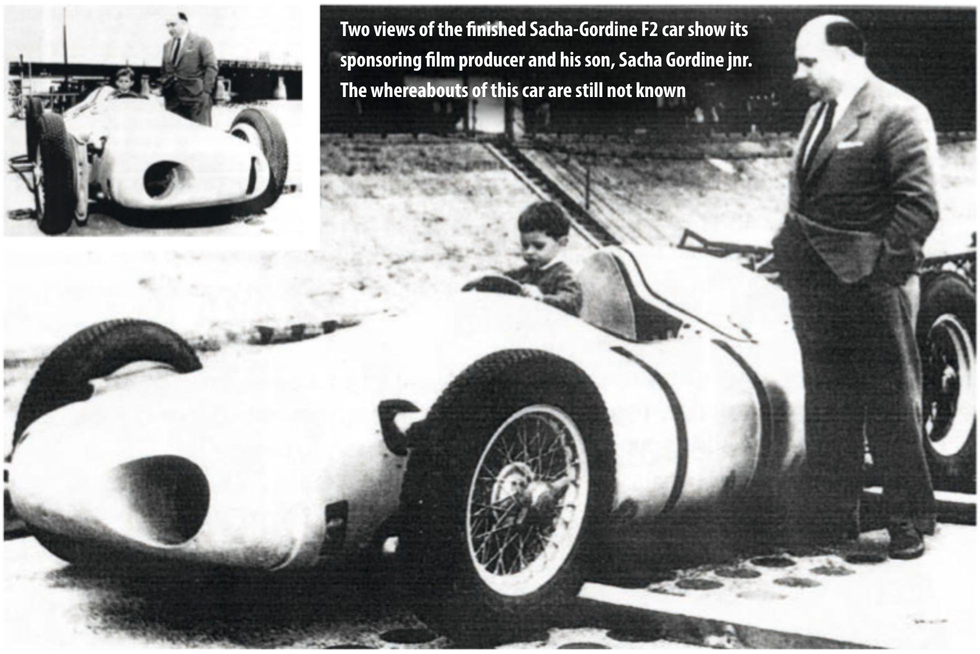
When Sacha Gordine died of a heart attack in 1968, aged 58, Régine Gordine did her utmost to track the racecar down, without success, leading François Jolly to write in 1980: 'All that remains of the superb Sacha-Gordine racing cars consists of a small technical file, plans, a few articles, a handful of photos, one or two machine tools for making connecting rods… and piles of invoices, although all the creditors have long since lost interest.'



Visitors to Levallois in January 1953 also saw the proposed alternative sports racing chassis taking shape. It kept the tubular ladder chassis and front suspension but with a single radiator



Among proposals from Italian designer, Giovanni Michelotti, for a range of Sacha-Gordine sports cars, this was one of the most appropriate. Sadly, no examples were ever built



Two views of the finished Sacha-Gordine F2 car show its sponsoring film producer and his son, Sacha Gordine jnr. The whereabouts of this car are still not known

Return to vendor

How hard is it to change manufacturers? For Wayne Taylor Racing, back with Cadillac after four years with Acura, it has been a huge learning process

By ANDREW COTTON

After four seasons with Acura, Wayne Taylor Racing (WTR) made the switch back to running Cadillacs for the 2025 IMSA Sportscar Championship season. In doing so, it rekindled a long affiliation with General Motors, which started in the 2000s with Pontiac and Corvette in the Grand-Am Series, before continuing into the DPi regulations with Cadillac.

WTR and Cadillac won the 24 Hours of Daytona three times together, as well as the 12 Hours of Sebring and Petit Le Mans. It was, therefore, major news when the team switched allegiance to Honda brand, Acura, ahead of the 2021 IMSA season. That partnership took it through the final two years of DPi, and through the start of the current GTP era using LMDh cars.

WTR started the relationship with Acura by taking victory at Daytona in 2021, and was heavily involved in the development of the Acura ARX-06. Acura added a second car to the line up for the 2024 season, but then made the dramatic switch back to running the Cadillac V-Series.R for 2025.

WTR previously ran Cadillacs with Dallara chassis very successfully in the DPi class, so the V-Series.R should feel like familar territory

Key differences

On paper, it should have been a straightforward move back to GM, but the Cadillac LMDh is a completely different beast to the Acura. Both use the same, mandatory hybrid system, comprising a Bosch MGU, Fortescue Zero battery and Xtrac gearbox. They run on the same tyres and fuel as each other too, and race at the same tracks. However, there are some key differences between the two cars. One is the engine: WTR has moved from running Honda's turbocharged V6 to GM's normally aspirated V8. The bigger departure, though, is going from an ORECA chassis to a Dallara one.

That said, Dallara produced the chassis for the Cadillac DPi-V.R that WTR ran with great success during the team's early Grand-Am days, so the relationship with the Italian

While the Acura the team used to run and the Cadillac use the same spec hybrid system, the engine format is completely different designer and constructor was already strong. However, there was little else that carried over from the DPi car to the LMDh, so the team was on a steep learning curve from the moment it first picked up its new cars in November 2024. That continued through to the first race of the renewed partnership, at Daytona in January 2025

One of the first things the team had to work out was the suspension layout. 'The ORECA had a de-coupled roll and heave damper, so the switch to that [from the Cadillac DPi] was new and a learning exercise,' says Brian Pillar, technical director at WTR. 'After two years we had optimised that. We then leave it and go to running heave dampers in each corner, but we have never run heave dampers, we have only run heave springs, so that got us to a seven-post rig test and [understanding how to] incorporate this into our strategy.'

Generating the required level of knowledge about how the suspension worked was the first issue, and the team is open in admitting it does not yet have a full picture of what it can do.

Height of fashion

WTR also needs to understand how to keep the chassis at a competitive ride height. 'The Dallara has similar trends to the ORECA in that we have to run as low as possible, but this is a low-rake car, while the ORECA is a high-rake car,' continues Pillar. 'With the ORECA, using the rake, you would find free

'We had a good vision for what we wanted, but the execution of that plan became quite difficult'

Brian Pillar, technical director at Wayne Taylor Racing

front downforce, with only small penalties to pay, so we lived in higher rake land for most of the time.'

Running the car flatter for the Daytona season opener led WTR's engineers into a different aero map, but they still had to figure out the right height at which to run the car, while at the same time maintaining the integrity of the skid block underneath. With the onboard measurement systems of the ORECA, they were able to start low and raise the car but, with the Cadillac, they had to start high and lower it as they didn't have the same tools.

'We don't have the heave damper strategy that's isolated,' says Pillar. 'Just lowering the car isn't easy for us. We had a good vision for what we wanted, but the execution of that plan became quite difficult.' WTR had worked with ORECA to put in some measurement tools that allowed them to quickly establish the optimal ride height, but that was not designed into the Dallara.

The way ride height is measured is also different between the ORECA and Dallara chassis, with the lasers positioned in different areas of the floor. The team therefore spent the pre-race test weekend at Daytona, and the subsequent practice sessions, measuring different ride heights to work out how best to set the car up.

Wake-up call

From a hybrid perspective, although the parts are spec, their job varies between running turbocharged engines and normally aspirated ones. The system can be used to mitigate turbo lag but is more of a turning tool than a power device. The cars are tied to a maximum torque curve and power output, which comes either from the engine, or a combination of engine and electrical energy, but the limits are absolute.

So, the hybrid system is used to help the car under braking, turn-in and acceleration, which meant WTR had a whole new map to create to get the most out of it. 'That was a wake-up call for us, dealing with the engine braking, and its effect,' admits Pillar. 'We minimised that in DPi, we tuned it slightly, but it was what it was. Then we went to the Acura, and they were doing things to ensure the turbo and boost lag control was minimised. It has bigger implications with this normally aspirated engine.'

This is where the renewed relationship with GM really began to bear fruit. Working closely with the powertrain group, the team

Pit stop strategies have been adjusted as fine details differ between the two cars. Cockpit temperatures were not an issue at Daytona due to cold condtions, but hot races may be challenging

didn't need to understand the car inside out to make it quick. 'I didn't understand [the scale of] these things, and GM gave us a better appreciation of engine braking, so it was educational for me,' says Pillar. 'They were telling me what the limitations were.

'We got into a discussion about diff' ramps. Ultimately, I said I need a certain level of something, tell me how you can best do this, give me your range of controls. We picked the best coast and drive range because I haven't had time to dig down into it, so we have leveraged the powertrain group and their experience. There were more opportunities to experiment with diff' settings in the [FIA] World Endurance Championship, and so we said we would take their guidance and do this together.'

Voyage of discovery

That process started with WTR's first test with the Cadillac last November. The engineers ran through three differential combinations to better understand the car and how they could use the controls to manage its mid-corner behaviour. Ultimately, they went for a setting that was safe and close to what Cadillac had already run with its other cars at Daytona, with room for development later in the season.

With knowledge of both chassis, the team knows the Dallara is heavier than the ORECA, which affects the c of g, and that has a knock-on effect to other areas of the car. Due to the front ride height differences and the weight balance, the front tyres clearly need different settings in terms of camber. 'Every car is different from camber gain, and that choice is made at the design phase of the car. The preco is not independent of cars,' says Pillar, referring to the camber and pressure limits set by the manufacturer, within the parameters set by IMSA.

'What's working really well is that the GM guys are not remote, they are based trackside… they pop in to talk to the drivers, and are very involved in the discussions with them'

Brian Pillar

'We have done experiments within the scope of the IMSA testing on camber, so more camber is more front grip, somewhat indefinitely, but the camber gain on the Dallara is not the same as on the ORECA chassis.

'The Dallara has some of the same tools, the weight jacking for example, and it has infinite geometry options, so that's pretty classic Dallara.'

However, the cockpit layout is different between the cars, which is something the drivers have had to familiarise themselves with. The way they can command the various settings is also not the same.

'It's interesting to see,' says Pillar. 'It is a different layout, a different way of doing things. A lot of time has been spent with the GM guys sitting down and presenting things in an alternate way. I have never seen so many graphs and presentations of how they are using the tools and their different strategies.'

People power

One thing that is becoming increasingly common in racing is a driver ambassador. This is someone who has had recent experience of the car, but is no longer competing. They now sit between the drivers and the engineering team as a sanity check for what the engineers are looking to apply.

The ambassador's job is to ensure the simulations can be managed in reality, which brings trust from the drivers that they will be given what they need to compete. It also means the engineers don't have multiple different opinions on what should be in the car. The drivers feed into the ambassador what they think, and it is up to the ambassador to present that to the engineering team.

'What's working really well is that the GM guys are not remote, they are based trackside,' says Pillar. 'It was more like a performance control guy, just doing the leg work. They are in the trailer next door, they pop in to talk to the drivers, and are very involved in the discussions with them.

'There have been a lot of controls that GM engineers have been good with, like the inter-person stuff. Dallara has two performance engineers. GM is building a group now and has two performance engineers in the trailer that are popping in for the in-person, visual things as we talk

Having access to the experience of the GM powertrain group has proved helpful, giving WTR engineers the opportunity to try various differential settings to fine tune the car's mid-corner behaviour

Though the no.40 car (shown) was taken out in a multi-car pile up at Daytona, WTR acquitted itself admirably on its return to the track with Cadillac, a fifth place showing great promise already

about the transition. It's not in big meetings, or documents presented, the big strides are when we put the people together.'

Brake balance

One area where the ORECA programme has fed into Cadillac is the braking system. During the 2024 season, Acura switched brake suppliers from AP to Safran, which meant the WTR drivers had experience of what to expect from the brakes. It was one less thing to learn with a car that is otherwise completely new.

'There has been a re-work of our position on master cylinder sizing, what we expect the driver to do, but we are familiar with the different temperature range from the Cadillac so we are almost doing our own experiments this way. That was an important step that would have been scary if we didn't have that experience of Safran,' says Pillar. 'They work differently, in a different range, but the drivers know what the feel should be and that helped a lot.'

One unexpected difference between the two cars is cockpit temperature. The ORECA had good airflow through the driver compartment, so very little needed doing to ensure the regulatory maximum cockpit temperature was not reached. IMSA's rules state that if the number is exceeded (measured according to ambient temperature) the car is called into the pits to cool down before it can return to competition. With heat soak, that's catastrophic for a race strategy.

'The crew honestly took one for the programme, giving up their usual practice time for us to learn about and sort out the racecar'

Brian Pillar

'The Dallara needs a little more cooling for the driver, with extra fans around the cockpit, ducting in the windscreen to evacuate the air, and the drivers wear cool suits,' says Pillar. 'It is still insanely hot in there. Drivers brought all manner of cooling solutions for their helmets to the Daytona race, but it was unseasonably cold during the event, which meant the process of cooling the cockpit could be delayed until later in the year.

Sequence of events

It might not be immediately apparent, but even the pit stop sequence has changed. From the location of the air jack connector to the rotation of the wheel nuts, there are differences between the two cars. This meant the mechanics had a lot to learn, even during the first race. 'The crew honestly took one for the programme, giving up their usual practice time for us to learn about and sort out the racecar,' says Pillar. 'We had 20 hours and 18 stops before it really mattered, so we had to come to terms with that.'

That is a reference to the nature of the Daytona race, which is typically about surviving the first 20 hours and getting onto the lead lap before sprinting to the finish.

There were incidences in 2024 of wheels coming off the Acura, attributed partly to the rotation of the wheel nuts, which were tightened anti-clockwise on all corners. In other words, the nuts on the left side were tightened in the direction of the car's front end, while the wheels on the right side were tightened in the direction of the rear. This was changed on the Acura after wheels did fall off, and on the Cadillac all nuts are tightened clockwise which has opened up more options in terms of pit and tyre strategy.

'It means we can take right-hand tyres and put them on the left side of the car, which is one of my favourite things to do at Daytona,' he says. 'I like the fact Dallara has done that, and I haven't seen any wheels falling off, so I'm confident of that. One thing is sure, it's going to be an adventure.'

On its return to racing with Cadillac, Wayne Taylor Racing finished a creditable fifth at Daytona with its no.10 car driven by Filipe Albuquerque, Brendon Hartley, Ricky Taylor and Will Stevens. The sister no.40 machine was eliminated in a multi-car accident during the eighth hour of the race. However, during the night mid-race changes did not produce the expected results in terms of performance, underscoring the team's need to test more with its new, and very different, machine.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Printed matter

How NASCAR is increasing its use of 3D-printing technology through a new commercial partnership

By BOZI TATAREVIC

NASCAR dipped its toes into additive manufacturing a few years ago when engineers at the stock car sanctioning body's Research & Development Center in North Carolina convinced leadership to source some consumer-level 3D printers to model a number of small parts. That trial led to the eventual acquisition of commercial quality printers from Stratasys, which has now resulted in 3D-printed parts appearing on every car that races in the flagship NASCAR Cup Series.

The Fortus 450mc was the first large scale 3D printer NASCAR acquired, and it was key in helping the series solve a driver cooling issue as it prepared to launch the current Gen 7 car for the 2022 season. Drivers commented that the propshaft tunnel area was becoming too hot during testing, so NASCAR designed and printed a NACA duct that was installed in the centre of the car's floor to direct cooler air into the tunnel region and reduce cabin temperatures. Once the Gen 7 started racing, NASCAR put the 3D-printed duct into series production and included it in the vehicle spec parts.

The race piece is printed using ULTEM 9085 resin, an advanced polyetherimide (PEI) thermoplastic material. This is a good material for racing applications due to its resistance to a broad range of chemicals and the fact it is flame retardant. That property, and the fact it remains mechanically stable even in extreme conditions, makes ULTEM a popular choice in hot environments like an engine bay. It can withstand temperatures of over 200degC for extended periods of time and won't lose its shape as temperatures fluctuate.

Build cycle

According to Tim Murphy, a senior design engineer for NASCAR, the additive manufacturing team can print around 10 of these ducts every 24 hours on the R&D Center's Fortus 450mc printers. This allows engineers to have a build cycle running every day and swap the part during regular working hours. So far, over 1500 of these ducts have been printed since the introduction of the NASCAR Gen 7 racer, which is the platform used by all teams.

NASCAR has really ramped up its commitment to 3D printing with the opening of a dedicated new 3D printing lab at its R&D Center in Concord, NC, which is filled with machines from Stratasys

In addition to the floor duct, NASCAR implemented a variety of other cooling measures to reduce cabin temperatures. One of the most visible was a windscreen-mounted driver cooling duct, which leads to hoses that cool the pedal box area as temperatures there can be uncomfortably high due to the exhaust below the floor.

This duct also goes directly from 3D printer to racecar, but is not printed at the NASCAR R&D Center. Instead it is printed through the Stratasys Direct service, due to the nature of the process used to create the components. These are made on a Stratasys H350 printer using a plant-based nylon powder that requires special facility considerations for its use. It therefore makes sense for Stratasys to host those types of machines and print on demand. Powder-based machines typically need a dedicated area to prevent cross contamination, so Stratasys keeps 85 of these units in a separate area at its facility.

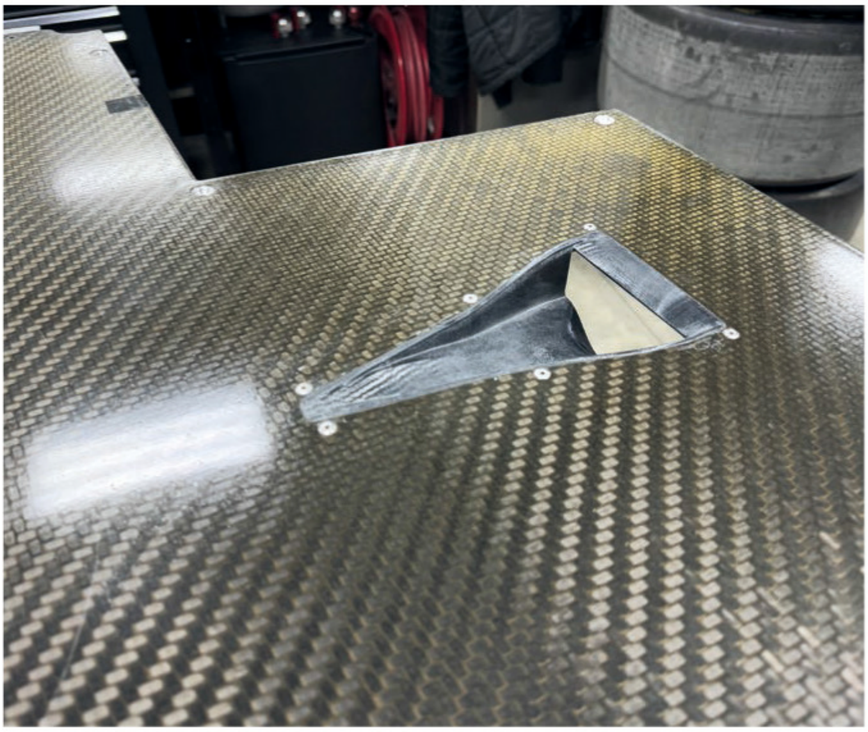
AM resource

Through the partnership, NASCAR engineering will now have access to even more additive manufacturing resources, including fused deposition modelling (FDM) through the F370, 450mc and F900 printers, and stereolithography

Capability now includes fused deposition modelling (FDM) on various machines, including this Stratasys F900 unit

The R&D Center's Stratasys 450mc printers are kept busy producing, amongst other components, the Gen 7 car's floor cooling ducts, which are made using ULTEM 9085 polyetherimide resin

ULTEM [9085 resin is] a popular choice in hot environments like an engine bay. It can withstand temperatures of over 200degC for extended periods of time and won't lose its shape as temperatures fluctuate



The 3D-printed floor duct was introduced into the Gen 7 racecar in 2022 to assist driver cooling in the cabin. It is now a spec part and over 1500 of these ducts have been printed on the Fortus 450mc machines at the NASCAR R&D Center

using a NEO800 printer. As well as parts production and tooling, these will all be used to support research and development initiatives at the R&D Center.

The acquisition of some of the larger printers proved beneficial during Covid when NASCAR collaborated with North Carolina-based Wake Forest University to assist them in printing various devices to test the effectiveness of face coverings. In addition, the NASCAR R&D Center was also able to print and distribute face shields during the pandemic.

Safety advances

The new, official partnership between NASCAR and Stratasys was announced in December 2024. It has allowed NASCAR to open a 3D-printing lab at its R&D Center that includes devices such as the Fortus F900, which allows engineers to print items as large as three feet (0.914m) in a single dimension. The F900's 36 x 24 x 36in (91.4 x 61 x 91.4cm) build area has produced items such as car seats, which have been used to study possible safety improvements for drivers, including a variety of different restraint combinations.

NASCAR engineers are also using these printed seats in crash studies, adding foam inserts to replicate those used by drivers in their cars and then strapping test dummies into them to study how the spine interacts with different types of seat foam. These types of studies have allowed NASCAR to update its specifications for seat foam and implement additional rules and recommendations to better protect drivers in the event of a crash.

NASCAR now recommends two inches of SFI 45.2 insert / padding be used for the seat interior and mandates at least 0.75in (19mm) of padding in the area underneath the driver. There are also specific designs for the head surround portion of the seats, showing how foam must be laid out to provide rigid support around both sides of the helmet, across the back of the helmet and to the forward most point of the helmet chin bar. The head surround opening may not exceed 12.5in (317.5mm) from side to side and the rear of the surround must contain at least three inches of NASCAR-approved impact foam between the seat surface and the back of the driver's helmet. NASCAR currently has two different seat foam specifications and all seats must meet one of them.

Gen 7 studies

That three inches of padding behind the helmet is a new development that came with studies surrounding the Gen 7 car. Previous Cup Series racecars required less than one inch (25.4mm) of foam behind the helmet, but studies of how the Gen 7 car crushes behind the driver led to an increase in the minimum requirement. Further studies of seat shape and positioning, along with how foam is layered, are ongoing, with the end goal always to best protect drivers during impacts, as well as from landings if a car leaves the racing surface for any reason.

The thickness of the foam is not the only factor considered when making safety decisions. The angle and shape of the sections play a role, as does material density. A delicate balance therefore has to be struck between too stiff, which negates the effect of the foam altogether, and too soft, which can allow potential rotational forces to come into play once a helmet touches the foam.

A wide variety of components are now being printed on the various machines at the NASCAR R&D Center, some for use in safety tests and crash studies, others to investigate developments in aerodynamic and cooling packages

Having machines big enough to print a complete seat has allowed engineers at the R&D Center to perform numerous tests to drill down on safety protocols for the foam inserts that are now mandated for driver comfort and safety

When it came to preparing the Garage 56 entry for Le Mans in 2023, the aerodynamics of a Gen 7 racecar had to be substantially altered, and front wheel tubs employed. Multiple iterations of the parts were 3D printed at NASCAR R&D for wind tunnel testing

Outside of safety improvements, the large-scale printers have also been used to print prototype wheel tubs for some of NASCAR's special projects, such as the Garage 56 car that completed the 24 Hours of Le Mans

Outside of safety improvements, the large-scale printers have also been used to print prototype wheel tubs for some of NASCAR's special projects, such as the Garage 56 car that completed the 24 Hours of Le Mans in 2023. While the Gen 7 car is not equipped with wheel tubs in the front because of how it could impact lift-off speeds on ovals, the Garage 56 car required them due to the nature of endurance racing.

Making a stock car aerodynamically compatible with the layout of the Le Mans circuit was no easy task, and the engineering team at NASCAR relied heavily on 3D printing during the limited time they had to test under controlled conditions and at road courses in the south east United States.

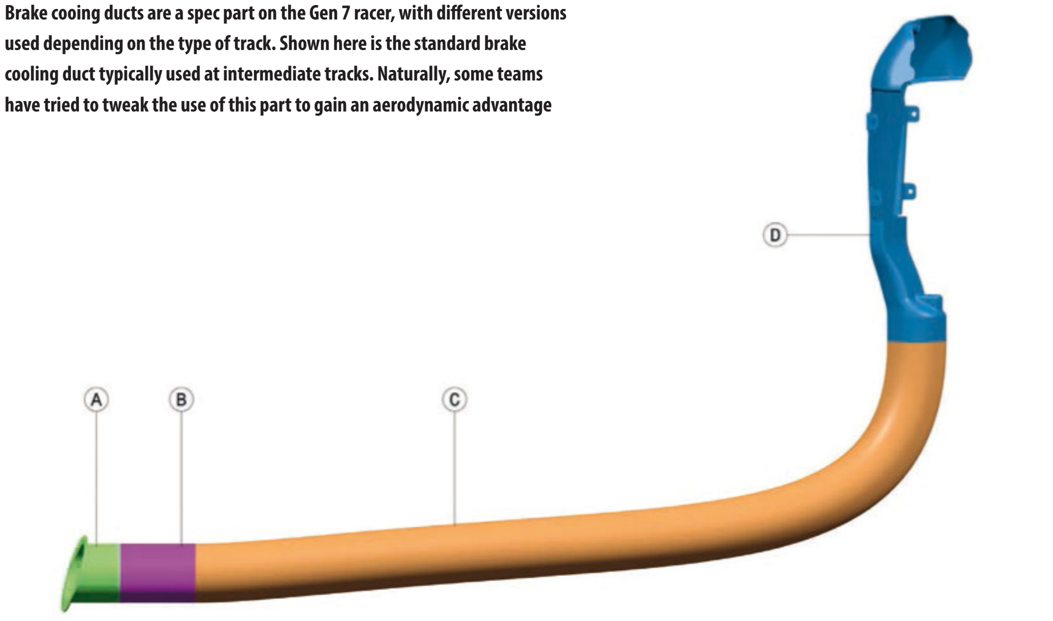
Dive planes were a prominent feature on the Garage 56 machine and 15 different versions were printed before heading to the wind tunnel to whittle those down to a couple of promising options that were then taken for track testing at Sebring. Only once a single version was chosen were the actual parts laid up in carbon fibre, prior to taking the car to France.

Target shooting

Safety improvements and performance studies are a large part of the 3D-printing workload at NASCAR's R&D Center, but it has also allowed the series to improve and speed up its scrutineering process. NASCAR now uses the Optical Scanning Station (OSS) from

While the major components of the NASCAR Gen 7 car are spec, there are still dozens of additional vents, ducts and brackets on a car that teams will do their best to try to exploit for a performance advantage

Brake cooing ducts are a spec part on the Gen 7 racer, with different versions used depending on the type of track. Shown here is the standard brake cooling duct typically used at intermediate tracks. Naturally, some teams have tried to tweak the use of this part to gain an aerodynamic advantage



Hawk-Eye to check car bodies, suspension and ride height for compliance prior to a race. The light projection targets used in the process, for example, are 3D printed.

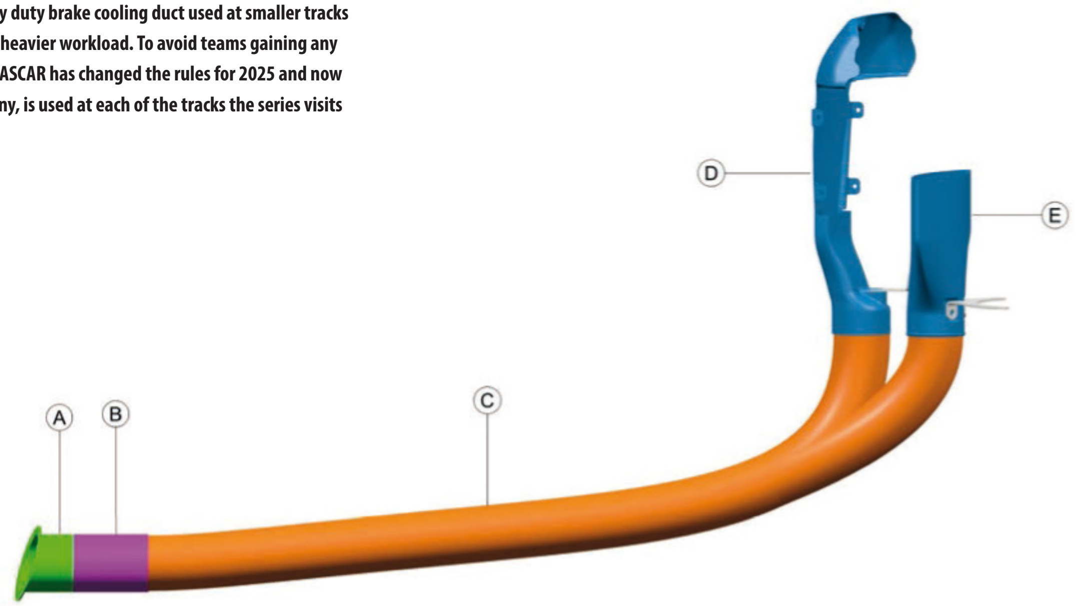
One of the areas in which these are used is the rear spoiler, which is made of a clear polycarbonate material. NASCAR officials traditionally had to coat the spoiler with developer spray to ensure the OSS detected light reflected by it. To make the measurements more accurate, and repeatable, NASCAR engineers designed targets that temporarily attach to the corners of the spoiler and printed them on one of the Fortus machines. The targets now travel with the track team and are used as routine as part of the technical inspection process. According to Murphy, around 50 per cent of the templates used at the track for scrutineering are now produced on NASCAR's 3D printers.

Performance advantage

Similarly, top teams also now have their own 3D-printing facilities and are using them to rapidly generate parts to perform aerodynamic studies, continually looking for small incremental improvements on track. While the major components of the NASCAR Gen 7 car are spec, there are still dozens of additional vents, ducts and brackets on a car that teams will do their best to try to exploit for a performance advantage.

One example of this is the front brake ducts. Leading teams have figured out that they can be used to alter airflow at the front of the car to maximise downforce, so have been busy printing subtly different designs to investigate this effect. Intermediate tracks don't usually require heavy duty brake cooling,

Being able to 3D print components in-house means NASCAR engineers can rapidly develop prototypes and test them prior to going into series production, either as printed or composite parts



Shown here is the heavy duty brake cooling duct used at smaller tracks where the brakes see a heavier workload. To avoid teams gaining any potential advantage, NASCAR has changed the rules for 2025 and now defines which duct, if any, is used at each of the tracks the series visits

yet some teams have run ducts purely for their aerodynamic benefit. NASCAR caught onto this as the 2024 season was winding down, and part of the first rules bulletin for the 2025 season is a chart outlining what type of brake cooling teams are allowed to run at each track. Brake cooling ducts are now outlawed at Charlotte Motor Speedway and Homestead-Miami, while smaller tracks are assigned a specific brake cooling package. Some of this ductwork was 3D printed by NASCAR during testing before it went into final production of the composite parts.

With the rise in availability of 3D-printing technology, NASCAR is really having to keep on top of the use of custom parts on the Gen 7 car. As always, it is a game of cat and mouse between teams and officials.

Stewart-Haas Racing pushed that game over the edge when it attempted to replicate the spec floor duct using its own printers during the 2023 season. Its engineers were able to produce a very close approximation of the official duct, until NASCAR inspectors decided to take a closer look. Only then was it discovered that the part did not match the pattern and materials of the spec duct, resulting in a $250,000 (£203,080) fine and six-race suspension for crew chief, Johnny Klausmeier, a 100-point owner and driver penalty and the deduction of 25 play-off points for counterfeiting a spec part.

3D printing is already playing a major role in NASCAR, but we can expect to see more advancements using the technology through the new lab at the R&D Center, both in safety components and in scrutineering. We can also be sure the game of cat and mouse will continue.

3D-printing technology really comes into its own with special project work, such as the Garage 56 entry that raced at Le Mans in 2023 and the NASCAR EV Prototype that broke cover in 2024

Tyre modelling 101

What it means and what really counts

By DANNY NOWLAN

When it comes to tyre models, most people are convinced it's either an impossible task or you need a degree in rocket science to complete the job. Others just content themselves with the notion that it's all hocus pocus. Even amongst those who accept they exist, I'm still blown away on a regular basis by the amount of misconceptions out there about what a tyre model is, and what you do with one.

I don't mean to trivialise the subject of tyre modelling, for it is no trivial matter, but there are certain key take aways a race and data / performance engineer can use quite readily. I discuss these at length in the ChassisSim bootcamps, but it's time these insights where shared on a larger scale. That will be the focus of this article.

Firstly, to set the scene, you need to move away from the school of thought that says tyre models are dictated from on high by some kind of supernatural deity. Tyre models are, in simple terms, a tool to help you understand what is going on with the tyre, and in turn help make sense of what the car is doing. Help being the operative word here. Anyone who thinks they have the perfect tyre model should really be locked up for their own safety!

The predominant tyre models out there are empirical in nature, the most often quoted example being the Pacejka tyre model. Those like the ChassisSim v3 tyre model are mostly empirical in nature but derive their thermal cues from first principle models like the Michelin Tame Tire model. However, once you dig underneath the mathematics, most tyre models can be represented by that shown in **figure 1**. This is a graphical representation of any tyre model that can be broken down into the form shown in **equation1**.

$$\begin{aligned} F'_{MAX} &= fn(F_Z, T_T) \\ F_y &= fn(\alpha, F_Z, T_T)\cdot C_{Fy\_MT}(\delta_{camb}, F_z)\cdot F'_{MAX} \\ F_x &= fn(SR, F_Z, T_T)\cdot \mu'_{TC}(\delta_{camb}, F_z)\cdot F'_{MAX} \end{aligned} \qquad (1)$$

Where,

F'_{MAX}	= Traction radius circle as a function of vertical load and temperature
F_y	= Lateral force applied to the tyre (N)
F_x	= Longitudinal force applied to the tyre (N)
C_{FY_MT}	= Lateral camber function.
$\mu'_{TC}(\delta_{camb}, F_z)$	= Longitudinal camber function
$f_n(\alpha, F_z, T_t)$	= Lateral slip angle function
$f_n(SR, F_z, T_t)$	= Longitudinal slip angle function

Effectively, the F'_{MAX} is the D term you see in the Pacejka function and the camber and slip angle is all that horrible trigonometric function that sends most of the human population running into the hills in terror.

The thing to remember here, though, is that your tyre force is simply a product of the traction circle radius, multiplied by the slip angle / ratio function, multiplied by the camber function.

Of all these terms, the central one to generating the tyre model is nailing the traction circle radius, or D term. Once you get to grips with this, everything else with tyre modelling will fall into place. Fortunately, there is a simple way to understand this.

To kick off this discussion, it's worth re-visiting the second order fit of the traction circle radius vs load characteristic. There are many forms this can take, but the most instructive way of looking at this is presented in **equation 2**.

$$TC_{RAD} = k_a(1 - k_b \cdot F_z)\cdot F_z \qquad (2)$$

Where,

TC_{RAD}	= Traction circle radius (N)
k_a	= Initial coefficient of friction
k_b	= Drop off of coefficient with load
F_z	= Load on the tyre (N)

Figure 1: The outline of an empirical tyre model

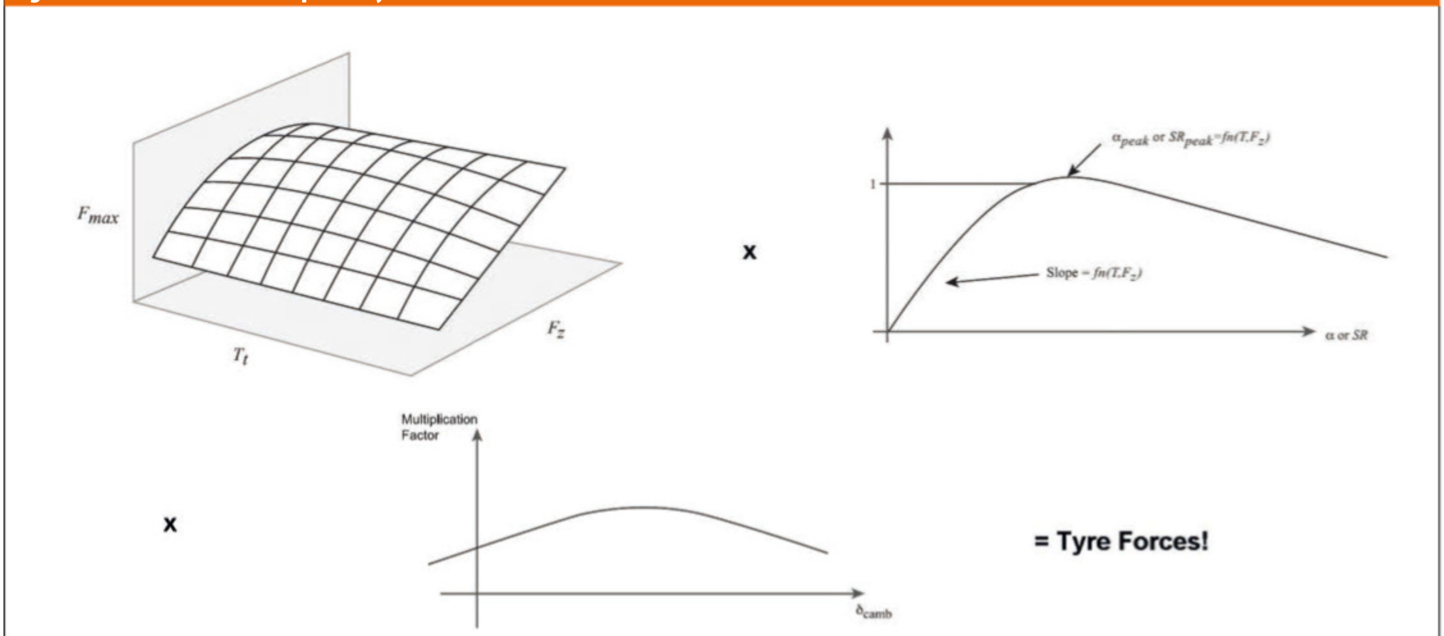


Figure 2: Second order plot of the traction circle vs load characteristic

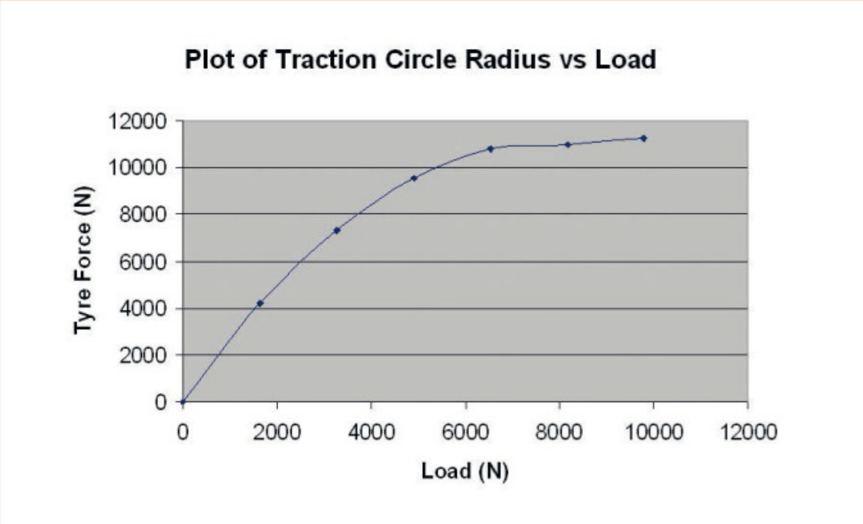
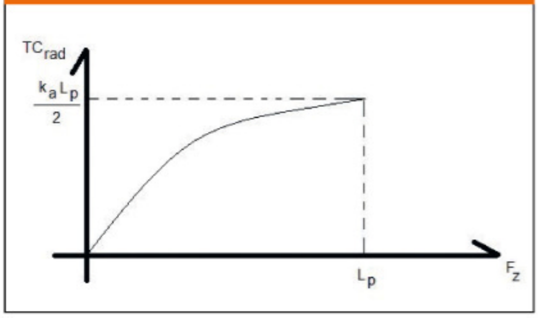


Figure 3: Graphical illustration of the peak load and traction circle radius values



Some typical values for this are presented below in **Table 1**.

Table 1: Typical open wheeler numbers for maximum tyre force with the coefficient of friction dropping off linearly with load

Parameter	Value
k_a	2
k_b	5.0 e-5 (1/N)

Plot this out, you should have something that looks like **figure 2**. Where things get interesting is the relationship between the initial coefficient of friction and the peak tyre load that produces the most force. If we take the derivative of **equation 1** with respect to load and set it to zero, we get **equation 3**.

$$L_p = \frac{1}{2 \cdot k_b} \qquad (3)$$

(3)

Where L_p is the load where the maximum value of the traction circle radius will occur. Doing a little bit more manipulation of **equations 1** and **2**, the maximum possible value of the traction circle radius is that shown in **equation 4**.

$$TC_{RAD\_MAX} = \frac{k_a \cdot L_P}{2} \qquad (4)$$

This is best illustrated graphically, and is shown in **figure 3**.

Compressed spin

What this shows is that the maximum force of a tyre can be described by its peak load and initial coefficient of friction. A spin of this curve is that as the peak load decreases, the shape of **figure 3** becomes more compressed. What this means is you have more set-up sensitivity. The downside is that if you exceed this load, the tyre model will go over the curve and grip will drop off.

The inverse of this is where the peak load is very large. In this situation, when you make a change, it will do very little.

Make no mistake, the relationship between the peak load at which the tyre generates its peak grip and the peak vertical load you see on the racecar gives you the heart and soul of your set-up. For example, if the delta between the peak load you see on track and the peak load of the tyre is between 20 and 30 per cent, this dictates a set-up with high roll and pitch centres and soft spring and damper rates. To (mis)quote that 1980s *The Pointer Sisters'* song, *Slow Hand*, this is a tyre that requires a lover with an easy touch.

Conversely, if that delta is in the order of 50 per cent, you really need to muscle the tyre. So this situation dictates low roll and pitch centres and high spring, bar and damper rates. This is a great rule of thumb that has served me very well.

Jake Galstad

In its simplest terms, the point of a tyre model is to help you, the race engineer, understand what is going on with your tyre, and from there to help make sense of what the car is doing

Whichever the situation, it is imperative you validate it from race data. The key reason for this is most tyre test rigs will overestimate peak tyre loads, mainly because a tyre test rig will simply not generate the temperature and pressure conditions you see on circuit. You can still obtain decent correlation from those models, but the set-up sensitivity will be awful.

The good news is that you can use **equations 2-4** and some simple force balance assumptions to get you started. I discussed this at length in my article on tyre modelling from nothing in 2016 but, if you don't want (or can't be bothered) to do this, you might want to re-think your choice of profession. Enough said.

Car sensitivity

The next thing to understand in the tyre model is the slip angle / slip ratio curve because this is the primary driver of how sensitive the car is to steer and throttle input. To do this, let's examine a typical non-dimensionalised tyre curve, as shown in **figure 4**. The horizontal axis is slip angle and the vertical axis is normalised force.

What this is showing is the default ChassisSim curve that has worked well across a multitude of different types of racecars. Before we go any further, a quick note about what happens when you exceed the peak slip angle. How that curve drops off is going to dictate how forgiving the car is. The more severe the drop off, the more the car is going to bite. What you see here is what I'd call a good all-rounder curve for both lap time and driver-in-the-loop simulation.

The reason this slip curve dictates the steering sensitivity lies in the derivation of control power. Referencing my earlier work, a linearised model for steering mathematically looks like that shown by **equation 5**.

$$I_Z\dot{r} = \left(a\cdot C_f + \frac{\partial N}{\partial \beta}\cdot\frac{C_f}{C_T}\right)\cdot\delta_s + \left(\frac{\partial N}{\partial r} + \frac{C_r'\cdot b - C_f\cdot a}{C_T\cdot V_x}\right)\cdot r + \frac{a\cdot C_f - b\cdot C_r'}{C_T}\cdot m_t\cdot a_y \qquad (5)$$

I'm not going to bore you with all the terms here. Suffice to say, the dominant term for steering is $a\cdot C_f$. The C_f term is given by that shown in **equation 6**.

$$C_f = \frac{\partial C}{\partial \alpha}\cdot\left(Fm_1 + Fm_2\right) \qquad (6)$$

Where,

C_f = Change in lateral force vs slip angle
$\frac{\partial C}{\partial \alpha}$ = Slope of the normalised slip curve
Fm_1 = Traction circle radius of the front left tyre
Fm_2 = Traction circle radius of the front right tyre

There is a camber multiplier term we have omitted here, but what is shown is the dominant term. Consequently, the less the peak slip angle, the more responsive the car is because the $\frac{\partial C}{\partial \alpha}$ term is bigger. The longitudinal implication of this is the smaller your peak slip ratio, the more your car will be sensitive to differential adjustments.
This explains why the peak slip angle and its slope dictate how sensitive the car is to steer and throttle inputs.

The last thing to discuss is the effect of camber. A failing of the Pacejka model is the more camber you crank on, the better the tyre gets. That is fine for a motorcycle tyre, but try telling an F1 or IndyCar team to run 20 degrees of front camber!

It is for this reason I went a very different way with the ChassisSim v3 tyre model with regards to camber. Mathematically, the formulation is shown in **equation 7**.

$$\begin{aligned}
C_{Fy_MT}\left(\delta_{camb}, F_z\right) &= 1 - sf_c_y\cdot\frac{\left(\delta_{camb}-\delta_{OPT}\right)^2}{100}\\
\mu'_{TC}\left(\delta_{camb}, F_z\right) &= \mu_{MULT}\cdot\left(1 - sf_c_x\cdot\frac{\delta_{camb}^{\,2}}{100}\right)\\
sf_c_y &= sf_c_y_0 + k_c_y\cdot F_z\\
sf_c_x &= sf_c_x_0 + k_c_x\cdot F_z\\
\mu_{MULT} &= \mu_0 + k_u\cdot F_z\\
\delta_{OPT} &= \delta_0 + k_\delta F_z
\end{aligned} \qquad (7)$$

Where,

$C_{Fy\_MT}(\delta_{camb}, F_z)$ = Lateral camber tyre force multiplier function
$\mu'_{TC}(\delta_{camb}, F_z)$ = Longitudinal camber tyre force multiplier function
δ_{OPT} = Camber at which most lateral grip is generated
δ_{camb} = Negative camber of the tyre
sf_c_y = Lateral camber sensitivity per camber degree squared/100
sf_c_x = Longitudinal camber sensitivity per camber degree squared/100

You can chase up the other terms if you so wish but, honestly, the load terms are there for fine tuning and keeping the F1 and

A failing of the Pacejka model is the more camber you crank on, the better the tyre gets. That is fine for a motorcycle tyre, but try telling an F1 or IndyCar team to run 20 degrees of front camber!

Figure 4: Non-dimensionalised tyre force curve vs slip angle

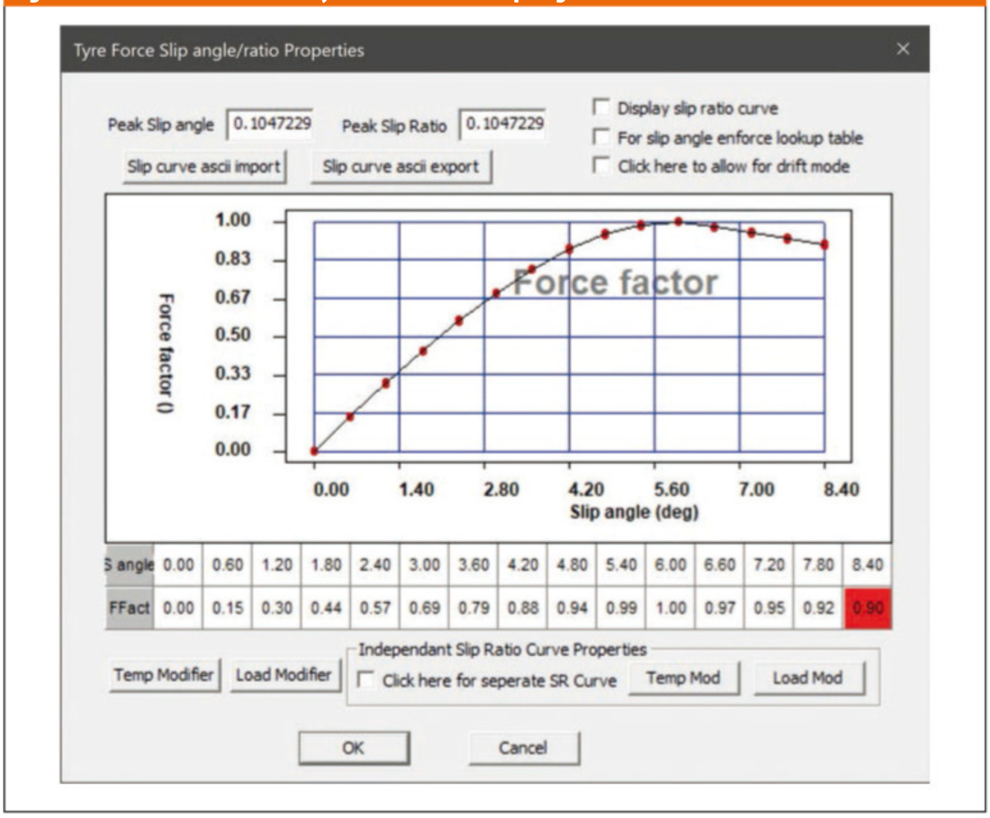
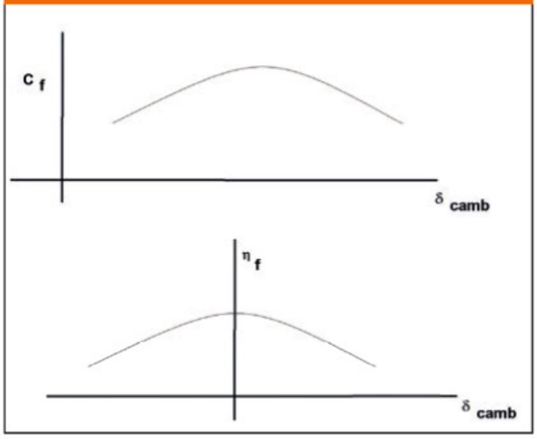


Figure 5: Graphical representation of the camber multiplier function



I cannot emphasise enough the importance of using race data to validate and populate your tyre model

factory sportscar guys happy (this is what happens when you have money to burn on vehicle modelling). The important thing to note here is you can treat sf_c_y and sf_c_x in most cases as constant terms. There are some exceptions that prove the rule, but this is a pretty good starting point.

The good news for any readers averse to mathematics is that **equation 7** can be summarised graphically. See **figure 5**.

So, for the lateral case, the peak of this curve is dictated by the peak camber, while the curvature of the graphs are dictated by the sf_c_y and sf_c_x terms. For the longitudinal case, the initial value is dictated by the μ_{MULT} term. This is also a key element in dictating the shape of the traction circle radius / ellipse. The bigger the μ_{MULT} term, the narrower the traction circle radius and the more biased the tyre is to traction.

The converse of this also applies and is one of the key drivers that decides whether you can or cannot carry speed into a turn. If you want to put ballpark figures to this, **table 2** gives some reasonable start values. Incidentally, these numbers haven't been pulled out of thin air. This is a collation of tyre model numbers from the ChassisSim community that have worked well, not just in correlation but for set-up sensitivity as well.

Pressure point

To put all this in perspective, it's worth repeating at this point that every tyre model out there is an approximation. I will never forget being at a lecture presented by Chris Van Rutten, developer of LapSim. Now Chris and I don't agree on a lot, but someone asked him a question about the Pacejka model and, since Chris studied under Professor Pacejka, he was well positioned to answer. He stated one of the reasons the Pacejka model became so big is that the good professor, being an academic, was always under pressure to publish his findings. The moral of the tale here is don't think of empirical tyre models like Pacejka, or ChassisSim for that matter, as anything more than tools and frameworks to help you correlate what you see on track and apply it.

I cannot emphasise enough the importance of using race data to validate and populate your tyre model. I didn't create the ChassisSim tyre force modelling toolbox for some weird form of intellectual entertainment, and I didn't give goodness knows how many lessons on how to use it because I like the sound of my own voice. This toolbox has saved my neck on more occasions than I care to remember, in formulae as diverse as Supercars, single seaters and sportscars, to name just a few.

In closing, then, hopefully this article has helped establish some very simple frameworks for you to start understanding the racing tyre. Make no mistake, this is no trivial undertaking, but there are some straightforward steps we can take to help navigate the jungle. Firstly, the number one driving term in a tyre model is the traction circle radius vs load curve. Get that right and everything will flow from there. Then, understanding the role of slip and camber will fill in the gaps.

While the scope of this article in no way gives us the space to tell the complete story, a lot of set-up questions about where to go with the car should fall into place once you've got your head around all this. And always remember to use race data, wherever possible, to fill in the blanks.

Table 2: Ballpark numbers for lateral camber sensitivies

Parameter	Sportscar / single seater	GT3 value	Touring car
sf_c_y_0	2-3	1-2	0.5 - 1
sf_c_x_0	2-3	1-2	0.5 - 1
k_c_y	0	0	0
k_c_x	0	0	0
μ_{MULT}	1	1	1

Jake Galstad

The most important thing to remember is that every tyre model out there is an approximation, a tool to help you correlate what you see on track and apply it to your racecar

Former Ferrari F1 engineer joins GM in sportscars

Padros joins Cadillac in the newly-created technical director role, after several years in F1

General Motors has re-organised its management team for the 2025 endurance racing season, appointing Charles Leclerc's former F1 race engineer at Ferrari, Xavier Marcos Padros, as technical director and Sean O'Shea as propulsion manager.

Padros joins Cadillac after working with Leclerc from 2019 until last May, but is also no stranger to US racing, having been chief race engineer for the Richard Childress Racing team in NASCAR between 2015 and '17.

O'Shea will focus on development of the Cadillac V-Series.R's hybrid powertrain. He previously worked for Bosch, which supplies the spec MGU installed in every LMDh car.

Padros and O'Shea arrive at GM three months after the company re-shuffled its senior motorsport management, with Keely Bosn becoming Cadillac programme manager and Jessica Dane taking over the Corvette Racing GT3 arm.

Cadillac creates F1 power unit division

Cadillac has registered itself as a power unit manufacturer and has appointed Russ O'Blenes as CEO of the new powertrains venture that will eventually see the American manufacturer supply its own Formula 1 cars. Cadillac will be on the grid in 2026, using Ferrari power units until its own engine project is complete by the end of the decade.

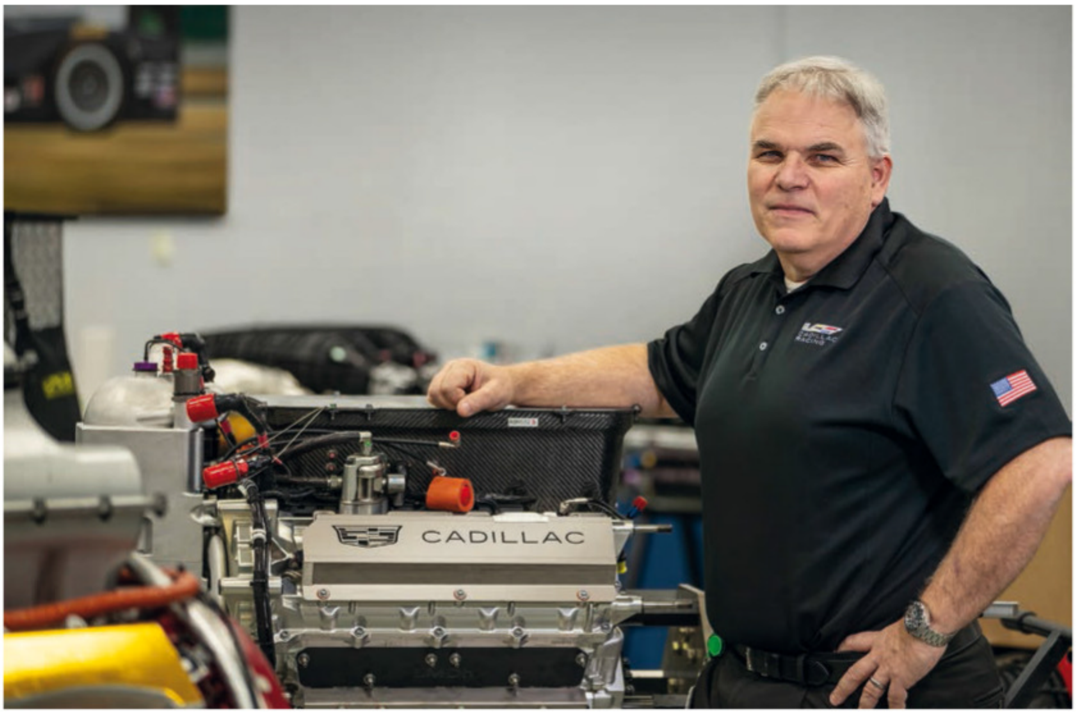
O'Blenes has led the development of the GM Performance and Racing Center in Michigan and was central to the development of the engines that appeared in Cadillac's LMDh and GTE racecars.

Plans are in place to establish a dedicated facility for the new GM Performance Power Units company near the parent firm's Charlotte Technical Center in 2026.

'In F1, we're going to demonstrate GM's engineering and technology capabilities on a global stage, and Russ is the right choice to lead the power unit team that will make it happen,' comments GM president Mark Reuss.

O'Blenes adds: 'I am truly excited to have the opportunity to build and lead the team that will bring an American-built F1 power unit to the grid. GM Performance Power Units is currently ramping up its team and is hiring in all areas of the business.'

Veteran engineer, Pat Symonds, recently started as an executive consultant for the Cadillac team. His departure from Formula One Management (FOM) was confirmed in mid-2024, after seven years working as its chief technical officer.



Russ O'Blenes worked on the IMSA Cadillac and Corvette C8.R engine programmes, so is well placed to lead development of the new Cadillac F1 power unit

Ford and McLaren poised to enter Hypercar in 2027

At least two new manufacturers are positioned to enter the Hypercar class in 2027, with Ford and McLaren ready to commit after years of consideration.

Both manufacturers are expected to build LMDh cars and compete in the FIA World Endurance Championship, which includes the 24 Hours of Le Mans.

McLaren was an integral part of the original Hypercar discussions and has long stated its ambition to race at Le Mans in the top class. The decision to develop an LMDh was taken to reduce the impact on the company's other racing activities, though it is understood no decision has yet been taken on which engine the car will use. McLaren does not have a power unit that is suitable for LMDh in its production cars and so was in talks with Ford to use an engine from its range.

Instead, Ford will now enter the top tier of sportscars with its own LMDh programme. The Blue Oval was also one of the guiding forces in the development of the LMH rule set, but felt the hybrid system did not have enough power and so elected not to pursue the project.

Now, the company is expected to start its new racing endeavour in 2027 with a V8 engine mated to an ORECA chassis. Ford announced its motorsport programme before the end of January at its annual conference held in North Carolina.

The American company is expected to build its own power units for the competition, likely from within its own range of engines.

As LMDh manufacturers, Ford and McLaren will both use the spec hybrid system from Bosch (MGU), Fortescue Zero (battery) and Xtrac (gearbox). The base LMDh chassis have all been designed, developed and raced, so the expectation is that both manufacturers will enter evolutions of existing LMDh cars.

Extreme H opens fuel cell development path

The planned Extreme H off-road series, which uses a spec Pioneer 25 chassis built by Spark Racing Technology and powered by a hydrogen fuel cell stack, will now allow car companies to bring their own fuel cell technologies.

The car had been developed with a fuel cell designed by Symbio, part of the Stellantis group. However, after discussions with the FIA and manufacturers, including BMW, Honda, Hyundai and Toyota, the regulations have been opened up.

'The decision behind this is if we have a single fuel cell supplier, that's advancing their fuel cell,' says Mark Grain, technical director at Extreme H. 'If we open it up, we believe we are going to open the opportunity for a lot more, and faster, fuel cell development across different manufacturers.

'This way we are sharing the knowledge, and that develops the whole breed.'

The Pioneer 25 is fuelled by hydrogen gas, which is injected into the cell stack where a reaction generates electrical energy. This is used to charge the battery, which serves as the primary energy source driving the pair of electric motors.

Symbio's motorsport director, Serge Grisin, says the company is 'open to the competition' based on its extensive groundwork already carried out with the Pioneer 25.

Although the first 10 cars have been built, Extreme H has yet to confirm its schedule for the 2025 season, including the start date.

Hybrid issues for LMDh cars at Daytona

A number of GTP prototypes suffered high voltage hybrid system issues in the build-up to the 24 Hours of Daytona.

BMW and Porsche principally were forced to change or repair batteries, while customer teams also faced issues with the MGU software and hardware.

The battery, motor generator unit and gearbox are all spec components for the LMDh cars, and have proved to be largely reliable since the platform was introduced in 2023.

Fortescue Zero, the battery manufacturer, traced the problem to a printed control board, but the problems arose at the pre-race test and throughout race week, so there were only limited opportunities to fix the problem.

Teams had preparation work to do for the IMSA season-opener, and extra issues surrounding the hybrid system added to the workload ahead of the race

IN BRIEF

Haas has named **Laura Mueller** as race engineer, becoming the first female to hold the role in Formula 1. She will engineer Esteban Ocon, starting with the pre-season test at the end of February.

GreenGT, a specialist in hydrogen fuel cell technology, has formed a strategic technical partnership with Pratt Miller. The collaboration is set to 'drive the development' of hydrogen-powered solutions for the defence, motorsport, mobility and industrial sectors.

Autotel has introduced a new MS51 pit lane intercom system that has a range of up to 400 metres from the base antenna unit, and can service up to eight devices per base. The system can operate as a standalone with radio interface to the car, or integrate with existing team radio headsets.

Aston Martin has appointed Andy Cowell as Formula 1 team principal, replacing Mike Krack. Krack will take on a new role as chief trackside officer, while Enrico Cardile will take charge of the factory-based development as the two roles are separated out at Cowell's request.

Jaguar Land Rover's **Defender** brand will use the Octa as the base model for its three-year Dakar Rally programme starting in 2026. The Octa features a 4.4-litre twin-turbo V8 engine. Prodrive will assist with modifying the vehicle for competition in the Stock class.

Italian brake company, **Brembo**, has signed a multi-year deal to become the official 'Braking Technology Partner' of IMSA. The deal will include Brembo explaining the braking technology in use in a series streamed on IMSA's YouTube channel.

Genesis Magma Racing is now expected to miss the first race of the 2026 WEC season as it is understood to have changed its engine supplier. Genesis was intending to use an engine from the former Glickenhaus supplier, Pipo Moteurs, but will now develop a bespoke power unit for the project.

Opportunity knocks

The journey to net zero is a path filled with promise

On 25 March, at the British Motor Museum, the MIA is holding its 22nd annual Energy Efficient Motor Sport (EEMS) conference. This event is always a sell out, with over 250 delegates and 30 showcases, but 2025 could be the most important year ever as climate change and net zero challenges are imminent, and increasing.

EEMS is both popular and important among motorsport leaders as its focus is on the business growth opportunities of what is now called 'the journey to net zero.' Delegates will discuss the potential of new technologies and opportunities for collaboration and partnership arising from significant changes in the world of mobility.

Previously, early starters have seized opportunities from the outset, their rapid response rewarding them well, but we are now on the cusp of a second wave of activity under a new United Kingdom government, one which is determined to deliver net zero solutions by 2030.

With more still to confirm, EEMS 25 already has leading executives from F1, Porsche, IndyCar, IMSA, Fortescue Zero and BTCC, as well as professors from Oxford and Warwick universities among our speakers.

All will focus on the commercial and technological opportunities for motorsport businesses that the journey to net zero will offer over the next five years.

Mutual benefit

Many have said the quality of networking opportunities at EEMS is invaluable, unique even. We aim to bring the automotive and mobility industries closer to motorsport, to the mutual benefit of all. I strongly encourage you to attend EEMS this year as so much change is approaching, and fast.

The changing fortunes of automotive companies as a result of legislation will continue to have a significant effect across motorsport, as manufacturers have always been an active, vital part of our industry. Since the first ever motor race, they have been our most important sponsors and partners. Now, tremendous pressure placed on their operations and finances, from stringent rules to heavy financial penalties, could prejudice those invaluable relationships.

Will these important automotive sponsors still see value in motorsport helping their brands reach even more millions of eyeballs through TV and online? Or will famous auto brands be replaced by Big Tech companies which already benefit from the popularity of hi-tech motorsport? It will take time for such change to take place, and the effect will be felt in disparate ways by different brands.

Some customers will *always* want to enjoy owning a high-performance car, and expect to see it in action, so the future of high-performance mobility in one sector at least is secure. Indeed, so is motorsport, which takes place on private roads and racetracks and enjoys a significant following among the public.

Commercial and technological opportunities on the road to net zero will be the focus of EEMS 25

Fuels will become ever cleaner, and cars' performance will be affected by the structure of the net zero option. However, the proven ingenuity of motorsport engineering will overcome these challenges and the sport will continue to entertain, though perhaps in different forms in the future.

These are the kind of discussions you will enjoy at the MIA's EEMS 25 (see www.the-mia.com/events), so please come along and share your knowledge, and exploit the opportunity to make new business friends.

Formula 1's proactive commitment to a net zero future is welcomed by all. The series confidently expects to show positive and early results for our industry, and the steps already taken are vital to the future of global motorsport. To appreciate its position, I urge you to look up F1's Impact Report. The MIA plans to secure maximum benefit for all in our industry from the exciting new business sector that F1 supports.

F1's actions will also encourage technology-based consumer businesses to develop their own solutions. It is essential for the future of motorsport that we act urgently, but intelligently, to be prepared for, and to overcome, the challenges that could appear at any time. Other technology sectors gain strength from motorsport's ability to resolve such challenges in an always short timeframe. To continue doing so in the field of net zero mobility over the coming years, where unforeseen challenges will inevitably arise, is essential. This valuable asset sits well with the culture of motorsport companies. Do it, do it well and do it fast are the bywords of motorsport engineering.

Proactive steps

Seeing our industry, and sport, reacting proactively to climate change will be very influential within government. F1 has already taken steps to reduce its air miles and emissions by changing the calendar to avoid unnecessary travelling between venues. In the UK, our main 'motorsport stadium' at Silverstone now produces nearly 100 per cent of its power from solar panels on the grandstand roof. These are just two examples of how motorsport is changing its ways.

My final, but most important, point on zero emissions involves finance – the essential fuel of motorsport. Leading sponsorship agencies confirm that major sponsors are already insisting teams demonstrate a clear plan to meet the challenges of climate change. No plan, no sponsorship.

I am sure 2025 will be another good year for motorsport, with plenty of challenges and new technology opportunities on the journey to net zero. Start your year well by coming to EEMS on 25 March. I will see you there. In the meantime, if we can help in any way, please contact us at info@the-mia.com

Chris Aylett is CEO of the MIA (Motorsport Industry Association) www.the-mia.com

It is essential for the future of motorsport that we act urgently, but intelligently, to be prepared for, and to overcome, the challenges that could appear at any time

Reality check

Daytona served a timely reminder that nothing in racing is ever certain

The build up to the 24 Hours of Daytona was a little more fraught than usual, with multiple GTP manufacturers needing to change their spec hybrid units. Porsche and BMW suffered battery and MGU problems, and teams played musical batteries at the pre-event test that continued into race week.

Some of the issues were traced back to a faulty part in the Fortescue Zero battery, which, in turn, led to other parts of it showing up with problems. It was a matter of luck as to who was given an ill system, but it was noticeable that the Porsche 963s were most affected, having fitted brand new parts for the 24-hour race. Other issues were then flagged, including a leaking MGU, software drama and other battery-related gremlins.

Understandably, given the circumstances, the mood in the paddock was one of frustration and anger. In place of a guarantee from the suppliers that everything had been fixed, the manufacturers did what they could to minimise the risk for the race, such as fitting proven parts that were not as fresh. Porsche's customer teams saw their track time reduced in the build up to the main event, with extra effort required from the mechanics.

These are spec parts commissioned by the race organiser, IMSA, and this is the third year they have been used. Teams rightly have an expectation they will be reliable at this point. The time and effort required to deal with problems with parts from suppliers commissioned by the sanctioning body puts more pressure on a team when it has other preparation items to click through ahead of the longest race of the IMSA Sportscar Championship season.

Problem solving

Behind the scenes, there was also frustration from the organisation and suppliers. This is a high-power battery, one that lasts for 150 hours, and many previous versions have done so. There was no change in specification, so no reason to expect the parts not to work as advertised. However, nothing in racing is certain, and reliability issues in racecars are a fact of life, spec or not.

Having identified the issue, Fortescue and the MGU supplier, Bosch, conducted their investigations. As the manufacturers must do when developing their cars, they need to understand the issue, produce a solution and deploy it, both quickly and effectively. Both suppliers had to roll out whatever fixes could be done trackside to teams running the dozen GTP cars going for victory in one of the biggest 24-hour races around. This was never going to be the work of a moment, and they had to conduct the process in a hurry to provide answers to the teams, who are also IMSA's customers, ahead of the race on Friday.

On top of this, many teams at Daytona had costly suspension failures, with some pointing out the kerbs at the Le Mans chicane had changed. Ultimately, the 24-hour race was completed without a hybrid failure, which was a relief to everyone in the paddock, but also testament to their work, from supplier and team perspectives.

The pressure that the manufacturers and teams were under was apparent. The ill feeling in the paddock was amplified by the fact this was the first round of the season, so an important one to get your season off to a good start.

The power of money

Talking to Doug Fehan, Corvette Racing's former programme manager, about Dale Earnhardt's drive at this race for his team in 2001, the comparison from then to now in the paddock was stark. Then, said Doug, Dale could not believe how good the atmosphere on the ground was between rivals. He asked how that was possible, and the answer was clear – they were not competing for a $5m prize fund like in NASCAR. If it had been larger, there is no way the paddock would have been as accommodating.

Dealing with spec part issues before the big race was an unwelcome addition

Now, the 24 Hours of Daytona is a much more professional affair that places substantial pressure on the teams, both financially and in terms of competition. Dealing with spec part issues before the big race was an unwelcome addition.

The other news coming from Daytona was the decision of Ford, and likely McLaren in the near future, to build and race an LMDh car, which would be eligible for IMSA and the FIA World Endurance Championship. According to paddock sources, both have chosen to focus on the WEC, and therefore the 24 Hours of Le Mans. For McLaren, the likelihood is it will not race in IMSA at all. That would be a shame for the sport's fans, but is understandable as McLaren won't have unlimited funds to run multiple cars on two continents. Ford is also likely to prioritise the WEC, but with some US races thrown in. Certainly, IMSA management were bullish about two new prototypes coming to the US. Time will tell if they see them both.

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Inside the world of modern motorsport technology
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Subscriptions
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Online: www.subscription.co.uk/chelsea/help
Post: *Racecar Engineering*, Subscriptions Department, Sovereign Park, Lathkill St, Market Harborough, Leicestershire, United Kingdom, LE16 9EF

Subscription rates
UK (12 issues) £84
Europe (12 issues) £100/€120
ROW (12 issues) £120/USD$165
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Seymour International Ltd, 2 East Poultry Avenue, London EC1A 9PT
Tel +44 (0) 20 7429 4000
Fax +44 (0) 20 7429 4001
Email info@seymour.co.uk

Racecar Engineering (ISSN No: 0961-1096, USPS No: 463) is published monthly by The Chelsea Magazine Company Limited, and distributed in the USA by Asendia USA, 701 Ashland Ave, Folcroft PA. POSTMASTER: send address changes to Racecar Engineering, 701 Ashland Ave, Folcroft, PA. 19032.

Printed by Walstead Roche Ltd
Printed in England
ISSN No 0961-1096
USPS No 007-969

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