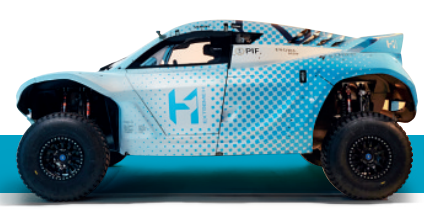

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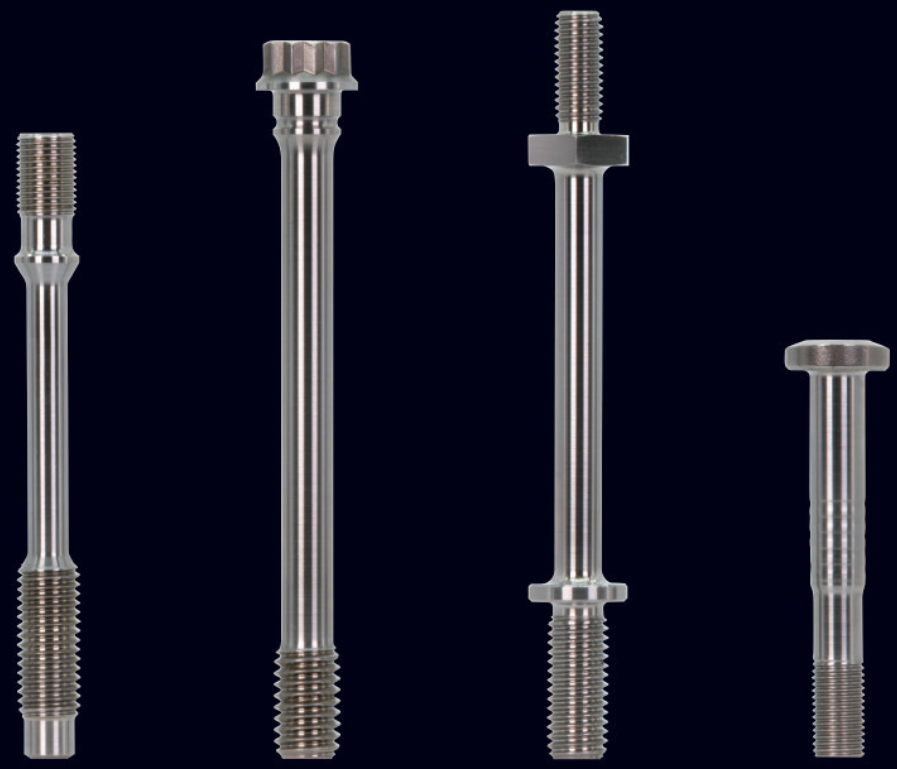

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ACTIVE AERO, ACTIVE IMAGINATION

LIGHTER, nimble, road relevant rockets, that will carry Formula 1 into a sustainable future? Or a ruleset that is too timid, with overly complex machines that will spoil the good racing we are currently enjoying?

If the 2026 Formula 1 regulations prove one thing, it is that you can't please all of the people, all of the time!

With a near 50-50 split between the ICE and electrical energy, active aerodynamics front and rear, sustainable fuel and the introduction of a push-to-pass system, the 2026 cars carry F1 into uncharted territory. Although maybe not *completely* new ground, because one thing is very familiar: the cynical, self-centred manoeuvring of the teams.

They appear to have wound up the drivers and sent them ticking in the direction of the media with the ammunition to grab headlines – and possible rule concessions.

Yes, the drivers have whinged. Of course they have: the setup a few of them have investigated in the simulator has taken them well out of the zone they are comfortable with, suggesting cars that are too fast on the straights, too slow in the corners. Not a great combination.

But remember, this is work in progress. The FIA says that right now the proposed cars' downforce has been reduced by 30% and drag by 55%. A huge shift. As renowned F1 aerodynamicist Willem Toet points out in his opinion column (see page 9), even at maximum downforce, the proposed cars still feature less downforce than the aero setup currently employed by the cars at Monza's speed-fest.

As Willem also notes, the FIA tech team is at a huge disadvantage in their poacher-versus-gamekeeper battle. They face the might of teams that have infinitely more capacity to circumvent the intent of the rules, than the FIA can harness to frame them in the first place.

Elsewhere in this issue, both Sergio Rinland and our Expert Witness – an F1 insider who would quite like to keep his anonymity and his job! – highlight areas where the governing body's 2026 proposals don't go far enough. Both are correct. But, overall, they accept that these regulations carry us in the right direction.

The worst thing the F1 tech team could have done is give the teams too much freedom. Instead, they have set the bar low at this stage, confident that they have enough tools at their disposal to mould the regulations as they evolve.

Of course F1 2026 won't satisfy everybody. But most of us have endured too many knee-jerk reactions from rule-makers in the past. Now, hard on the heels of the well-researched 2022 ruleset, I get the feeling that there is genuinely a long-term plan in place. RT

Mark Skewis
EDITOR

F1 2026 REVAMP BEATS OFF THREAT FROM FORMULA E

How active aerodynamics and new Override mode paved the way for more electrification. By **Mark Skewis**

THE unveiling of Formula 1's proposed 2026 regulations attracted much debate on the road relevance of its championing of active aerodynamics, hybrid technology and sustainable fuel. What wasn't mentioned, was the elephant in the room: Formula E.

The success of the FIA's all-electric World Championship posed an existential threat to Formula 1, which had long tied its colours to the internal combustion engine mast. In many ways, the upstart new series was the catalyst for F1 embarking on its long journey to the promised land of its more sustainable 2026 regulations.

It's easily forgotten now that the new ruleset was formulated against the backdrop of Honda's bombshell announcement of its exit from F1, citing its preference to focus on more road relevant electrification. At the same time, OEMS that had traditionally supported F1 – or been coveted by it – such as Porsche, Audi, BMW and Jaguar were committing instead to Formula E. Even Mercedes, the reigning world champions at the time, had one foot in both camps...

Temporarily rocking, Formula 1 needed to respond: should it capitulate, bow to pressure to forsake the ICE and instead go electric, or should it stand its ground? This was F1 at the crossroads. Or, if you believed some of the critics, it was F1 arriving at the last combustion engine party.

Unprecedented questions had been asked of a category that prided itself on being the pinnacle of motorsport. The 2026 regulations amounted to its response – a riposte that has attracted a record number of power unit manufacturers, including entries from Audi and Ford, Honda's return to the fold, and Cadillac waiting in the wings.

Too slow, too complex?

Lighter, nimble cars featuring innovative active aerodynamics that will carry Formula 1 into a sustainable future? Or slow, unnecessarily complex machines that will frustrate the drivers, spread the grid further and threaten F1's position at the summit of motorsport?

The debate raged in the aftermath of the publication of the proposed 2026 rules. The new cars will be 30 kg lighter, 10 cm narrower and have engines with a near 50-50 split between electric and internal combustion power. They will also use fully sustainable fuels.

Active aerodynamics will be introduced to optimise the use of the new engines. Cars will have front and rear wings that open on the straights to reduce drag and increase speed, but then close to increase downforce for cornering performance.

With the Drag Reduction System (DRS) consigned to history by the active aero, overtaking will instead be facilitated by a power-boost system for a car following another.

FIA president Mohammed Ben Sulayem said: "The key features of the 2026 regulations are advanced, sustainable technology and safety.

"Our aim, together with F1, was to produce a car that was right for the future of the sport's elite category. We believe we have achieved that goal."

As ever, the drivers' main concern was the speed of the new cars. Nico Hulkenberg, who will drive for Audi, reported that the 2026 machine was slow when trialled in the simulator.

McLaren team principal Andrea Stella acknowledged, "There's a lot of work to do – the cars are not fast enough in the corners and too fast in the straights. So these two aspects need to be rebalanced."

James Vowles, Williams team principal, agreed: "It's imperative that we are still the leading series in motorsport. That's how I see us. And therefore, we need to make sure that we're maintaining the performance and speed we have. Right now, there's a mismatch there, fundamentally. The performance difference

to an F2 car could be as small as a few seconds. And that's starting to get a little bit tight, especially when you compare it to the other series around the world. But these are draft regulations. I'm confident we'll get to a better solution. It's not that we're so far away. Just a little bit more work required, though."

Another criticism levelled at the new rules concerned the apparent complexity of the aerodynamics.

Asked whether the different 'X' and 'Z' aero modes would cause confusion for fans, Vowles put matters into perspective.

"It goes back to what's the intent behind these rules," he said. "The intent behind these rules is let's go to a different power unit formula, let's go to synthetic fuel, let's go to a different environment in that regard. And I think all of that is quite good. In terms of the X modes... So, just for clarity, that's effectively reducing drag in a straight line and the Z mode, which is increasing downforce through the corners. I actually quite like the concept to be automated. It's not that the drivers will have to twiddle anything on the steering wheel. We can optimise the car in those circumstances.

"I actually think it's quite a clever way of having a more efficient car in that environment. So that complexity of things, personally, I'm comfortable with it, and I think the world will get used to it quickly. I think what we're talking about more is how do we make this a product that is just the pinnacle of motorsports, and what's the right formula that achieves that?" ▶

Override for overtaking

THE introduction of an Override button is one of the biggest changes as F1 battles to improve the quality of its racing spectacle.

Although the 2022 aero regulations did, for a while, achieve their objective of allowing cars to race in closer proximity, that effect has waned. Increasingly, overtaking has relied on the use of the DRS (Drag Reduction System).

For 2026, the problem is being tackled in two ways: an aero concept designed to minimise the dirty wake produced by the car ahead; but also the use of an 'override' button that increases the amount of electrical energy available to the chasing car.

"The Override function works in a similar way to DRS," explained Jan Monchaux, FIA Single-Seater Technical Director . "If you are within a given distance, before the end of a lap to the car in front of you, then for the following lap, you will be given the possibility to use more electrical energy than your opponent. And that boost of electrical energy is there to replace what used to be the rear wing opening, to give a car that extra push to potentially go and try to overtake. " RT

Courtesy of F1

BELOW Active aerodynamics facilitate the greater use of electrification in the 2026 car

Audi AG

BELOW Audi was lured in by the new powertrain regulations, featuring a switch to sustainable fuel

Explaining the introduction of active aerodynamics, Jason Somerville, FIA Head of Aerodynamics, said: "One of the aspects of the 2026 power unit is the greater reliance on electrical energy. If you were to drop the 2026 power unit into a current car, given the underlying drag level, the energy required to push the car through the air is rather high, and that wouldn't be very well aligned with the characteristics of the power unit. We would end up with a severe drop off in speed on the typical main straights. So, the focus for 2026 aerodynamically has been to reduce the base level of drag of the car, while trying to maintain a good level of downforce in the corners, and that's led us towards active aerodynamics."

"Our industry has decided to make quite a severe change of direction to try to align itself a little bit more with the world we're living in in 2024," noted Jan Monchaux, FIA Single-Seater Technical Director. "As an engineer, I find that after 20 years I'm happy to see we are capable of opening up ourselves to active aerodynamics, even if it will be regulated and limited. Every high-end premium car has active aero on the road and I think nowadays, thanks to technology, we are in a far better position than maybe 30 or 40 years ago to develop these systems in a safe and reliable manner.

"I'm glad that we are going to have tools that help to solve quite a few challenges engineers, especially aerodynamicists, are currently facing. Being able to decouple your straight-line performance from cornering performance, I think it's going to be a very interesting, interesting journey." RT

Focus on electrification

ANDY COWELL, the architect of Mercedes' dominant start to Formula 1's hybrid era, was impressed when he examined the fine detail of the 2026 powertrain regulations for Race Tech's World Motorsport Symposium.

A near-tripling of electrical power is at the heart of those rules, though the headlines are perhaps inevitably captured by the opportunity for F1 to become the poster-child for the automotive industry's move towards sustainable fuel.

Jan Monchaux, FIA Single-Seater Technical Director, explained the aims behind the Technical Regulations, saying: "First and foremost, we want to ensure we deliver a great show for the fans. But we are trying to also merge into the regs changes that we all felt, and the industry also felt, are a must. So it's trying to align the wishes and need to have great entertainment for all the spectators, but also trying to be a little more relevant for society, in terms of sustainability."

The power unit has been simplified for the new era, with the removal of the MGU-H that recovered the energy of the exhaust gas. Instead, the combustion engine will use sustainable fuel and a much larger MGU-K which is effectively recovering more braking energy to be fed into the bigger battery or directly to the axles.

"We took the opportunity to significantly increase the electrical power from the MGU-K, almost tripling it from 120 kilowatts to 350 kilowatts," said Monchaux. "We want to have the focus of the development on the energy storage and the MGU-K, which means the combustion engine is not supposed to become a performance differentiator as big as it potentially is now. So the rules are getting a bit stricter. And to just ensure, also for the newcomers, that the focus goes towards electrification, which is something we wanted to promote much more." RT

COMMENT *Willem Toet*

THE CAT-AND-MOUSE GAMES BEGIN

Renowned Formula 1 aerodynamicist **Willem Toet** looks at where the teams will focus their ingenuity with the new cars – and proposes a fix to address complaints about lap time

FOCUSING on the aero parts of the new rules and staying with what is in the public domain, I see challenges ahead.

Teams can't do research yet so can only estimate performance change, and they all complain that the rules are too restrictive. Similar concerns for 2022 did not lead to cars with the same aerodynamic performance.

The rules dictate an active, dual-mode aero setup that drivers can switch between. One for relatively high downforce and one for low drag and very low downforce. This is achieved by adjusting the front and rear wings at the same time.

The cars, in their high-downforce mode (Z mode) have less downforce and drag than a Monza-spec car would have today. That though is before the teams attack the aero. For sure teams will increase both the downforce and the drag of this mode with their development work. That's likely to include raising the back of the cars again, though not as much as we saw in the past.

Drag will still be low in Z mode, so there are likely to be fewer drag/downforce levels being developed by teams. They can concentrate on maximising downforce in the Z mode and maximising drag reduction for the DRS mode (called X mode). This is how the FIA plan to get more lap time out of a lower total-energy budget.

Today, when the DRS is deployed, downforce is removed from the rear wing which is located behind the rear wheels. That means there is less leverage pulling the rear down behind rear axle centre, so the front has an increase in downforce which is why you see sparking from the (front) skids during DRS deployment. The new rules will allow balanced front and rear downforce losses. The drag benefit will still come from the rear wing and flow changes induced by it. For example, rear wheels have reduced back pressure in X mode, so they have less drag, as will the floor.

Keeping a powerful floor in X mode will allow earlier deployment of X mode on straights so this is likely to be a focus of the teams.

> *"Even in their high-downforce mode the new cars have less downforce and drag than a Monza-spec car would have today"*

Even with the budget cap and with the, ludicrous, number of restrictions placed on aero research, teams have dramatically more than enough resources to find ways around the regulations than the FIA has to investigate and write the rules. This is a problem.

The 2022 rules (aero part) were developed with a group that was about 10% the size of the average F1 squad's aero department at the time. This is why, very intelligently developed rules (which did make overtaking easier) are having their effectiveness eroded by larger teams. I believe the FIA should have a technical team of an analogous size to that of an average team, so their efforts to produce better racing are eroded more slowly by the devious and ingenious efforts of the F1 teams.

As soon as one team finds a loophole that allows them a performance advantage, others will copy the concept. The rule-makers should be in the position to investigate concepts and evolve the rules to ensure close racing is maintained.

Cooling will be another area for development. Front brake cooling will be a massive challenge as there is no energy harvesting there and straight-line speed is higher while corner speed is going to be a bit lower. Powertrain cooling will be a bit easier due to top speed, but ICE driving energy recovery during corners (only way to get enough energy into the batteries) will increase cooling needs back towards those of today.

I am not a fan of the new powertrain regulations, understand, but don't agree. From aero, I believe overtaking will be easier, at least initially. No purist likes the concept of a DRS or second car benefit, but it does assist with legitimate overtaking.

Teams express concern about lap times. Here is a fix, and this is something I would like to see. Have two front and rear wing legality zones of the present (frankly, small) size and larger zones. Dictate which is to be used race by race, just as the DRS deployment is changed now. If lap speeds are too slow, FIA can select bigger wings. If the FIA allow teams to select, this would allow a team to vary their strategy, though only Monza would make the small wings tempting. Same concept will allow annual lap time tuning of the regulations.

Hypercar extension, hydrogen delay

ABOVE The futuristic lines of the H24EVO

THE transition of the Le Mans 24 Hours to hydrogen has been further delayed. But a flurry of announcements, including the launch of the striking H24EVO and Saleen's return, suggested it could be worth the wait.

The Automobile Club de l'Ouest, organiser of the 24 Hours of Le Mans, has now put back the introduction of hydrogen regulations until 2028, citing safety reasons. At the same time, it has extended the homologation cycle for current Hypercar class cars until the end of the 2029 season.

The latter move ensures "the stability of the technical regulations as new manufacturers join the competition each year," but it also crucially buys more time for the tricky transition to hydrogen.

"As a fan of the sport this is an incredible moment for sportscar racing. This is the platinum era," said IMSA president John Doonan of the Hypercar extension. "Today marks two things, stability and opportunity. My hope is that with this announcement other manufacturers will take a look at the top category. We are thrilled to carry on this great moment."

IMSA's convergence with the ACO Hypercar class has sparked a stampede of manufacturers back to top-flight endurance racing. The fast-growing grid, further swollen by the successful introduction of the LMGT3 class, has also prompted the ACO to postpone the introduction of the new LMP2 ruleset by a further two years, from 2026 to 2028.

Hydrogen hype

Mission H24's outgoing H24 electric-hydrogen prototype was joined on track by Alpine's Alpenglow Hy4, Ligier's JS2 RH2, and Solution F's Foenix H2 for a demonstration lap ahead of last month's big race. But it was the news off the circuit, as much as the action on it, which will have heartened the ACO.

The unveiling of a show car of the H24EVO, a sleek new prototype, certainly caught the eye.

The car's maximum power output is now 650 kW or 872 bhp, rather than the 350 kW (470 bhp) of the previous-generation car, and weight has been reduced from 1480 to 1300 kg. The power density of its hydrogen-electric powertrain is 50% higher than before.

Where its predecessors were designed to experiment with hydrogen fuel cell technology, the H24EVO will actively chase performance, with the help of official fuel cell supplier Symbio.

"The H24EVO marks a new step for MissionH24: lining up a hydrogen electric prototype capable of competing with conventional thermal cars," said ACO President Pierre Fillon. "Hydrogen will not be on the track, it will *compete* on the track."

Jean-Michel Bouresche, CEO of H24Project and co-president of MissionH24, said: "The objective that we have set for ourselves is that the H24EVO is the first electric-hydrogen prototype approved by FIA and that it presents a level of performance equivalent to the best GT3s. To do this we must integrate the latest technologies to have the necessary power. I would like to take this opportunity to salute Symbio's very strong involvement in the H24EVO program."

Where the early hydrogen prototypes were bulky, the H24EVO is essentially a single-seater with prototype bodywork (for packaging purposes), with a new tub from Adess. It houses two 700 bar hydrogen tanks that store 7.8 kg of H2 (down from three tanks in the H24), a 400 kW lithium battery and an 872 horsepower electric motor. Stint lengths of 30 minutes and a two-minute pit stop for refuelling are the targets for the project, which will hit the track early in 2025. RT

Saleen to return with hydrogen prototype

FORMER GT1 Le Mans class winner Saleen Automotive has announced plans to return to the endurance classic with a hydrogen-powered prototype.

The California-based automotive manufacturer has signed a partnership agreement with Solution F, which ran its hydrogen combustion-powered Foenix H2 on a demonstration lap at this year's event. The French engine manufacturer is to supply an all-new twin-turbo V6 for the American manufacturer's future road-going supercars.

The engine has the ability to operate on both hydrogen and traditional/synthetic fuels. Solution F will design, manufacture and develop the unit at its French site in Venelles, with technical support from its partner Motul, which will supply specific lubricants.

The French-American partnership will initially involve the co-development of an experimental car based on the Foenix H2, and powered by a hydrogen combustion engine, which will be demonstrated in the United States toward the end of 2024.

"We believe the long-term solution for transportation will be multi-faceted where hydrogen and synthetic fuels are the future in environmentally friendly engines, while still offering the ultimate in performance, and traditional fuelling convenience," commented Steve Saleen.

Renowned for its racing heritage, Saleen won its class at Le Mans in 2010 with the S7.

Solution F was acquired in 2022 by the GCK Group, which is a key player in the decarbonisation of the transport sector. RT

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WAE rebranded as Fortescue ramps up $6.2 billion decarbonisation push

FORTESCUE's US$6.2 billion decarbonisation strategy continues apace, with the rebranding of WAE to Fortescue Zero and opening of a new state-of-the-art technical innovation centre in Kidlington.

The re-brand of WAE, originally a spin-off from the Williams F1 team, emphasises the businesses' ambition to become a zero emissions operator by 2030 and fully eradicating its use of fossil fuels.

The company is renowned for its ground-breaking projects in high-performance battery systems, electrification and zero-emissions technology. The latest example, the battery it has developed for the Extreme H series featured elsewhere in this issue, will be produced at the new Kidlington site.

The facility is billed as a major boost to jobs, manufacturing, and green energy in the United Kingdom. The US$23 million site will be home to 300 highly skilled workers, with up to 50 more jobs to be created across the next year, adding to Fortescue's pledge to create over 1,000 jobs across its Oxfordshire sites.

The Kidlington facility will focus on the technical development, testing and prototype production of batteries and zero emission powertrains for a wide range of applications, including motorsports, mining haul trucks, and other off-road and automotive applications.

Fortescue Executive Chairman and Founder, Dr Andrew Forrest, said, "This new technical innovation centre in Kidlington will not only drive the leading edge of decarbonised motorsports, but also lead the way to decarbonising heavy industry as well.

"Fortescue bought Britain's best racing battery maker not only to help decarbonise our own operations, but to help other businesses to adopt zero emission technologies as well, and cement UK as a green technology and manufacturing leader."

ABOVE Fortescue Executive Chairman and Founder, Dr Andrew Forrest and Fortescue Zero CEO, Judith Judson at the opening of the Kidlington facility

Among the first batteries produced at the Kidlington site, will be those used to power Fortescue's prototype 240 tonne mining haul trucks in Australia.

Fortescue Zero CEO, Judith Judson, said, "Fortescue and other companies need the battery and green technology solutions that will be manufactured at Kidlington, to decarbonise their operations. The world can't afford for businesses to wait, so we are showing them that moving to zero emission solutions and away from fossil fuels is not only possible, but can be profitable as well.

"The knowledge we have learned from racing is applied to everything we do, including our mining haul truck battery systems and other electric powertrains. It is what sets Fortescue apart."

The Kidlington site is co-located on the Oxford Technology Park and will have the capacity to produce and test up to 500 prototype battery systems per year with a total production capacity of 50 MWh/annum. RT

Formula Student to use all sustainable fuels

THE Institution of Mechanical Engineers (IMechE) has extended its partnership with Motorsport UK and Coryton Fuels to provide sustainable fuels to all ICE competitors at this month's Formula Student event at Silverstone.

The initiative is a part of continued efforts by organisers to reduce the event's carbon footprint.

"Motorsport UK recognises that motorsport needs to have a broad view of the future propulsion solutions and incorporate sustainable technology, including fuels, within their genesis," explained Motorsport UK Technical Director, Ian Smith.

"Formula Student is a key opportunity for young, talented engineers to get their first experience of competitive motorsport and many go on to have professional careers in the sport, or associated industries. From the very start of their careers, we want them to consider how emerging technology can be included in designs, without compromising overall performance."

The SUSTAIN Racing E85 and 95 RON E10 fuels offer an 80% reduction in greenhouse gas emissions for the combustion vehicles when compared to fossil fuel-based equivalents. Both are second-generation advanced biofuels, created from agricultural waste, and have been designed to be a drop-in solution.

The fuels made a successful debut at last year's event, where a third of combustion engine teams opted to run them. They included competition winners MoRe Modena Racing from the University of Modena, Italy. This year 33 teams will use them.

David Richardson, Director at Coryton, the company behind the SUSTAIN Racing brand, said: "Sustainable fuels have a huge role to play in the future of motorsport and we're already seeing that in many series across the world. That's why it is fantastic to have this opportunity to show the next generation of engineers what sustainable biofuel can do, and to allow them to experience it in action.

"The fact that last year's winners used SUSTAIN Racing fuel just proves there is no drop in performance – but there is huge potential for the future of a cleaner motorsport industry." RT

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Lancia returns to world rallying

LANCIA, the most successful manufacturer in the history of the World Rally Championship, is to return to the sport in which it first carved its formidable reputation.

A competition version of the new Ypsilon road car will breathe life back into Lancia's rally effort – 33 years after the factory team closed its doors with 15 WRC titles to its credit.

The manufacturer will initially enter only the junior Rally4 division, seen as a category for aspiring young drivers. However, there is speculation that the programme could be a stalking horse for a later Rally2 entry or even a return to the top tier in 2027.

In its pomp, dominating with cars like the Stratos, 037 and Delta, Lancia was so successful that there were even discussions about building a Formula 1 engine for Toleman. Now owned by Stellantis, the brand views rallying as a significant marketing lever as it attempts to revive a name that has laid dormant for years. It previewed its all-new Ypsilon Rally4 HF alongside the road car derivative.

ABOVE The Lancia Ypsilon HF has rally fans excited

Where its road car base model is powered by a 100% electric 240-hp engine, the Ypsilon Rally4 HF will be powered by a 1.2-litre, turbocharged 3-cylinder 4-valve-per-cylinder engine that delivers 212 hp. Like other Rally4 machinery, it will be front-wheel drive and use a five-speed sequential transmission and mechanical limited-slip differential.

"Lancia has always been in people's hearts, its competitive soul represented by some iconic models," commented Luca Napolitano, Lancia brand CEO. "And that sporty heart is starting to beat again today! Those same fans will be the new customers of Lancia of the future!"

The new car bears the HF logo that is the historic signature of high-performance Lancia models. Originally introduced during the 1960 Geneva Motor Show, when a group of passionate Lancia car owners founded the "Lancia Hi-Fi" ('High Fidelity') club, the logo then became a hallmark of the HF Squadra Corse Lancia, founded in 1963 by Cesare Fiorio. He would go on to head the works rally squad and, eventually, the Ferrari F1 team, while the HF would become the signature for many of the brand's victories. RT

WRC hybrid reprieve as FIA u-turn targets stability

THE World Rally Championship will retain its hybrid-powered Rally1 cars for another two seasons, carrying the sport to a new 2027 ruleset.

It had been announced earlier in the year that the hybrid systems would be axed for next season, with aero changes introduced to bring the performance of Rally1 and Rally2 cars closer together. Following a backlash from teams, however, the FIA World Motor Sport Council has revoked the plan, revealing that the WRC Technical Regulations for Rally1/2 cars will remain unchanged for the coming two years.

Manufacturers had complained that the investment for the current ruleset had already been made. The decision buys them a two-year lead time to adapt to the technical changes, which will be confirmed before the end of the current season. In return, the FIA sought long-term commitment from its current Rally1 teams: Toyota, Hyundai and M-Sport.

"The WRC is hugely important to the FIA, and I have had a lot of conversations with the manufacturers over the past weeks about its future direction," said FIA President Mohammed Ben Sulayem. "It is clear now that we all need to have technical stability for the next two years, but at the same time it is important for the FIA that, in providing this stability, we receive the same positive commitment from the manufacturers."

Thierry Neuville, a WRC title contender with Hyundai Motorsport, said: "It is good that we have the stability the teams have requested and from the meetings we had in Sardinia, it looks like there are some interesting proposals on the table for the future development of the sport. In addition to this, the FIA's increased promotional efforts promise to elevate our sport's profile and deliver greater value to all stakeholders. As a driver, I am excited to see the changes that will not only maintain but enhance our connection with fans worldwide, ensuring that the sport continues to grow and thrive." RT

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Racing drivers will be better with AI, says di Grassi

FORMER Formula E Champion Lucas di Grassi has offered an informative take on the transformative potential of artificial intelligence (AI) in motorsport.

"The inevitability of AI's ascendancy is indisputable," he suggested. "Those who fail to embrace its potential, including racing drivers, risk being left behind in the wake of progress."

In recent months Race Tech has encountered a number of startling AI revelations. Among them was the belief of Robin Tuluie, a former F1 title winner with Renault and Mercedes and now founder and co-CEO of PhysicsX, that simulation could be replaced by deep learning.

Motorsport's governing body is bracing itself for possible regulatory battles as use of AI evolves, but it too can foresee AI advances slashing wind tunnel use with aero development becoming a digital-only process. FIA aerodynamicists tested one AI model against inputs taken from their own dataset with impressive results: not only was there a striking correlation between the two, but the CFD simulation consisted of around 300 million cells and took three hours to solve on 640 CPU cores, whereas the AI inference took 11 seconds on a single GPU.

The volume of data produced during a race weekend – an F1 car generates more than 1.1 million telemetry data points per second – makes motorsport an obvious battleground for AI.

"Presently, within the domain of Formula E, the utilization of AI beyond social media applications remains restricted. Nevertheless, the prospect of its broader integration looms on the horizon," di Grassi said in his latest DIG DEEP blog. "Given the copious data generated in motorsport, it stands as an exemplary candidate for embracing the AI revolution. Beyond enhancing performance, there exists a significant opportunity to commercialize AI systems. The development of specific models can yield superior solutions across various areas, such as optimizing electric motor coil wiring, streamlining magnetic flow, or reducing weight.

"When judiciously deployed and complemented by adept software development, AI emerges as a potent tool for enhancing efficiency, reliability, and safety."

Envisioning human-AI collaboration across diverse domains is plausible, suggested di Grassi. In the long run, he can foresee a scenario in endurance racing where cars alternate between autonomous and human-driven stints, with AI learning and optimizing from human input.

Before that, he predicts we may witness real-time car setup adjustments based on AI analysis of cornering tendencies when tyres degrade.

The technology could also, he predicts, transform our use of simulators.

"AI holds promise as a tool for drivers in pre-event simulator sessions as the technology matures," di Grassi said. "Transitioning beyond the driver-in-the-loop model involves creating simulator drivers mirroring human limitations while aiming for perfection... An optimized virtual twin capable of accumulating extensive simulated experience can serve as the ultimate reference point to refine on-track performance comparisons. Imagine what a virtual twin that can drive millions of laps could optimize: the racing line, car set up and strategies.

"It is evident that drivers of the future will compare data with their optimized virtual twin and learn from it."

In light of these developments, he concluded that failure to embrace AI implies lagging behind the curve. "Analogous to abstaining from internet usage, refraining from AI adoption is self-defeating as it denies access to critical data reservoirs," he said. RT

ABOVE di Grassi hard at work for ABT Cupra in Formula E

FIA/Formula E

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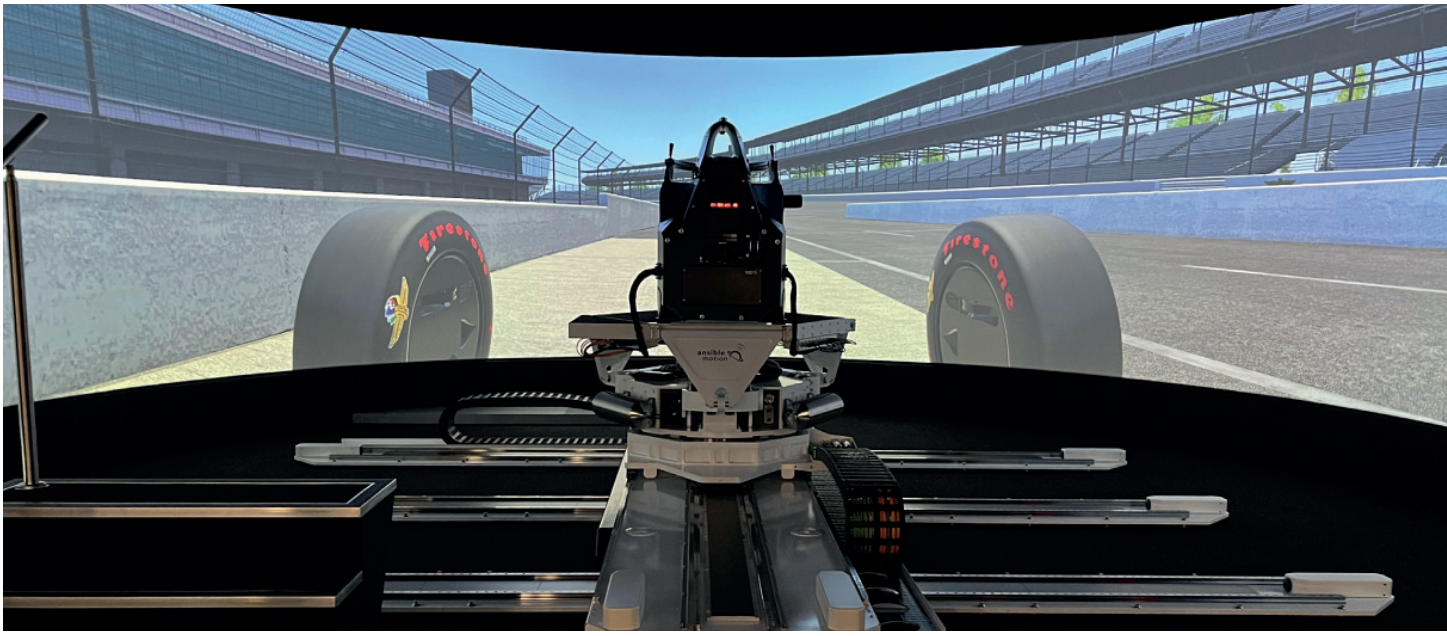
New HRC USA sim to generate 1.5 MB of data each second



HONDA Racing Corporation USA (formerly Honda Performance Development) has unveiled its next generation Driver-in-the-Loop racing simulator at the company's Indianapolis operations centre.

The new DIL simulator features multi-body vehicle dynamics physics simulation software, capable of generating up to 1.5 MB of data each second, with approximately 2,000 available channels. The simulator, commissioned from Ansible Motion, also features multiple cameras recording each session, synchronized to match with the logged data.

The new DIL simulator is a major step forward from HRC's original simulator, which first went into operation in 2013 and had received several significant upgrades through its service life.

"The vehicle physics models have continued to evolve from the original simulator, including the tyre models, and our data acquisition capabilities are exponentially higher than previously," said Ben Schmitt, head of the Vehicle Performance Group at HRC US. "The new motion platform, cockpit and vision systems create a vehicle dynamics experience for the drivers that is our closest recreation yet of real-world conditions."

One of several Honda IndyCar drivers to use the new simulator in preparation for this year's Indianapolis 500, two-time "500" winner Takuma Sato was highly enthusiastic following his session. "This simulator uses a completely new philosophy," he reported. "The movement inside the car is much more immediate, the feeling the driver has is much more accurate. It feels a lot more realistic than anything I've experienced before. It's a huge improvement.

"We're constantly looking for more correlation between the digital world and the real world. That is always a challenge. However, today the simulator model is very sophisticated, and now very close to the 'real world' – even in yaw, which was never possible before. You can feel what's happening in the car more precisely, more accurately, than ever. It's very impressive."

Utilizing a modified Indy car cockpit, the HRC DIL simulator can rotate a full 360 degrees in yaw, with the driver having a 270-degree view from a screen 2.5-metres high and nine metres in diameter to project the on-track images. The simulator can be set up to replicate a current Dallara-Honda Indy car, the Acura ARX-06 hybrid GTP car, and a variety of Honda and Acura concept racing vehicles.

The aerodynamic models used include Honda simulation data obtained through the Honda Manufacturing & Development 1:1 scale "HALO" wind tunnel in Ohio; while powertrain models are the result of Honda and HRC simulation technology. A variety of tyre technology models are available, including both HRC and third-party models; while laser scanning with high-resolution point cloud road surface measuring is used to develop the individual track models. RT

ABOVE The new simulator was utilised by Honda drivers racing in this year's Indianapolis 500

Lola and Porsche commit to Formula E Gen4

LOLA CARS and Porsche have endorsed Formula E's technological roadmap by joining Nissan and Jaguar in committing to compete in the Gen4 era of the series.

While specific technical details for the Gen4 era are yet to be revealed by the FIA and Formula E, it is confirmed that the cars will feature 600 kW of power, up from Gen3's 350 kW, and 700 kW regenerative braking, compared to the current 600 kW – a significant increase.

"Right from the outset, we regarded our Formula E commitment as long-term," said Michael Steiner, Member of the Executive Board for Research and Development at Porsche AG. "The evolution of racing vehicles shows how much development potential there is in e-mobility. Going forward, we want to glean even more knowledge from Formula E that we can transfer to our roadgoing sports cars. As one of the most competitive series in motor racing, it's already pushing us to achieve technological excellence. We look forward to continuing to shape the championship and contributing to the advancement of e-mobility."

"Like Formula E, we want to add innovative technologies and increased sustainability to motorsport – and be at the cutting edge of new developments," added Thomas Laudenbach, Vice President Porsche Motorsport. "The world championship offers a first-class stage for this: racing at the highest level, public interest worldwide and high technological relevance. The knowledge from racing flows directly into our sports cars: motorsport engineers sit shoulder to shoulder with colleagues from road projects. After all, we don't develop technology for the sake of technology – it must benefit our customers."

Porsche joined the innovative electric racing series at the start of the 2019/2020 season.

Lola, another iconic, globally renowned motorsport brand, will join as a manufacturer from next season for the new Gen3 Evo era. The latest commitment to Gen4 will take its participation in the championship through to at least 2030, across six seasons.

Lola's commitment to Formula E is the first of many projects to come, as the British company bids to re-establish itself as an industry leader in sustainable engineering and motorsport. With the focus on electrification, hydrogen and sustainable fuels, its commitment to Formula E will act as a stepping stone to further innovate in these key areas.

Jeff Dodds, Chief Executive Officer, Formula E said: "Their trust in our series for their latest venture into electrification and innovation is testament to our ability to attract the biggest names in motorsport, as well as our joint ambition to continue to grow this championship."

Mark Preston, Motorsport Director, Lola Cars Ltd, said: "Formula E is an ideal platform for powertrain and software development that we can use for broader motorsport and automotive applications.

"We feel the opportunity for innovation in this series will only increase as the performance of the cars and technology develops, giving greater scope to develop innovative technologies across global motorsport and in the broader zero emissions transportation space." MT

BELOW Lola's return to motorsport grew a step closer with the shakedown of a Formula E car powered by the drivetrain it has co-developed with Yamaha

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"The best I have participated in. Very interesting topics; I especially welcome the AI subjects, which were highly innovative. I like the spirit and the ambience of this symposium: friendly in the form, serious in the way the subjects are treated; where questions, answers and discussions are really open and where the debates are real. It is also a good opportunity to network and really useful to see a mix of young and more experienced engineers sharing their ideas."

Bernard Niclot, ACO Consultant

WINGS AIN'T WHAT THEY USED TO BE!

Our **Expert Witness** – an F1 insider who must retain anonymity – addresses the key questions raised by F1's aerodynamics overhaul for 2026

The new rules have just been released to the media, but how long have insiders been working to them already – and how comes?

"The new rules have continually evolved over an extended period of time, numerous FIA versions, during which there has been interaction between the governing body and the teams. Equally, apart from within these bounds, development work is not allowed to start on the final set of aero regulations until the start of 2025. Which were not due to be approved, ratified, and published via the World Council until the end of June 2024. Therefore, amongst the F1 aero community and now the media, the concluding CAD visuals and intent is there, but patience is required for the final wording, freedoms – or lack of them – and clearance to start actual development work."

> *"Size and weight are part of making things greener and it helps the racing, so why didn't the FIA go further?"*

Why do we need this aero upheaval?

"Two reasons, the main one being the new powertrain regulations. With a serious emphasis on electrical energy for 2026, almost trebled, and fuel levels dropping to 70 kg, the cars must have significantly less drag to contribute to this very serious efficiency challenge.

"The second is that through the natural performance chase of the teams, some of the original overtaking and car following homework has been lost since the last major aero regulation overhaul in 2022. Therefore, a reset to create a much lower drag coupled with better ride height behaviour, improved wake and ability to follow and race is the 2026 direction."

X and Z modes will be new to the fans. Can you explain how they work?

"Z mode is the full aerodynamic downforce and drag configuration of the car, utilised in grip-limited cornering conditions, wings front and rear in their highest load condition. X mode is similar to the DRS condition we have now except it is at both ends of the car, has two flap elements being articulated front and rear and will be permitted to be used far more extensively around the lap regardless of the cars' proximity to one another. This is ▶

ABOVE The CAD renders of the new cars may be released but the negotiations on details still rage behind the scenes

Courtesy of F1

Getty Images/Red Bull Content Pool

> *"Powertrain will be king"*

significant as it means active aero will no longer be the overtaking tool within one second of the car in front; it will be powertrain energy."

Some drivers have criticised the new aero rules as unnecessarily complex. Is that really fair?
"At this stage of both powertrain and aerodynamic immaturity, potential DIL simulator scenarios that they may have been exposed to will have been quite different and a concern. Too much energy management instead of driving the car as hard as they would like to, also difficult to truly establish the raceability and overtaking with other cars until rules are fully clear. Give F1 engineers the tools, time and budget and the performance levels transform very quickly."

The return to ground effect was trumpeted as the right solution in 2022, but won't these new cars have less ground effect now? Why is that?
"Ground effect is a very efficient way to produce downforce, so much so it starts to dominate the car characteristics, and in 2022 was also a strong contributor to the improved wake shape for the following car. The problem is this

ABOVE Active aero in 2026 will effectively give the cars a double DRS, with both front and rear wings opening

BELOW The improved racing of the '22 rules reset has been eroded by the teams' development push

Getty Images/Red Bull Content Pool

creates a tendency for cars to run extremely low and very stiff to extract the most performance the majority of the time.

"Porpoising, and driver – even car – struggles with this aerodynamic bouncing and impact with the track was not something the FIA wanted to continue. Therefore, while the improved wake is still an essential criterion, the ability to do this and have aerodynamic car performance at a greater distance from the ground is also the target."

Active aero has been with us in the automotive sector for decades, so why has it taken F1 – the pinnacle of the sport – so long to catch on?

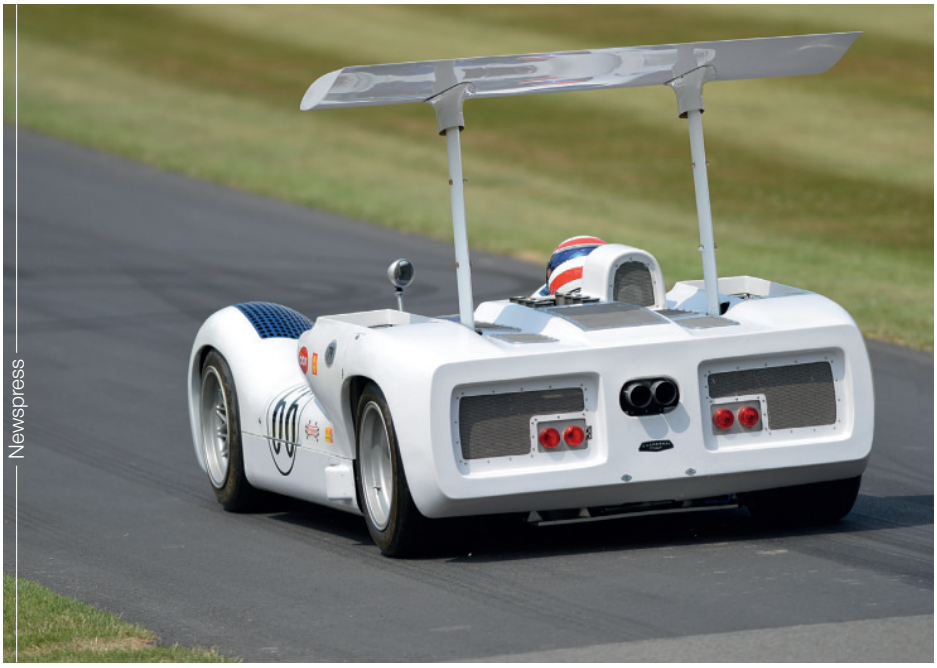
"Part of it has been safety concerns. In the past there have been incidents, some incredibly serious, where movable aero devices have jammed or failed in motorsport. In a road car this gives you a drop in efficiency or a change in cooling behaviour at legal road speeds, with a couple of exceptions where rear spoilers have been necessary at higher speeds and styling solutions. When it goes wrong on a race car, a section of circuit that was flat or a braking zone that was a hundred metres is then the scene of a large accident. However, both safety and the reliability of the mechanisms to operate these devices have come on a long way in the last decade."

Movable front wings were legislated for use in 2009, weren't they? Did anyone use them?

"The movable front flaps in 2009 were an attempt at giving the following car more authority and less understeer when following closely, but the level of benefit in the wake at that time was not enough to make it widely adopted." ▶

BELOW Active aerodynamics have been part of motorsport since Jim Hall's pioneering Chaparrals of the '60s

BOTTOM There was provision in the rules for the 2009 cars to have movable front wings, but the benefits weren't sufficient to tempt most of the teams



Newspress

Haven't you guys always employed active aero anyway, harnessing aero elasticity in skullduggerous fashion!
"True. But deflection tests and measurements have increased and become more comprehensive.
Also, you need the input to deflect something from its design position to a more desirable one; for aero that's load coupled to speed in a particular direction. So, not easy to utilise aeroelasticity at lower speed, or from position A to position B. Opening the flaps for X mode is in the opposite direction to the aerodynamic load, hence fast acting hydraulic mechanisms will be necessary."

What do you make of the 'Override' function? Is it a clever way of doing things?
"With the aero change of Z and X modes necessary for car efficiency it becomes the essential new powertrain version of 'DRS', or 'push-to-pass' as it is called elsewhere. Within a certain distance of the car in front, you will have additional energy to deploy compared to them to assist your ability to overtake. Moving even more authority to energy and powertrain.
"When so much of the FIA aerodynamic effort is all about the ability to follow and improve the racing, it is curious that you still need the powertrain electrical 'bonus' to give an additional benefit to guarantee an overtake. I think it shows just how much emphasis this new era wants to put on the energy efficiency and its management."

What will be king in 2026? Aero or the powertrain?
"Powertrain. Definitely to start with, not dissimilar to 2014. The OEMs that have spent the time and effort to have this right from the beginning will in my view have a significant advantage. As with any technical upheaval at this level, new regulations create diversity of both solutions and performance until they gradually converge again over time."

Courtesy of F1

The last ruleset featured an unprecedented amount of research, but I hear there hasn't been a single wind tunnel test this time around? What have you heard, and has enough research gone into these rules?

"As far as we know it's all been developed in CFD, which is effective for understanding the off-body flow characteristics for wake structures and the ability to race. It is however computationally resource and time heavy, which can mean you have to economise on the amount or type of ground that is covered. There are a couple of principles that the jury is out on, but until a final version is published and then developed it is perhaps unfair to judge."

Getty Images/Red Bull Content Pool

ABOVE The competitive pecking order will inevitably be reshuffled by the revamp, with successful powertrain development dictating the initial order

LEFT The aero revamp targets much lower drag, better ride height behaviour and improved wake

> *"Give F1 engineers the tools, time and budget and the performance levels transform very quickly"*

How much road relevance do the new cars have?

"With most new road cars now having to be mild to significant hybrid and with all fuels improving their sustainable content, F1 is on-message with these steps on powertrain. The concern is really if the balance achieved is correct, if the IC component is being significantly used as a generator, the cars still being too large and too heavy (even if this is also a road car problem), it will feel like a missed chance. F1 should be the pinnacle from both a technical and racing perspective. Ultimately, if the mixture fails to engage, the new formula will have failed."

Too large and too heavy? Ah, so you're not falling for the 'nimble car concept' jargon either?'

"A step has been taken to make the new cars smaller and lighter, but it is notoriously difficult with such a big technology change at the same time to be able to achieve those ambitions. However, size and weight is also part of making things greener, more efficient and it helps the racing, so why didn't the FIA go further?"

"We are going to have to improvise as we go. That makes it a little scary"

The launch of Extreme H heralded the start of a new era for motorsport. **Chris Pickering** talks to the architects of the world's first hydrogen racing series

"**I THINK** there's still this feeling of vertigo. A sense of going into the unknown." That's how Formula E and Extreme E founder Alejandro Agag describes his latest venture, Extreme H.

The hydrogen fuel cell-powered off-road series had its official launch last month, but its competition debut is promised for next year – at which point it will effectively replace the battery electric-powered Extreme E championship.

If it was anyone other than Agag we'd perhaps treat that timescale with a pinch of salt. After all, hydrogen has had a troubled gestation in motorsport and there have been a number of false starts already. But the 53-year-old Spaniard has a track record of achieving the impossible. Crucially, his organisation also has a working car, well into its test schedule, with two more prototypes being built as we speak.

"We already have a car that works, so we know that we're going to have a race," he

Photos: Matt Ben Stone / Extreme H

comments. “But there are still a lot of unanswered questions about how exactly we’re going to do it. We are going to have to learn or improvise as we go. That makes it a little scary, but that’s also what makes it interesting.”

The cars and the format will both draw heavily upon experience gleaned from Extreme E. The motors and inverters, understood to come from Helix, are carried straight over, having proved reliable in the punishing environments of the battery electric series. The battery, supplied by Fortescue ZERO (formerly known as WAE), is based around the same internal architecture as its predecessor too, albeit re-sized and re-packaged. But that’s about where the similarities end. Delve into the details and almost everything is new or substantially evolved.

This is where Agag’s leap into the unknown comes in. “I think what Extreme E was lacking was unique DNA that differentiated from the rest,” he comments. “The format – racing in remote locations and so on – was fantastic. The fans loved it, and the viewing figures were great. But there were other electric championships already, so we weren’t really bringing anything new to the table in terms of technology. If a manufacturer was using motorsport to develop its technology that was in Formula E. Now we become *the* platform for hydrogen.”

It helps, of course, that Extreme H will be a spec series. Furthermore, it will be entirely dedicated to hydrogen, with no need to balance its strengths and weaknesses against other technologies.

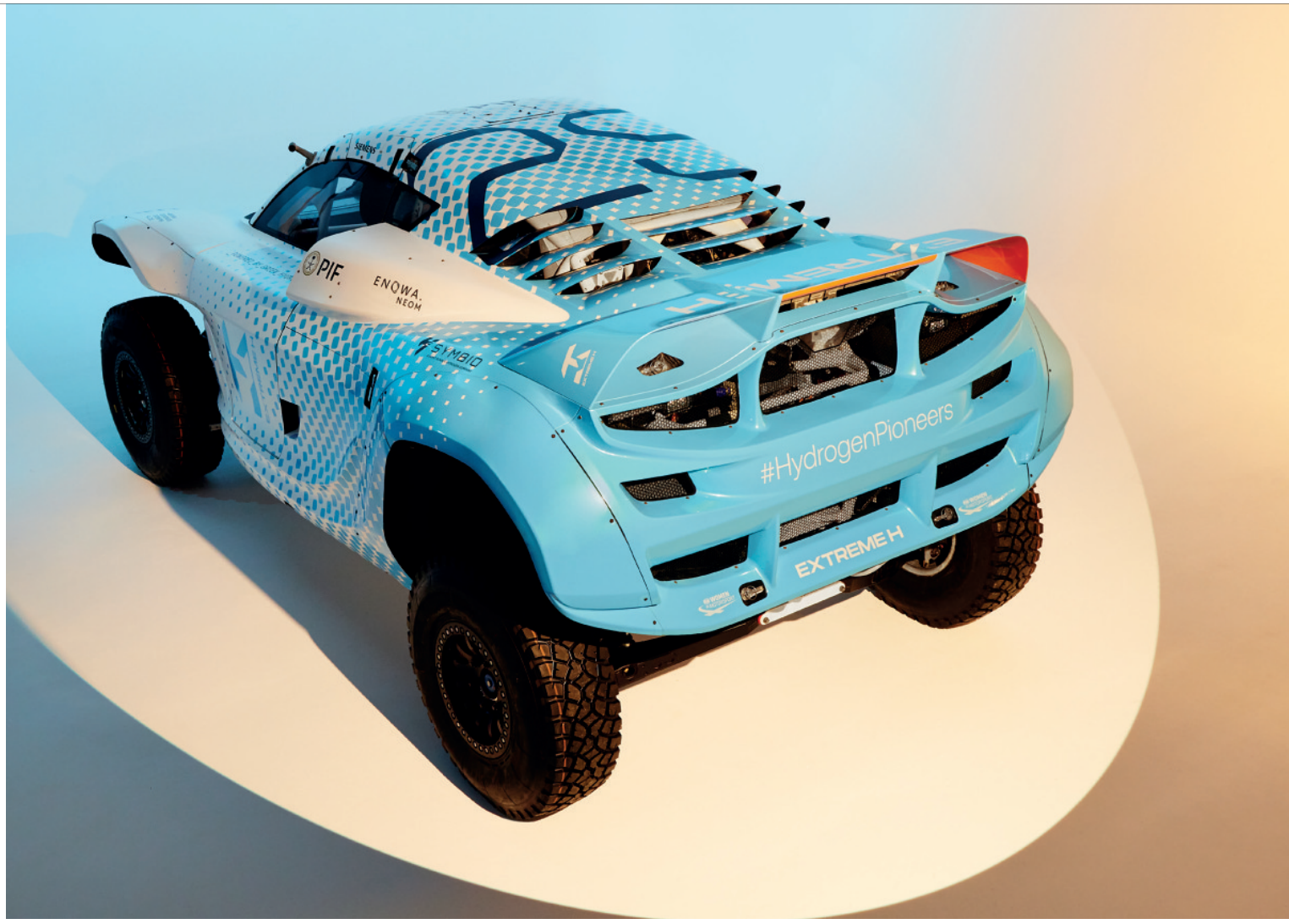
Making a start

Agag and his colleagues already have ideas about how their hydrogen race series could evolve in the future. For now, though, he says that the important thing is to make a start.

“What we’re focusing on is a format that works now,” he says. “It’s a bit like the early days of Formula E. People were saying, ‘What are you doing? The driver can only do half the race in one car and then they have to come into the pits and jump into another one?’ But we just wanted to get started. Once you get started you can come back and improve, but there’s nothing to improve upon if you don’t take that first step.”

Extreme H technical director Mark Grain echoes those sentiments. “You only ever get one chance to do something for the first time,” he comments. “That will always be something that everybody that’s involved in this project can be rightly proud of and always look back on. There’s definitely that ▶

LEFT The chassis is narrower than its Extreme E counterpart, with a new central driving position



element of excitement to it."

It's been a busy 12 months or so since Grain – a veteran of more than 30 years in Formula 1 and IndyCar – took over the post.

"We did our first validation and shakedown test on tarmac back in December and since then we've been out every month up until the end of May. We've tested predominantly in southwest France at places like Château de Lastours, where a lot of the World Rally Championship and Dakar testing takes place. I'm pleased to say that's gone very well. We've racked up more than 1,800 kilometres – so equivalent to three Extreme E seasons already."

Perhaps surprisingly, Grain likens it to his time in single-seaters: "It's not like we've got an existing car and we just need to find a bit more pace. This is an all-new car. There are elements that we've carried over, but the way they combine is totally different. It's a lot like Formula 1 in that respect. You've got to take this new concept and turn it into both a reliable car and a fast car."

The key performance target was to be at least as fast as Extreme E, and Grain reports that both the driver feedback and the outright performance figures indicate that this has already been achieved. The top speed of the Extreme E car, for instance, is quoted as 200 kph, but we're told that the new car has been clocked at 206 kph during testing.

ABOVE The addition of regenerative braking will be a new feature for Extreme H

> *"Once you get started you can come back and improve, but there's nothing to improve upon if you don't take that first step"*

That's despite the extra weight that it carries. The battery may be smaller–– the cube shape of the Extreme E pack flattened into a rectangular slab – but above it sits the fuel cell, and the hydrogen tanks in front of that.

In total, the weight rises to a not-inconsiderable 2,200 kg – 300 kg more than the Extreme E machine. That sounds like a lot. And it is. But the Extreme H car is still comfortably lighter than a fully-fuelled T1+ Dakar car or roughly the same as a road-going super SUV like a Porsche Cayenne Turbo or a Lamborghini Urus. The centre of gravity height, however, is said to be considerably lower than that of the Extreme E car, while the power output is higher.

RIGHT Where Extreme E brought nothing new to the table in terms of technology, Extreme H will be exploring new territory

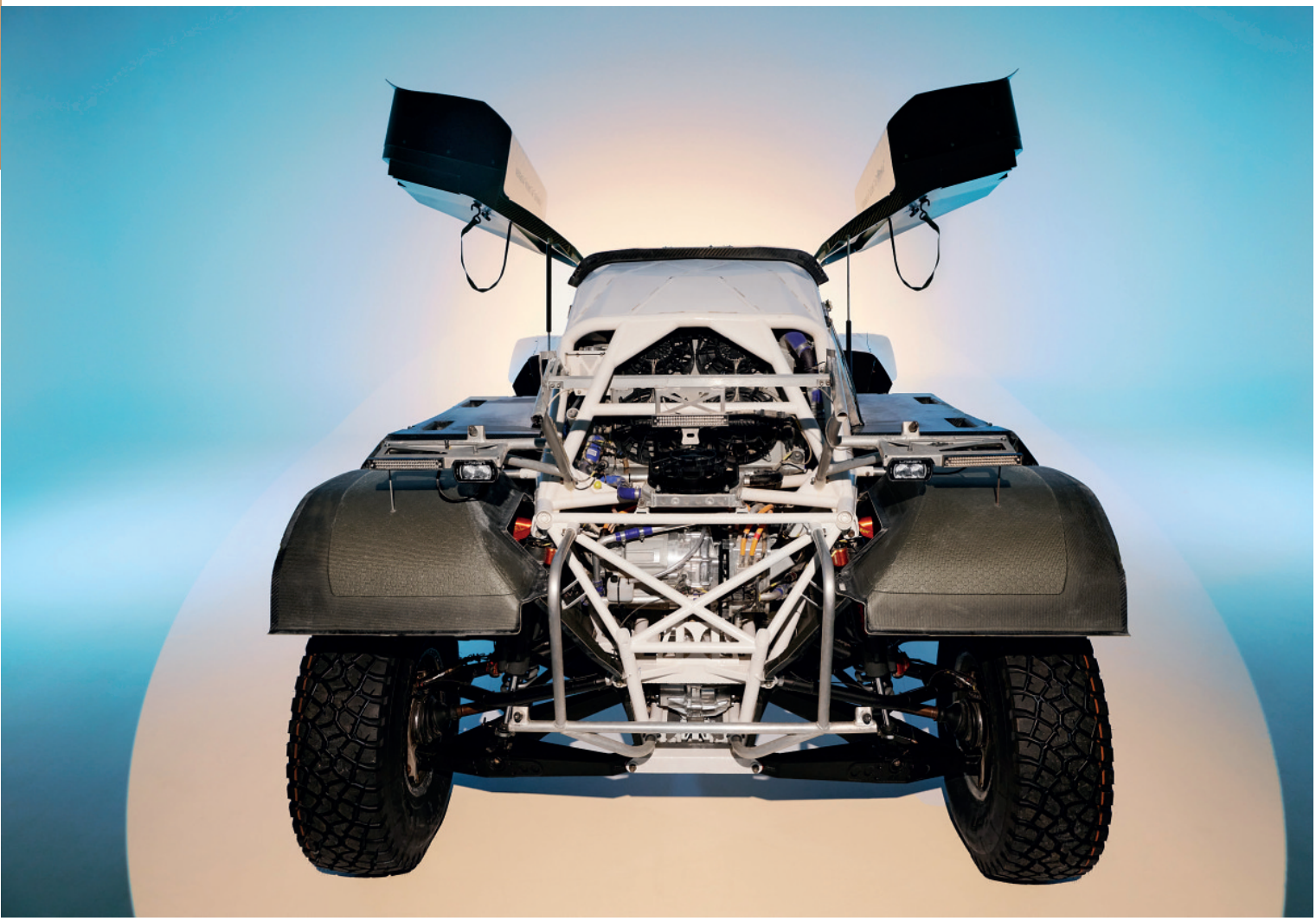
At first glance, the tubular steel spaceframe chassis looks similar to that of its predecessor, but it's a completely new design. The chassis itself is narrower, with a new central driving position making the Extreme H car a strict single-seater. Likewise, the suspension carries over its double wishbone layout, but the geometry is all new.

The exact specification of the fuel cell has yet to be finalised. Extreme H is due to evaluate one final iteration next month with its supplier Symbio, after which the final round of track testing will be carried out and production will commence.

What we do know is that the fuel cell will run at or close to its maximum output of 75 kW, acting as an onboard generator for the lithium-ion battery pack. In so-called Boost Mode, the output of the two systems will be combined to give a maximum of 400 kW. The rest of the time, however, the power will be limited to the 325 kW output of the battery pack, while the fuel cell churns away in the background.

"After an Extreme E heat, the car is recovered to the garage and then immediately gets plugged into a charger. We've done away with that for Extreme H," explains Grain. "The battery will only be charged by the fuel cell. So, the fuel cell will recharge the battery when it's in the garage and then it will form part of the total output once it's out on track."

A new feature for Extreme H is the addition of regenerative braking (deemed unnecessary on Extreme E cars, where the battery had sufficient capacity to run on a total loss basis). This was a ▶



BELOW The fuel cell sits above the battery. Although 300 kg heavier than the Extreme E machine, the car's centre of gravity is lower

relatively late addition to the programme, but testing is said to have gone smoothly so far.

In fact, the test programme in general has gone well, according to Grain. "I don't want to tempt fate, but we feel we're in a very strong position already with performance and reliability," he says. "We have some detail stuff we still need to address like brake master cylinder sizes, but apart from that it's just putting some mileage on the final-spec fuel cell before the test programme concludes."

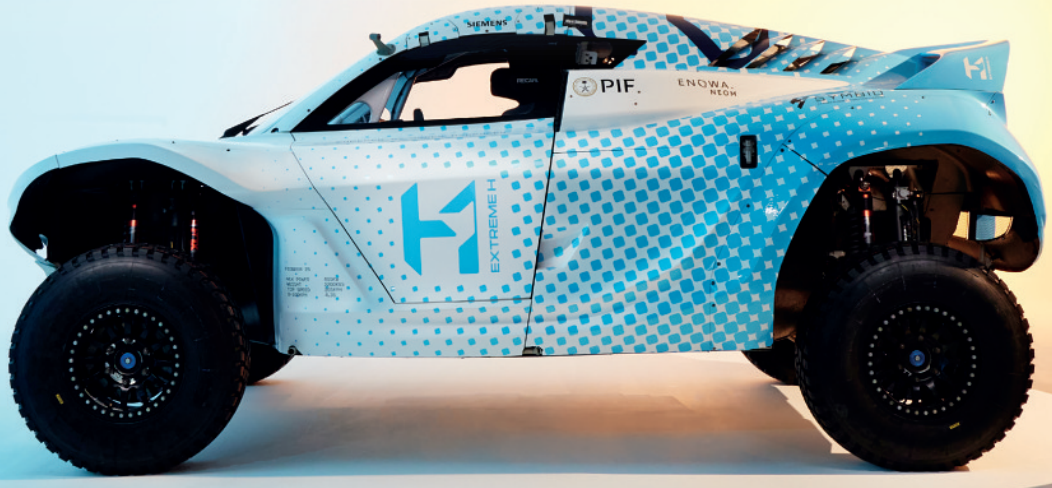
Safety

There are a lot of myths and misconceptions around hydrogen, Grain believes. The Extreme H technical team has spent a lot of time investigating the real challenges behind this exciting new technology.

"Once you get past that image of airships bursting into flames a century ago, the fact is that hydrogen is actually very safe," he comments. "As well as all the safety work done by SPARK in Paris, we've got a relationship with a company called GeoPura in Detroit, which is working on supersonic CFD simulations that can show what happens when a hydrogen line ruptures. The gas is so light that it doesn't hang around waiting to catch fire or explode; it just dissipates."

As part of its work to explore the future of hydrogen in motorsport, Extreme H has worked with Formula 1 and the FIA to set up what's known as the Hydrogen Hub. This is a group of OEMs, championship promoters, technology developers and other interested parties, ranging from the World Endurance Championship to NASCAR.

"What we're hoping to do there is pass on our learning," comments Grain. "One of the really exciting things at the moment is working with the



RIGHT The new car has already racked up more than 1,800 kilometres – the equivalent of three Extreme E seasons

> *Once you get past that image of airships bursting into flames a century ago, the fact is that hydrogen is actually very safe"*

FIA on how to define the regulations around things like crash tests."

The second prototype chassis, which is under construction at the moment, will be sent to the UTAC facility in France for crash testing in August.

"We're working very closely with the FIA to set the technical framework for the safety. Much of that revolves around how it withstands impact – we've got a crash structure in the roof, underbody protection, side impact structures and also a cradle that sits above the hydrogen tanks in the car," says Grain.

The future

The Extreme H approach is very much focused on what can be practically achieved with hydrogen here and now, but the team also has one eye fixed on the future.

One of the biggest topics of conversation around hydrogen motorsport is liquid storage, following the FIA's statement earlier in the year that it wished to focus on this technology. Agag, however, doesn't believe that it's the right solution for Extreme H.

"I think doing an event like the Dakar or Le Mans would be very challenging with gaseous hydrogen," he comments. "A hydrogen-fuelled truck has already completed the Dakar, but it's not easy. The main challenge is the volume of fuel that you need to store. With liquid storage I think it will become a very viable option for those long-distance events. But for Extreme H, we have short races, and the technology is not there yet.

"The tanks still need development; the cost and energy impact of liquifying the fuel is not really practical outside of racing; and road cars won't go to liquid. I think the OEMs will be much more interested in gas. I think liquid is also considered safer than gas if you're going to carry a lot of hydrogen, but that's only really a concern for long distances. If you keep the pressure low, the safety concern is greatly reduced."

ABOVE Extreme H will be testing cutting-edge hydrogen technologies in a competitive racing environment from 2025

Part of the issue is the extra complexity generated by liquid storage versus the benefit it brings, he says: "Personally, I was slightly disappointed when I looked into how much extra hydrogen you can store in liquid. I was expecting maybe 20 times, but it's more like two and half times, so we're still talking about quite a big tank for a long-distance event. If you can go 420 kilometres on two or three kilos as a gas, you can do 700 kilometres on 10 kilos as a liquid. And then you have a Dakar car."

Different configurations

Agag says he sees hydrogen as one element of a much wider portfolio that will include numerous different technologies to meet the world's rapidly rising energy demands. When it comes to Extreme H, he reiterates that the focus will remain on hydrogen. Nonetheless, he foresees different powertrain configurations within that concept.

"I think the next step is to have different fuel cells, but then to go into hydrogen combustion," he says. "That can take different forms. You can use a combustion engine as a generator to charge a battery; you can use the combustion engine on its own; you can use a combination of the two. I think those will be the avenues for the future of Extreme H rather than liquid hydrogen."

Here and now, Extreme H is already on the brink of a world-first, with the hydrogen-fuelled car scheduled to make its public debut with a demonstration run at the Hydro X Prix in Scotland. The test programme should be concluded later in the summer. And then full-scale production for the world's first hydrogen race series will begin.

BELOW Extreme H was officially unveiled on the River Thames in London, aboard St Helena, Extreme E's floating base. The ship is used to transport the championship's freight and infrastructure, minimising Extreme E's emissions by 75 per cent compared to airfreight

EXPLORING THE NEXT FRONTIER

With hydrogen expected to be the next major frontier for endurance racing, **Chris Pickering** talks to two of the pioneers leading the journey

Photos: DPPI/Ligier Automotive

ABOVE The JS2 RH2 has completed over 5,000 km of testing but the Le Mans demonstration was the most important lap of its life

You don't even need to look at the Ligier JS2 RH2 to tell it's a racecar. It's not the name that gives it away either, although the French brand certainly conjures up images of howling Matra V12s and flame-spitting Cosworth DFVs. Instead, as with its iconic forebears, it's the noise you notice first with this thoroughly modern GT racer – a characteristically turbocharged burble at low speeds, which gives way to a six-cylinder rasp as the revs soar towards the red line.

Perhaps future generations will see it differently, but for millions of us, this is the soundtrack to motorsport. And it's something that the JS2 RH2 delivers abundantly. However, the important thing about this car is what's missing. The 3-litre twin turbocharged high power V6 has been converted to run on hydrogen, producing 602 hp and 650 Nm of torque, but zero carbon dioxide. You won't find a hybrid system packed with lithium and rare earth metals, either. The energy storage here comes from the most abundant element in the universe.

The project began in October 2022 as a joint venture between Ligier Automotive (formerly the LMP2-winning OAK Racing squad and Onroak Automotive car manufacturer) and Bosch Engineering. It's a technology demonstrator, loosely based around the Ligier JS2 R race car, but with a thorough programme of re-engineering to accommodate the radically different fuel system and to convert the production-based V6 to run on hydrogen.

Although the JS2 RH2 shares its name and silhouette with JS2 R, the changes beneath the skin are far reaching. While the standard car has a tubular steel spaceframe, Ligier Automotive has developed a bespoke carbon fibre monocoque to accommodate the triple hydrogen tanks on the JS2 RH2. The firm has also taken care of the chassis integration and the vehicle dynamics. Bosch, meanwhile, has developed the engine control including the fuel system, the hydrogen storage system and the functional safety systems.

We last spoke to the engineers behind the project around a year ago when the JS2 RH2 had just completed its first major test at Magny-Cours. Since then, the fundamental layout has remained unaltered, but there's been a comprehensive programme of testing and development, refining the car in time for its most important outing to date – a high-speed demonstration at this year's 24 Hours of Le Mans.

Proven technology

While a competitive hydrogen class may still be several years away – assuming things stay on track with the plans laid down by the FIA and the ACO – the JS2 RH2 is a proven vehicle, which has completed over 5,000 km of testing. During that time, it's faced conditions ranging from summer heatwaves to winter blizzards.

"We tested right through to the end of November last year then carried out some maintenance on the car over the winter, including a precautionary change on some of the fuel system components, some new electrical components and a gearbox refresh. We also did deeper measurement analysis to further fine tune our software strategies and calibration before the car started testing again in March," comments Pierre Humbert, senior project manager for hydrogen engine sports and racing cars at Bosch Engineering.

Ligier Automotive's site director Julien Jehanne says the testing has been very positive: "We're really happy with the way things have gone. We've covered a full endurance racing distance over the past 12 months and the reliability has been very good – we've still got a lot of the original components on the car. There's still some scope to optimise the chassis and the aerodynamics for better performance, but that's normal activity for us so we're confident that we can do that."

> *"Liquid hydrogen would be a step change in complexity"*

Much of the physical testing has been carried out at Bosch's tight and twisty Boxberg proving ground in Germany, but the focus of attention has always been on a certain 13.6-kilometre-long ribbon of tarmac in the Sarthe.

"Le Mans has been the first priority for us this year," admits Humbert. "At the beginning, we weren't sure if we were going to be doing one lap, two laps or maybe more. There are some very long straights, so we needed to check if we'd be okay with the fuel autonomy and the temperature evolution in the tanks. In the end, the schedule for the event only gave us time to do one lap, but the simulations ▶

showed that we could do two laps at full performance, plus a third cool-down lap. We also wanted to get an idea of the car's top speed and its lap time around Le Mans."

Exactly how fast the car will lap the circuit still remains unclear, for a downpour of rain just prior to last month's demonstration left it on a slippery track without the right tyres or setup for conditions.

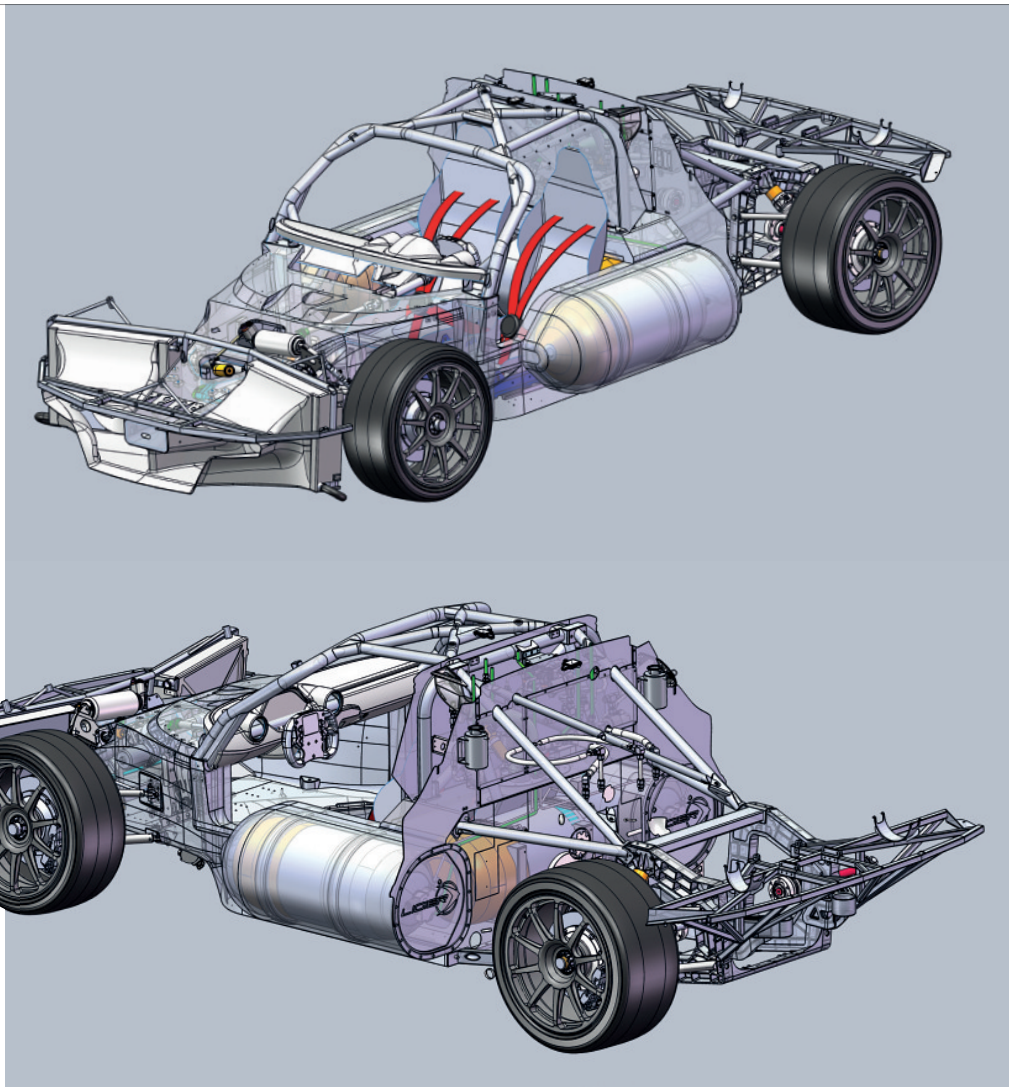
"It was a very special feeling to have the honour of showcasing our demonstrator in front of so many people," says Humbert, who took the wheel for the occasion. "The vehicle worked flawlessly during the lap, so we are very proud of the work accomplished by the Bosch Engineering and Ligier Automotive teams.

"From a driver perspective, I could not wait to realize this dream of driving on the legendary 24 hours track. I was prepared for a bit of stress due to the responsibility, but the last-minute rain made it even more stressful!

"For organizational reasons, the demo lap was unfortunately not a complete lap and all vehicles had to leave the track shortly before the start/finish line. In addition, it rained very heavily shortly before the start, so that the track was wet and a very high speed was not possible for safety reasons. But with a top speed of 230 km/h and a time of 5 min 30 sec we are still very satisfied."

Bosch's simulations suggest somewhere in the region of 4 minutes to 4 minutes 10 seconds was likely had the rain not intervened. Humbert emphasises that the simulation is primarily focused on the powertrain, with comparatively basic models used for things like tyre behaviour and aerodynamics, so there's some leeway on those figures, but the faster end of that range would put the JS2 RH2 right up there with the quickest LMGT3 times recorded at the recent Le Mans test day.

Top speed is predicted to be around 290 kph, which could make the Ligier fractionally quicker in a straight line than an LMGT3. Further testing at a Bosch high-speed test track confirmed that the car was still accelerating at 280 kph at the end of the straight. More importantly, it did so repeatedly and reliably. This sustained high-speed testing also gave the team a chance to check the fundamentals, such as ensuring that the bodywork had sufficient rigidity to prevent fouling the wheels at higher aerodynamic loads.



ABOVE Seen here in CAD, the JS2 RH2 uses three 700-bar hydrogen tanks

RIGHT Big moment: the JS2 RH2 lines up in the pitlane, with the Foenix behind, ready for the world premiere demo lap reserved for hydrogen-powered racing cars

Going the distance

The performance figures certainly look encouraging. However, range – or rather stint length – could be a bigger challenge as things stand. Bosch's original simulations assumed that the tanks would be filled to their 700-bar design pressure, but a change to the planned facilities at the circuit meant that there was only a 350-bar filling station on-site, so the tanks were effectively half-empty.

"After we realised that we would be starting at a lower pressure we went back and repeated the simulations," explains Humbert. "We looked at how the pressure in the tanks would change, and in particular, we looked at the temperature, to make sure it would never go below the minimum limit. In the end, because of the weather, we finished the lap with more hydrogen remaining than expected."

While the engine faces the normal challenge of dissipating the heat of combustion, the fuel system has the opposite problem. Like any gas, hydrogen heats up when it is adiabatically compressed (during refuelling) and cools when it expands (as the gas is consumed and the pressure falls in the tanks).

The JS2 RH2 uses three off-the-shelf 700-bar type IV hydrogen tanks from Norwegian green tech firm Hexagon Purus. These are rated for the standard road car temperature range of +85 deg C down to -40 deg C, Humbert explains.

"We apply a bit of a safety factor, so we generally aim to operate between -30 and +65 deg C. However, we've been fine-tuning

our tank temperature control strategy and we would now be confident to go much nearer to the absolute minimum temperature limit," he says. "One of the key factors is the lining material used inside the tank, but there are new technologies coming for gaseous tanks that use a composite liner rather than a polymer liner, which could potentially allow us to go down to lower temperatures safely."

The temperature in the tanks has to be carefully regulated to maintain safety and durability. If it drops too low, the ECU automatically gradually restricts the engine's power output to reduce the hydrogen mass flow and therefore the temperature drop.

Even starting at a reduced pressure of 350 bar, a full lap or more at racing speeds should be comfortably achievable, but that's a long way from the 12-lap stints that the LMGT3 cars are expected to manage. Bosch is working with its partners on a concept that should improve matters, at least partly.

"We're trying to find a better solution for storing gaseous hydrogen," comments Humbert. "We think it will be possible to store considerably more hydrogen in the same volume as we have now – and we're not talking 50 per cent more, but at least twice as much. We're also looking at ways to move away from a pure cylindrical form to a new type of enhanced conformable tanks that could be shaped around the car's packaging volume. That would give us the same performance as a gasoline car and greater range than a battery electric car with zero impact emissions."

> *"The same performance as a gasoline car and greater range than a battery electric car with virtually zero impact emissions"*

Liquid future

For road cars, he believes gaseous hydrogen will be preferable to liquid storage because of the boil-off issue at such low temperatures. That said, Bosch Engineering envisages hydrogen primarily being used for high performance luxury brands that are looking to retain the emotional appeal of a combustion engine rather than everyday applications.

For motorsport, where the energy requirements are greater, the personnel are specially trained and the refuelling takes place in a designated facility, the long-term solution may well be liquid hydrogen. This approach isn't without its challenges, but Jehanne believes that it will be the way forward.

"Following the FIA announcement that motorsport would be going to liquid hydrogen we started working on some storage and distribution concepts here at Ligier Automotive," he comments. "To do that, there are a lot of things that will be required that aren't available today for a ▶

racing car – things like a cryogenic pump system. We don't have any specific plans yet, but the aim is to develop a demonstrator as soon as possible."

So far, things have gone well with the gaseous storage. After 12 months, the car is still running on the original tanks and distribution units. Much of the pipework is unchanged too. There's an acceptance among the engineers, however, that liquid hydrogen would be a step change in complexity.

"It's another level, I would say," comments Humbert. "With liquid hydrogen you need to keep it at -253 deg C in the tank, and there's a lot we don't know yet. For instance, we know that the hydrogen in the current car warms up a lot as it travels down the pipes – it might start at -20 deg C in the tank, but by the time it reaches the injector rails, which are small diameter rails in the middle of a hot engine, it's up to +40 or +50 degrees. The liquid hydrogen will warm up and turn to gas as it travels down the pipes; we think it will still be a lot colder than it is now, but we don't know how much colder. We need to find facilities that can test our components at those sorts of temperatures, for example."

Bosch is also looking into liquid storage and Humbert notes that it brings a number of advantages beyond the obvious benefit of compact storage. The density of hydrogen is heavily dependent on temperature, so working at a lower temperature will increase the mass of fuel that can be injected in a given timescale.

"You want to be able to inject a lot in a very short time and as cool as possible to avoid possible pre-ignition in the combustion chamber, which might allow us to extract more performance," he explains. "Cooler temperatures will also cool down the injector, which is currently one of the biggest challenges with hydrogen injection, where it's working dry and you don't have the cooling effect of gasoline. Another benefit for motorsport is that you don't have any thermal limitations when you're refuelling with liquid hydrogen, so you could refuel as fast as you like."

A lot of work has already gone into developing rigorous safety systems for hydrogen vehicles. The JS2 RH2 features high-strength anti-intrusion panelling to protect the tanks, a passive ventilation system to expel any hydrogen from a leak or internal component failure and an individual leak detection system at each tank. However, the challenges multiply with liquid storage. The hydrogen can pool on the floor if it spills, for instance. Even more worrying is the fact that the ultra-low temperatures can potentially liquify oxygen, creating an extremely flammable mixture.

"It's a really complex new world, in terms of safety. The FIA has really put a high challenge in front of us," comments Humbert.

Alternatives

It seems unlikely that battery electric vehicles will ever be able to contest events like the 24 Hours of Le Mans. But there is another low carbon option in the form of sustainable gasoline, which is arguably an easier solution. It's an area that Ligier and Bosch are both involved in, and also one that Le Mans and the World Endurance Championship are currently embracing through the tie-up with TotalEnergies. So why not just stick with a sustainably-produced gasoline blend?

"There is room for more than one solution, but the key benefits of hydrogen are that you have no CO2 emissions at all – it's not just a question of releasing the CO2 locally and then offsetting that when you make the fuel – and you have almost no other carbon-based emissions like CO, HC and particulate," explains Humbert. "Likewise, you still have NOx – depending ▶

BELOW The car acts as a high-speed research laboratory as the engineers further their understanding of hydrogen combustion

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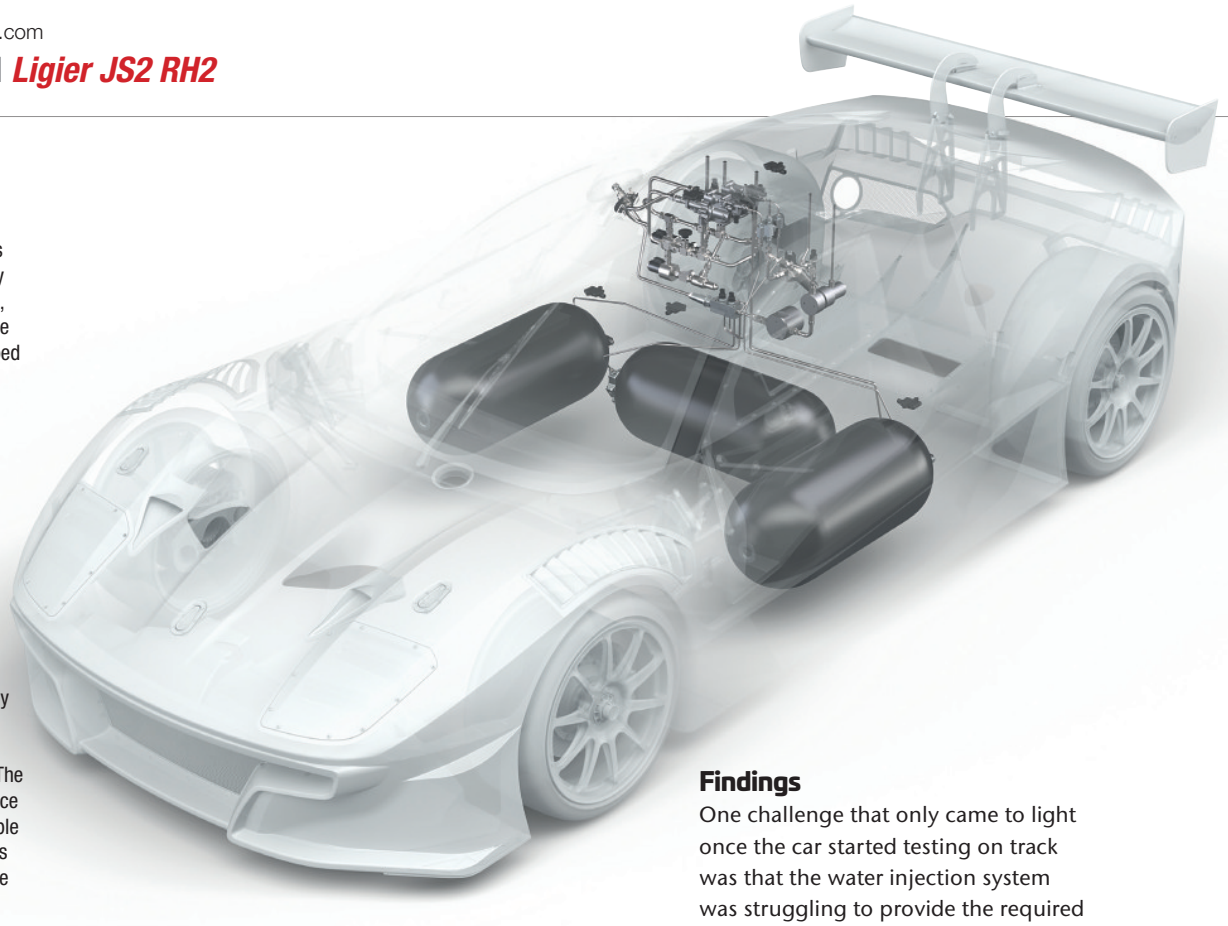

RIGHT The design is currently dictated by the cylindrical tanks, but new conformable tanks could be shaped around the car's packaging volume

BELOW Bosch Motorsport is already a technical partner for the ACO on the Hypercar category. The company's experience could prove invaluable as Le Mans prepares for a hydrogen future

on the air-fuel mixture – and if you go towards lambda one you might start getting ammonia, but we are pretty confident that all of that could be addressed with the right aftertreatment and engine control strategies. The fuel efficiency is also higher than with a conventional gasoline engine."

One of the biggest arguments in favour of sustainable gasoline is that it can be a direct 'drop in' replacement for fossil fuels. Hydrogen does require substantial modifications to both the fuel system and the control strategy, but the changes aren't as fundamental as you might expect. As Humbert points out, the engine in the JS2 RH2 is still very much a production gasoline engine that has been adapted to run on hydrogen rather than a clean sheet design.

"It was a big surprise, to be honest," he comments. "If you run a lean burn engine, you'd need to make changes to the turbochargers, but when it comes to lambda one, like we run on this engine, we can achieve the same power as a gasoline engine with no significant modifications to the hardware outside of the fuel and ignition systems.

There are changes. Notably, a water injection system has been added to control the combustion temperature, which allows the engine to run in the high-power zone around lambda one without running into issues with pre-ignition.

Calibrating this system has been one of the biggest control challenges on the engine – especially once the engineers began pushing for greater performance.

"With a gasoline engine you mainly use the ignition timing to control knock. For hydrogen, you tend to get pre-ignition if you run close to lambda one, so the first thing you do is run a little bit leaner," explains Humbert. "We adjust for that cylinder-by-cylinder, but we realised that this hadn't been accounted for in the original lambda control strategy, so that was trying to enrich the whole cylinder bank to counteract the increased lambda value. That was one of the things we discovered during the deeper analysis over the winter as we began to get higher pre-ignition frequency while pushing the engine performance higher."

The current engine was built to demonstrate the concept rather than to push the boundaries of performance, he notes.

Findings

One challenge that only came to light once the car started testing on track was that the water injection system was struggling to provide the required flow rate under high lateral G loadings. The system has since been refined, but Bosch's work on the engine calibration has also significantly reduced the amount of water injection that's required.

Running the car on track also gave a better indication of drivability. A lot of work went into the post injection strategy, which sees small quantities of fuel injected after the main burn and before the exhaust valves open. This increases the energy in the exhaust gas and improves turbocharger response. "This is the sort of thing that we can develop on the test bench, but you only really find out how well it works once you get the vehicle out on track," notes Humbert.

Similarly, the boost control was modified slightly following the cold temperatures at the test in November.

Porsche AG

Durability

Durability is a key concern on any engine, but dealing with hydrogen brings a whole new series of challenges, Humbert explains: "We've started to notice some areas where the hydrogen is having an influence and we would maybe benefit from changing some materials, but that's really a bit beyond the scope of this project. Our focus at Bosch is on the components and the software strategy – we're not really an engine builder. The purpose of this engine is for us to learn about running on hydrogen, so that we can support our customers best."

Hydrogen embrittlement is a known issue on the valves and injectors of hydrogen combustion engines. This occurs when hydrogen is absorbed into the surface of the metal, reducing its ductility. Running without the lubricating properties of gasoline, the standard gasoline injectors have been found to last for 50 to 70 hours. The use of water injection also brings challenges around wear and corrosion.

None of these problems are insurmountable, but it does mean that engineers working on hydrogen powertrains keep encountering new problems. For instance, hydrogen is an extremely small molecule, which makes it very difficult to contain, so at the beginning of the project the team had to define what actually constitutes leakage and what was considered normal.

"In the first stages we had to speak with the tank manufacturer and find out what to look for and when it's potentially a problem," notes Humbert. "For instance, you can get a small amount of hydrogen trapped between the liner of the tank and the outside skin – it's not a leak as such, but it does mean that you might detect a small amount of hydrogen at a specific OTV venting output. It was just a little problem, but for three weeks we weren't sure if we'd have to stop and change all of the tanks. That was all part of the learning process."

The passive ventilation system, which ducts air past critical components to extract any hydrogen in the event of a leak, has also been refined over the winter to bring warm air from the front radiators to limit the temperature drop in the tanks. "This system does slightly increase the temperature, but that wasn't something we saw in simulation, so it's an interesting finding from the track testing," notes Jehanne.

> *"You don't have any thermal limitations when you're refuelling with liquid hydrogen – you could refuel as fast as you like"*

Future plans

There are no plans to race the JS2 RH2 as it stands, but both companies involved in the project are contemplating where the journey towards hydrogen motorsport might lead.

"From a Ligier perspective, there are several different options," says Jehanne. "We could partner with a manufacturer to build a hydrogen car, we could build our own car for an existing championship or we could look at doing a one-make championship. It's a bit early to say, but we are keen to see the combustion engine on track for as long as possible."

Ligier Automotive already has experience with all three of these business models. The Ligier European Series is currently in its fifth season of single-make racing; Ligier cars such as the JS P2 have won races under their own banner; while the company has also partnered with the likes of Morgan and Lamborghini.

Bosch is focusing on a different aspect, Humbert explains: "Our aim is to get involved with a lot of components, so that could be a customer coming to us to develop their car together with our components, our engine control strategies and our hydrogen storage control unit. Similarly, if the series wanted to use some spec components, we could supply parts to the whole championship. We certainly wouldn't be producing our own car."

It's hard to say when these plans might come to fruition. Initially, the ACO was targeting 2026 for the introduction of a hydrogen class at Le Mans. Following the decision to go to liquid hydrogen that's been pushed back to 2027 and, last month, to 2028, but Jehanne believes it was the right call.

"We're all learning," he says. "We're part of the FIA's technical working group on hydrogen and we find that we're going forwards at the same rate as [the regulators]. I think we need some more understanding before we can put a definite date on any of this."

While the timescale remains unclear, there does seem to be a consensus that hydrogen will be the next major frontier for endurance racing – and possibly Formula 1 as well.

The JS2 RH2 may not be the first hydrogen car to lap Le Mans (that honour has already gone to the fuel cell-powered GreenGT H2), but when the twin turbocharged V6 barked into life for last month's demonstration lap, it still turned plenty of heads.

BELOW Simulations and testing suggest the car should be able to eclipse the top speeds of GT3 machinery


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ASTON'S QUEST FOR THE UNFAIR ADVANTAGE

With GT3 cars now playing a starring role on the world stage, **Chris Pickering** examines the development of Aston Martin's Vantage GT3 Evo

THERE was a time when GT3 was considered a junior formula. Somewhere for well-heeled amateur drivers to hone their skills on Sunday in time to be back in the boardroom on Monday. These days, the Pro-Am format remains a key part of the concept – particularly in the ACO and WEC events, where each car has to have at least one bronze driver – but GT3 is now the premier GT class.

It's this category that a manufacturer now has to be in if it wants its customers to be on the top step of the GT podium at Le Mans or Daytona. That's cemented GT3's position in The Big League – underscoring a gradual progression towards more sophisticated cars and more professional teams that has been unfolding for the past decade or so.

Aston Martin has been a constant presence in GT racing throughout that time. The Vantage, in its various guises, has picked up no less than seven podiums at Le Mans since 2012. A GT3 version of the 'AM6' Vantage was first introduced in 2018, but the car that you see here is the heavily revised Evo version that broke cover earlier this year.

With this car, the Vantage GT3 has once again moved a step closer to the sophistication of the old GTE machines, as Aston Martin Racing's head of performance, Gus Betelli, explains.

"The GT3 is now a lot closer to the GTE, technologically," he comments. "The main difference is that the GTE was a little bit more of a raw racecar if you like; the engine was a lot more heavily developed, for instance, and there was no ABS. It was always very popular with the drivers ▶

ABOVE The Aston Martin Vantage GT3 Evo spearheads a new era of top-flight GT racing

because it drove like a racing car. The GT3 is very much on that level now, but it's a bit more friendly."

He believes that attitudes towards GT3 have indeed shifted since the class came to Le Mans and the World Endurance Championship (WEC): "I think there's naturally a lot more manufacturer interest and investment in the class now. You can see that everyone's putting a lot of effort in, and it's expanding quickly."

The GT3 category works on a homologation basis, with development of each car effectively frozen once the homologation has been approved. Prior to that, the regulations allow a reasonable degree of freedom for manufacturers looking to develop a new GT3 car.

> *"When we evolve an existing design, we're never looking for outright performance. That's counterintuitive for engineers"*

The core monocoque must come from a commercially available road car, subject to a minimum production volume defined by the FIA. Likewise, the engine must be in the same orientation and broadly the same position as the road car, but much of the rest is left open to the manufacturers.

"There aren't many fundamental constraints," explains Betelli. "Obviously, you're not allowed to take a front-engined production car and put the engine behind the driver or something like that, but we have a reasonable amount of freedom. We can cut the road car shell where required to install a roll cage, we can move the engine lower down and further back to improve the centre of gravity, and we can do pretty much whatever we like to the suspension."

Theory of evolution

When Aston Martin Racing launched the first competition variants of the AM6-era Vantage in 2018 it was essentially starting from scratch, with a new chassis, a new transmission and a new twin turbocharged V8 that were fundamentally different in concept to the earlier cars. The GTE version arrived first and was subsequently developed into the GT3.

This time, there's only the GT3 car to consider, and this Evo version carries over the main chassis components and the drivetrain from its predecessor.

"That definitely made our lives easier. We had a very compact timeframe to get the car developed – it started testing in July last year and was homologated in December in time to go to Daytona in January," says Betelli. "So having the confidence in the powertrain and those big reliability items definitely helped a lot. And we could focus on the areas that we're trying to improve."

Top of the list for these improvements was heavily revised suspension, as well as an all-new aero kit, designed to improve drivability and expand the car's performance window in line with the latest targets for GT3.

"We found that we could get the performance we needed out of the previous car as a factory team with experienced drivers, but it was tricky for customer teams and amateur drivers. We wanted to improve the drivability and usability of the car," comments Betelli.

The Vantage GT3 runs double wishbone suspension in place of the multi-link setup used on the road car. There are significant changes to both the geometry and the dampers on the Evo, aimed at making the car easier to drive. Tyre life was another factor, with tweaks to the geometry to reduce operating temperatures.

"One of the main aims with the suspension work was to increase the anti-dive geometry," explains Betelli. "This reduces the amount of weight transfer

RIGHT Large louvres in the front wheel arches evacuate high-pressure air and reduce lift. The exhaust outlets now discharge just behind the base of the front wheel arches

RIGHT An all-new aero kit is designed to improve drivability and expand the car's performance window

BELOW As much downforce as possible was targeted to place the car in a favourable part of the BoP window

and aero transfer under braking and in the corners. On the previous car, we had a lot of dive, which pushed the front splitter closer to the ground and shifted the balance forward. The rear tyres on the GT3 struggled to keep up with the grip on the front during the entry phase."

The reason for this approach on the previous car was that it was derived from the Vantage GTE. In that class, the manufacturers were allowed to run bespoke tyres. Aston Martin discovered that it could exploit the dive to maximise performance if the right tyres were fitted, but it made the car tricky to drive on the control tyres mandated for GT3.

"We did a lot of simulation in the development of the new kinematics, but we also modified the subframes and the mounting points on an older car and tested four or five different geometries on track before we picked one to continue with the development," notes Betelli.

Aero work

There's a strong culture of simulation at Aston Martin Racing's engineering partner Prodrive and the majority ▶

of the aerodynamic work was also carried out in the virtual world. A combination of CFD, wind tunnel and track test data from the previous car gave the engineers a strong baseline from which to start.

"It took a lot of time and a lot of iterations in the simulation to get there, but when we went to the wind tunnel it confirmed that we were exactly where we wanted to be, which was a very pleasing result," recalls Betelli.

The revised GT3 aero targets called for more downforce for a similar drag level, pushing aerodynamic efficiency to higher levels. Additionally, the engineers were keen to address the pitch sensitivity of the old car. The front splitter has been shortened to shift the centre of pressure rearwards, while large louvres in the top of the front wheel arches are designed to evacuate high-pressure air and reduce lift. Notably, the exhaust outlets have also been moved to this area – now discharging just behind the base of the front wheel arches.

Following the current trend in GT3 cars, the Vantage now runs a set of dive planes, as well as large vents behind the front wheels that Betelli likens to the old DTM machines. At the back, there's an even larger stack of louvres that allow high pressure to escape from the rear, reducing drag, plus a revised rear wing.

> *"Pushing aerodynamic efficiency to higher levels"*

"You can really see how much more aggressive the aero is on the car – especially in the area behind the wheels," notes Betelli. "We also wanted to incorporate the design changes from the revised road car. Overall, the target was to be right at the top of the aerodynamic performance window and to get as much downforce as possible."

In theory, the outright downforce and drag figures should be largely academic in a performance-balanced series. However, operating in a favourable part of the window futureproofs the car against BoP changes and gives the teams more setup options. Drivability and consistency at those performance levels is the other key target.

"These cars are very dependent on aero now," comments Betelli. "They're not Formula One cars by any means, but they're so close together with the balance of performance that consistency can make a big difference across the course of a race – if you can ensure that you don't lose too much aero performance following other cars and you don't wear the tyres out too quickly."

Qualifying times at this year's Le Mans in the LMGT3 class were around six seconds off last year's GTE-Am pace. Compared to that category, Betelli says that both downforce and drag have gone up, changing the performance profile of the lap.

"The GTE was very efficient," he comments. "You could have good levels of downforce without a big increase in drag. That car did particularly well at Le Mans – we had four years in a row where at least one Vantage finished on the podium. The only reason for the different targets in GT3 is because that's where the regulations have gone."

Slower lap times across the board at this year's Le Mans don't tell the whole story, however. As Betelli points out, the bespoke GTE tyres alone are thought to account for three or four seconds of that deficit.

The performance-balanced GT3 ▶

BELOW D'station Racing's win in the Suzuka 3 Hours marked the car' s first international victory, in the prestigious SUPER GT series GT300 class

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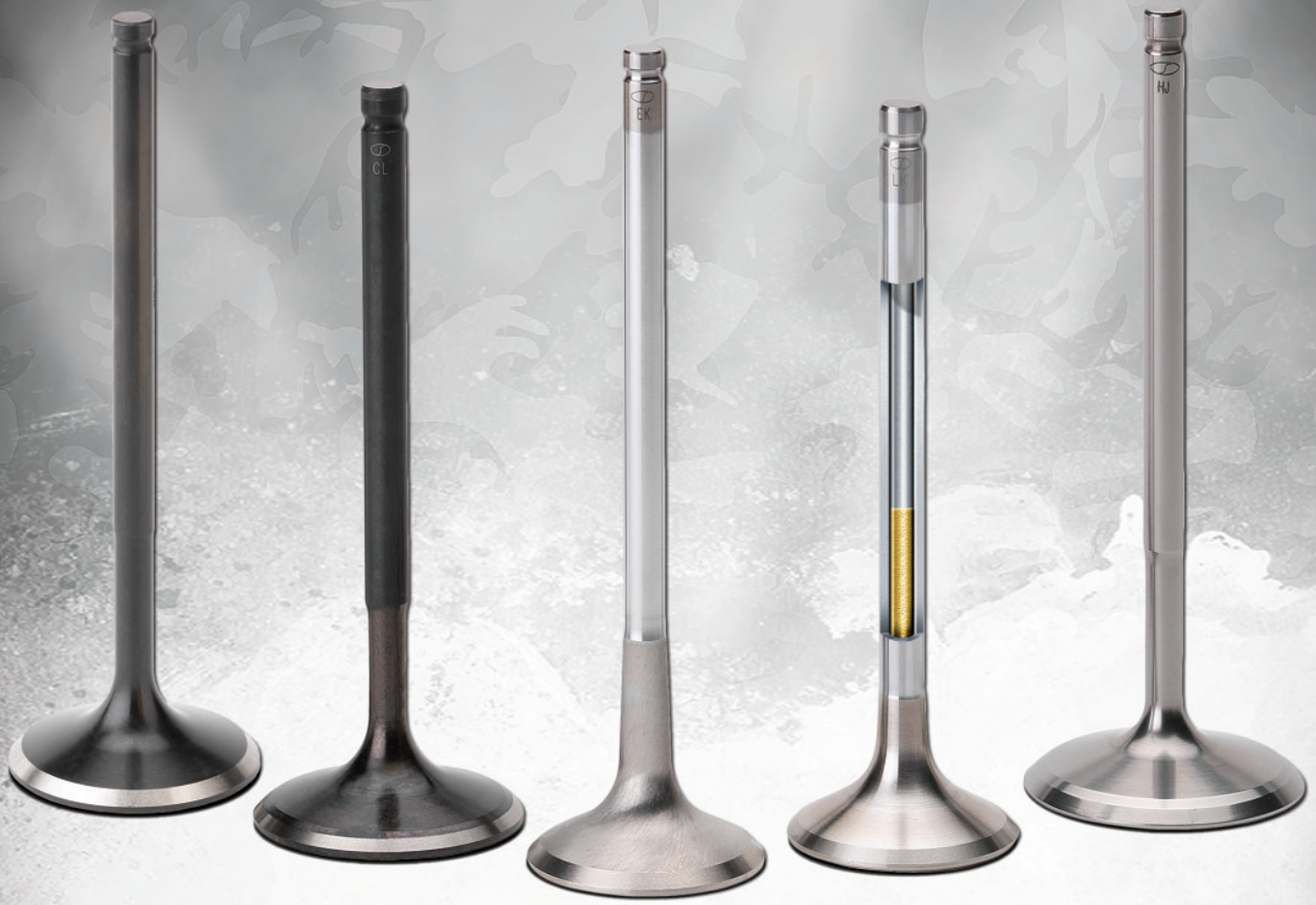

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regulations were specifically crafted to allow cars of varying shapes and sizes to compete against each other. There are front, mid- and rear-engined designs ranging from four-seat muscle cars to sleek supercars all competing against each other. It works too, as demonstrated at Le Mans, where the top five included a Porsche 911, a BMW M4, two Ford Mustangs and a Lamborghini Huracán. Certainly an eclectic selection.

The setup is clearly different, but Betelli feels that the BoP process is clever enough to cope with the contrasts between the various cars. Nonetheless, he does say that racing in a performance-balanced series changes the mindset somewhat.

"It takes some time to adapt, to be honest," he comments. "When we evolve an existing design like we have here, we're never looking for outright performance, and that's counterintuitive for engineers. Instead, all the focus goes on being consistent and being good on the tyres. Like any form of endurance racing, it also places a lot of emphasis on having a car that's reliable, easy to work on and easy to drive across a full 24 hours. That's what will make the difference at the end of the day."

ABOVE There are now more than 25 examples, contesting 10 GT series across the world. The Heart of Racing IMSA squad scooped the new Vantage GT3's first WeatherTech SportsCar podium finish at Detroit, followed swiftly by a win at Watkins Glen

Fighting torque

The GT3 regulations (including their GTD and LMGT3 derivatives) are used in a large variety of events, ranging from sprint races to endurance marathons. Last year there was even a privateer attempt to enter a Vantage GT3 at Pikes Peak. The beauty of the category is that fundamentally the same car can compete in any of these events and Aston Martin was keen to ensure that the new Vantage would be as versatile as possible.

"We wanted to change as little as possible," explains Betelli. "The only aerodynamic difference between FIA events and LMGT3 is the shape of the dive planes, and that's only really because of the different wind tunnel processes that are used. Additionally, LMGT3 uses torque sensors to enforce the power limits, whereas the other series use boost control."

Betelli says he was sceptical initially but he has ended up as a big fan of the LMGT3 torque sensors: "It does make it a lot easier for the organisers to regulate the BoP across all the cars. For the teams, it's easier as the energy usage is calculated and you don't need to worry about fuel capacity or fuel consumption."

The downside to using torque sensors is that they

require a sophisticated closed loop control system to keep the engine output as close to the stated maximum at all times without breaching it. Not surprisingly, it's a similar level of complexity to the torque control systems used on the Hypercars. It's also central to the sporting regulations of the event – if a torque sensor fails, you have to stop and repair it, which is likely to be game over.

In the end, the two Vantage GT3s running at Le Mans this year had no issues with reliability. They both qualified in the top third of the pack, with one finishing ninth, while the other crashed out on Sunday morning. Not perhaps the result that the teams had been hoping for – there was talk of aiming for the brand's 20th class victory in the pre-race press releases.

Of course, there's half of the season still to come. Beyond that, Aston Martin has pledged to continue competing at all levels of GT racing when the much-anticipated Valkyrie finally makes its Hypercar debut next year. Not only is the GT programme helping to prepare for this new challenge, but Betelli says he can see the knowledge transfer flowing both ways.

"I think there's a lot of experience from GT racing that can be translated to Hypercar; the performance is obviously another level but the technology is not that much different. It's still four wheels going around a track as fast as possible, so I'm sure there's a lot of exchanges there that could benefit both programmes," he notes.

While Hypercar opens up the possibility of competing for another outright win at Le Mans, it's sure to be GT3 that will generate more customer sales – perhaps doubly so now that the category spans everything from national-level sprint events to the biggest prize in international sportscar racing. RT

ABOVE The learnings with the GT3 car could translate into benefits for next year's Hypercar campaign

LEFT Performance could be extracted from the old GTE car by professional drivers but it was tricky to drive on the limit consistently

"Saying, 'We have to save the planet' is not the way to engage traditional fans"

All photos: Penske Entertainment

RIGHT Launching a sustainability crusade is one thing, but it will only work if you take the fans with you

The pressure is on to match speed with sustainability, but how do you transform a 108-year-old event that is steeped in a tradition of gasoline? **Olivia Hicks** reports from the Indianapolis 500

BY 5:45 a.m., the streets of Speedway, Indiana held bumper-to-bumper traffic. Gas-guzzling, souped-up trucks vied for a parking spot within walking distance of the race track, with passengers handing over $40 for a prime spot in a neighbour's front yard. The beer – soon empty cans that would spill over bins onto the trackside lawn – already started to flow. And a man, throwing out a few lewd comments, humped the air as a car revved its engine. The spectacle of the Indianapolis 500 had begun even before the 33 race cars consumed a single millilitre of fuel.

Set against a backdrop of Indiana's suburban Americana chains, a slashed state environmental agency budget and the nation of 24-lane highways, the Indianapolis Motor Speedway (IMS) doesn't scream "clean and green".

Despite it all, this year marked the event's most sustainable running yet. Its hardest task isn't hitting emission goals, though, but rather trying to convince resident gearheads that sustainability belongs on track.

Americans are a tough crowd for selling environmentalism in racing, especially at a race as old as the Indy 500. How do you transform a 108-year-old event that is steeped in a tradition of gasoline? It doesn't happen overnight, says Logan Waddle, sustainability project lead for Penske Entertainment – owner of both the NTT IndyCar Series and IMS.

The big question remains: "How do we influence that change to happen faster than it is currently?" he says.

Sustainability at IMS, a new venture, is fractured into four separate categories: transportation, energy, ecosystem and waste. When the COVID-19 pandemic slowed and racetracks began ▶

opening their gates to the public again, Penske Entertainment's owner, Roger Penske, dedicated a full-time role to reaching sustainability goals in each of Penske's four companies.

When Waddle started his current role in 2021, after working in Facilities and Operations and the ticket office, he was quick to address the reality of making a historic track sustainable: "As you can imagine it being a 40-hectare facility that was built in 1909, there are a lot of inefficiencies."

From recycling vehicle fluids through Safety Clean and minimising chassis waste via its supplier Dallara, to adding LED lights and sifting through recycling and compost bins, the sustainability team has made progress in a few short years. It's also been the site of several firsts: In 2021, the Indy 500 became the first global motorsport event to earn Silver Certification

> *"The hardest task isn't hitting emission goals, but trying to convince gearheads that sustainability belongs on track"*

from the Council for Responsible Sport and last year IndyCar became the first U.S. motorsport to use 100 per cent sustainable race fuel.

But what Waddle and his staff of four interns can't control are two of the biggest obstacles: fan waste and public opinion.

With 350,000 people lining the speedway, fans are encouraged to bring in their own coolers full of race day snacks and six-packs. Waddle says it keeps alive the foundation of racing heritage while solving a food and water scarcity problem for the speedway. The only catch? IMS can't control the containers fans bring in.

"It's almost impossible to manage our waste stream," Waddle explains. "You have fans that do bring in styrofoam coolers, fans that do bring in single-use plastic, and film and those types of things. So it makes our sorting process of our recycling a lot more challenging."

Fast food

Waddle is the poster-boy for waste diversion. His enthusiasm over recycling bins is palpable and admirable, if not a bit humorous considering the major thrill is sweeping by those bins at 385 kilometres per hour on track.

He's the first to admit the series is behind. Its recent venture into recycling is a prime example. The slogan "Reduce, Reuse, Recycle," gained popularity in 1976 when the Resource Conservation and Recovery Act

ABOVE Convincing its diehard fans of the need to change old habits is IndyCar's hardest task

passed in the states. Despite recycling's surge in the late '70s, it's still novel in IndyCar. It was Waddle who rallied support for adding the green bins at the speedway.

"It's a lot of behind-the-scenes stuff that a fan might not see around here, but it's made our practices so much better and has helped us reduce our waste so much," Waddle says.

IndyCar inches forward hesitantly. While external sources, also known as scope three emissions, make up 80 to 90 per cent of the series' carbon footprint, public opinion may be the tougher obstacle.

"When you think about motorsports or venues in general, you don't think about sustainability first, especially with a series like ours that burns fuel and [is] travelling across North America," Waddle says.

Motorsport, like politics, is values-based.

Maggie Kuhn is a Will Power superfan. Showing up with Team Penske's logo plastered to her body and a Power cardboard cutout balanced in two hands, she's visibly vibrating with something between anticipation and elation. In Indiana, there are rows of Maggie Kuhns, all showing up to support the driver of their choice. It's the kind of belief that is only seen

BELOW The fans of the future are more likely to heed the sustainability message

on ballots and in front of altars. The kind of steadfast faith that pushes a race car past the finish line.

Where environmental policy has worked is when values are woven into the argument, rather than scientific facts. Take Georgetown, Texas, for instance. How did a Republican oil town become the heart of America's wind energy industry? By never uttering the ill-fated two words, "climate change". By 2017, the small town was one of the only cities totally fuelled by renewable wind and solar power. The decision wasn't about saving the turtles or clearing the smoggy air, but rather, money. With tax incentives and a payout of roughly $10,000 a year per turbine, the decision was personal.

ABOVE & RIGHT IndyCar became the first U.S. motorsport to use 100 per cent sustainable race fuel

BELOW A fleet of electric trucks is one of the weapons in the speedway's armoury

American motor racing is tasked with the same challenge: make sustainability personal.

"I can't be going out there saying, 'We have to save the planet!' which is obviously how I feel but it's not the way to engage with traditional fans," Waddle insists. "So really, it's about joining a cause together. I think what has helped us a lot is saying, 'Hey race fans, come on out and enjoy your time at the track. And while you're here, help us reduce our footprint by recycling.'"

The Indy 500 continues to look and feel like a traditional motor race in the face of electric series' increased stateside presence. When Formula E sped through the Portland International Raceway for the first time last June, it was the equivalent of a racing revolution: The gentle hum of the electric powertrains ▶

allowed for easy conversation with your seatmate, fans could seek shade under tents while sitting on bicycles powering phone chargers and few concession stand food wrappers ended up in the bin. The whole scene seemed contradictory to American motorsport.

IndyCar keeps the roar of engines and embraces the culture of booze, debauchery and country music while quietly working to make sustainability possible. And that's precisely the trick.

"That's more relatable to fans and to the industry. You can't rebuild your life to be net zero, but you can make changes in your life to be better for the environment," Waddle explains. "You're seeing the evolution of internal combustion engines to electric and soon hydrogen out on the road, but most people aren't driving electric vehicles right now in the state of Indiana, at least. And so I think that it makes our story [relatable]. To our fans, it's taking the sport that they already love and leading by example, by taking the steps in that direction to protect the sport for future generations."

Motorsport series founded on sustainability – like Formula E and Extreme E – have excelled in luring in a young, hip and eco-conscious audience. While eco-series continue to face their own set of challenges – namely claiming legitimacy in performance – they started from scratch. IndyCar, however, is more representative of the challenge every other industry faces, including automotive manufacturers.

ABOVE A lot has happened behind the scenes to reduce waste and improve the practices employed

Unlike Formula 1's high-brow constructors – Ferrari, Aston Martin and Mercedes – IndyCar must sell vehicles to the American masses. With deep ties to Detroit's automotive factory lines, teams sport one of two engine manufacturers: Chevrolet or Honda.

General Motors – owner of Chevrolet, Cadillac, Buick and Hummer – aims to slash all tailpipe emissions by 2035 and is "on its way to an all-electric future".

Honda boasts a similar story. The Japanese manufacturer may have started out 6,576 miles away from Indianapolis, but now produces the top-selling small car in America: the Honda Civic. Honda plans to reach carbon neutrality by 2050, along with using 100 per cent sustainable materials.

History of road relevance

The Indy 500 has a track record of accelerating road car development. During the inaugural race in 1911, the rearview mirror made its first appearance. It would revolutionise road safety in the decades to come.

Now a hundred-some races later, IMS faces another road relevance issue: how to prove performance and sustainability can coexist.

"The rearview mirror was invented here, turbocharged engines were invented here, seatbelts were tested here, those safer barriers: so many classic things that we take for granted today in the automotive industry were piloted here at IMS," Waddle ▶

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says. "So for me, I think sustainability is that next step."

This year's 500-mile event made a pretty convincing argument.

The race result came down to a final lap shoot-out. Arrow McLaren's Pato O'Ward was lined up to stand drenched in milk atop the podium before Josef Newgarden's Team Penske Chevrolet swung around to snatch his second and consecutive Indy 500 win. The race had squeezing, swerving, flailing engines and all.

While Waddle worked on discreetly containing off-track emissions, attention was solely on track where IndyCar's foray into sustainable fuel was central.

At the beginning of the 2023 season, the Streets of St. Petersburg became the first race where all teams used 100 per cent renewable fuel. While IndyCar's European counterpart, Formula 1, tests a 50 per cent hybrid system ahead of the 2026 engine regulations and first introduced electric power in 2009, IndyCar is a bit behind schedule. Sustainable fuels cut down the global dependence on fossil fuels and have reduced IndyCar's greenhouse gas emissions by 60 per cent, but they aren't an entirely "clean" solution. Biofuel, or fuel from plant sources, still releases carbon emissions through combustion.

Despite IndyCar's impending switch to a hybrid system, sustainable fuels have become part of the series' brand, and whichever city IndyCar visits, it's hard to miss the bargaining from Shell. In Indianapolis, a reminder of the environmental shift hung in the form of banners from local businesses around Monument Circle and slipped into post-race reports. In Detroit a week later, Scott Dixon's victory didn't just see him saving fuel, but "just enough Shell 100% Renewable Race Fuel to reach the finish while parrying the charging [Marcus] Ericsson," read the official press release.

The series' focus on selling sustainable fuel to fans is to be expected: refuelling, outlawed in Formula 1 in 2010, is ever-present as a team's tank load often determines who crosses the chequered flag first.

Despite fuel sourcing contributing to the bulk of IndyCar's net zero marketing strategy, neither IndyCar nor IMS have a public decarbonization deadline. However, Waddle insists the speedway and series are tracking emissions.

"Behind the scenes, what we're going through right now is evaluating what we can actually achieve with a decarbonization strategy, and what's within our boundary before we say it publicly. We work with consultants and we track our emissions for the entire organisation across all scopes. There are some

RIGHT Technology seen through a sustainable lens: Shell's Re-Refined Base Oil component, announced during the Month of May, offers a 50 per cent reduction in GHG emissions compared to the base oil used in the 2023 series

BELOW McLaren trialled a new core material made from recycled plastic bottles in its weight jacker at the Indianapolis 500

organisations who have their strategies in place and don't necessarily track all of their emissions," Waddle says. "We want to have the data to show that we can do it before saying it."

In an era of 2030, 2040 and 2050 net zero carbon emissions deadlines streaming in from automotive manufacturers and investors, there's pressure to put a date on environmental efforts to ensure accountability, even if companies aren't on track to meet them.

IndyCar is transparent about a few facts and figures. Mostly those consist of the positives: Renewable Energy Credits purchasing 100 per cent of electricity during the month of May, using battery electric tractor trailers to transport tyres in "the first zero emissions tyre transport solution in motorsport" and IndyCar's transporters using 100 per cent renewable diesel. However, they also acknowledge that travel – an integral part of motorsport – is the top emissions source.

As team personnel fly from Wisconsin and California to Ohio and Portland, the emissions add up.

> *"The decision wasn't about saving the turtles or clearing the smoggy air but, rather, money"*

"Europe is just ahead of us right now on the solutions that can be found for travel. We don't have very much or very accessible rail transit or zero emission transit here in North America," Waddle explains. "So figuring out how do we reduce that footprint from travel? How do we incentivize carpooling and biking and walking and those types of things in the markets where it's available and also make it easy for everyone to do so?"

Environmental impact

Despite being ahead of IndyCar, Formula 1 has a heavier environmental impact. McLaren's breakdown of emissions by series ranks Formula 1 as the top emitter, contributing to 79 per cent of company emissions while IndyCar comes in second place at 10 per cent. Formula E follows at seven per cent while Extreme E accounts for just one per cent of total emissions, according to its 2023 Sustainability Report.

The first constructor to employ the widespread use of carbon fibre in a Formula 1 car, McLaren Racing attempts to extend series-specific sustainability practices from one continent to another. However, IndyCar's American base and technical spec regulations limit individual teams' innovation. While the papaya-coloured racing company may lead by example with a 2030 deadline to slash emissions in half, McLaren's IndyCar branch doesn't control the input or disposal of vehicle materials.

"It is important to understand that in IndyCar, we have less control over the design and construction of cars compared to F1 constructor teams. Most carbon fibre parts, from chassis to aero package, are specified by the IndyCar series. That said, we seek more circular alternatives in the handful of areas where we can modify the car," Cristina Padilla, Arrow McLaren 's senior sustainability specialist, says. "For instance, our Indy 500 cars trialled the use of a new core material – a filler in the weight jacker, a device used on ovals to manage weight distribution diagonally across the car – made from recycled plastic bottles. This new material not only saved resources, but it was lighter in weight and more cost effective.

"The materials we build our cars with, similar to those in the automotive industry, tend to be carbon intensive. Think carbon fibre, steel, aluminium, etc," notes Padilla. "That is why it is such a priority for us to identify and trial alternative materials – like those made with recycled content or natural materials."

Transformation

IndyCar may well lag behind the fledgling motorsport series in the sustainability stakes, but Waddle contends that the comparison with other sporting championships and venues, even within motorsport, isn't particularly fair or accurate.

"IndyCar is transforming what's already the most historic race in the world and a historic racing series. We're not building it around sustainability," Waddle says. "Not to discredit anything Extreme E or Formula E do because they're doing great work and they should be very proud of everything that they've done, but for us, the challenge is: how do you take what already exists, and use your routes of innovation and technology within the lens of sustainability to make your series better for the environment?"

But if IndyCar isn't comparing itself to others, how are emissions "on track"? The series' North Star is the Sustainable Motorsport Index and the collaboration – rather than competition – between NASCAR and Formula 1.

Before the Indy 500 can start publicly slashing emissions, it first needs to win over its own fan base and suppliers.

"It seems a lot of times like the external parties who have an impact on emissions think I'm coming in to ruin their sport when I'm trying to protect it," Waddle says. "I think that we have to decarbonize in order to continue having this greatest spectacle in racing and to keep this tradition going that we have here with the Indianapolis 500 and the IndyCar Series. Some folks view it as more work or more money. But for me, it's really about the next step in our journey as an organisation and as an industry."

NORTHERN LIGHTS

Scandinavia is adopting an all-electric Touring Car formula that could provide a path to a motorsport future far beyond the shores of northern Europe. By **Andrew Charman**

IT should possibly come as no surprise that Scandinavia is set to be the scene of the boldest move towards electrification in Touring Car racing yet seen – the Nordic countries have long led the adoption of the electric vehicle, the EV, amongst consumers and in December 2022 more than 80 per cent of new cars purchased in Norway were electric.

At the end of 2021, there were around 300,000 rechargeable passenger cars on Swedish roads. Such vehicles accounted for half of sales over the following six months, more than a quarter of them full EVs.

So the rebranding of the Scandinavian

All photos: STCC

Touring Car Championship (STCC) is perhaps a natural progression, while also providing a future for a series that has faced challenges in recent times, including the bankruptcy of its then organiser in 2019. Evolving from a merger of the Danish and Swedish Touring Car championships in 2011, the STCC has been run for TCR-spec cars since 2017.

A year earlier, however, some of the core competitors in STCC began looking to the future and the possibilities of electric propulsion, and the championship announced its intention to go electric in 2022, planning to run its first season in the following year. This was, however, delayed, organisers blaming delays in the production of 12 new cars for the series. Now it is all systems go for an inaugural 2024 season.

The 2024 STCC will be the first electric national touring car series but not the first of all. Formula E, the standard-bearer for electric motorsport, has tried and struggled to run tin-top support series alongside its headline single-seater World Championship. The first was the Jaguar I-Pace eTrophy – an 'arrive-and-drive'-type championship with cars prepared by Jaguar that was organised as a support between 2018 and 2020 before being ended by the COVID-19 pandemic.

Turbulent transition

Much more recently a 'NextGen Cup' was announced as a support to Formula E's European rounds in 2024, again to an arrive-and-drive format with its cars based on electric Mini Coopers. Much to the bemusement of Formula E personnel, the NextGen Cup pulled out just one week before the first round was due to take place at Misano in April, blaming delays in getting the junior series ready for weekends with the World Championship. It plans to race later in the year, with some rounds alongside the DTM series for GT cars.

The most high-profile attempt at all-electric touring car racing so far has been ETCR. Launched in 2018 by WSC Ltd, the organisation led by Marcello Lotti that had established TCR as a highly successful Touring Car format across the globe, ETCR was intended to change the public perception towards electric touring car racing. At the time François Ribeiro, head of Eurosport Events which promoted the series, said: "The industry is changing energy for the very first time – motorsport cannot ignore it and say we will run a combustion engine for the next 20 years."

Manufacturers were encouraged to build their own cars to the regulations and following a COVID-caused delay the first Pure ETCR series took place in 2021 with cars from Alfa Romeo, Cupra and Hyundai competing. Meetings were run in a very different format to traditional ▶

LEFT The switch to an electric format could be the saviour of the STCC

Touring Car races, competitors progressing rallycross-style through short heats to a final, and for 2022 the series gained FIA World Cup status. But before the 2023 season it was canned, its demise blamed on the various parties involved failing to agree on a future direction.

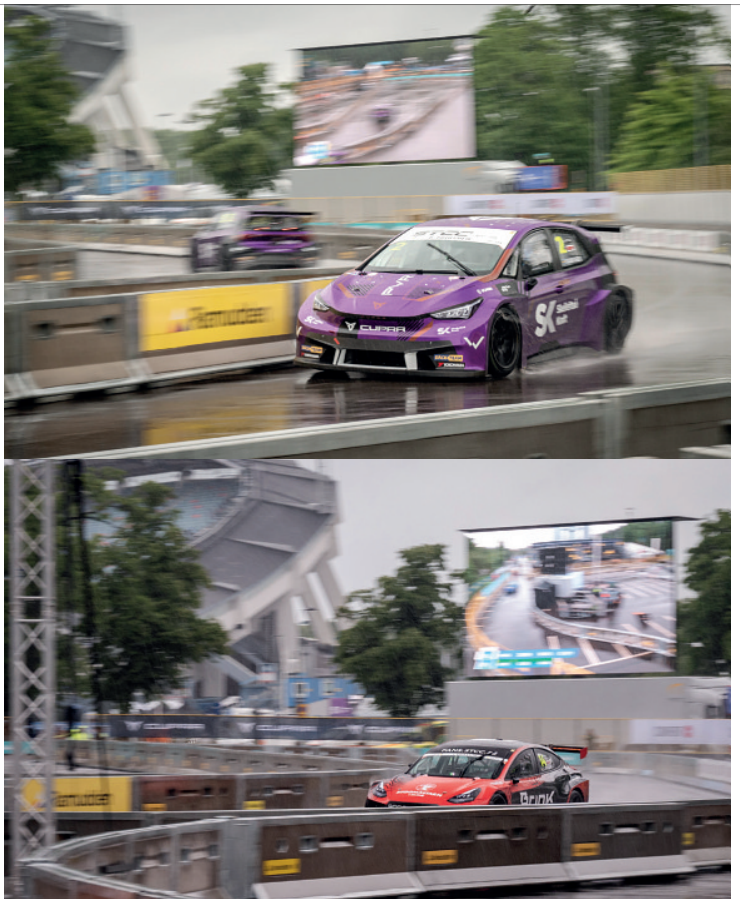
New power, old style

So the STCC appears to be stepping into dangerous territory as it enters its first season of electric power, but in many ways the series seems to be going about things in a correct way, taking a more traditional approach rather than trying to reinvent the wheel. Cost has been a central factor, encouraging a concept of simple races and an equally simple set of technical regulations in comparison to the complex four-motor ETCR machines.

In 2019 Francois Ribeiro predicted that to run an ETCR car would require a similar level of financial investment to the budgets of the former World Touring Car Championship – which had in 2018 resulted in the WTCC adopting the far cheaper TCR format. Certainly the ETCR route would be a non-starter for even the most affluent national series.

The initial six-round, five-meeting STCC series, which began on 8-9 June, includes three rounds raced in a head-to-head format similar to ETCR, and following the Formula E lead, racing in temporary city-centre venues in Helsingborg and Gothenburg. But the other three rounds will be to typical race formats on the Ljungbyhed, Ring Knutstorp and Mantorp Park circuits.

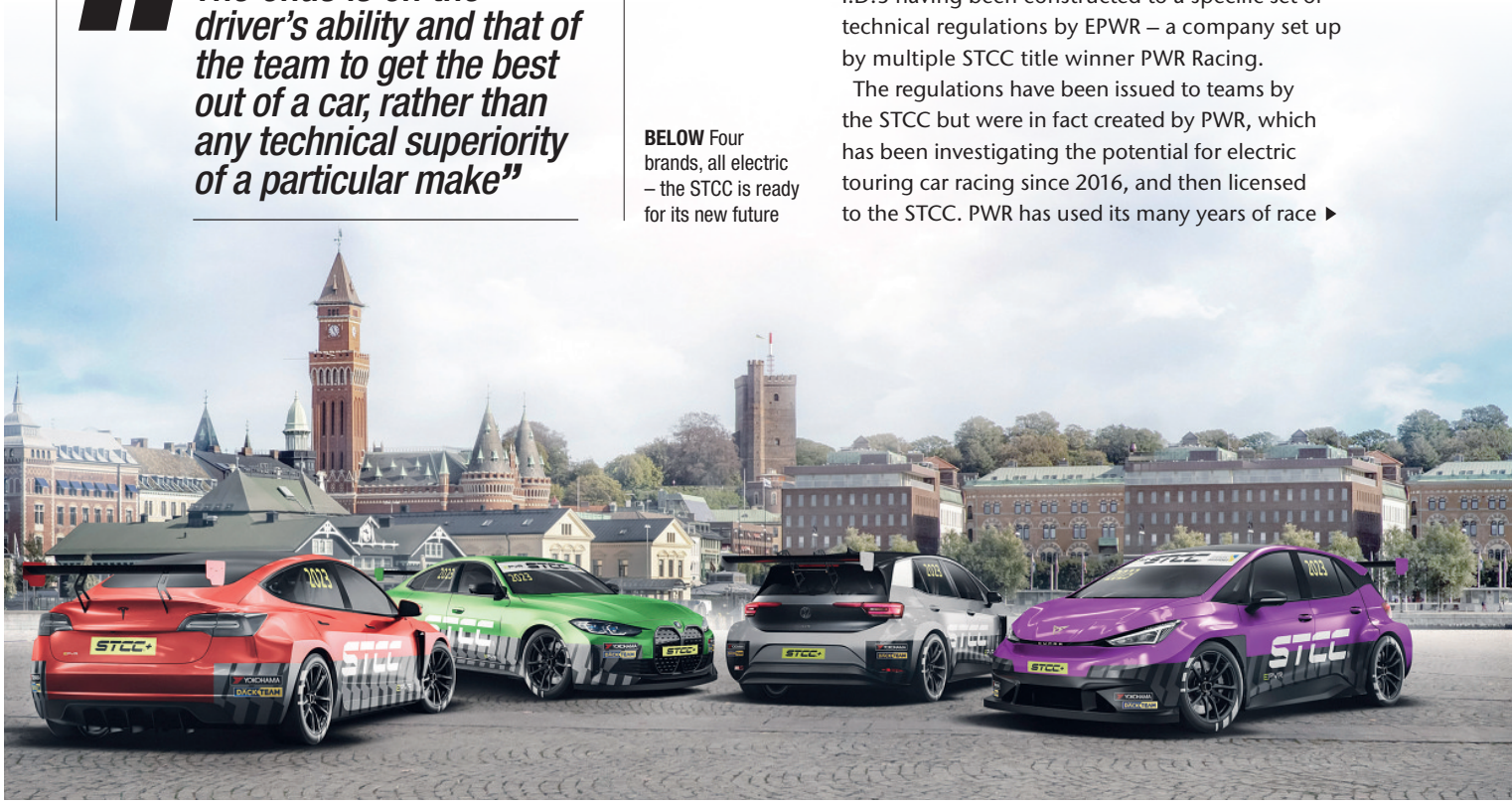
> *"The onus is on the driver's ability and that of the team to get the best out of a car, rather than any technical superiority of a particular make"*



ABOVE The STCC premiere weekend took place in Gothenburg, using a Head-2-Head format

Four brands of car have been confirmed for the 12-strong field that comprises the opening season of competition, three examples each of a BMW i4, Cupra Born, Tesla Model 3 and Volkswagen I.D.3 having been constructed to a specific set of technical regulations by EPWR – a company set up by multiple STCC title winner PWR Racing.

The regulations have been issued to teams by the STCC but were in fact created by PWR, which has been investigating the potential for electric touring car racing since 2016, and then licensed to the STCC. PWR has used its many years of race ▶



BELOW Four brands, all electric – the STCC is ready for its new future

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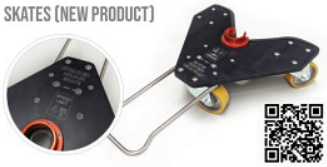

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experience, particularly with the TCR formula, to create regulations it believes will encourage the entry of manufacturers to the electric series at a reasonable cost and without the competitive issues such as Balance of Performance regulations that have been a perennial area of controversy in TCR.

The STCC car

While four body shapes are racing in the initial season of the STCC, they are very similar underneath – these electric cars follow a basic format that has proven successful in series such as TCR and the NGTC regulations of the British Touring Car Championship, of maintaining differentiation between competitors while mandating a number of spec components.

The guiding principle is cars that are visually different, thanks to the body styles of their individual brands, but to a very similar format underneath, which promotes exciting racing without needing constant Balance of Performance changes to maintain stability across the competing brands. PWR was very keen to put the major onus of competition on the driver's ability and that of the team to get the best out of a car, rather than any technical superiority of a particular make.

Janne Ljungberg, Technical Director of EPWR, headed up the build of all four varieties of race car and remarkably the start points were used examples of the road cars. "We didn't really try to talk to the OEMs," Ljungberg says in an exclusive interview with Race Tech. "With some brands you can buy a new shell but with some cars it is impossible even with really good connections, so we have taken used cars as our base."

Once the cars had been stripped, almost nothing apart from the shell itself was re-used. "Not even the doors," Ljunberg says. "We were able to re-use door handles, wiper mechanisms, small parts, but nothing else."

Generally the BMW, Cupra, Tesla and Volkswagen shells needed little modification (the Cupra and VW being very similar to each other anyway), before the attachment of specified front and rear subframes with the suspension mounted on them. However ▶

BELOW Inside the Cupra: a familiar environment for the driver in an unfamiliar type of car

RIGHT Much pre-season work took place with the new hardware, here the first test at Mantorp Park in May

the Tesla and BMW's aluminium components needed to be changed.

"The Tesla has some aluminium parts integrated into the chassis, the same for the BMW – the Tesla rear wheelarches are made from aluminium so we needed to create turrets from steel to take the MacPherson suspension," notes Ljunberg. "On the Cupra and the I.D.3 this was not a problem as there was already steel in the wheelarches. Things like that, small differences between the cars, but it could be done very easily."

The Tesla also contributed a feature replicated across all of the cars, thanks to the replacement of the road car's standard-fit glass roof. "We had to replace it with carbon, so to equalise we had to cut the roofs from the other three cars and replace them with carbon also," says Ljunberg. "Doing this also helps with weight."

Common electric hardware

The chassis setup is also common to all four cars – the subframes provide mounts for MacPherson suspension with Öhlins DFV dampers. Six-piston front brakes with 375 mm diameter discs are fitted, with four-piston calipers and 295 mm discs at the rear, and with the EV norm of regeneration of 50 kW. Calipers and discs are supplied by Alcon; the pedalbox by AP Racing. The 18-inch wheels run 250/660 Yokohama tyres.

The same electric hardware is installed across all four models. The basic format is a single electric motor from Cascadia Motion driving the rear wheels; the layout was chosen to promote exciting racing, while use of the single motor is a core element of keeping costs down – ETCR cars had some four motors mounted on individual axles.

ABOVE Testing was also carried out at the third circuit on the calendar, Ljungbyhed, here with the Volkswagen and BMW leading the way

Early series publicity stated the motor power at up to 550 hp with 660 Nm of torque, though according to Ljungberg the final power setting is still being determined. "We haven't quoted a maximum power yet – we are testing in higher temperatures now and the race distances are not yet fixed, so our final setting is still to be determined. Sometimes it might be better to have a bit less power and be able to complete more laps as a result."

The energy is provided by a 45 kWh/800-volt battery pack. This flat pack, supplied by STARD in Austria, is mounted in a frame in the same location under the floor as the road car's battery pack but much more rigid. "We have had to create new mountings for the battery pack, though in the same basic location under the floor between the front and rear wheels," Ljungberg reports.

The electric norm of a single-speed transmission – supplied by Sadev – is fitted with adjustable ratios. Teams are very limited in the technical changes ▶

BELOW The Tesla looks the right shape to be a Touring Car, and perhaps an essential element of any initial electric championship

they can make, however – there is not a traditional differential but a spool and this is sealed by the championship. Ljungberg does not anticipate any serious policing problems in this or any of the sealed elements of the car, saying: "Some people might think to make changes is easy because it is an electric drivetrain but it's not so. All the items are locked and even if a team were to crack the code of say the ECU, put it this way, if you are already at the maximum, it's difficult to get more..."

The battery pack is liquid-cooled using cold plates – electric car cooling is by the nature of the powertrain an area of concern, but with races likely to be of only a short duration again Ljungberg does not foresee serious issues in this area. "In the testing we have been doing so far we have seen the battery temperature rising during the day, but the amount of driving and charging we are doing on a test day is far more than we will be able to do on a race weekend. So we should be safe there," he says.

Battery charging is being overseen by Ekoenergetyka, globally renowned for manufacturing and installing fast chargers. The company will install 60 to 80 kW charging stations and 30 kW mobile chargers at race weekends.

Base weight of each car with driver aboard is 1450 kg – some ballasting may be necessary to meet this target due to the slightly different configurations of each base shell and the mounts required to attach components to them, but no major issues are expected and certainly no BoP weight changes during a season.

While few official performance figures have yet been released, the cars are stated to have a sub three-second 0-100 km/h time and a top speed in the region of 300 km/h. Much like in the British Touring Car Championship, the aerodynamics are focused towards looks rather than effectiveness to promote close racing – similarly the drivers have no traction or stability control to benefit from.

Electrification does require one other essential safety feature alongside the FIA standard of roll cage, carbon fibre safety cell and window net. All cars are fitted with RESS, a lights-based warning system that informs teams in the pits, and in the case of an incident rescue crews, whether the potentially high-voltage machines are safe to touch.

Powering up

The Tesla was the first STCC electric race car unveiled in September 2023 and EPWR worked hard to finish the 12-strong field in time for pre-season testing which took place at all three circuits ahead of the first round in June. Brink Motorsport will campaign the Tesla and the Cupra will be raced by PWR Racing, which has won four of the last six STCC championships.

RIGHT EPWR has completed a busy winter constructing 12 new electric race cars for the series, three each of four brands

BELOW The Cupra and Tesla may appear different in size but the cars have been carefully constructed to ensure equal weight

Exion Racing, meanwhile, has made a major commitment to the series by agreeing to run a six-car squad, adding the three VW I.D.3s to the BMWs it originally intended to run and moving its base to Ljungbyhed to accommodate them. According to Exion team principal Kevin Engman, a former STCC driver, the team is not underestimating the challenge of running so many cars but this is mitigated by electric race cars requiring far less resources than do combustion-engined ones.

Ten cars took part in the final pre-season test at Knutstorp, with the Tesla of Tobias Brink fastest and the field covered by just under two seconds around the 2.070 km circuit.

Robert Dahlgren bounced back from his disqualification in the opening Head 2 Head of the STCC premiere weekend in Gothenburg – for an incorrectly-mounted bracket on his Cupra – to win the second race ahead of Jimmy Eriksson's Tesla. The series was due to revert to a more conventional sprint race format for its second event.

Ljungberg believes that all the potential technical issues with the STCC's bold new direction have been addressed and he is particularly confident of not needing to step into the snake pit of balance of performance regulations. "The cars will all race with the same weight and there are some differences between the models so you need to compensate for that. We will keep the heaviest one and add kilos to the others to bring them up to it," he says. "At the moment I don't think there will be any problem going without the balance of performance."

> *"Battery costs remain the major concern for the championship's budget-friendly aims"*

Into the unknown

Battery costs remain the major concern for the championship's budget-friendly aims, and Ljungberg admits the initial investment has been significant. But he believes once the systems are in use and the series moves into future seasons those costs will become more manageable: "Hopefully in successive seasons costs will get lower – it is a bit of an unknown."

He is also ready for any potential future demand on EPWR's resources that could result from a successful first season of electric competition, and potentially interest from other electric car brands – or Touring Car championships. "There has been some interest from other electric brands, and we will be looking to see what might be done," he says. "EPWR will have the capacity to accommodate them – not for this season but in future years."

Going all-electric is a bold step for any Touring Car championship, but after a few years battling the increasing costs of national-level competition, and in an environment where the electric vehicle is becoming dominant, there is little surprise that Scandinavia has been the first to take this path. Electric racing could just be the saviour of the STCC, while what happens in 2024 in northern Europe and beyond will be watched very closely across a motorsport world slowly coming to terms with the fact that the electric question is going to need answering, sooner rather than later. RT

All photos: Maserati

ABOVE The Formula E program spearheads ambitious plans to forge a reputation as a pioneer in electrification

LIGHTNING STRIKES TWICE

With two Formula E wins, the iconic Italian luxury car brand is once again a serious player in top-flight motorsport. **Chris Pickering** talks to Giovanni Sgro, head of Maserati Corse

LIFE has been something of a rollercoaster for the Maserati MSG Formula E team. The first few rounds of its debut season in 2022-2023 were character building, but from Berlin onwards it felt like the fuse had been well and truly lit, with a podium on the German airport circuit, followed by a lights-to-flag victory at Jakarta and another podium on Maserati's home round in Rome.

Things seemed to be going well for the Trident in its first season of international single-seater racing since 1957. But then the trials and tribulations returned. Chief engineer Jeremy Colancon left the team at the end of the season, followed by the shock exit of team principal James Rossiter a few months later.

This year started with a promising fourth place for Maximilian Günther in Mexico, but rookie signing Jehan Daruvala found himself on a steep learning curve in the second Maserati, with several retirements along the way. Again, though, the middle of the season proved to be a turning point, with Günther securing another win in Tokyo and third place in Misano. After that it was Daruvala's time to shine with top 10 finishes in Berlin and Jakarta, while Günther suffered back-to-back retirements in Germany.

So, plenty of promise and occasional flashes of brilliance, but perhaps not the consistency that the team would have hoped to have achieved. Nonetheless, it demonstrates that Maserati is once again a serious player in top-flight motorsport.

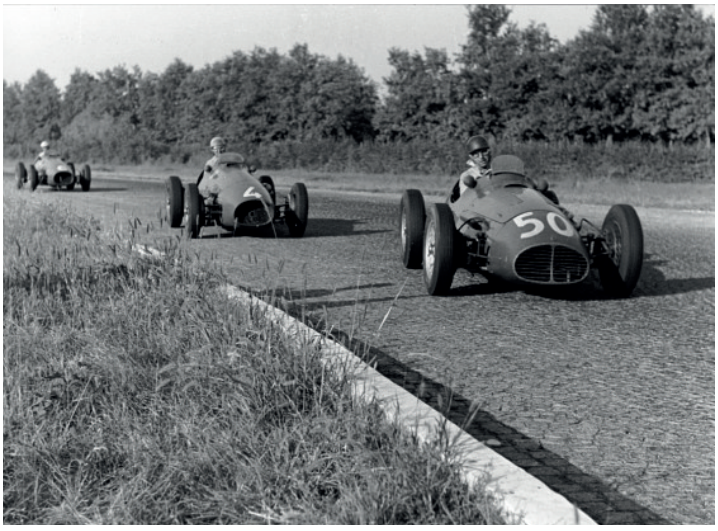
The roots of the team actually stretch somewhat further back. Based in Monaco, it's one of the original Formula E teams that has raced in the series since its very first season in 2014 – initially under the Venturi banner. The agreement with Maserati was reached ahead of the 2022-2023 Formula E World Championship, which saw the introduction of the current Gen3 car.

A change to the Formula E rules allowed Maserati to enter the series with re-branded powertrain hardware from its Stellantis sister brand DS. Software, however, plays a defining role in Formula E, and this would be unique to the new team.

Software driven

As Maserati's second season in Formula E nears its climax, Giovanni Sgro, head of Maserati Corse, is looking back on an exciting couple of years.

"The first half of 2023 was a bit challenging, but after the Berlin podium with Max [Günther], I think things turned around and we had a really strong momentum that took us from being last with our drivers to middle of the pack," he says. "We really wanted to carry that momentum on into this year, and I think we did that, with Max scoring points in every race [up to Berlin] and ▶



BELOW The Modena-based brand has a rich sporting DNA, founded on the racetrack. Here Juan Manuel Fangio's Maserati A6GCM is chased by the Ferrari 500 F2 cars of Ascari and Farina at the Italian Grand Prix in 1953

taking the win in Tokyo. Things seem to be going in the right direction."

Maserati is the first of the famous Italian luxury brands to compete in Formula E, and the campaign coincides with the company' announcement that it will have an all-electric version of all its models by 2028. "Getting the cars on track has been a great opportunity to showcase that," notes Sgro.

Formula E powertrains are homologated on a two-year cycle, which means that all the teams are using carryover hardware this year. As such, software is the key opportunity for individual teams to make up ground, with changes commonly implemented from one race to the next.

The energy management strategy is a huge part of the software optimisation, with radically different circuit configurations from, say, Misano to Monaco. Likewise, the software is tailored to each individual driver's preferences.

One of the biggest factors is the use of regenerative braking, which has been applied on both ends of the car since the introduction of the front powertrain at the start of Gen3. As well as the quantity of energy that's harvested, the regenerative braking strategy has an impact on the drivability of the car, the tyre behaviour and the battery temperature.

"The software technology allows you to really analyse data from one race to the other and improve immediately," comments Sgro. "Last year, we had a new car, a new powertrain and a new tyre manufacturer, so all of that was part of the learning curve. I think the improvements between last year and this year also come from the confidence that the drivers have in the Gen3 car. Even understanding the performance capabilities of the car takes some time when you have a big leap like we did from Gen2 to Gen3. It's the most efficient racecar in the world, capable of regenerating 40 per cent of its energy and ▶

ABOVE The Formula E campaign is a good fit for a brand intent on producing an all-electric version of all its models by 2028

RIGHT It's not just fans engrossed in the strategy of Formula E: Giovanni Sgro, head of Maserati Corse, watches the timing screens

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Günther is an experienced Formula E driver who has previously raced for Dragon, Andretti and Nissan, but his best championship result so far came with Maserati last year. Daruvala is new to the series, having risen through the Formula 3 and Formula 2 ranks, alongside several years in the Red Bull Junior Team and a young driver test with McLaren. Sgro speaks highly of both drivers.

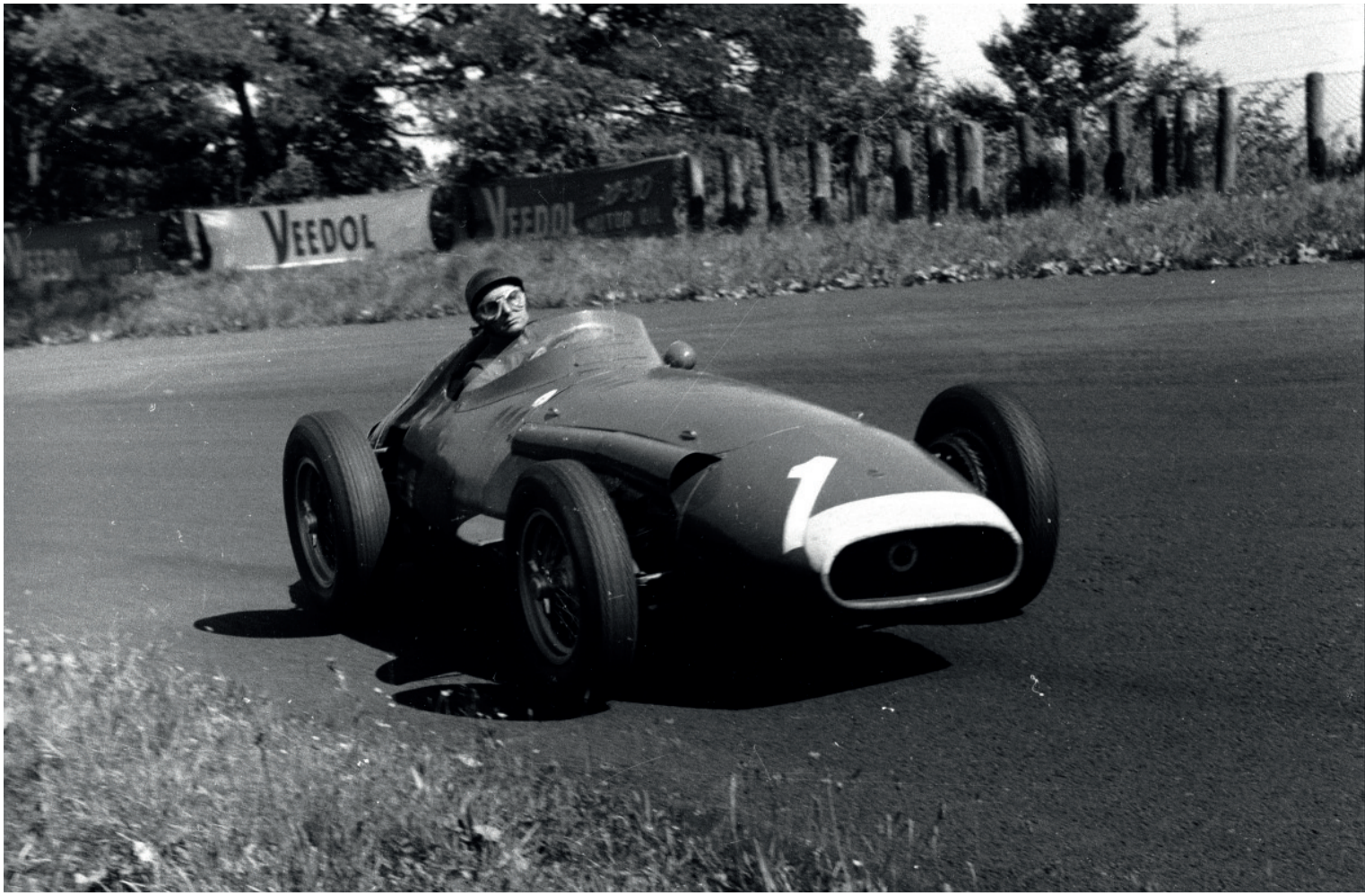
"Jehan [Daruvala] is super committed and I find him to be well grounded under the pressure of having to compete against more seasoned drivers," he comments. "And Max I think has really found a groove within his racing capability. He's always a real threat – whether he's in P3 or tenth, you know he's always coming.

"In Sao Paolo, for instance, we were starting at a disadvantage after we had to make a change to the powertrain, which had left us with a 20-second penalty, plus a 10-second penalty in the pits. After that, Max went from 22nd to ninth. You can't do that unless you feel comfortable in the car and confident in your own skillset. I feel those two things are in perfect balance and that's where we've made a big difference this year."

That sense of ease with the car and the circuit partly comes down to preparation work on the simulator, Sgro believes.

"I think it comes down to two or three different strategies around how you use the energy of the car," he notes. "There's a lot of coasting in Formula E and knowing when to brake, when to coast and how best to manage that is a specific skill."

ABOVE & BELOW Maximilian Günther's triumph at the 2023 Jakarta E-Prix (above) delivered the Maserati brand's first World Championship single-seater victory since Juan Manuel Fangio's win at the 1957 German Grand Prix (below)



FIA/Formula E

BELOW Maserati MSG Racing's second Formula E victory, at the 2024 Tokyo E-Prix, marked a turning point for the team

With its electric road car programme in full swing, Sgro says that Maserati is looking to learn from the engineering that goes into Formula E. But there's also a knowledge transfer that takes place on a more human level: "The knowledge that we gain from the drivers themselves is very important. These are some of the best drivers in the world and the way they drive those cars is incredible knowledge for us."

Growing spectacle

Formula E delivers plenty of wheel-to-wheel action, but it's also a heavily strategic sport, where the drivers work in parallel with their race engineers to manage their pace and their energy consumption. "If you don't assess how much energy you're going to need for a specific race at a specific track, you're not going to win," Sgro states. "We've seen a driver [in another team] who was leading the race fail to finish because they ran out of power. Formula E has such a big strategic element that being in front on the first lap doesn't mean you're going to finish first at the end. You really need to manage your power, understand who's in front of you and behind you, and how you're going to use your Attack Mode. Having two or three different strategies and knowing how to adapt to different scenarios is key."

The lengths that Formula E drivers go to in order to preserve energy can be seen in the now-familiar 'peloton' racing approach. Here, the aim is to use as little energy as possible in the early stages of the race, while still keeping in touch with the main pack for a frantic dash during the final laps. This can result in the drivers of some of the fastest-accelerating cars in the world going to almost comical lengths to limit their energy usage at the beginning of the race – last year's leisurely cruise away from the lights at Portland being a particularly vivid example.

Sgro emphasises that speed and excitement are vital ingredients for Formula E, but he believes that the strategic element helps to enhance the spectacle as well.

"Do I think that it will be nice to have battles for the full 40 minutes? Sure, but I think they do a really good job with the energy they have [and] with the regulations they have to make those 40 minutes as exciting as possible. The unpredictability of the race ensures that when it comes to the end you are really on the edge of your seat," he says.

More speed and more power would improve the racing even further, but he says he's confident that it will come: "Formula E has done a really great job over the last 10 years of making the space more appealing to a broader audience. I think we'll see a lot more changes between Gen3 and Gen4, with more speed for more of the race and exciting duels popping up more frequently."

While Formula E has undoubtedly established itself as part of the motorsport mainstream in that time, it remains a relatively young championship in outright terms. Sgro says this has fostered a sense of camaraderie among the teams, who are keen to see the championship as a whole do well.

"Everyone wants to compete against each other, and everyone wants to win the championship, but it's also a very sportsmanlike environment. There's a very positive outlook when we have meetings with the other teams and the governing body," he comments. "If the championship grows, it gets more visibility from the consumers and the fans. If that happens, more commercial partners come to the table, which adds more value to the championship. Overall, you get more opportunity to grow the platform, expand broadcasting rights, visit new cities... who knows where it'll be in another 10 years."

For now, though, the main focus is on the closing races of Season 10, with half an eye on Season 11 and the forthcoming Gen3 Evo regulations.

'NIMBLE' CAR CONCEPT? DON'T MAKE ME LAUGH!

Sergio Rinland believes the 2026 F1 regulations are a step in the right direction but still too timid

A COUPLE of issues ago we wrote about the success, or otherwise, of the 2022 F1 regulations, triggered by comments from Mercedes Technical Director James Allison. We argued that the rules should contemplate reducing grip and increasing power.

Well, even though we confess we were too late to influence the rule-makers for the 2026 F1 regulations, that is exactly what they have just announced, among other changes, for the 2026 rules.

To summarise, the changes are as follows:

- Powertrain Unit increase of the electric motor power proportion closer to 50/50 with the ICE engine and an increase of overall power by about 10%.
- Deletion of the MGU-H (Mercedes' 'unfair advantage' for many years and not much use for production engines) and the use of e-fuel, fuel made from CO2 captured from the atmosphere and from hydrogen separated with electricity. This flagship policy effectively increases the lifespan of current ICE engine production to reduce climate impact – a big incentive for the OEMs supplying Power Units.
- 30 kg weight reduction, which will add up to an increase of 15% of power-to-weight ratio. Not huge, but a step in the right direction.
- A 'push-to-pass' power differential instead of DRS to assist overtaking on the straights. (I would prefer none of this, in order to encourage drivers to take some risks to overtake under braking!)
- Slightly shorter and narrower cars. Again, not huge but a step in the right direction.
- Downforce reduction of 30% and drag reduction of 55% when full front and rear DRS is deployed. These last features will increase stability and safety on the straights in comparison with rear-only DRS and is the correct use of active aerodynamics. Some of this downforce reduction will be achieved by the deletion of the all-powerful – and Red Bull 'unfair advantage' – rear beam wing.
- Front wings 100 mm narrower. This will not only reduce front downforce, but will save a few dollars on front wing parts damaged in wheel-to-wheel combat!
- The other downforce reduction will be achieved by reducing the 'power' of the diffuser, even mandating a small 'flat bottom' section. I don't necessarily agree with this new floor rule. I think the same or even better would be achieved by further reducing front and rear wings.
- A welcome safety increment of the Front Impact Structure strength to allow it to absorb multiple impacts, similar to what IndyCar stipulates. There are also new roll hoop regulations in light of Zhou Guanyu's accident at Silverstone in 2022.

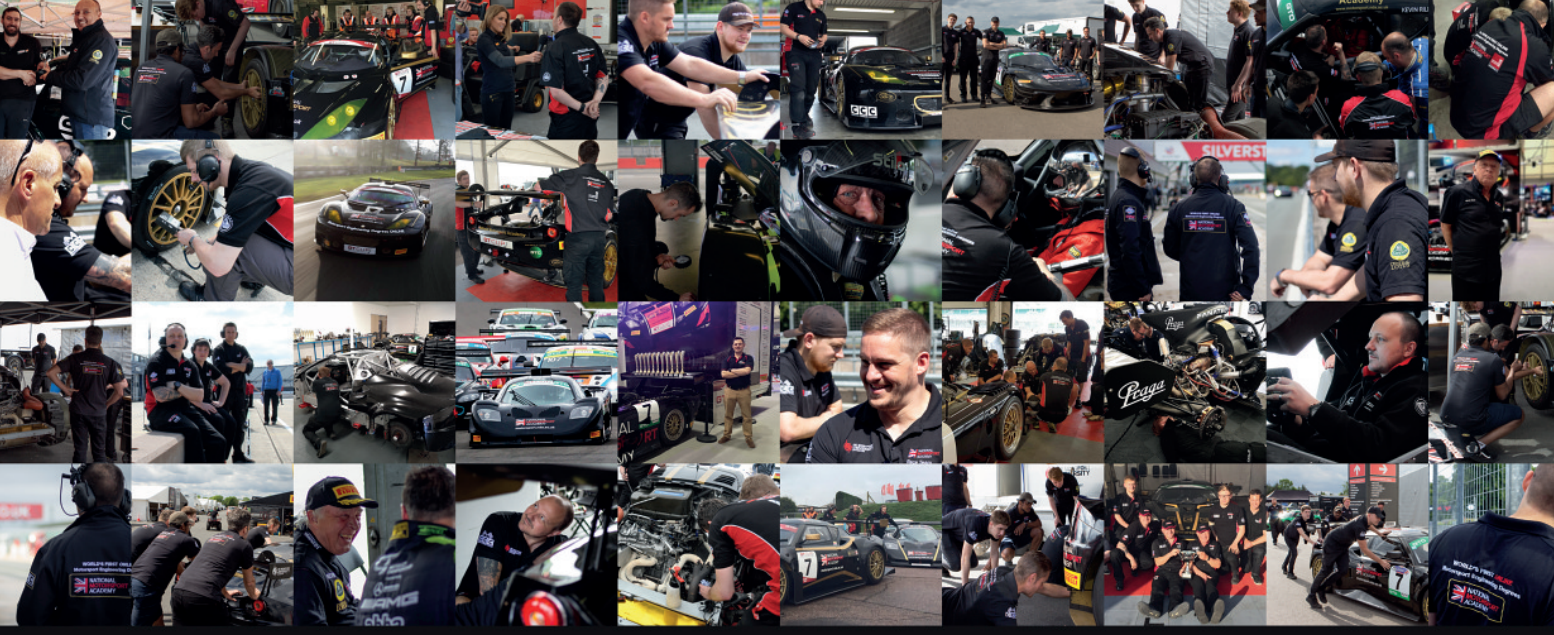
The FIA hails these changes as the creation of the 'Nimble Car' concept. That is like suggesting rhinos are 'nimble animals' if we compare them with Asian elephants! Nimble cars were the 1500 cc Formula 1 cars of the 1960s at 450 kg – a far cry from the current near one tonne F1 cars!

Overall, these are all steps in the right direction. As we noted a couple of issues ago, the FIA's reduction of the cars' performance does risk getting too close to that of current F2 machinery. Indeed, a few drivers who tested these regulations in the simulator suggest that the cars 'feel slow'. The FIA insists that the regulations are currently work in progress and that it deliberately set the performance bar low, knowing all too well how quickly the teams are capable of adding speed to their cars. Whether the rest of the FIA's racing pyramid is slowed, or F1 performance increased, it is essential that the status quo is maintained, with F1 retaining its position as the 'pinnacle of motorsport'.

In my humble opinion, these are still timid changes. These rules are designed on one hand to appease the current OEMs and to attract new ones, and on the other to tamper with motorsport to keep what for some is a good spectacle. I still think that wheel-to-wheel fighting and overtaking under braking/turn-in is what racing is all about. Overtaking on the straights is akin to LMH cars passing GT cars at Le Mans: not that exciting.

BELOW The 2026 car concept has received a mixed reception

Courtesy of F1



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