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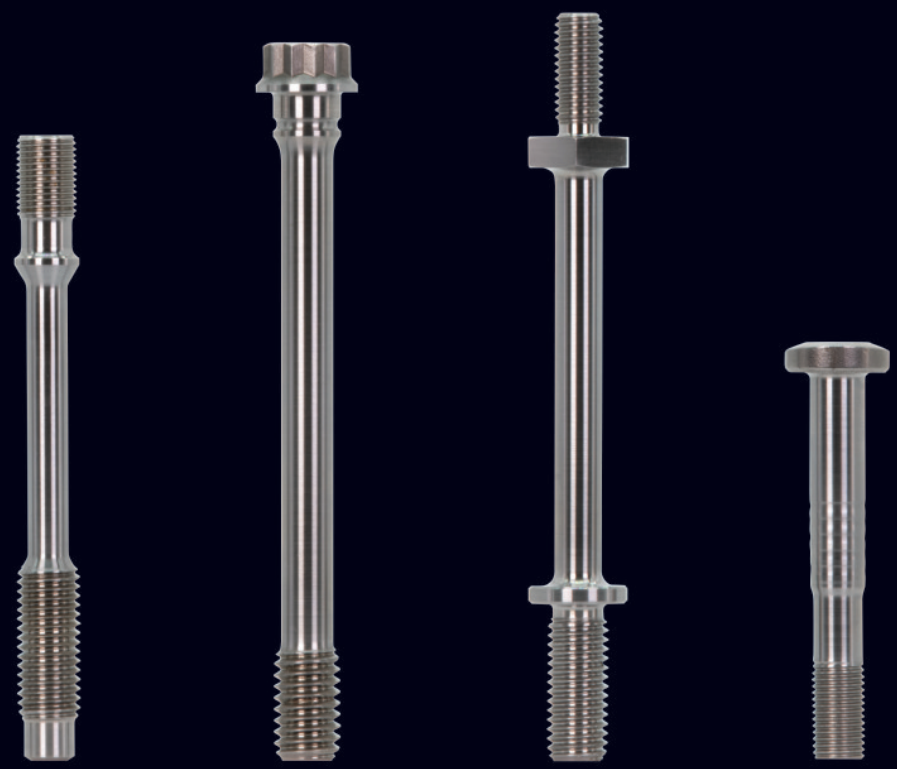

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NO AVOIDING THE S-WORD

NOT entirely sure the s-word I was visualising is the term that instantly sprang to your mind!

Truth told, my s-word, 'sustainability', didn't cross many people's minds until quite recently. But now there is no escaping it.

Some might not think that sustainability and motorsport necessarily go together; those who work in the industry know that they are not such strange bedfellows. After all, motor racing has always been about efficiency. It's how powertrain designers and aerodynamicists make their cars go faster.

But perhaps that attitude is just a cop-out? The whole landscape is changing and we need to change with it.

As Alan Gow, chief executive of the BTCC, the world's most successful touring car championship, recently suggested, these days you can't even get through the door of a potential sponsor without addressing the s-word.

That emphasis is reflected in this Issue: Julia Pallé, Formula E's vice president of sustainability, talks of the challenges along the eco-trendsetting electric series' journey; Mark Grain, Extreme E's technical director, discusses the transition to Extreme H, due to become the world's first hydrogen fuel-cell-powered FIA World Championship; and Mark Rushbrook, of Ford Performance Motorsports, explains why Supervan 4.2 is the Blue Oval's biggest marketing weapon.

Indeed, the sustainability issue now permeates every level of the sport. Even suppliers of hitherto 'conventional' technology are now instrumental in making the electrification of motorsport a reality. PFC Brakes, supplier to IndyCar, offers us a fascinating insight into the challenges of the US sport's new hybrid era, which commences in 2024.

In our news pages, meanwhile, you can read how the sight of NASCAR's first EV – with an SUV bodyshell, no less – predictably provoked a big reaction from its fanbase. Some didn't waste time sitting on the fence, if you know what I mean. The uproar was understandable, for this is a divisive issue.

As NASCAR acknowledged, the whole industry is currently in a state of flux, with the future technical direction unclear.

Only one thing is certain: climate change, sustainability and motorsport's role in that journey, are now issues we need to embrace rather than evade. RT

Mark Skewis
EDITOR

ELECTRIC NASCAR POISED TO GO PUBLIC

Hydrogen also investigated as NASCAR explores future. By **Mark Skewis**

NASCAR has already designed, built and tested its first electric racecar. But the sanctioning body's Chief Operating Officer, Steve O'Donnell, insists that "everything's on the table" regarding the sport's future technical direction.

NASCAR's fanbase went into overdrive last month when a leaked image shared on X (formerly Twitter) appeared to show a NASCAR prototype with a crossover (SUV)-style body and electric underpinnings. The prototype bore a resemblance to the Chevrolet Blazer SS that will hit the market in the spring of 2024.

Sources suggest that the car is built on NASCAR's next-generation chassis, with modifications to accommodate electric powertrain components. The Next Gen car was built on a modular platform with flexibility in mind – a point illustrated by NASCAR's successful Garage 56 foray at the Le Mans 24 Hours.

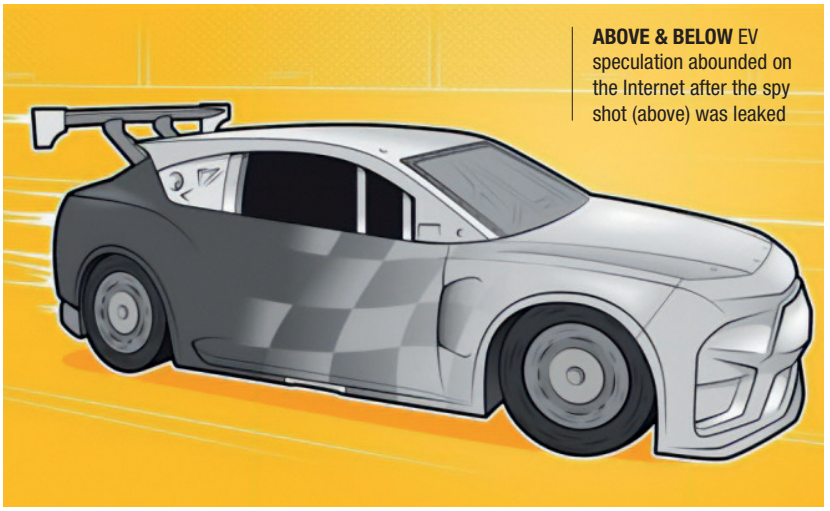
The suppliers involved in the Next Gen project were originally tasked with future-proofing the design to accommodate hybrid power. This option was initially considered for the Hendrick Motorsports Le Mans Camaro project, but ultimately rejected on grounds of weight, complexity and the tight timescale.

Since then, the automotive industry's energy transition has quickened pace. NASCAR has been tugged in several different directions in discussions with its OEMs, and decided it needed to be ahead of the game when it came to EVs. Its new prototype is scheduled to test at Martinsville Speedway in December, with future demonstration runs acting as a barometer with which to gauge the reaction of the NASCAR fanbase.

"A lot of work has gone on at the R&D department around EV," admitted O'Donnell during the annual 'State of the Sport' address. "We have a car. We have an


Getty Images/NASCAR

LEFT The Next Gen platform was successfully tailored for Le Mans. That adaptability could be harnessed as the base for an SUV-bodied EV NASCAR



ABOVE & BELOW EV speculation abounded on the Internet after the spy shot (above) was leaked

BELOW NASCAR sent a contingent to Japan to see the liquid hydrogen technology being developed by Toyota

> *"The auto industry is in flux. There's a lot of technologies being looked at. Things change almost monthly"*


Toyota

alternative body style with that car. I would not look for us specifically to go racing with it. I think you could see it showcased at certain events next year…"

However, there are other potential avenues for decarbonizing the sport and NASCAR signalled its willingness to explore all options by taking a contingent to Japan recently. Its officials had witnessed Toyota's hydrogen combustion-powered Corolla racecar give a demonstration at this year's Le Mans centenary celebrations.

The Corolla H2 is the first racecar in the world to compete on liquid hydrogen, using cryogenic storage tanks which operate at -253 dec C. Intrigued by the project, and aware that it needs to keep abreast of the hydrogen space, the US series opted to investigate further.

"We want to kind of test each and every form [of ▶

technology],” said O’Donnell. “Really excited about what our team’s put together around an electric car. Again, wanted to showcase that to the fans and explore other technologies, as well.

“We’ll continue to look at what forms of racing we would bring outside the U.S., what technology is under the hood. A lot of opportunities for us as a sport, be it alternative fuels, electric, hydrogen. Everything’s on the table, which is unique for I think us as a sanctioning body in terms of having that Garage 56 program, having our Next Gen car designed specifically for all kinds of different power units.”

The good news for NASCAR is that it has time on its side, with the upheaval of the move to the Next Gen car having proved so successful. The organization targeted safety improvements in the second year of the category, and delivered on them. The race action also continued to underline the fact that lesser teams can now compete with the sport’s giants.

ABOVE The State of the Sport conference shed light on NASCAR’s EV readiness

> *“A lot of work has gone on at the R&D department around EV. We have a car. We have an alternative body style with that car”*

BELOW Chevrolet’s new Blazer EV, taking the SUV with the storied name into the electric realm for 2024, is typical of the body shape NASCAR is considering

“We wanted to see continued excellence on the racetrack in terms of the number of drivers that are able to win, and probably even more importantly the number of organizations that were going out and being able to compete, not have a fluke win, but really compete for race wins race in and race out,” said O’Donnell.

“You’re seeing 23XI, Roush Racing, Trackhouse, JTG go out there and really have a shot to compete. We saw 15 different winners. 10 of the 16 organizations won a race this year. That’s incredible. The OEMs have all been represented. All three OEMs made our Final 4.”

So while the fans were understandably sensitive to the revelations regarding an EV SUV-style prototype – the reactions ranging from “kill it!” to genuine excitement at the prospect – the series has bought itself some time to test the water before making big changes.

“The challenge remains for us what engine package are we going to be running, specifically around Cup,” said O’Donnell. “The good news is all of our existing OEs are very open to dialogue now about where the new technologies are going.

“As everybody here reads about the auto industry. It’s in flux, right? There’s a lot of technologies being looked at. Things change almost monthly in terms of what is going to be in the hands of consumers. We need to get that right.” RT

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Andretti Cadillac could become "true works team"

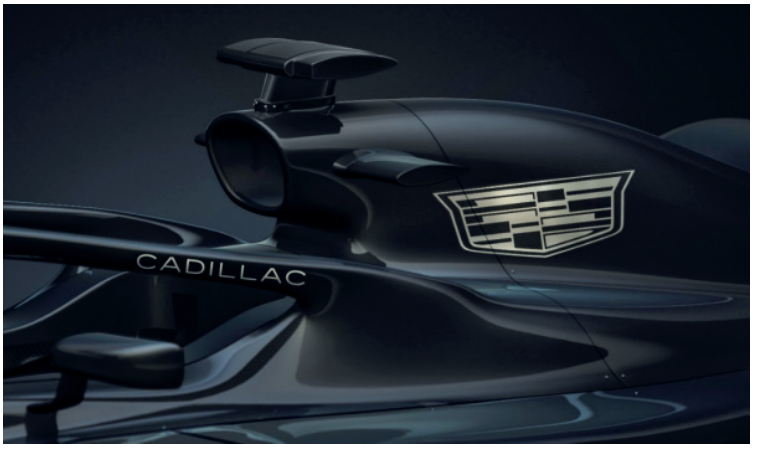
GENERAL MOTORS is to build its own Formula 1 engine in 2028, ramping up pressure on F1 to accept Andretti-GM's entry.

The FIA has approved Andretti's Expression of Interest, but the bid still has to clear the hurdle of approval by F1's commercial rights holder, Liberty Media. The latter has been lukewarm on Andretti's potential entry so far, when it appeared Cadillac would merely badge a Power Unit supplied by Renault.

Now, GM's formal registration as a Power Unit manufacturer, revealing that it will build its own engine within two years of its proposed entry, could be a game-changer.

"We are thrilled that our new Andretti Cadillac F1 entry will be powered by a GM power unit," said GM President Mark Reuss. "With our deep engineering and racing expertise, we're confident we'll develop a successful power unit for the series, and position Andretti Cadillac as a true works team. We will run with the very best, at the highest levels, with passion and integrity that will help elevate the sport for race fans around the world."

GM's development and testing of prototype technology is already underway. In a statement it said: "Engineering a F1 power unit will advance GM's expertise in areas including electrification, hybrid technology, sustainable fuels, high efficiency internal combustion engines, advanced controls and software systems."



BELOW The Andretti Cadillac F1 entry will be powered by a GM Power Unit starting in 2028

Le Mans delays hydrogen-powered class

THE introduction of a category for hydrogen-powered racecars at the Le Mans 24 Hours is being delayed a year to 2027.

Pierre Fillon, president of the Automobile Club de l'Ouest, cited delays created by safety concerns as the reason for the postponement.

"2026 is not realistic, it's (now) 2027," Fillon said of the proposed Hydrogen category, which is set to be introduced ahead of a targeted hydrogen-only top class at Le Mans for 2030. "Because we have to spend some time working on the safety, it has taken longer than we expected. 2027 is more realistic."

Fillon also clarified that the new ACO-led MissionH24 electric-hydrogen prototype, which is expected to begin track testing in early 2025, should be considered separate to the Le Mans hydrogen program.

"H24 is not for Le Mans. H24 is for the Michelin Le Mans Cup, ELMS maybe, but the target performance for H24 is GT3, not more," Fillon said. "We are not a manufacturer. The car is just a laboratory to learn what we have to do in terms of safety and refuelling. We have learned a lot with this car."

Even with a year's delay, the timeline for hydrogen cars – both fuel cell and combustion – to make the 2027 target might appear intimidating. However, when Toyota revealed its hydrogen-combustion prototype, the GR H2 Racing Concept, at Le Mans in June, technical director Pascal Vasselon indicated that it would be feasible to race as early as 2026.

Hyundai and BMW are also known to be engaged with the discussion process in the ACO's technical working group.

Although the introduction of the hydrogen category has been pushed back on multiple occasions, the latest delay doesn't look like a big issue, given that the current hybrid-powered LMH and LMDh rulesets are booming.

LEFT Toyota's GR H2 Racing Concept is the highest profile recruit to the hydrogen category

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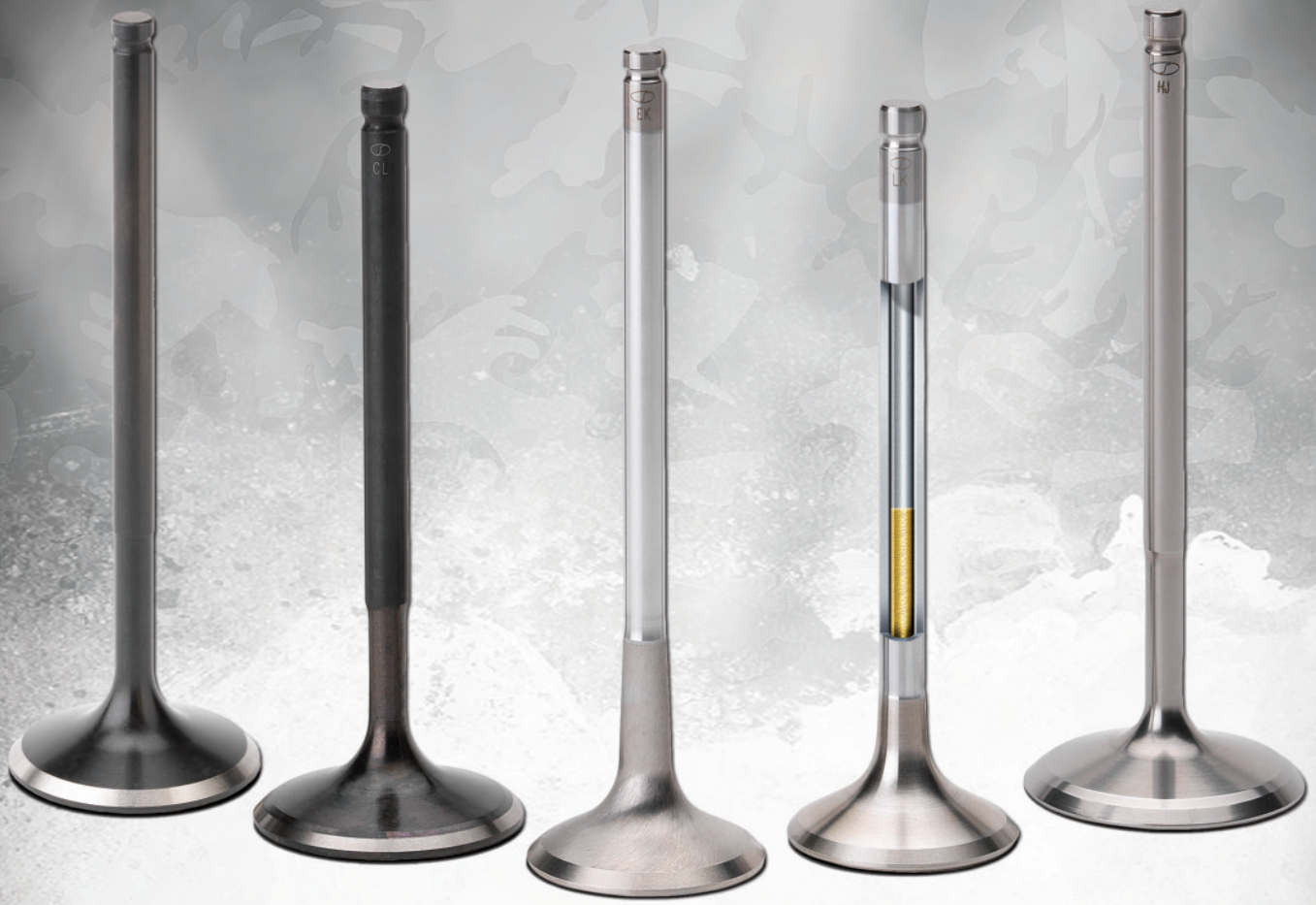

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Toyota reveals advances with liquefied hydrogen

TOYOTA has revealed a range of improvements made to the liquid hydrogen-powered Corolla with which it is experimenting in the Super Taikyu race series in Japan.

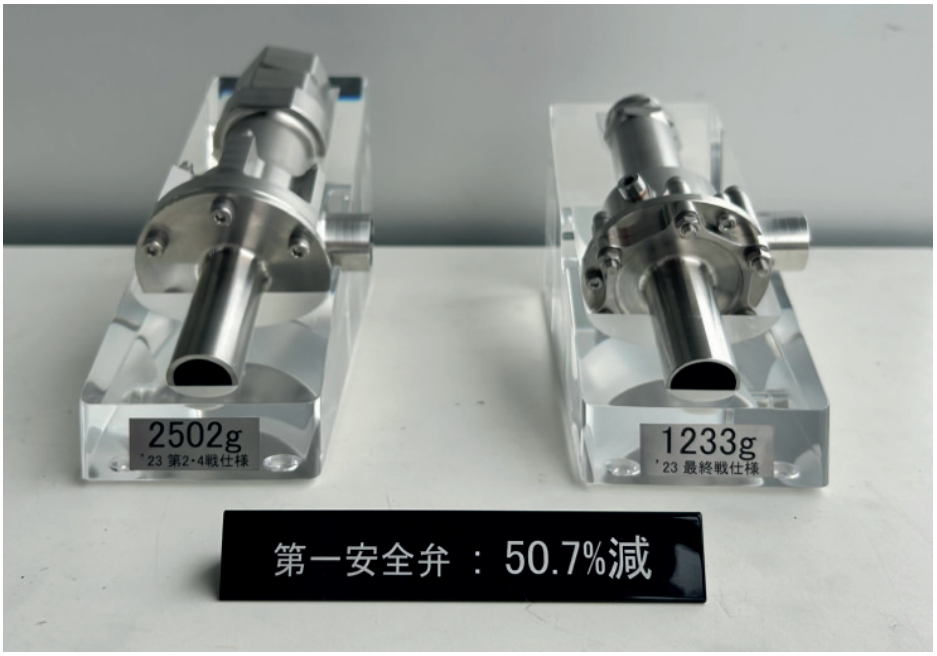
The engineers switched from gaseous to liquid hydrogen this season, with the car first competing in the Fuji 24 Hours race in May. Since then, their familiarity with the technology has enabled a substantial evolution of the ORC ROOKIE GR Corolla H2 Concept.

Several breakthroughs have improved engine performance. Liquid hydrogen pumps must generate high fuel pressure with stability to achieve high output. Toyota has improved the pressure boosting performance and durability of the pumps, which have been challenges, to achieve the same level of output as gasoline and gaseous hydrogen engines.

Cruising range has also been increased. The maximum number of laps that could be driven on a single hydrogen fill-up at the Fuji 24 Hours race in May was 16. The team is now targeting 20-lap stints thanks to improved accuracy in determining hydrogen tank fullness, reducing the amount of boil-off gas by reducing the heat entering the tank, and optimizing fuel injection when the gas pedal is not fully depressed.

With a better understanding of the necessary safety features, the team has been able to make major weight reductions by adjusting factors such as thickness and number of parts. As a result, it has been able to reduce the weight of the tank, safety and boil-off gas valves, roll cage, high-pressure hydrogen system parts, and other components to achieve a vehicle weight of 1,860 kg, 50 kg lighter than the 1,910 kg it weighed at the Autopolis race.

ABOVE The liquid hydrogen-powered Corolla is attracting increasing levels of interest, with a delegation from NASCAR recently flying to Japan



BELOW Safety valve before (left) and after (right) weight reduction

Toyota, like other major motorsport manufacturer Porsche, is also addressing the challenge of CO2 capture technology. It is running a trial initiative to install a CO2 capture device on the hydrogen-powered Corolla's engine compartment that utilizes its large-volume air intake feature and the heat generated by combustion.

More specifically, a CO2 absorption device will be installed at the inlet to the air cleaner, and a CO2 separation device that uses heat from engine oil will be installed next to the air cleaner. The separated CO2 will be captured in a small tank filled with an absorbent.

The equipment used to absorb, separate, and capture CO2 from the atmosphere will use filters coated with an absorbent developed by Kawasaki Heavy Industries, Ltd that can release CO2 at lower temperatures than conventional absorbents, thereby increasing CO2 capture efficiency.

With the ambition to achieve a carbon-neutral society also gaining momentum elsewhere, Toyota has installed the hydrogen engine in a commercial HiAce to conduct on-road feasibility testing on public roads in Australia. RT

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Formula G to fill "green racing void"

FORMER F1 and Formula E racer Nick Heidfeld says that Formula G, the forthcoming dual-power, all-electric racing series, will "fill a green racing void" in the motorsport structure.

Formula G is the rebrand of the ACE Championship, brainchild of former Mahindra Racing team principal Dilbagh Gill and Heidfeld. Their vision is for affordable and accessible green energy racing. Formula G will compete as a support series on the same tracks, on the same weekends, as existing combustion engine, alternative fuel, and all-electric powered racing events.

Gill said that Formula G has secured all contracts and suppliers necessary to begin competition. This includes the building of a brand new open-wheel all-electric race car, the "FG-ETwin".

Featuring the unique technical ability to be raced at reduced power by a junior driver, and then at full power by a professional driver, the FG-ETwin allows the creation of a two-race format series using a single car. This dual-power technology also reduces all costs of competition, enabling teams to run two races with the budget and crew required for a one car entry.

When first announced as the ACE series, the launch featured a Gen2 Formula E car. But the FG-ETwin package is to be built using the expertise of QEV Technologies. The electro-mobility pioneer has experience in Formula E, Extreme E and as a vehicle manufacturer in the RX2e rallycross series.

Formula G's inaugural season, commencing in late 2024, will feature independent championships in four regions (to be announced soon), each with 10 team franchises, and 40 drivers, 20 of which will compete in the reduced-power championship "F-G2", and 20 professional drivers competing in the full powered "F-G1 Championship".

"When Nick Heidfeld and I created ACE, we always envisioned two series with the same teams competing around the world at its own events," said Gill, Founder and CEO of Formula G. "As we listened to team owners, promoters, owners of other motorsports series, and various stakeholders, it became clear that each region had its own economic and sustainability challenges and goals that we needed to address if Formula G was to become the leading support series in the fastest growing and underserved sector of motorsports.

"I am proud that after receiving support at every level of the sport, Formula G, by launching as a support series in multiple regions, is the first global series to create affordability and accessibility, unique by region, that will enable Formula G to attract more diversity in team owners, drivers, mechanics and engineers, while creating significantly more career opportunities on and off the track."

"This is a championship I am extremely passionate about, and I wanted to be involved since the moment Dilbagh presented his vision," said co-founder Heidfeld. "As a driver, I recognise the barriers that stand in the way of the opportunity to race competitively and progress through different levels. I believe Formula G is a truly unique racing platform that breaks down many of these, and will create previously unavailable opportunities. At the same time, Formula G will also fill a green racing void that everyone in the sport, from teams, to drivers, sponsors, and promoters, and most importantly race fans around the world, have all been waiting for."

Formula G's new car is set to hit the racetrack at the end of 2024. RT

BELOW Tech partner QEV Technologies has widespread experience, most recently helping Formula E front-runner Avalanche Andretti with its energy management strategies

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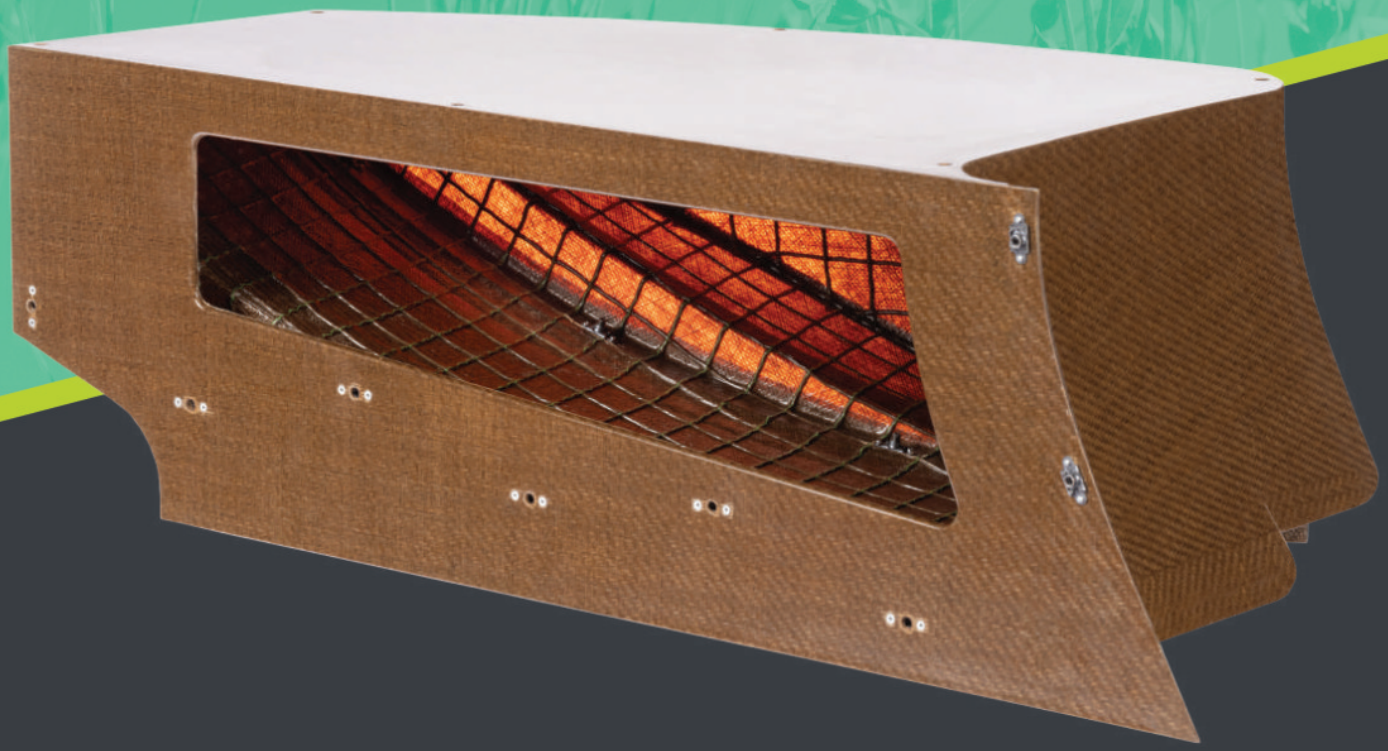

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Ford announces new Mustang for 2024 NASCAR Cup Series

FORD Performance has unveiled the new Mustang for the 2024 NASCAR Cup Series, based on the Mustang Dark Horse.

Ford unveiled the all-new Mustang Dark Horse just over a year ago, marking the first new performance nameplate for Mustang since 2001. It is the most track-capable 5.0-litre V8 street-legal Mustang ever and has inspired the current roster of Mustang cars that started racing this year in the Repco Supercars Championship in Australia and Formula Drift series.

In the months ahead, Mustang Dark Horse racing variants will be eligible to compete in GT3 and GT4 classes globally and in addition, Dark Horse R will compete in the Mustang Challenge Series and many grassroots racing events. From 2024, Mustang will be eligible to race on six continents.

"If she gallops as fast as she looks, it's going to be a good year," said Brad Keselowski, driver and co-owner of Roush Fenway Keselowski Racing, after seeing the new NASCAR Cup model. "Mustang is an iconic American car made famous around the world. I think of how Mustang has evolved over the years and how NASCAR has evolved along with it and they're just two brands that go together."

Mustang has been a fixture in NASCAR since entering the Xfinity Series full-time in 2011. Since graduating to the NASCAR Cup Series in 2019, Mustang won a manufacturer's championship and series-best 18 races in 2020, and a driver's championship with Joey Logano in 2022. Ryan Blaney drove Mustang to its second straight NASCAR Cup Series championship at Phoenix Raceway last month, at an event that saw Ford win all three of NASCAR's major touring championships for the first time in its history.

"It's been such a great car for us and a great icon for us since 1964, both as a road car and as a race car for that entire time," Mark Rushbrook, global director of Ford Performance Motorsports, said. "When we as a company made the commitment to have a seventh-generation Mustang for the road, we knew instantly in motorsports that that meant a new wave of Mustangs for us on the racetrack.

"When we switched from Fusion to Mustang in Cup in 2019, that was a big deal. But now to be updating this Mustang in Cup to the seventh-generation Mustang, and especially the new model with a Mustang Dark Horse, to really make a statement about what Mustang is as a road car, as a sports car and as a race car at the highest level in NASCAR is important."

The new body style is set to debut in competition for the exhibition Busch Light Clash at the Los Angeles Memorial Coliseum on Feb 4 with improvements from the 2023 Mustang.

Most noticeable on the 2024 Mustang Dark Horse that stands apart from the current model is a sleek new nose on the front, coupled with character lines that stretch from the fender to the door. The manufacturers in NASCAR – Chevrolet and Toyota, in addition to Ford – have a tight window in which they can manipulate their respective vehicles, Rushbrook said, but still enough room to make a difference.

"Where you are within that box is still important," he said. "So repositioning as you can to truly optimize that, every little bit of performance counts. But there's also a lot of performance that simply isn't characterized in that submission process of how the cars are truly raced on these variety of tracks, as well as trade-off decisions that are made in terms of drag versus downforce.

"It's hard to make improvements in both – we certainly did in this case – but in our '23 car, maybe some of our trade-offs weren't in the optimal place that you could see. We were really strong on superspeedways, and that hurt the performance a little bit on the intermediate tracks. So being able to reposition where we are in the box is an important step for us, as well as optimizing some of the detailed racing conditions to make sure we're the most competitive in all those situations." RT

RIGHT Ford's new NASCAR Cup Series car is based on the seventh-generation Mustang

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Red Bull's 2026 PU developed with Siemens Xcelerator

SIEMENS Digital Industries Software has revealed that Red Bull Ford Powertrains has leveraged the Siemens Xcelerator portfolio of industry software to develop its F1 Power Unit for the 2026 racing season.

Ben Hodgkinson, Technical Director, Red Bull Powertrains Ltd, said: "Siemens Xcelerator is the digital backbone of our design and manufacturing journey, enabling us to concurrently engineer hundreds of rapid design evolutions across a large newly formed team; ensuring each designer has visibility and knowledge of what their colleagues are working on.

"It is especially challenging as we don't have the luxury of historical data; every component, down to the nuts and bolts of the engine, has to be modelled from scratch. This means the design quality and ease of use from Siemens' NX, combined with collaboration and lifecycle management with Teamcenter, is a critical factor for success."

In addition to Siemens' NX software for product engineering and Teamcenter software for product lifecycle management (PLM), the Red Bull Ford Powertrains team leverages the simulation and test capabilities of Siemens' Simcenter STAR-CCM+ software to assist with design and validation across the project.

"The motorsport industry is aggressively pursuing a cleaner, more sustainable future that requires radical reinvention of how teams and suppliers approach all aspects of their development activities. By leveraging the benefits of digital transformation, delivered through the use of Siemens Xcelerator, we're able to help motorsport partners in the field with their discovery, invention and ultimately, delivery of new cleaner solutions on the track, where rubber meets the road, in timescales previously thought unattainable," said Robert Jones, executive vice president, global sales and customer success, Siemens Digital Industries Software. RT

Breakthroughs in connectivity target transformation of fan experience

BRITISH engineering and technology pioneer McLaren Applied is partnering with mmWave technology leader Blu Wireless to deliver ultra high-speed telemetry solutions for motorsport applications. Through the collaboration, the two companies are targeting new breakthroughs in connectivity performance in the dynamic motorsport environment, providing a data pipe that can handle all data and video streams from a race car in real-time.

The solution will combine Blu Wireless' mmWave technology with McLaren Applied's intelligent motorsport gateway on-car telemetry hardware, with McLaren Applied also providing systems architecture, integration, and support. The solution includes McLaren Applied's patented software that ensures stable connectivity for vehicles and transportation moving at high speed. The software aggregates data across multiple networks and is a key enabler in the application of the mmWave technology for multi-gigabit connectivity across all race car platforms.

ABOVE The solution is now ready for deployment in motorsport race series

The technology has been successfully tested over the last 12 months across multiple tests in the UK and North America, including demonstrating multiple HD video links on race cars travelling at speeds above 165 mph. McLaren Applied's design and systems engineering team is currently preparing the system for imminent deployment in racing.

Sam Guest, Head of Motorsport Telemetry, Control & Analytics at McLaren Applied, said: "McLaren Applied leverages its 30-plus year heritage in motorsport to enable a more intelligent and connected approach for a wide-range of moving vehicles. We expect this new technology to deliver an even more engaging race experience for motorsports fans, with the potential to incorporate live gaming and other forms of interaction."

Mark Halliday, Head of Product and Programmes, Connected Intelligence, added: "The new collaboration with Blu Wireless is aimed at bringing a step change in connectivity in the harshest of race environments by offering new levels of speed and stability to inform race-winning strategies".

Mark Barrett, Chief Commercial Officer at Blu Wireless, said: "We are excited to apply our cutting edge mmWave technology to the challenging world of motorsports. Our robust, gigabit connectivity and tailored system is certain to deliver real-time, almost life-like experience and will enhance the nail-biting excitement of motorsport for viewers." RT

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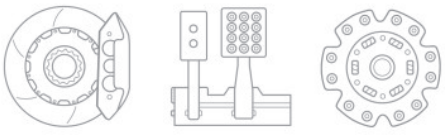

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AI and F1 tech combined to decarbonise mining industry

BRITISH technology and engineering company McLaren Applied has partnered with one of Indonesia's largest mining contractors, PT Pamapersada Nusantara (PAMA), to immediately expedite the process of decarbonising its operations.

The transformation of crucial sectors such as transport, construction and manufacturing are seen as key to the transition to a sustainable future. In order to facilitate the scale of change needed, however, vast quantities of raw materials will still be required.

From lithium and cobalt for electric vehicle batteries, to bauxite and cadmium for solar panels, mining will play an integral role in securing the resources needed to transform society. It is therefore critical that the mining industry itself is equipped with the tools to decarbonise as rapidly as possible, allowing it to lead the way in enabling a more sustainable future.

To that end, McLaren Applied's cutting-edge technology – spanning more than three decades in F1 and other global motorsport – is being harnessed.

With fuel representing 25-30% of a mine's operating expenses, any gain in efficiency can have a large impact on pollution, productivity and costs. Such gains are hard won, with PAMA haul trucks capable of carrying around 100 tons of mined material over steep, uneven ground operating in a dynamic environment which requires constant analysis. Ever-changing variables such as payload, weather, terrain and route all affect the driving technique required to ensure maximum efficiency.

While the widespread introduction of electrified or hydrogen-powered mining trucks remains some way off, the application of accurate, real-time fuel analytics can represent a cost-effective way to make an instant impact on both consumption and emissions, increasing efficiency and accelerating decarbonisation.

LEFT The tech has proved so successful that PAMA is expanding its use to a second site

While traditional fuel analytics can only provide mine managers with performance reports for the previous day or shift, too late to keep pace with the rapidly changing situation, McLaren Applied's cutting-edge Fuel Analytics Service is far more advanced.

Formula 1-derived technology collects detailed live data from multiple sensors onboard PAMA's fleet of mining trucks, transmitting it to cloud-based servers and using it to inform a powerful machine learning-based algorithm.

The Fuel Analytics Service references the data received against a full digital model of the mine, using specially developed AI tools to instantaneously calculate what changes the driver should make to optimise fuel efficiency.

Learning from the behaviours of the most efficient drivers over the last three-days' worth of data, the model instructs vehicle operators in real time, offering live feedback to ensure optimal driving, maximising efficiency and minimising fuel consumption in any conditions.

Since implementing McLaren Applied's Fuel Analytics Service on the trucks at its MTBU mine, data has shown fuel savings of up to 4.5% across the selected cycles or routes versus a control group of drivers not yet using the system. Extrapolated across the total fuel required to operate PAMA's mining operations each year, the potential for immediate and impactful efficiency gains is clear.

When examined more granularly, the top 25% of PAMA's drivers using Fuel Analytics were found to save up to 6.5% in fuel and carbon emissions, while simultaneously improving their cycle time by 5.6% as well.

This improvement in productivity in particular, achieved thanks to the Fuel Analytic Service's real-time recommendations, demonstrates how smoother, more consistent inputs can reduce braking and acceleration, benefitting both speed and efficiency.

The already impressive efficiency gains seen to date can be further linked to key secondary benefits. Reduced maintenance requirements and costs, thanks to decreased wear and tear on the mechanical components of the heavy trucks due to smoother, less frequent inputs, will lead to long-term positive financial and operational outcomes.

The technology, which is demonstrating its instant impact today, will remain applicable even once the electric and/or hydrogen trucks enter service, with the gains in efficiency offered by the service continuing to offer cost, productivity and efficiency improvements for years to come.

Pak Hendra Hutahean, Vice President Director at PAMA, said: "The immediate impact of McLaren Applied's Fuel Analytics Service has helped to improve both the productivity and efficiency of our operations. We are delighted with the results." RT


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REALISTIC DRIVING SIMULATORS IN THE WORLD

Autotech Driveline partners with Continental to distribute RSX Motorsport ABS systems in North America

AUTOTECH Driveline has announced a partnership with Continental to be able to offer their RSX Motorsport ABS systems in North America. This partnership helps to expand its current Autotech Driveline offerings that already include brands like Wavetrac Differentials, Holinger Engineering, and Drexler Automotive.

"We look forward to working with Continental and being able to supply everyone from race teams, club racers, and Formula Student teams with a highly advanced, comprehensive, and user-friendly motorsport ABS solution," said Dana Clark, Manager, Autotech Driveline.

Continental's new CES RSX motorsports ABS unit, based on its high-performance MK100, has been designed for all types of racing vehicles. It claims that its new software approach provides the best braking performance in-class, outperforming competitors on bumpy courses such as the Nürburgring Nordschleife.

With the origin in the series product, Continental's MK100 electronic brake system has been proven in use. For motorsports applications, the MK100 setup is chosen according to the special needs in this area, as front/rear brake circuit split in combination with a balance bar.

Continental says the ABS is suitable for all kinds of drivetrain, is cockpit-adjustable, features easy installation through bespoke wiring harness and utilization of existing wheel speed sensor architecture, and has a Diagnosis-Interface included in the kit.

BELOW Continental's RSX kit is now available in North America

Ginetta unleashes G56 GT4 Evo

BRITISH sports car manufacturer Ginetta has revealed its latest creation, the 2024 G56 GT4 Evo.

The Evo model builds upon the success of the original G56 GT4 in GT motorsport series globally. In addition to improvements in cooling, it chases on-track performance gains with revisions to improve tyre heat and degradation. This includes adjustments to the suspension, roll development, a higher platform height, and larger wheels and tyres on both axles.

Mike Simpson, Ginetta's Director of Motorsport, said: "We have had many cars circulating in endurance racing in tough climates over the last years; the Evo upgrade is the accumulation of listening to customers/teams and developing what we believe is the best GT4 car on the market.

"We have strived for greater top speeds within the Balance of Performance (BOP) management; adding weight lower down in the chassis gives us some wins in safety and torsional stiffness. The increased weight and higher ride height of the car has allowed for more emphasis on the straight-line capability of the Ginetta, making it a very competitive car for both gentlemen and professional drivers."

Noteworthy changes to the aerodynamic profile, including a visually striking bonnet and alterations to the rear wing, contribute to gains in overall aerodynamic efficiency. There have been major changes to the cooling package around the engine and into the cockpit, with improvements to air-conditioning to reduce cockpit temperatures.

The G56 GT4 Evo's first year of competition will include a production run of 20 cars, with half already reserved by existing customers.

Ginetta conducted extensive testing on a dyno, at its Blyton Park test track, at Silverstone, Donington Park and recently secured victory in the 4-hour Ultimate Cup race at Magny-Cours in France. Evo components will also be tested in the Creventic Middle East Cup to guarantee performance and reliability for 2024 GT4 customers.

RIGHT A key focus is on the redesigned bonnet and cooling system

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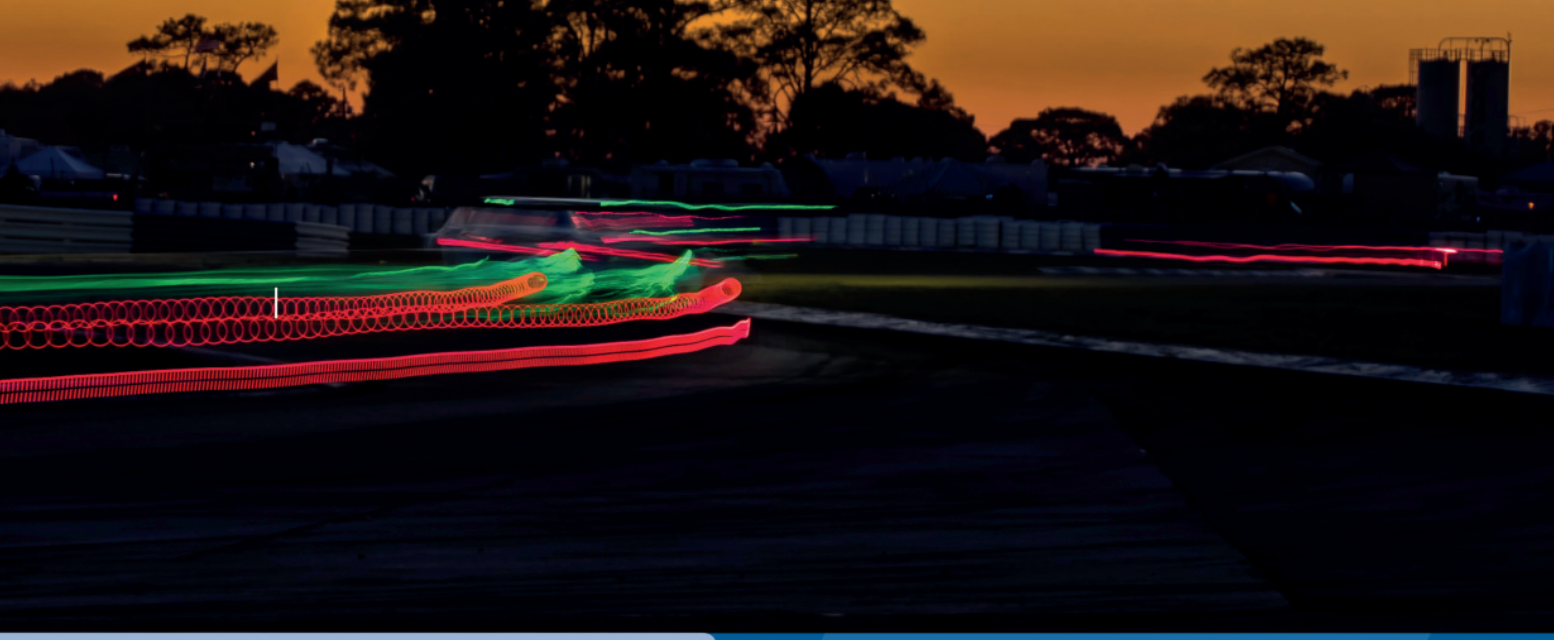

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THE FUTURE OF AVIATION IS TAKING SHAPE

Sooner than expected, spectators will begin to feel guilt-free about flying to sporting events. **Chris Ellis** explains why

FORMULA 1 is aiming to become a net zero sport by 2030, and is already making good progress in achieving this.

F1 has undertaken a detailed carbon footprint analysis of the CO2 emissions generated by its operations, events, logistics and race cars. For an entire race season, approximately 256,000 CO2 equivalent tonnes are generated, of which 47% is due to flying personnel and equipment. However, the CO2 resulting from spectators flying to races currently averages about 20,000 tonnes per race, so their annual 'F1emissions' are at least six times more than F1's 'internal' flying emissions. So, from a climate perspective, solving the spectator emissions problem is key, and this is true across all international sport.

The good news is that a convincing solution is already on its way. The U.S. government has just funded JetZero and partners to develop and build a large 'blended-wing' demonstrator which will have *half* the fuel consumption of its conventional equivalent. Its first flight is planned for early 2027, using a SAF (sustainable aviation fuel), but the blended-wing body provides the extra space needed for hydrogen fuel tanks, and a 'hydrogen airliner' version is expected to follow soon after. A subsidiary of Northrop Grumman (Scaled Composites) will build the prototype, which makes the project and its timescale distinctly credible.

Currently, an Airbus A350-1000 has to be filled with 125 tons of conventional fuel for a flight of 16,100 km. However, it would need less than 35 tons of liquid hydrogen, not 125/2.8 tons, because of the massive reduction in take-off weight, which means less energy would be needed to reach altitude, and for most of the rest of the flight. But liquid hydrogen will still need more than twice as much space to store it as Jet A-1 or SAF, because of the thick tank walls needed to insulate the hydrogen. The space required inside the airframe for the large cryogenic tanks means a blended-wing design is essential to provide medium- and long-range flights.

Because hydrogen airliners will need so much less energy to fly, the cost of refuelling the first large hydrogen airliners may be less than using Jet A-1 even *before* they can be brought into service, so the business case for developing and using the new airliners will be based mainly on the costs they save, with 'green flying' merely an attractive bonus.

RIGHT The US government-funded JetZero 'blended-wing' project could be a real game-changer for the aviation industry

The cost of refuelling with 'solar hydrogen' is predicted to fall to less than $3/kg by 2035 for flights from the Middle East, making it even cheaper to use than untaxed kerosene. This could make it attractive for flights from the Middle East to Europe to carry sufficient hydrogen for their return flight. This would increase the weight of the aircraft by less than seven tons on initial take-off, adding very little to the cost of the first leg, but it should reduce substantially the fuel bill for the return flight, given the level of tax on conventional aviation fuel for flights from Europe by 2034. Emirates and other airlines may find this very interesting…

Attraction of Hydrogen

The weight savings resulting from hydrogen's high specific energy will make it more financially attractive to the aviation industry than to any other sector. This should give investors in hydrogen production increased confidence that the demand from the airlines will grow fast, and that they will be prepared to pay a (slight!) premium to ensure supply priority. Aviation will be the leading application for hydrogen, years ahead of any other major sector, mainly because it will become fully cost-effective when its price falls below $4/kg, while most other sectors will need to wait until it drops to $2/kg or less.

By 2026, when airline executives will be able to visit Scaled Composites and see the full-sized JetZero demonstrator almost ready to fly, most of the aircraft then on order from Airbus and Boeing will become effectively obsolete. This is because the BWB concept is more efficient for all sizes of airliners, and JetZero is claiming its demonstrator will need only half the fuel used by its conventional equivalents, over most routes.

So the possibility of a big fall in orders for its conventional offerings may be the main reason why Airbus is currently saying it will probably use a familiar type of airframe in its ZEROe project, rather than one with blended wings. However, if JetZero is correct, a conventionally-shaped ZEROe demonstrator will need *twice* as much hydrogen as a BWB design for the same range, when finding enough room for the hydrogen tanks is the major airframe design challenge, even in a blended-wing design. Consequently, a hydrogen-powered blended-wing airliner is a major short-term threat to Airbus and Boeing. Until they build their own…

Now imagine it's 2030, and you want to get from your lovely home to Silverstone. Of course you could go by car, but you have a new fuel-cell-powered eVTOL four-seater capable of taking off from your tennis court and carrying you directly to the landing zone near the racetrack. Faster than any other way, and – what a view! And it's autonomous, enabling it to bring you home safely, no matter how much champagne has flowed! Sadly, your 250 GTO will stay at home because you have become convinced Climate Change is for real. How big will the eVTOL parks at most racetracks need to be by 2035?

So please keep flying - the airlines will need your money to pay for the wonderful new aircraft that will remove your 'flight guilt'! And make most flights much cheaper! RT

Getty Images/Red Bull Content Pool

BELOW Slashing the emissions produced by F1's huge fanbase, both at the races and at home, is crucial

ATL

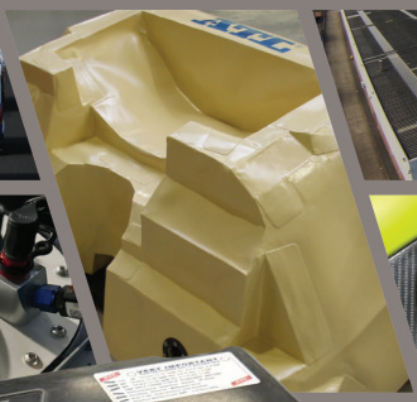
*"We call them **safety fuel cells**, they're explosion proof, and so they're in great demand in racing cars and marine craft, and some specialized land vehicles."*

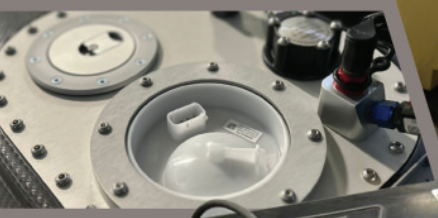
Peter Regna | ATL Founder, 1970

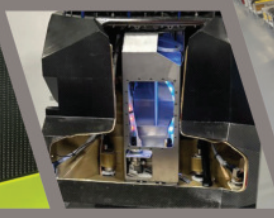
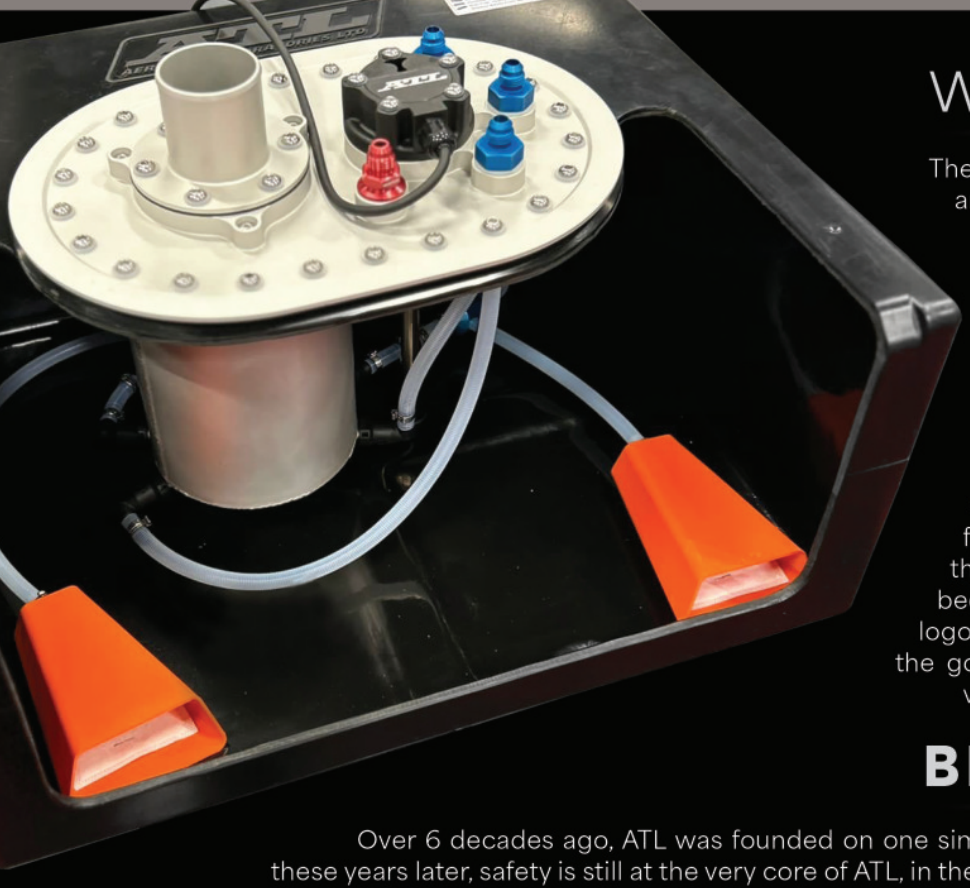
A NEW ERA...

ATL

BEYOND SAFETY



WHY **REBRAND?**

The ATL rebrand represents the alignment and unification of ATL Inc. *(New Jersey, USA)* and ATL Ltd. *(Milton Keynes, England)* into one global powerhouse, driven by a common vision that is reinforced by a shared set of company values.

THE **LOGO**

Simple, yet iconic. ATL, the acronym for Aero Tec Laboratories, has stood the test of time for decades and has become one of the more recognizable logos in motor sports. For the rebrand, the goal was to introduce a sleek, modern version that still holds true to our roots.

BEYOND SAFETY

Over 6 decades ago, ATL was founded on one simple, yet critical, principle - **Safety**. All these years later, safety is still at the very core of ATL, in the values we uphold and in the products we manufacture - many of which are hand-crafted with pride by a legion of highly skilled technicians. However, to fully understand the entire scope of ATL, you must look **Beyond Safety**.

BEGINS NOW

FROM ZERO *emissions* TO HERO

Racing in some of the most remote corners of the planet, Extreme H will – quite literally – carry the development of hydrogen fuel cells into new frontiers. By **Chris Pickering**

EXTREME H promises to break new ground when the hydrogen fuel cell off-road series begins in 2025. The core concept may be shared with its all-electric sister series Extreme E, but the switch to hydrogen is nonetheless a big step.

Fuel cells have been used in motorsport before. Swiss outfit GreenGT and Delft University's Forza team have both demonstrated sports prototypes powered by the technology. Meanwhile, French engineering company Gaussin successfully completed the gruelling Dakar Rally with a fuel-cell powered truck in 2022. On top of that, the Automobile Club de l'Ouest (ACO) is looking to introduce a new class at the 24 Hours of Le Mans in 2027 that will be open to both fuel cells and hydrogen combustion engines.

Extreme H, however, looks set to be the first series dedicated exclusively to hydrogen fuel cell powered vehicles. What's more, it's set to receive full FIA World Championship status in 2026.

So far, hydrogen has shown a lot of potential in motorsport, but the reality hasn't always lived up to the promise. The first appearance of a fuel cell car at Le Mans was supposed to happen a decade ago, but despite a number of demonstrations, the technology has yet to race at the 24 Hours. Extreme H has also been pushed back – its launch was initially slated for 2024.

But there are good reasons to believe Extreme H will be the real deal. For a start,

series founder Alejandro Agag and his team have a proven track record of taking ambitious concepts and turning them into a reality, with both Formula E and Extreme E to their name. On a practical note, the series plans to stick quite closely to the vehicle template laid down by Extreme E, giving the engineers a well-established starting point.

"We've already demonstrated through Extreme E that EVs aren't just for shopping trips and the school run. There's an opportunity here to do the same for hydrogen," comments Mark Grain, technical director of Extreme E.

"Hydrogen fuel cells are such a fast-developing technology – not just for motor vehicles, but aircraft and commercial vehicles as well. We want to play a part in advancing this technology, using our harsh environments. While OEMs might be on a five-year development cycle, we can advance technology that much faster in motorsport. It really is an opportunity for racing to improve the breed."

A fuel cell is essentially an onboard generator coupled to an electric powertrain. Experience with Extreme E meant that the technical team already had a very good understanding of the power and energy requirements for the new series. The next step was to investigate whether it would be practical to package a fuel cell onboard the car that would satisfy those requirements. It soon became clear that the answer was yes.

"There was some initial research done with our vehicle partner Spark Racing Technology to ensure that the fuel cells which are currently available would support the race durations and refuelling windows required for our format," comments Grain. "It was quickly established that there were no concerns about that, so we set about finding a fuel cell partner."

The company they turned to, which will soon be announced, has worked closely in Europe with a number of pioneers in the field of zero-emission mobility.

Battery sizing

While the initial simulations had demonstrated that current fuel cell technology would work, the question remained what size fuel cell would work best for the Extreme H car. Fuel cells are relatively slow to respond, and work best at a fixed output, so a battery ▶

BELOW Extreme H will use the well-established starting point of Extreme E to become the first series dedicated exclusively to hydrogen fuel cell powered vehicles

ABOVE A major international series providing wheel-to-wheel racing for hydrogen fuel cell cars will be a landmark moment

of some description would be a prerequisite to store and release energy for transient demands. Broadly speaking, the bigger the battery, the smaller the fuel cell would need to be.

The Extreme E technical team worked closely with Spark, the yet-to-be-named fuel cell supplier and battery provider WAE to determine the optimum solution. It uses the same fundamental technology as the Extreme E battery pack, but with a reduced capacity.

As in Extreme E, the battery sits between the cockpit and the rear motor, in much the same place as you might expect to find the fuel tank on a conventional off-road racer. The main difference with Extreme H is that the pack has been flattened from a cube into a slab, which sits at the base of the chassis. The fuel cell sits directly above that, with the hydrogen tanks on top.

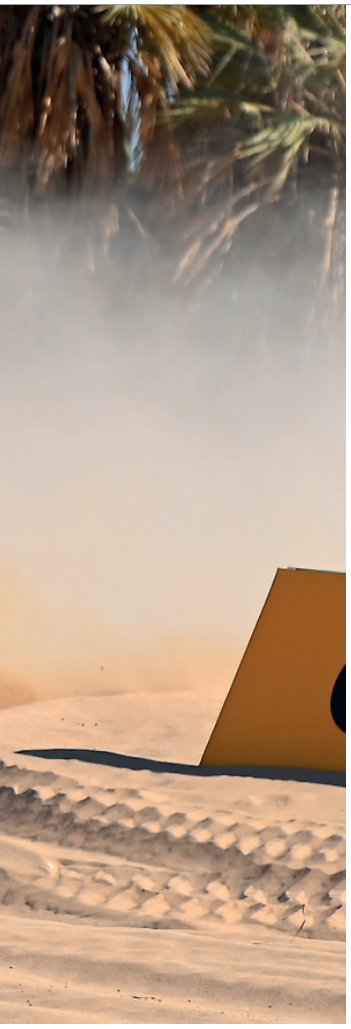
RIGHT Extreme E tech director Mark Grain

The tanks are road car items supplied by Toyota. They're built to the industry-standard T4 regulations and operate at up to 700 bar pressure.

"It's these sorts of areas that we're hopeful that we can help push forward and develop in due course. But for now we've been very much guided by the fuel cell supplier's previous experience when it comes to fuel cell size, packaging and performance," notes Grain.

As the design started coming together, the fuel cell partner began testing the race-spec items on its dynos. Meanwhile, Spark was working through the finer points of the packaging. Both aspects turned out to be reassuringly straightforward, Grain explains. "In terms of packaging the fuel cell into the car, the greatest challenge was making sure that we had the right levels of impact structure," he comments. "The battery was sitting a lot lower, which gave a natural space for the fuel cell. It was quite easy to accommodate the cooling package and the rest of the hardware around that. And then that's all enveloped in a composite impact structure, which sits inside the car's tubular steel spaceframe."

The finished car is expected to be somewhat heavier than the Extreme E machine – not just due



to the hydrogen hardware, but also as a result of other upgrades made to the chassis, suspension and drivetrain. These include more robust driveshafts and re-designed suspension geometry, all of which has a knock-on effect on the mass.

Much of the expertise behind this has been drawn from the US off-road racing scene. Californian suspension specialist Fox has been Extreme E's official damper supplier since the start of Season Two, bringing a wealth of experience to the project. Other US design consultants have also been drafted in to advise on the suspension geometry.

"We were aware that one of the limitations of the Extreme E car is dealing with large angles of bump and droop, and the angulation that puts into the driveshafts," comments Grain. "The danger is that it can snatch a driveshaft going over a jump and then fail a CV joint or a driveshaft. So we've looked at both the design of the components to make them more robust and also the suspension geometry to limit the driveshaft angles."

Overall, the Extreme H car is expected to tip the scales at around 100 kg more than its battery-only equivalent, with total mass increasing from 1,895 ▶

Florent Gooden /DPPI

RIGHT Alejandro Agag, here signing the World Championship deal with FIA President Mohammed Ben Sulayem, has a proven track record for turning difficult concepts into reality

Airbus

RIGHT Hydrogen fuel cells are a fast-developing technology (this is Airbus' ZEROe hydrogen fuel cell engine demonstrator), but motorsport has the ability to innovate quicker than other sectors

kg to around 2,000 kg. The target, however, is to ensure that the performance meets or exceeds that of Extreme E right from the start, before pushing further.

Safety and durability

While independent projects like the GreenGT H24 have helped to demonstrate the feasibility of this technology, there's not yet a universally recognised set of guidelines for hydrogen in motorsport. Extreme E and its partners have worked with the FIA to define a series of requirements for crash test methodologies and loads.

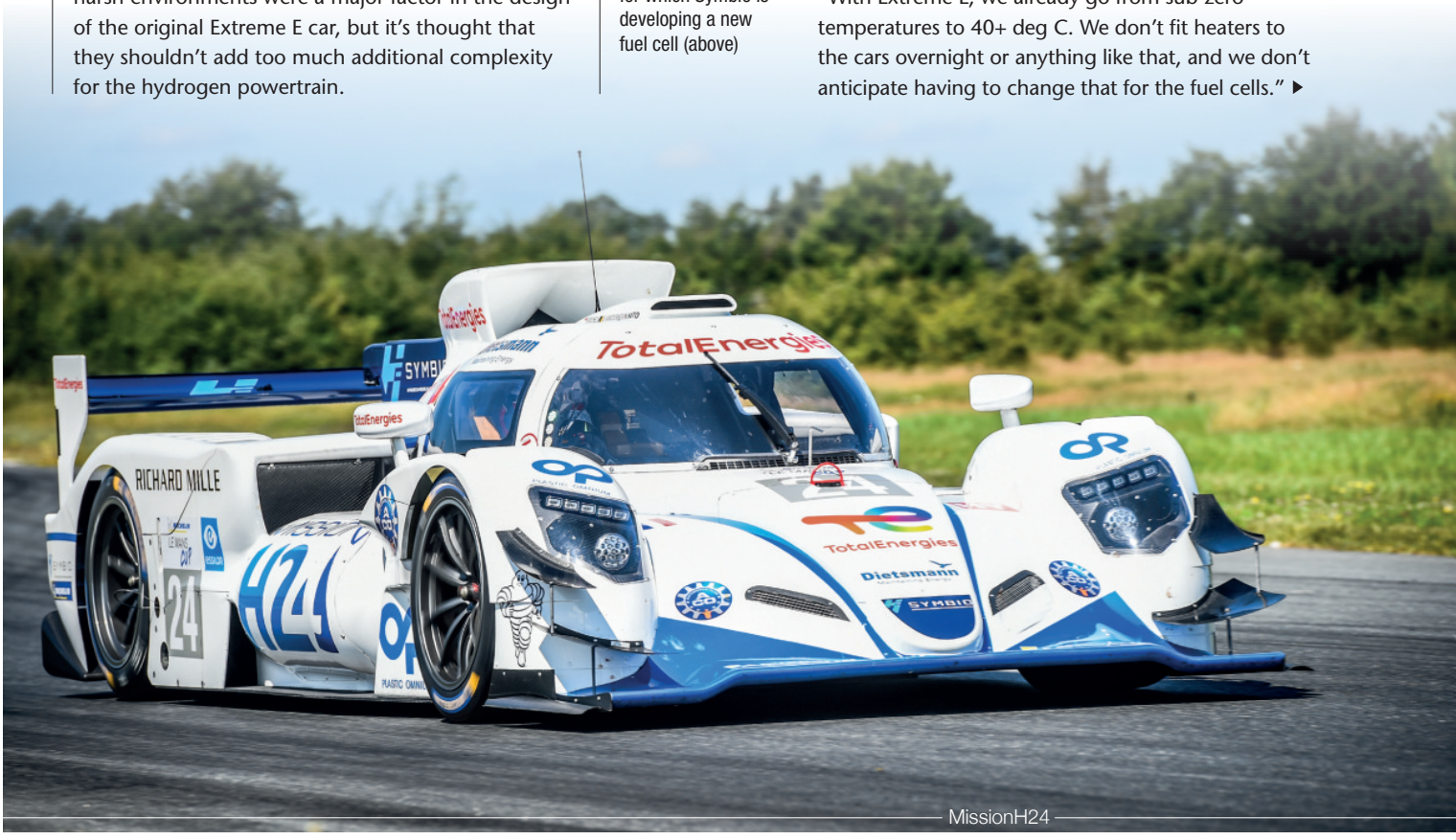
"We approached the FIA with a blank sheet of paper," comments Grain. "Although there are parallels to things like the Dakar and the WRC, it's a bit different here as we're racing wheel-to-wheel. What we do have is three years of data from Extreme E, but when it comes to the hydrogen aspect we're doing everything for the first time."

It's been a journey of discovery, he explains: "There's been a lot of work back and forth building samples for the conical impact structures and the walls, which are then pushed into poles or stations. That process has taken a little longer than then estimated, but with good reason."

Extreme E has an excellent safety record, but it's been known to produce some dramatic crashes along the way. Another factor to consider is the unique environments the series visits, which range from Arctic glaciers to the deserts of the Sahara. These harsh environments were a major factor in the design of the original Extreme E car, but it's thought that they shouldn't add too much additional complexity for the hydrogen powertrain.

ABOVE & BELOW
The highest profile hydrogen project to date has been the MissionH24 Le Mans car (below), for which Symbio is developing a new fuel cell (above)

"Fuel cells don't need to be wrapped up in cotton wool. There are already road cars and other vehicles out there that use this technology. Part of what we want to do is demonstrate that they are durable in these extreme conditions," comments Grain. "With Extreme E, we already go from sub-zero temperatures to 40+ deg C. We don't fit heaters to the cars overnight or anything like that, and we don't anticipate having to change that for the fuel cells." ▶



MissionH24

Extreme E

LEFT & RIGHT Despite the perceived fragility of batteries, Extreme E has yet to experience a single failure as a result of a crash

BELOW The unique environments which the series visits were a major factor in the design of the original Extreme E car, but shouldn't add too much additional complexity for the hydrogen powertrain

Refuelling

ONE of the recurring questions with hydrogen in any application is refuelling. While rapid refuelling of an energy-dense gaseous fuel is one of the technology's key selling points, it relies on an infrastructure that's far less mature than high-voltage battery charging, let alone conventional fuels.

This isn't quite the obstacle that you might assume, though. Extreme E's TV-orientated format requires a reasonably rapid turnaround between heats, but it doesn't feature pit stops. The relatively limited quantities of hydrogen involved also mean that it can comfortably be transported in tube trailers.

"We are a long way down the line to selecting a partner to provide the refuelling equipment," explains Grain. "We're envisaging a central point in the paddock where the cars will roll through and refuel, very much like you might do with a hydrogen road car. The research on this has been done, and we believe that it'll be a very straightforward process."

Extreme E already uses a fuel cell to supply power to the paddock. Here, water and sustainably-sourced methanol are put through a reformer to create hydrogen. The hydrogen is fed into a 200-kW marine-spec fuel cell, which outputs through a DC-DC converter that stabilises the voltage.

In endurance racing, GreenGT, working in partnership with TotalEnergies, has already demonstrated a portable hydrogen refuelling rig, which was small enough to fit into a 20-foot shipping container. The solution for Extreme H is likely to be something similar. RT

WAE

> *"Fuel cells don't need to be wrapped up in cotton wool"*


Extreme E

The terrain itself poses a greater challenge, but Grain says that careful attention to the anti-vibration mounts should be sufficient to provide the necessary levels of impact and vibration resistance. This has already been proven with shaker rigs and simulation work, we're told. Overall, he believes the durability targets will be no harder to achieve with a fuel cell than they would be with a battery. And despite the perceived fragility of batteries, Extreme E has yet to experience a single failure as a result of a crash.

In fact, the biggest technical challenges may not even relate to the fuel cell at all. Grain stresses the importance of improving the overall package: "A lot of the learning has gone into how we design a car that provides great wheel-to-wheel racing off-road. It's about the handling of the car, the centre of gravity, the suspension dynamics and so on.

"Since we've been working with Fox, the dampers have evolved quite a lot. The suspension has been getting progressively stiffer to provide a better balance between impact absorption and cornering ability, while still allowing enough adjustability to tailor it to the different surfaces. That's a trend that's continuing as we move into Extreme H."

First steps

Our conversation takes place at the start of November. At this point, Spark and the Extreme E technical team are flat out on the first prototype for Extreme H, dubbed Chassis Zero. The hope is that it will be finished by the end of November and beginning its shakedown tests before the end of the year. A comprehensive test programme will follow in 2024, before the series kicks off in 2025.

Extreme E will continue to run as normal next year – possibly with an Extreme H car taking part in some demonstration runs at the tail end of the season. Beyond that, things are a little less clear-cut. No official decision has been made yet on the future of the battery-electric series once Extreme H arrives. It's been speculated that Extreme E will be discontinued at that point, but Grain says that a number of other possibilities remain open at this stage – including perhaps combining the two different classes into one event.

Whatever the format, a major international series providing wheel-to-wheel racing for hydrogen fuel cell cars would be a landmark moment. And this, says Grain, is part of the appeal of the project. "I've been fortunate enough to be involved with several firsts in motorsport. I was there at Le Mans with McLaren when we won the event on our first attempt, for instance," he comments. "Recently I caught up with the chief engineer at Spark and he sent me some photos of the first Extreme H car in build, and it really dawned on me that we're right on the edge of another significant first." RT

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PAT SYMONDS, Chief Technical Officer, Motorsport Division, Formula 1

"This was my first time attending the World Motorsport Symposium and it was an overwhelmingly positive experience. The quality of people, content and discussions were at the highest levels but the camaraderie amongst those in attendance really stood out. I plan to mark it on my calendar now for 2023 and bring several people from NASCAR to attend. Can't wait"

ERIC JACUZZI, Managing Director, Aerodynamics/ Vehicle Performance, R&D Center, NASCAR

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AN UPDATE ON BRAKING NEWS

The arrival of electric and hybrid powertrains poses new challenges for motorsport brake experts. **Chris Pickering** consults two of the key players at PFC Brakes

SOMEWHAT counterintuitively, the ability to slow down has always been a key part of going quickly. Whether it was four-wheel brakes versus two-wheel brakes in the very early days, the arrival of disc brakes in the fifties or carbon-carbon coming of age in the early eighties, innovative braking systems have long offered a race-winning advantage.

That remains true today. But the link between slowing down and speeding up has become even more fundamental with the arrival of electric and hybrid powertrains in motorsport. Slowing down isn't just about shedding excess speed anymore; it's about harvesting energy.

"One of the biggest incoming trends is energy being taken away from the brake system by electrical regeneration," comments Paul Rankin, design engineering manager at Performance Friction Corporation (PFC).

As the sole brake supplier to IndyCar, PFC has been preparing for the series' transition to hybrid power in 2024. Rankin admits this isn't the most complex application of hybrid technology. Unlike LMDh or Formula 1, there's no brake-by-wire functionality, and the overall energy recovery levels are relatively low, but the addition of the hybrid system is still the primary factor behind a comprehensive series of updates to the brake package for 2024.

"You can get away with running much smaller brake packages on heavily-electrified cars because there's so much regeneration," he says.

"Hybridization and electrification allow the engineers to move the unsprung mass to the sprung mass," suggests Luis Maurel, global director of motorsports for PFC, when considering the impact of these trends across the industry. "Adding an electric motor acting as generator leaves the possibility of reducing the brake package mass. This fact is beneficial for the whole traction of the car and stability."

"If you look at a Formula E car, the brakes seem tiny inside the wheels," says Rankin. "IndyCar is a bit different, because there may be times when the cars aren't using any regen at all. The hybrid system adds a significant amount of weight and power, and sometimes the mechanical brakes will have to cope with that on their own, so we have to size them for that scenario."

Shifting balance

As with most hybrid racecars, the new Indycars can only apply regenerative braking to the rear wheels. With no brake-by-wire system to compensate, the balance of the mechanical brakes has to be shifted forwards to compensate. This tends to result in rears running cooler, while the fronts run hotter.

The bulk of the IndyCar season takes place on road and street courses, but oval races like the Indy 500 still remain a big part of the spectacle. On the superspeedways, drivers can go for laps at a time without touching the brakes, which are generally only used for collision avoidance and coming into the pits.

That might not sound like the most promising environment for energy recovery, but drafting plays such a big part in oval racing that the drivers should be able to syphon off energy while slipstreaming the car in front. From the brake system's perspective, however, the long ovals are relatively straightforward.

> *"Sustainability and brake emissions are driving the adoption of new materials"*

Where it gets tricky is the road courses, and in particular the street tracks. These tend to have long straights punctuated by 90-degree corners, instead of the high-speed sweepers you might find on a permanent racetrack. Exactly how the energy will be ▶

ABOVE The mass of the disc will be increased and the cooling improved as part of the new package to cope with the transition to hybrids. Like F1, IndyCar employs a carbon-carbon setup. The discs and pads are both based around carbon fibre in a graphite (carbon) matrix

Ferrari makes history with new PFC endurance compound

PFC BRAKES has launched a new endurance compound – named 82 (front) and 84 (rear) – for GT cars, scoring excellent results right from its debut at Daytona.

The compound was notably used when the Frikadelli Racing Ferrari 296 GT3 secured an emotive and historic victory for the Scuderia at the Nürburgring 24 Hours. The Frikadelli 296 GT3, crewed by David Pittard, Felipe Laser, Nick Catsburg and Earl Bamber, took the chequered flag in triumph after 162 laps, the longest distance ever completed at the German event. It was the first victory by a non-German marque for 20 years and was Ferrari's first outright success at the prestigious event.

The new endurance compound is completely adapted to the new generation Bosch ABS, thanks to its digressive curve between the front and rear axles, and works for Endurance and Sprint applications.

"We are working hard with the coming Daytona 24 Hours as our main objective," says Luis Maurel, global director of motorsports. "Nowadays the data around the cars allows the engineers to set up the car very quickly and precisely, with a very good balance. To use different compounds between sprint and endurance racing changes the set-up completely. They would love to have just a single pad compound for both sprint and endurance races. The drivers love this idea as well, keeping the same feeling and behaviour. With our new compounds we are very close to having a pad that offers amazing "mu" figures and big endurance." RT

ABOVE Ferrari wrote a page in motorsport history by winning its first 24 Hours of Nürburgring with PFC's mew endurance package

harvested has yet to be confirmed, but it's thought there will be times on these tracks too where the mechanical brakes have to do all the work themselves, placing huge demands on the discs and pads.

"The way we're coping with the extra weight and speed of the cars is to increase the mass of the disc and improve the cooling," explains Rankin. "So the calipers have stayed the same, but the rest of the wheel and brake components are changing. The end result is that when the temperatures are elevated – up at 800 or 900 deg C – they will shed that heat a lot quicker, to keep the temperatures in check."

The number of cooling holes in the disc has been increased. There's also a new hat design to further aid cooling, along with revised pads. As in Formula 1, a carbon-carbon setup is used, with the discs and pads both based around a carbon fibre in a graphite (carbon) matrix. A variety of heat treatments can be used to tailor the friction characteristics from one application to another, but within IndyCar the same process is used for all tracks.

In the zone

The materials used for road and street courses are the same as those on the ovals. Instead, the brake temperature is regulated with a set of cooling ducts, which the teams can tailor to their own requirements. These are generally removed altogether on the fast ovals, blanked off to varying degrees on the road courses or opened up completely.

> *"One of the biggest incoming trends is energy being taken away from the brake system by electrical regeneration"*

PFC has also developed a pad retraction system for use on ovals, which pulls the pads completely off the disc to eliminate the small degree of drag that can otherwise occur. The impact of this drag reduction is relatively minor in percentage terms, but at 230 mph it adds up to a significant difference.

Carbon-carbon brakes are light, and they can withstand more heat than traditional cast iron discs, but the downside is that they need to be up to 350 or 400 deg C to work comfortably. Below around 300 deg C or above around 800 deg C the wear rate increases significantly, and at low temperatures the braking is less effective. The same is eventually true at high temperatures, but PFC's testing has shown carbon-carbon brakes can function at up to 1,600 deg C when required.

The temperature isn't just significant for the brakes themselves. Heat transfer from the discs into the wheel bearings can have a serious impact on durability, Rankin explains: "The right rear wheel

ABOVE & BELOW Compounds are changed from one track to another in NASCAR, which provides a challenging environment for brakes. PFC equipped the winner of the NASCAR Cup Series finale, Ross Chastain claiming his second victory of the season in his Trackhouse Racing Camaro ZL1 at Phoenix Raceway

bearing experiences a lot of load on an oval, and that alone can make it get quite hot. So, if there's additional temperature being put into that right rear bearing from brake drag it can lead to bearing failure. One of the things that the pad retraction system does is that it helps to keep these temperatures in check."

The larger discs and pads will keep the new IndyCar brakes within this sweet spot, although they actually run somewhat cooler than their predecessors.

"What we've seen in the first tests with Ganassi and Penske is that the same driver will experience a reduction of around 100 deg C. That's good in view of the weight increase," comments Maurel.

While the hybrid system is the main source of the weight increase for 2024, it's part of an ongoing trend that has pushed IndyCar brakes harder and harder over the last few years. The Aeroscreen that was added in 2020 added a significant amount of weight (in revised 2023 form it's said to weigh around 24 kg). Prior to that, the universal body kit that was adopted in 2018 reduced downforce and drag. That meant the drivers were hitting higher speeds on the straights but having to slow down to lower corner entry speeds, resulting in higher brake demands.

Bigger wheels?

According to the PFC engineers, there's a general trend towards front brake sizes increasing right across the board.

"The biggest disc that you can fit in an 18-inch wheel is 400 mm, and for that size we're right on the limit of the temperature for cast iron. We can see over 1,000 deg C, which is very high for those materials. Even the brake pad sweep is very big," comments Maurel. "So, we think that there must be some change in the coming years."

The easiest solution would be to retain the comparatively affordable cast iron discs, but to bring the sizes closer to those found on high performance road cars, where 19, 20 ▶

Photos: Getty Images/NASCAR

or even 21-inch wheels are becoming common. At least, that's the easiest option for the brake manufacturers. Increasing the wheel sizes would entail abandoning the 18-inch tyre diameter that's seen in everything from domestic touring cars to LMH prototypes, meaning a significant shift for the tyre manufacturers, as well as revisions to the suspension geometry and kinematics.

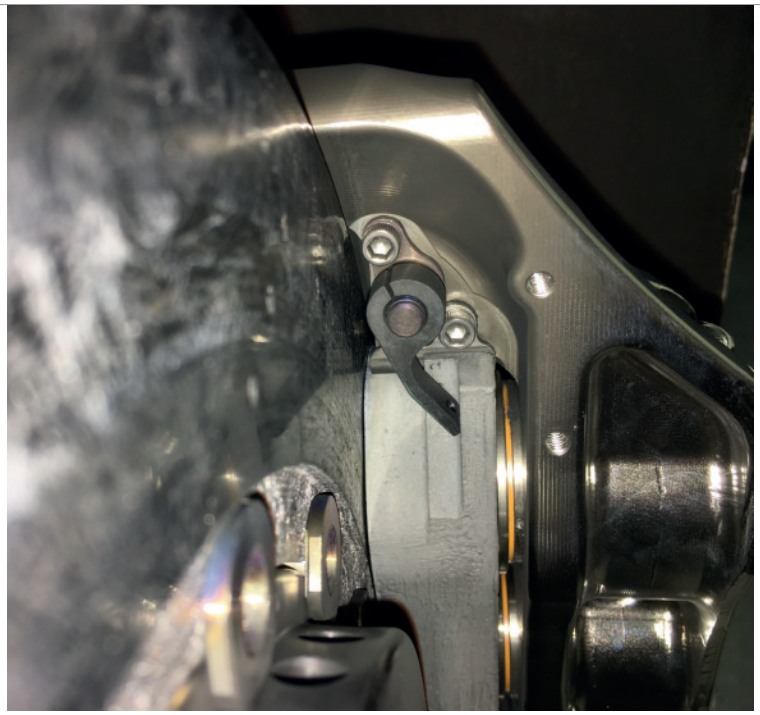
> *"Testing has shown carbon-carbon brakes can function at up to 1,600 deg C when required"*

Despite these challenges, Maurel believes bigger wheels are likely to be the best response to rising brake temperatures: "We are starting to see brake failures in NASCAR, because the temperatures are getting so high. GT2 is another challenge, with the cars there producing almost 700 hp. If the GT2 cars went hybrid, it would be a real challenge, because we are already on the limit."

Pad formulation for ABS

It's a particularly challenging situation in the GT categories where ABS is used, he points out. The pad formulation for ABS and non-ABS pads is already completely different. In ABS-equipped applications, the tendency is to significantly reduce the coefficient of friction (μ) on the rear to decrease the level of ABS intervention ("what starts at the rear inevitably comes to the front and makes life difficult," notes Maurel).

In non-ABS categories like NASCAR, the ability to modulate the brakes becomes very important. "NASCAR is quite challenging, because after the end of practice the car is left in parc fermé, so you need a compound that will work well with the soft tyres in quali, but also in the long stints of the races," comments Maurel. "In IndyCar, we're the sole supplier, so we can pick one configuration that works for all circuits, but in NASCAR we're up against other brake manufacturers, so we change the compounds completely from one track to another." ▶



ABOVE The company has developed a pad retraction system for use on ovals

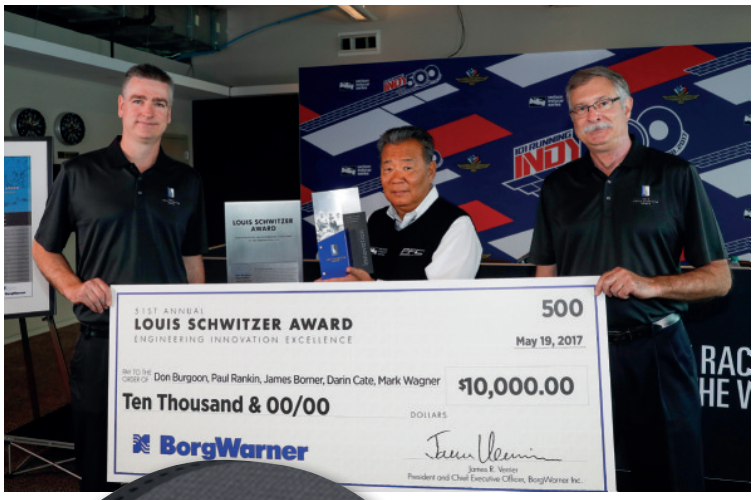
BELOW PFC now supplies all of IndyCar's ladder series, including the INDY NXT by Firestone series and the rebranded USF Pro Championships Presented by Cooper Tires

Penske Entertainment

While NASCAR's superspeedways are largely flat out like they would be in IndyCar, the short ovals can be a very different proposition. At tracks like Martinsville, the discs and pads only get a couple of seconds of respite going down the straight before the driver is hard on the brakes for corner entry again.

The GT300 category in Japan is said to be a particularly good place to test brakes. The class runs to a special set of regulations and uses extremely soft tyres that have been developed as a result of a three-way tyre war between Bridgestone, Dunlop and Yokohama.

"The cars are very quick due to the sticky tyres. And although they use the same ABS systems as you'd find in Europe, there's very little ABS intervention in the dry because of those tyres," comments Maurel. "The circuits in Japan are also very challenging," he continues. "Motegi is perhaps one of the most difficult, because it has a very grippy surface and a very high brake demand. It's a good place to try brake pads and look at how they behave – what they're like for modulation and power. Although it's an ABS formula, sometimes what works there also works in NASCAR."



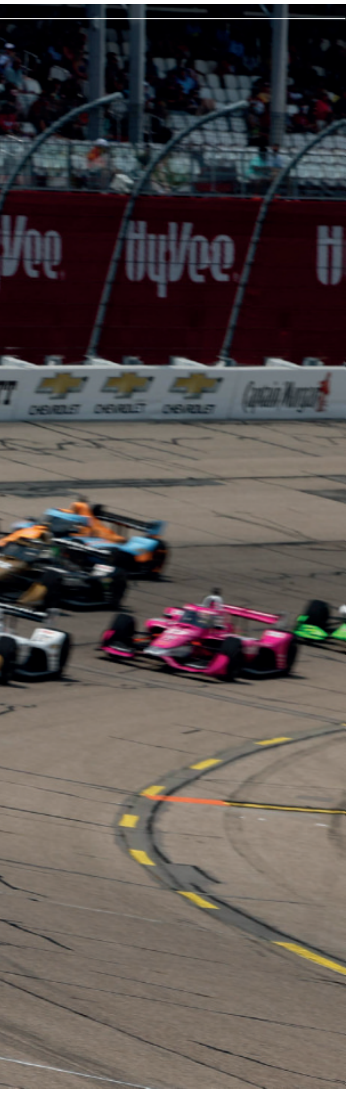
LEFT A render of the new front disc assembly for the 2024 hybrid IndyCar

Penske Entertainment

ABOVE The GT300 category in Japan is a particularly good place to test brakes

LEFT PFC has been an integral part of IndyCar's own technical journey. In 2017 it won the coveted BorgWarner Louis Schwitzer Award for the innovation and implementation of its V3 Disc Technology

BELOW The addition of the hybrid system is the primary factor behind a comprehensive series of updates to the IndyCar brake package for 2024



New materials

Carbon-ceramic brakes are now commonly used on road-going supercars. These are cheaper and more durable than the carbon-carbon brakes used in high-end race applications, and they offer much better low temperature performance.

Historically carbon-ceramic brakes weren't thought suitable for sustained track use as they can degrade at high temperatures. However, recent advances in the technology have raised the possibility of carbon-ceramics being used in motorsport, where they could offer a middle ground between cast iron and carbon-carbon.

The jump to carbon-carbon is another possibility that would solve the temperature concerns without increasing the wheel size, but it would be a big step up in costs, Maurel warns: "Carbon-carbon is maybe three or four times more expensive [than cast iron]. On the other hand, the GT cars often change rotors during a race weekend, even in a sprint race, whereas IndyCar teams use the same rotors all weekend.

Sustainability quest

"The other challenge is the low-temperature performance. In GT racing, you have a mixture of Pro and Am drivers and not everyone is braking in the same way. But that doesn't mean it won't happen at some point. In motorcycle racing, it was very difficult to keep the carbon-carbon brakes up to temperature when it was first introduced, but now it's much easier, and they even use it in the wet."

For PFC, as for the rest of the industry, the issue of sustainability is increasingly a catalyst for change. The company is committed to improving its environmental impact, not only on product design or production, but by also working hard to optimize its supply chain efficiency.

Working closer to its suppliers and customers (new facilities and production in Spain), consolidating shipments, promoting sea shipments against air ones, improving packaging, and using recyclable and reusable materials are just a few of the myriad challenges PFC is facing.

Sustainability and brake emissions are also driving the adoption of new materials. PFC is working on new resins for conventional pads, as well as ways to make carbon-carbon brakes more sustainable.

That task is being met on multiple fronts. PFC Brakes is supplier not only to some of the most important single-seater manufacturers, such as Dallara, Tatuus and Ligier, but to many other car manufacturers for GTs, TCR, Rally or E-projects, such as Porsche, Alpine, Ford, Nissan, Hyundai, BMW, AMG, Ginetta, Radical, MG, QEV, and Unplugged Performance.

"There are new raw materials that we are evaluating for our brake pads, which are much more environmentally friendly," comments Rankin. "It's something we've already been looking at for 15 or 20 years. Regulations are now coming in, for instance, to ban the use of copper in street pads, but that's something we started eliminating 15 years ago on the racing side."

With brake particulate emissions becoming an increasingly big topic on the road car side there's an opportunity for motorsport to lead the way once again. The same applies to everything from ABS calibration to regenerative braking. After more than a century of innovation, it seems that brake systems still have more to give. RT

SUPERVAN RETURNS

The mount of the reigning NASCAR Champion, Ford is returning to F1 whilst also engaged in the World Rally Championship. So how comes its latest technical tour de force is a transit van? **Hal Ridge** talks to Mark Rushbrook, global director of Ford Performance

Ford

FORD, like the majority of automotive manufacturers, is engaged in trying to make new technologies sexy to its consumers. It uses motor racing to spread the message, while also harnessing its competition arm for innovation and research.

The American giant is currently best known by the masses for its forthcoming return to F1, its NASCAR success and continued support of M-Sport's World Rally Championship programme. Yet for all the know-how on display at elite levels, the most obvious recent manifestation of the Blue Oval's drive to highlight sustainable technology in the motorsport arena has been with its Supervan concepts.

Supervan, in its three previous guises, was about making transit – famous as one of the most popular practical vehicles on the planet – extraordinary with ludicrous performance compared to its road-going cousin. Supervan 1 was effectively a Ford GT40 with a transit bodyshell, while Supervan 2 was based on a Group C chassis with Cosworth engine; the same concept, but with a 3.5-litre HB V8 F1 engine, was used for Supervan 3, later using a more practical 3.0-litre V6.

Fascination

At the Goodwood Festival of Speed in 2022, Ford revealed Supervan 4: a four-wheel-drive, all-electric, high-performance transit.

"Supervan [historically] created so much interest, fascination and spectacle, we were all aware of that, certainly with being fans of Ford and motorsport. We were always looking for that opportunity to say when should we do a Supervan 4," explains Mark Rushbrook, global director of Ford Performance. "There were certainly opportunities before, but never necessarily the right proposal, the right way to do it, the right timing or the right technology. Ultimately what led to Supervan 4 was sitting at Goodwood in 2021 with our Mach E 1400, a fully-electric high-performance demonstrator, and just discussing what we could do the next year, so that's what we did."

The Mustang Mach E 1400, intended for drifting, drag racing and demonstrations, was created by Ford and partner RTR as ▶

LEFT It's a transit van, but not as we know it: the successful assault on Pikes Peak with Supervan 4.2

a case study to show customers what an electric powertrain was capable of, free of strictly governed sporting and technical regulations. Supervan followed that trend. This machine was intended to impress and engage, not to win races. Well initially at least…

"With our big push with fully electric vehicles and the e-Transit coming, that was really the right time – it's about helping tell the story of the future in a compelling, fascinating way that will get people's attention and acceptance," says Rushbrook. "It was fantastic seeing Supervan 4 run up the hill, but that then led to thinking, 'Okay, what next?'"

The seed had been sown, and the demonstrator was suddenly set for competition. But Ford needed to compete somewhere where the concept would fit, allowing it to govern the development itself. In an era where motorsport is so heavily regulated, there are few real opportunities that jump out. The most prestigious is obvious, however: the Pikes Peak International Hillclimb.

"We had a lot of different ideas," recalls Rushbrook. "One was to go to Pikes Peak. We wanted to not just go fast, but *really* fast, to the point that we built a whole new vehicle. It wasn't just changing a little bit of bodywork on the existing Supervan, it was an all-new build to optimise weight reduction, aerodynamics and the electric powertrain itself."

Supervan 4.2, like its predecessor, has been created in partnership with Austrian firm STARD, and is a significant step on in performance.

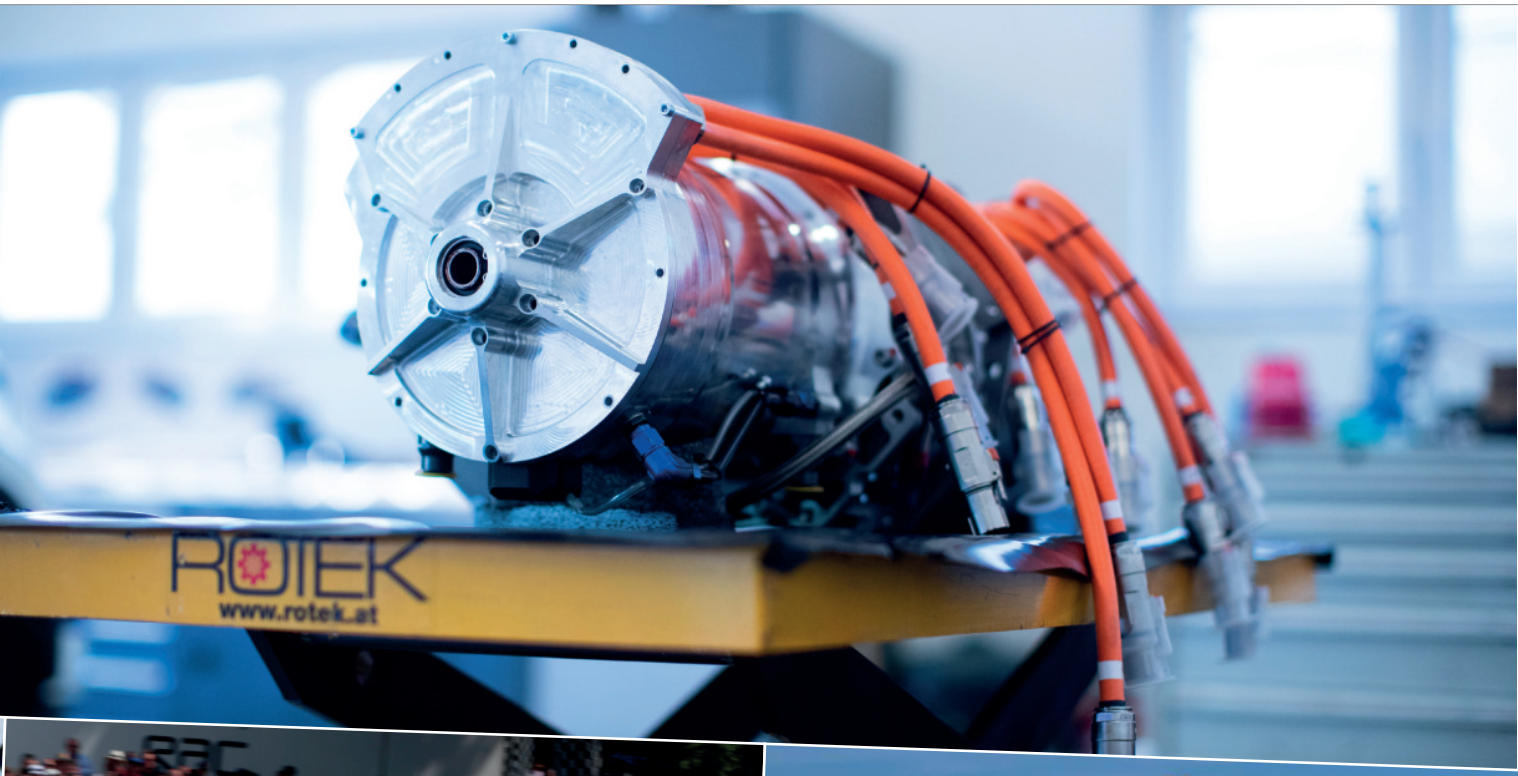
While Supervan 4 was a four-motor machine with an interior to resemble that of the roadgoing e-transit, 4.2 is designed as a thoroughbred racing machine. Anything unnecessary was immediately shelved, including one of the motors.

Weight saving was a key ingredient to optimising the performance from the electric powertrain. But ultimately, this is a totally fresh build, based on a tubular spaceframe chassis, clad with carbon fibre bodywork.

The already wild-looking Supervan 4

RIGHT Supervan 4.2 was conceived to showcase Ford's electrification expertise, free from the constraints of rules

All photos: Ford



TOP The crowd-wowing Ford Pro Electric SuperVan 4.0 that debuted at the Goodwood Festival of Speed in 2022 packed a high-voltage punch thanks to the collaboration with STARD

ABOVE Left to right, the transformation of Supervan: From a mid-engined V8 on a GT40 platform in 1971; to a Cosworth DFL engine and Group C C100 base in 1984; a Cosworth HB-engined Mark 3 Transit in 1994; and the 2,000 PS Ford Pro Electric SuperVan 4 collaboration with STARD in 2022

became even more extreme for 4.2, to improve aerodynamic efficiency. Downforce was increased to 2,028 kg at 240 km/h, with key changes made to the rear spoiler and front splitter with the target of high downforce but low drag and low ride height sensitivity.

However, the concept never saw a wind tunnel. "It was all CFD," notes Rushbrook. "We have really good correlation with our CFD tools, wind tunnel, on track and on road so we didn't feel like we needed [to use the wind tunnel]," says Rushbrook. "Certainly when we first tested the vehicle it was performing exactly where we expected it to be. But we made extensive use of aero engineers, CFD tools and our HBC computing power to get to a good place."

While Ford was able to assist in some areas, in others STARD took the reins. The Austrian outfit is arguably most famous for creating the world's first electric prototype rallycross car – long before such things were considered for competition use – and the implementation of the Projekt E category within World Rallycross in 2020.

Triple motor concept

The second STARD UHP 6-phase motor and inverter from the front axle on Supervan 4 was dropped. Instead, the single unit at the front was joined by a transversely-mounted twin-rear motor setup – the triple motor concept a similar but much updated version of the firm's rallycross project, controlled by a MoTeC VCU.

The motor change brought less power, now 1,050 kW and 1,200 Nm torque, but increased drivability and energy efficiency. A fresh battery pack was adopted, using STARD's Ultra High-Performance Li-Polymer NMC pouch cells, with the battery positioned differently in the chassis compared to Supervan 4, to align with the aerodynamics and airflow. ▶

"A lot of Supervan 4 was about being able to go fast, but with power and spectacle," says Rushbrook. "When it truly came to Pikes Peak and optimising the amount of energy you have, the size, weight and placement of the battery pack, the useful power in the motors, the simulation very quickly showed that you didn't need two motors in the front; one was enough, given the tractive effort and the amount of extra energy that you consume with a fourth motor. We even packaged around the aerodynamics and airflow, that dictated the battery pack placement."

The four-wheel-drive concept featured fresh drivetrain design, including a pair of single-speed transmissions, one front and one rear, with multi-disc limited slip differentials.

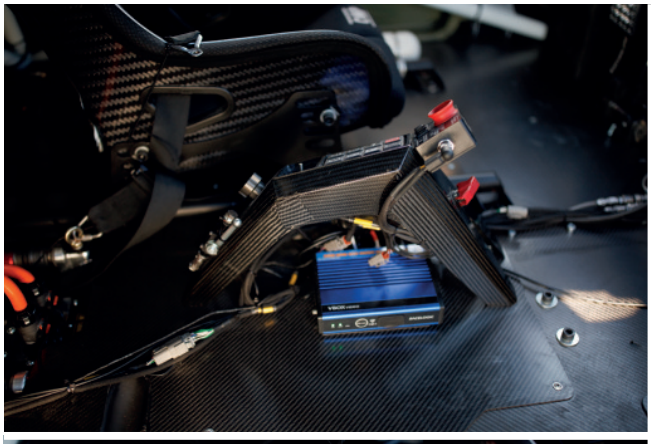
Torque blending system

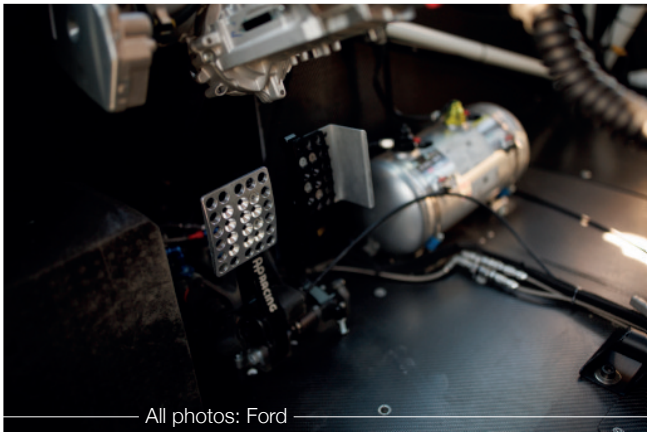
Alongside 600 kW of combined regen power, controlled by a driver-adjustable torque blending system, an Alcon braking package is installed, with 6-piston calipers at the front and 4-piston at the rear, featuring carbon ceramic discs. The double-wishbone suspension is supplied by KW Competition, with 5-way adjustable twin tube dampers and springs at each corner. Huge 18" x 12.5" OZ Racing magnesium wheels are clad with Pirelli P Zero tyres.

The end result? Multiple Pikes Peak winner Romain Dumas drove Supervan 4.2 to a time of 8:47.682 in the 101st running of the 156-corner event in June, to win the Pikes Peak Open Division by almost 40 seconds. In the process he finished second overall, just six seconds shy of outright victory.

"We're in so many different series, but with our demonstrators we can really go create any spectacle, any place we want," points out Rushbrook. "There is also a lot of history at Pikes Peak as an event and for Ford and a lot of eyeballs that get put onto it. The rules are written in a way that they're not overly restrictive – we wanted to compete but with some freedom in the rules to allow us to truly innovate and learn in the electrified powertrain space. It's a great place to be: you can see Pikes Peak in pictures and videos, but when you're there yourself it's a whole different thing. To be part of it was fantastic – to deliver on our goal of winning the division, to set a division record, [even] faster than the target we set ourselves." ▶

ABOVE & BELOW
Supervan 4.2 is the poster-child for Ford's E-Transit technology





All photos: Ford

Halo special-edition projects are relatively commonplace for OEMs to do something outside the normal championship-based competition in motorsport, much like Volkswagen, Bentley and Peugeot's efforts at Pikes Peak in recent years with various concepts.

For Ford, the objective is two-fold: to test different technologies and innovations while also making concepts outside of the norm attractive.

Acceptance process

"We learn so much," says Rushbrook. "This is a real test bed where we get engineering learning back into the company and it finds its way onto the production cars as well. But, it's also a way to tell the story to our fans and customers, that electrification is a great performance technology, that there's great capability in performance and to start that acceptance process. Not everybody wakes up and says, 'Hey, I want to buy an electric vehicle.' There are people who love combustion engine vehicles; *we* love combustion engine vehicles and what they're capable of, but there is a need in this world and in markets to have fully electric vehicles. This is a way for us to learn more about them, but also to show fans how great they can be and start that adoption process, so if not today but a year, five years or 10 years from now, people will want to buy these great electric products."

> *"F1 a badging exercise? The motor, inverter, software, analytics were all important. The list is 10 times longer now in terms of our engagement and learning"*

Ford is conspicuous by its absence in headline electric motorsport categories such as Formula E, World Rallycross and Extreme E. It seems the flexibility of using whatever platform it wants is often more important than achieving results in competition, with racing the clock at Pikes Peak an exception.

"It's mostly about the freedom to learn what we want to learn, because there are no rules. We can do whatever we want with batteries, inverters, software, motors, we can truly learn what we want to learn, not defined by the racing series. Then we can tell whatever relevant story we want from the product we're doing, in the shape of the vehicle we want," says Rushbrook.

"It's certainly not a knock on Formula E.

Red Bull Content Pool

BELOW Grand Prix racing returned to Las Vegas last month. The rise of F1's popularity in the US, allied to its strong sustainability messaging, persuaded Ford to gamble on making its own F1 comeback


Red Bull Content Pool

RIGHT Red Bull Racing Team Principal Christian Horner and Jim Farley, CEO of Ford, pose for a photo on the grid prior to the F1 Grand Prix of Miami. The two companies' partnership is already exceeding expectations

They have a lot of manufacturers in there and have built it up a lot, but it's restricted on what you can learn, the amount you can learn and the shape of the vehicle you're racing. Whereas these demonstrators, we can learn anything we choose to, we can race it or put on a spectacle any place we want in the world."

But, having said all that, Ford is making a return to a non-electric motor racing series. In February 2023 the tie-up with Red Bull Racing for 2026 was revealed. Not electric in F1, but Hybrid. Add to that a drive by motorsport's headline act to deliver on a sustainable fuels target by 2026, and being net carbon zero by 2030.

Undoubtedly lured by the Liberty Media, Drive-to-Survive-fuelled upturn in exposure for Formula 1, Rushbrook explains that the sustainability angle is important for Ford – both as a branding exercise, and working alongside Red Bull with the development of its powertrain technologies.

"The overall vision that they [F1] have and commitment made to be net carbon zero, to have the sustainable fuel, to have more power coming from the electric part of the powertrain for 2026, all of that was important for us. It wasn't the only reason, but that commitment was important for us and that is a big area actually that we in our partnership as Red Bull Ford Powertrains learn on the electrification side. Yes, we're working on the combustion engine side, the turbo and everything else, talking to ExxonMobil about the fuel development, but the electrification side was important for us and the ability there in developing a new battery ▶

Ford

ABOVE Supervan 4.2 didn't just win its division at Pikes Peak, it blew the opposition away

" You need to be efficient every hour, every minute, every second"

RUMOURS have long been rife that NASCAR could be looking at alternative propulsion options for the future. But although discussions have taken place about the introduction of electric technology, for now the Next Gen cars, introduced so successfully to the NASCAR Cup Series last season, remain unashamedly ICE.

With its driver once again crowned champion in '23, Ford remains a key player in the discipline alongside Toyota and Chevrolet. Last month the Blue Oval revealed its new Mustang Dark Horse for the 2024 NASCAR Cup Series.

Yet for all the group's current investment in electrification, Mark Rushbrook, global director of Ford Performance, insists that the technology used to power the machines isn't that relevant to Ford's involvement.

"By racing our Mustang anywhere we learn more about Mustang aerodynamics, so we've actually had the same aero team working on the Mustang for Australian Supercar, for NASCAR, GT3 and GT4, so we're able to share that across our different racing series and also with the mainstream team working on the road car Mustang," he explains.

"In NASCAR itself, beyond that body, a lot of the learning is more around the process than it is about the car itself or the technology. We actually brought into the company the first full six-degrees-of-freedom driving simulator to put in our tech centre in North Carolina back in 2014, and we showed that it could work very effectively in motorsports – in NASCAR and our other series and ultimately the Ford GT programme. In series where you can't test physically, you can get the same benefit or nearly the same benefit from the simulator."

The Ford Performance boss explains that those learnings are directly translatable into the road car arm of the company: "We proved the effectiveness of the simulator in motorsports, in NASCAR, and were able to show that to the production road car team so that they then adopted that technology. We've continued advancing that programme ever since, to the point now where we have three simulators at our tech centre in North Carolina and every new one has become more advanced, with more travel, more capability."

The payback from the demands of motorsport has a similar effect in so many other areas, Rushbrook insists: "It's similar with wind tunnel testing processes, coming up with very efficient ways – because in motorsport you have limited time in the wind tunnel, depending on the series and what the rules are – but you need to be efficient with every hour, every minute, every second that you spend in the wind tunnel. So we advance our wind tunnel aero development processes to be efficient and competitive there and we can transfer those same processes to the road car.

"It's the same for CFD (Computational Fluid Dynamics). We've developed a lot of advanced processes there that have been shared and gone to the road car as well. In NASCAR for us it's more about processes than it is about components or specific architecture." RT

ABOVE & BELOW The Mustang Dark Horse was created with the help of the new 200 mph Rolling Road Wind Tunnel that will shape the next generation of Ford electric, hybrid and gas vehicles

Ford

cell, battery pack and the chemistry involved. The motor, the inverter, the software, the analytics were all important reasons very early in the discussion of what we wanted to be part of."

Little detail was given about Ford's input into the project when it was first announced, Red Bull having already created its own powertrain department in light of Honda, officially at least, withdrawing from F1 engine supply at the end of 2021. Assumptions were made about Ford's involvement being perhaps just a badging exercise. Rushbrook firmly puts those thoughts to bed.

"I would say what I just rattled off is a quick list, really a short list of what was created in the early discussions with Christian [Horner, Red Bull Team Principal] and Dr [Helmut] Marko in terms of what were we interested in contributing and being part of and learning. I would say that short list is 10 times longer now in terms of all the things we actually are engaged technically in contributing and learning in that partnership, it's fantastic. It's like once we had those initial conversations, it's just taken off since then in terms of the opportunity and the partnership."

BELOW Much as it supported going the hybrid route, it is important for Ford that its rally cars still sound glorious for fans

Red Bull Content Pool

> *"Even though in WRC it is a spec hybrid unit, we have still learned a lot"*

Traditional ICE sound

Of course Ford is also already actively involved in a hybrid-powered World Championship, the WRC, albeit in less of a capacity than it once was, with its support of British firm M-Sport's programme. Rushbrook recently attended meetings with the FIA and WRC Promotor about the future of the discipline during the Central European Rally. He was keen to reiterate how important both the switch to hybrid powertrains had been for Ford, and that the Rally1 machine still produces the traditional ICE sound that has become so divisive in the discussion around electric motor racing.

"Even though in WRC it is a spec hybrid unit [provided by Compact Dynamics], we have still learned a lot because of what we're able to do with the software and calibration, and learning about the hardware that has transferred for us," he maintains. "For fans to see the Rally1 car moving under pure electric power, that was important for the messaging. It's not ready to go full electric because the technology is not ready to go into the existing rally format, so I think hybrid is a really good place to be and where it should be for the foreseeable near future.

"The way it [hybrid] is implemented and still a great sound, when these fans are standing out in the fields and the forests along these roads sometimes on cold, rainy days, it's important that it's engaging, and the sound of the car is glorious to hear. That is important for us, but we also take advantage of those spaces, like we ran a Supervan 4.2 on a handful of the stages at the Central European Rally with Manfred Stohl and the fans love it – it's something very different."

Future vision

Clearly here and now Ford's objectives surround electrification, even if it's attached to an ICE in hybrid form, but what about the future? The world is yet to discover if electrification is truly the long-term answer, and the use of Hydrogen continues to be bandied around.

"We always look at our five-year cycle plan, sometimes even further than that – in Formula 1 we're committed through 2030 – but we're always looking for the right series, that includes the vehicles, the cars, the SUV, the trucks, the powertrain technology," says Rushbrook. "What we've shown with our quadrant strategy with Mustangs, off-road, electric demonstrators and F1, that completes us in many ways in terms of what exists today and for the foreseeable future. We're not looking today for any big departures from that, we've got our heads down delivering all of that but we meet every quarter to make sure we don't lose that forward vision and that we're watching everything that is coming, in terms of what the opportunities are, do we want to change our strategy and do we want to advocate for anything different? Right now we're not.

"Hydrogen is not a priority for us in motorsports at this point. If and when it comes in different series, and if it makes sense for us, we'll certainly give it that due consideration but it's not anything we're lobbying for right now."

Uncertainty remains over the medium-term future for motor racing. One thing is for sure though, Ford has been a staple part of motor racing for over a century and that doesn't appear likely to change any time soon. RT

ENERGY TRANSITION DRIVES MOTORSPORT INNOVATION

Mark Skewis introduces the nominations for this year's RACE TECH technical awards, the winners of which will be revealed at the World Motorsport Symposium

WHAT a year! This was a season when issues that had previously been high on the 'European' agenda, such as electrification and sustainable fuels, impacted on American motorsport.

IMSA introduced hybrid powertrains to its flagship GTP sportscar racing category, and IndyCar embraced Shell's sustainable fuel as part of its wider sustainability push. Both were landmark achievements.

So it was only fitting that American motorsport had the opportunity to treat European fans to a teste of what they had been missing: the Next Gen NASCAR was undoubtedly one of the big stars at the centenary celebrations of the Le Mans 24 Hours.

From F1 to NASCAR, the Dakar Rally to the Le Mans 24 Hours, no aspect of motorsport has remained untouched by the energy transition being grappled with in the wider world. It's no longer just the pioneering electric series, Formula E and Extreme E, which have sustainability written large on their calling card.

Such issues shape the direction of motorsport's innovation at present. They are duly reflected in some of the nominations for this year's technical awards.

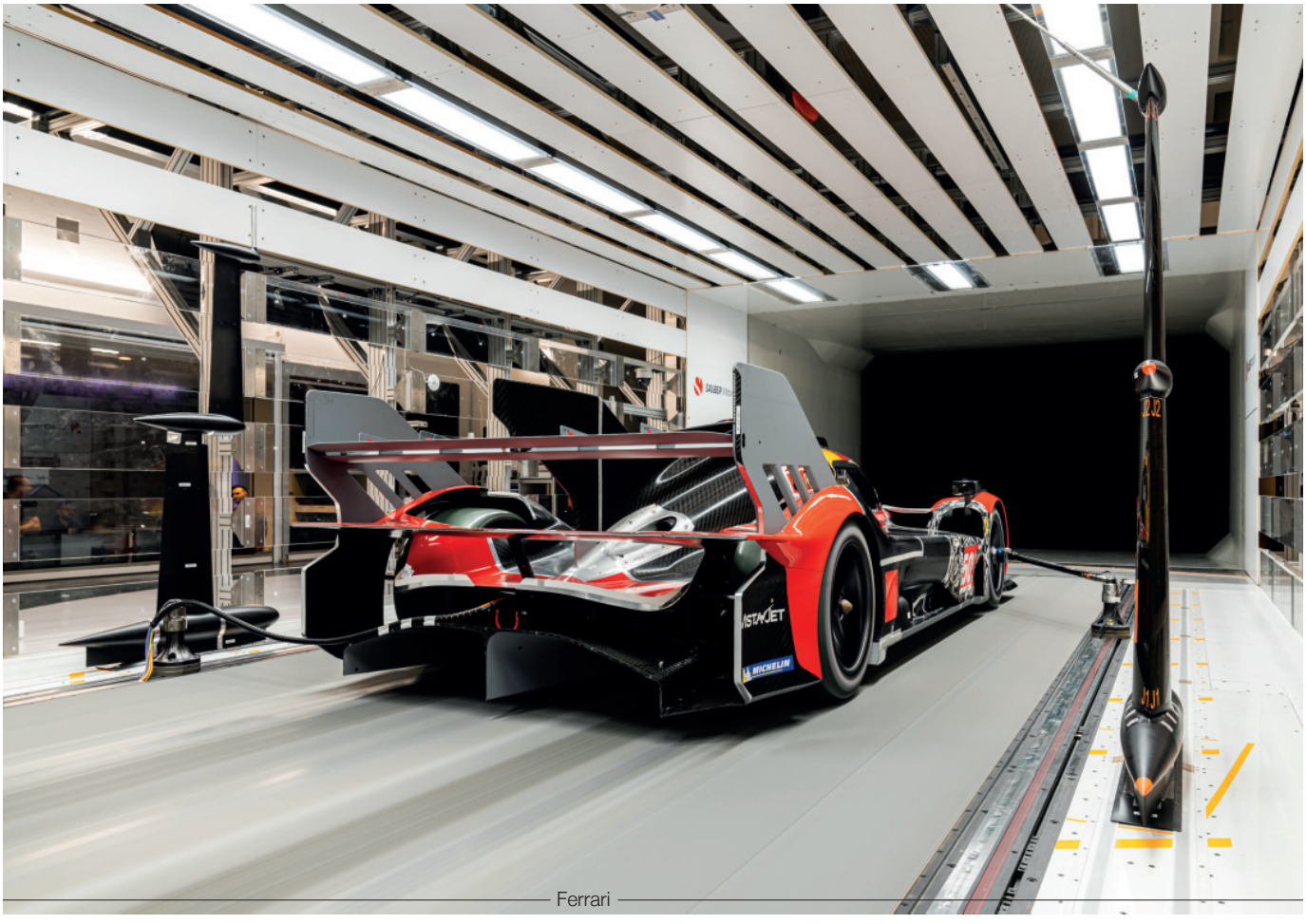
DINO TOSO RACECAR AERODYNAMICIST OF THE YEAR

Ferrari

Nominated for its 499P

FERRARI'S triumph at the Le Mans 24 Hours centenary race was perhaps the motorsport story of the year.

The Italian manufacturer's success, returning as a factory effort after a 50-year absence, generated headlines around the world.



Ferrari

ABOVE Ferrari's first overall win in the world's most famous motor race since 1965 was an epic feat

Unfortunately, it was the story *behind* the story, a last-minute change in the Balance of Performance handicapping, that made the biggest waves within the motorsport ranks.

The dramatic decision certainly impacted its major rival, Toyota. That was a shame, because the controversy inevitably detracted from what was one of the most epic duels in the history of the great race.

To win first time back at Le Mans, on territory that Toyota had made its own for the previous five years – the Japanese manufacturer had left nothing to chance, by simulating hundreds of 'what-if?' scenarios – was a huge achievement.

Yes, Toyota might have won every other race in the World Endurance Championship, but Le Mans remains the glittering jewel in the crown. While Ferrari undoubtedly targeted the French classic with the aerodynamic package that it homologated for the season, so did its rivals. Nor was the car a slouch elsewhere, as its podiums at Sebring, Portimão and Spa had already demonstrated in the build-up to Le Mans.

Ferrari's 499P was the product of more than 3,000 hours of testing, with CFD and wind tunnel results validated in the simulator and on the racetrack.

It was also a car that, from the very start, looked *right*. Much was made of the 499P's design being refined with the support of the Ferrari Styling Centre, but this was not a car compromised by the styling cues that gave it a distinctive Ferrari look.

LEFT The 499P's aero package was superior to its rivals

WILLIAM KIMBERLEY GREEN TECH AWARD

GIVEN that the award is particularly close to our heart, we will present the William Kimberley Green Tech award only in the years when we find a sufficiently innovative and outstanding candidate. While most new products are now designed with an element of sustainability in mind, the judging panel did not feel that any one nomination warranted the award this year. RT

The downforce and drag limits set by the performance windows specified in the rules are not particularly hard to hit, leaving constructors room to add their own visual cues and pursue different design solutions. But if generating downforce wasn't a problem, doing so in a useable way was a different matter.

The wide vee angle employed in the engine allowed more freedom for aerodynamic innovation in the underfloor region, but Ferrari was at pains to seek what it referred to as "consistent, attainable and versatile performance". That might sound a given, but word is that even Ferrari's competitors grudgingly accept that the Scuderia's aero package avoided some of the pitfalls that plagued its rivals. ▶


Getty Images / Red Bull Content Pool

Red Bull Racing
Nominated for its RB19

WITH hundreds of people working in each team's aerodynamics department, success at the pinnacle of the sport can never truly ne ascribed to one man. But when the fingerprints all over Red Bull's aero division are left by a man of whom even rival aerodynamicists can speak reverentially, it certainly gives you a head start.

That's exactly what Red Bull got in 2022, when F1's aero revolution swept in with a partial return to ground effect. Adrian Newey, the team's Chief Technical Officer, is renowned for always hitting the ground running in a period of rules upheaval. Add to that his precious previous exposure to ground effect, at Fittipaldi back in 1980. That experience gave him an edge in the struggle to mitigate porpoising; it also developed a better understanding of the coupling of aero and suspension. That wisdom is clearly evident in the commencement of a new Red Bull dynasty.

This year's RB19 consolidated the lessons of its predecessor. The Honda Power Unit may well have been the best on the grid, but the overall package appeared to be good in all areas: aerodynamics (both downforce and drag), ride, handling, suspension, and set-up.

"There's not one thing, it's a culmination of everything working together in harmony and unison," suggested Red Bull boss Christian Horner.

ABOVE Red Bull's mastery of the ground effect regulations propelled the RB19 to record-breaking exploits

The team's understanding of aero elasticity, ride height and porpoising notably enabled it to exploit the power of the Drag Reduction System like no other car, leaving the RB19 head and shoulders clear of the field.

Some called the record-breaking machine the greatest F1 car of all-time. Max Verstappen wasn't always quite so complimentary. Nor were his rivals.

When the car did struggle, in Singapore where a new Technical Directive had been introduced to police wing flexibility, conspiracy theorists pounced. Had Red Bull's secret finally been rumbled?

It appeared not! By the end of the campaign, its winning streak had resurrected the old debate about introducing a Balance of Performance that could peg back the champions.

NASCAR
Nominated for its Garage 56 Hendrick Motorsports Camaro ZL1

THOUSANDS of hours of work went into the joint project between NASCAR and Hendrick Motorsports to field a Garage 56 entry at Le Mans.

With its long straights and fast sweeping corners, the French circuit poses a unique challenge. Whilst this was no ordinary Next Gen Camaro, neither was it a ▶

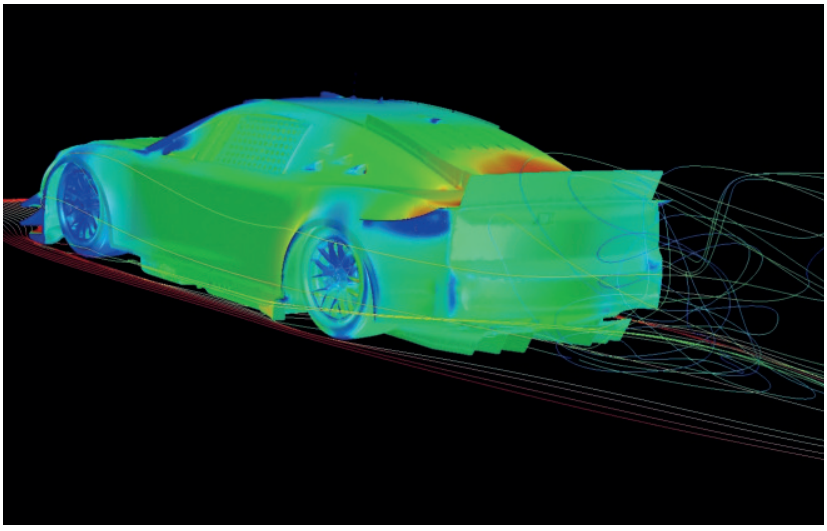
ABOVE & BELOW
NASCAR's Garage 56 project was no marketing gimmick. The car's GT-beating pace was the result of nearly a thousand CFD runs, backed by wind tunnel tests and work in the simulator

GTE car with a few NASCAR stickers hastily applied. The underlying concept was true to the stock car ethos, with a thumping pushrod V8 and the same fundamental chassis as the Next Gen cars (albeit with a spot of weight reduction).

Where the Garage 56 car differed most significantly was its aerodynamics. Its need to lap at a speed that wouldn't interfere with the rest of the race set the agenda for the whole project.

It was clear from the outset that the focus would have to be on corner speeds, using the Porsche Curves as a reference.

The quest for increased downforce began at the nose of the car. NASCAR had already worked on a high front-downforce concept during the original development of the Next Gen car. Though it went unraced, it gave NASCAR's aero team an immediate starting point for the Garage 56 project.



The resulting splitter was larger and more prominent than the standard item, with strakes set inside. There was also a set of dive planes to deflect the air flow upwards, pushing the nose down.

The same process saw the addition of substantial canards on the rear quarter panels and some detail changes ahead of the rear tyres.

NASCAR was keen to maintain the stock car appearance by using a spoiler rather than a GT-style wing (although a substantial rear wing was tested out of curiosity). This meant that much of the downforce would have to come from underneath the floor, so the focus was on feeding the diffuser as effectively as possible.

"We looked at how we could make the leading-edge sections around the middle of the floor ingest more air," explains Eric Jacuzzi, Vice President, Vehicle Performance at NASCAR. "The Next Gen floor already does that pretty well, but we were going for everything we could get underneath the car, so it was a pretty significant change."

Around 70 different configurations were eventually run in CFD – each across a spread of 14 different points, giving 980 individual runs.

Two wind tunnel tests of around 10 hours each at the Windshear facility in North Carolina accounted for the majority of the development testing, followed by a third test to generate a comprehensive aero map for use in Hendrick Motorsports' driving simulator.

The endeavour was rewarded handsomely, for the NASCAR actually ran at the front of the GTE class for a while, putting it in the high-20s overall in the 62-car field. Two late mechanical problems – unplanned stops to change the brakes and gearbox –dropped the NASCAR effort to 39th overall, but just to finish was a win in itself. ▶

RACE POWERTRAIN OF THE YEAR

Toyota

Nominated for its Corolla H2

TOYOTA'S pioneering hydrogen-powered Corolla made headlines earlier this season for the wrong reason, forced to miss the Super Taikyu Series race at Suzuka following a fire caused by a hydrogen leak during private testing.

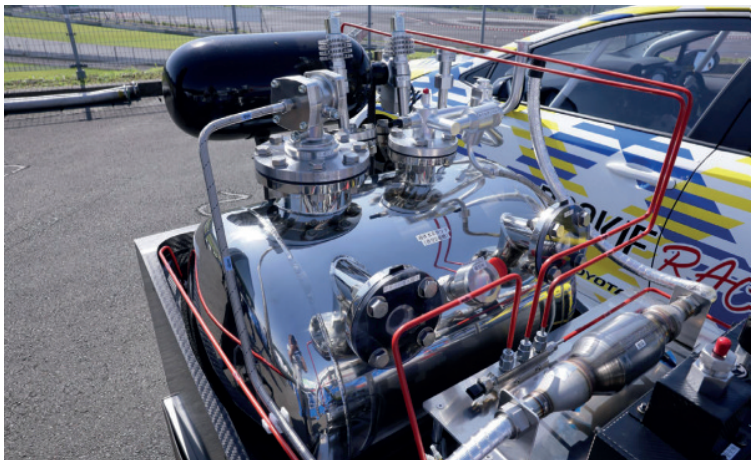
Fewer column inches were dedicated to its major success: completing the Fuji 24 Hours with its experimental Rookie Racing-entered Corolla running on liquid hydrogen.

The fire was not directly caused by the fuel change from gaseous hydrogen to liquid hydrogen. The leak was traced to the loosening of a pipe joint, caused by vibration. As the piping joint is located near the engine, the leaked hydrogen ignited when heated.

The Corolla had been run on gaseous hydrogen since its first entry in May 2021. Over the past two years, it has evolved with each race in areas such as output, torque, cruising range, and filling time.

The next stage of the project was to explore liquid hydrogen, which offers higher energy density than compressed hydrogen gas, potentially reducing the volume and weight of the fuel tanks. However, the need for cryogenic storage presents its own challenges in areas such as developing fuel pump technology that can function in a low-temperature environment, preventing hydrogen from naturally evaporating from the tanks, and establishing regulations for vehicle-mounted hydrogen tanks.

"We're fighting to create a future for the internal



ABOVE & BELOW Toyota's experiments with liquid hydrogen on the racetrack are breaking new ground

combustion engine by tackling a technology deemed unfeasible for cars, in the uncharted territory of -253°C," explained driver Masahiro Sasaki, referring to the cryogenic storage. "While various hurdles still remain, as with gaseous hydrogen we hope that our agile development on the racetrack will feed back into everyday cars."

For gaseous hydrogen, tanks are filled at high pressure and must therefore be cylindrical. When the fuel is in a liquid state, however, there is no need for tanks to be pressurized. In the future, fuel tanks could be shaped conveniently for under-floor mounting, offering the potential to improve packaging efficiency. Switching the fuel from gas to liquid also allows for more compact mobile hydrogen stations.

Moving forward, Toyota will focus on challenges such as maintaining the ultra-low temperature of -253°C during refuelling and storage, and dealing with natural vaporization as tanks heat up, as it strives to pick up the pace of technological development. The speed of that progress will only increase now that Toyota's all-conquering Le Mans Hypercar squad is investigating the use of hydrogen combustion in the GR H2 Racing Concept, announced at this year's Le Mans 24 Hours.

Jaguar

Nominated for its I-Type 6 Formula E powertrain

THE complexity of the new Gen3 Formula E cars was immense. They featured higher top speeds, faster acceleration and more than double the regenerative capacity of their predecessors, with a new front powertrain and some 40% of energy used recovered by regenerative braking over a race distance.

Such was the focus on efficiency that a new style of racing even developed midway through Season 9: 'peloton' cycle-style contests where drivers slipstreamed each other, jockeying as they waited for one to attempt a decisive break.

What the all-electric series lacked in noise, it compensated for in excitement. New records were set for the fastest average lap time and the highest speed. There were more race leaders and more overtakes in the series than ever before, with most races featuring triple-digit passes.

But although every team led a race for at least one lap, one manufacturer stole a march when it came to adapting to the new Gen3 regulations: Jaguar.

It didn't look that way from the opening races, with Porsche dominating the early points standings, but the Weissach squad suspected that Jaguar's fragility masked the true situation. Jaguar's customer team, Envision Racing, pounced whenever the German squad faltered but it wasn't just consistency that was responsible for the balance of the contest tilting in its direction. As the campaign unfolded, Jaguar had a clear edge in qualifying, as it did in cooler temperatures and on stop-start track layouts.

ABOVE Jaguar split eight race wins with its customer team

Jaguar's works squad and its customer team eventually shared eight race wins, with Envision clinching the teams' title. The manufacturer will start the new season next month as the clear favourite.

Season 9 was billed as a triumph for the underdogs, with Envision's success mirrored by the manner in which Avalanche Andretti, Porsche's satellite operation, propelled Jake Dennis to the drivers' crown. But these supposedly giant-killing feats don't tell the full story. With the manufacturers having to concentrate on development of their powertrains, customers were left free to focus more heavily on car settings for the individual circuits.

Jaguar's works squad, Jaguar TCS Racing, was aided in the development of the electric powertrain for the I-TYPE 6 by GKN Automotive. The latter's software engineers were fully embedded into the team with their focus on advanced powertrain cooling, software development, test and validation.

Software is a key battleground as the series moves ▶

forward. At present, the optimisation of the powertrain has a much greater impact on performance in Formula E than the conventional chassis tuning tools with which most race engineers are familiar.

The first single-seater to feature a front and rear powertrain, the Gen3 must be considered a huge success. Fast-charging next?

Cadillac

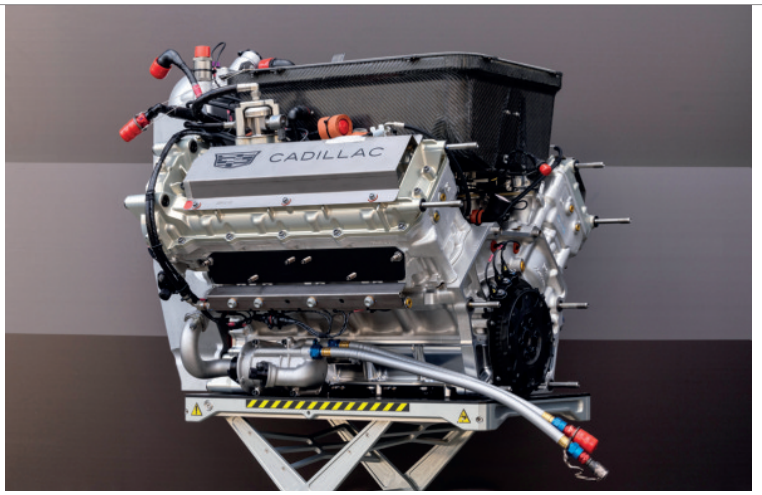
Nominated for its LMC55R GTP powertrain

CADILLAC'S first podium finish at the 24 Hours of Le Mans, returning to the iconic race after more than two decades away, prompted great celebration. Its clean sweep of GTP titles in the IMSA WeatherTech SportsCar Championship was a feat that unleashed euphoria.

The dawn of the LMDh hybrid era prompted Cadillac's engineers to opt for a bespoke 5.5-litre naturally aspirated V8 ICE, codenamed LMC55R.

Other than a few fasteners, we're told, it shared nothing with other General Motors engines. It was much larger than anything used by the GTP opposition in the IMSA series, whose engines ranged from 2.4 to 4.6 litres, and it was the only LMDh powertrain to buck the trend of turbocharging.

The combustion efficiency of a naturally aspirated engine is now considered such that it made the route a viable one, saving the weight of a turbo and intercooler as the team pursued an aggressive weight target. It also made for fewer components, potentially improving reliability in a new formula that came together against the backdrop of a frighteningly tight timeframe and the added complexity of the hybrid system.



The latter was a landmark moment for North American motorsport. While the hardware for the LMDh hybrid system – brought from concept to reality by Bosch, WAE and Xtrac – is shared across all competitors, the software is defined by each entrant and became a major battleground.

Cadillac opted for a cross-plane crankshaft. It created one that weighed slightly less than some of the flat-plane options it evaluated, but the engine still revved to 8,800 rpm. Chosen to cut the danger of damaging vibration, the cross-plane crank also gave Cadillac's V-Series.R prototype a distinctive sound that was particularly well received at Le Mans.

Although it carried the flag for IMSA's LMDh contingent in the World Endurance Championship, it was back on home ground that Cadillac Racing excelled. It registered two victories, six podiums overall and two pole starts in the nine-race season to clinch the GTP Manufacturers' Championship. Cadillac also won Manufacturers' titles in 2017, 2018 and 2021 in the IMSA DPi era. RT

ABOVE & BELOW
Powered by the LMC55R n/a DOHC V8 hybrid engine, the Cadillac V-Series.R harried LMH opposition to claim a Le Mans podium finish

Richard Prince/Cadillac

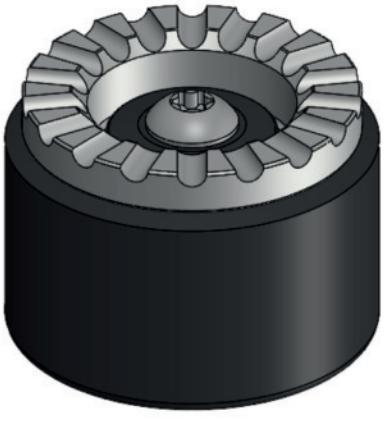
DON BURGOON MOST INNOVATIVE NEW MOTORSPORT PRODUCT OF THE YEAR

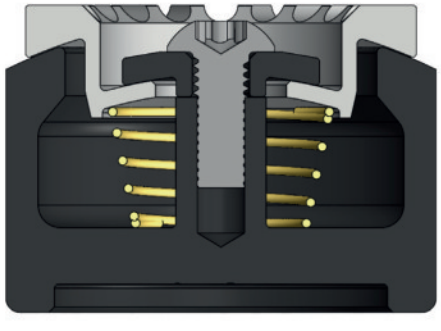
A few of the innovative new products that transformed the 2023 season – and will shape 2024

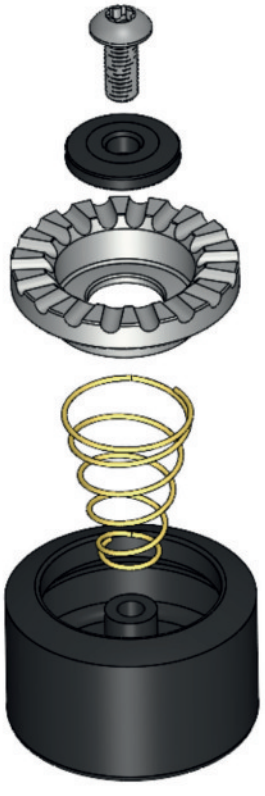
Alcon

Nominated for its SMART (Spherically Mounted ARTiculating inserts)

MUCH of Alcon's new business is currently in the defence sector, where it recently won a contract to supply 70 Jackal armoured vehicles. But that hasn't prevented it from featuring prominently in world motorsport. Its influence ranged from the launch of Ford's new Mustang GT3, through to the spectacular Ford Supervan 4.2's Race to the Clouds at this year's Pikes Peak International Hillclimb.







BELOW An exploded view of Alcon's Spherically Mounted ARTiculating inserts

Its latest motorsport innovation, officially announced last month, has been designed, developed, and deployed this year, successfully trialled on a rally application.

Branded SMART, for Spherically Mounted ARTiculating inserts, the solution addresses brake pedal feel degradation from uneven or taper-worn brake pads.

Taper-worn pads – when the pad friction surface wears unevenly or at different rates across the disc contact area – introduce an angular gap between the pad and the caliper piston as the contact relationship is no longer parallel. A brake caliper with taper-worn pads will consume more brake fluid in closing this angular gap when the brakes are applied and therefore present a longer brake pedal travel to the driver, degrading confidence and lap/stage times into the bargain.

The SMART product is a piston insert intended for motorsport applications. It compensates for pad taper wear and will mitigate its propagation by resolving any angular gap between the piston and brake pad.

The SMART piston assembly comprises an insert that is retained by and articulates between two spherical surfaces. This then restores the co-planar/parallel relationship between the piston and the brake pad backplate.

"We already have this system in the marketplace, and we're looking to drive the technology into other areas of motorsport," says David Clegg, the company's principal motorsport brake engineer.

Dynisma

Nominated for its DMG-1 simulator technology

SIMULATORS were once the preserve only of Formula 1's elite. Now, the innovation that underpinned the inception of Dynisma's DMG-1 has brought the next generation of ultra-realistic driving simulators within reach of the wider motorsport industry.

Leveraging its experience with some of the best in F1, Dynisma's DMG-1 has been created as a standard, productionised simulator, bringing the essential performance and functionality of a bespoke F1 DIL simulator within the reach of formulae such as F2, Formula E, WEC and GT racing.

DMG-1 is billed as an order of magnitude

meanwhile, can evaluate more aggressive set-ups in simulation than previously possible, and make key decisions in virtual testing.

Dynisma's Open Architecture allows DMG-1 to run the customers' preferred choice of software for vehicle, tyre and track modelling, data collection and management. The company maintains that it is totally agnostic in terms of the software that people use.

"Our F1 simulator was acclaimed as a generational leap forward in realism," says Ash Warne, Dynisma CEO. "Now DMG-1 is an equal leap in commercialisation and industrialisation."

faster than some competing systems, offering a step change in realism. To achieve that, the company has re-evaluated three core aspects that are already hot topics among simulator manufacturers: latency, bandwidth and smoothness.

The technology features class-leading motion bandwidth up to 100 Hz in all six degrees of freedom (DOF) and world-leading motion latency of less than 5ms.

Dynisma has also gone to great lengths to eliminate sources of coarseness or mechanical noise. This encompasses the whole mechanical and electrical design of the system, including the motion control algorithms, the actuators and the joints. This elimination of the parasitic motion present in other systems now enables movements below the human perception threshold to be rendered.

The end result of optimising these three key areas is that drivers receive a broader range of information, with a higher degree of fidelity and no perceptible lag.

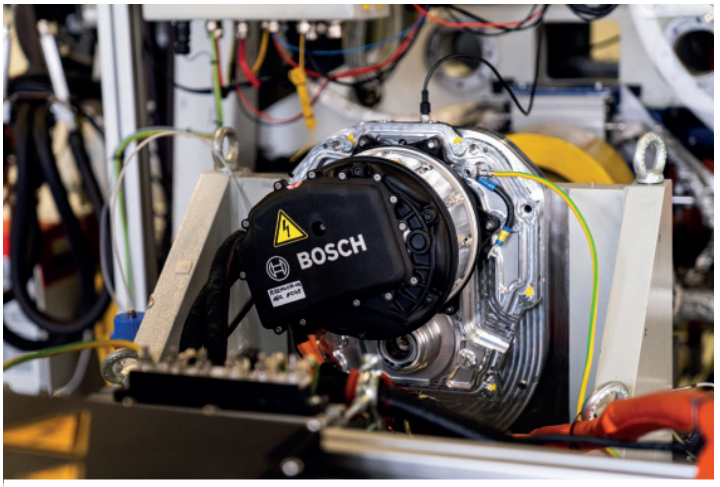
The company reports that, for the first time in a simulator, even a truly unstable car can be driven and evaluated. This allows drivers to respond to events such as braking instability and oversteer instantly. Their engineers,

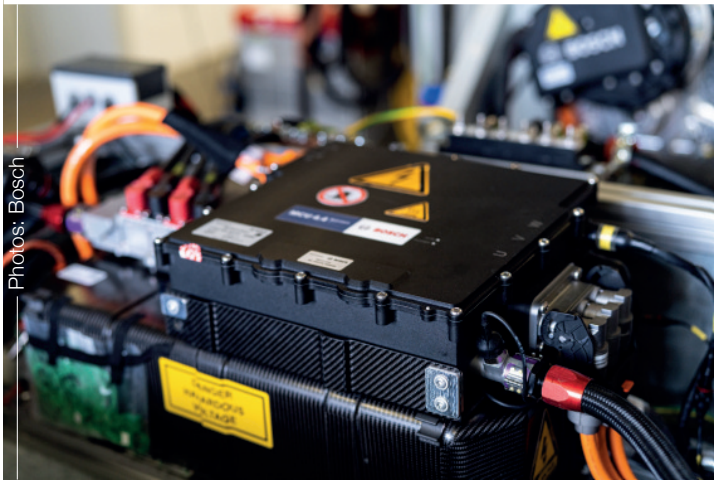
Bosch

Nominated for its LMDh hybrid system

SPORTSCAR racing arrived on the brink of a new golden era when the Le Mans Daytona hybrid (LMDh) prototypes took the flying start at the Rolex 24 At Daytona in late January. But the start of one endurance race marked the end of another – the one just completed by the engineers of Bosch Motorsport.

That race had begun in 2019 when an order was placed for the development and integration of a uniform hybrid drive system for all LMDh race cars. Now, after less than three years, a pandemic, and ▶





Photos: Bosch

ABOVE Developed and proven in F1, the DMG-1 tech is now viable for lower formulae

ABOVE & BELOW RIGHT The electric motor (MGU), above, and motor control unit (MCU) that underpin Bosch's hybrid system for the LMDh category

several thousand hours of work, the highly complex prototypes are helping transform endurance racing.

The new class emphasizes fuel savings, sustainability and cost efficiency by including uniform units such as the rear-wheel hybrid drive system. Behind the scenes, accommodating the wishes and requirements of so many different manufacturers and configurations made for a mammoth challenge.

A core team of 50 people at Bosch Motorsport worked on the project, with additional support from a wide range of specialist departments from the entire Bosch Mobility Solutions business sector. From the initial theoretical planning and simulations, test bench and shaker tests to real driving trials, they fought their way from milestone to milestone.

The road was strewn with difficulty, and there were some low moments, such as when the inverter broke early on the shaker rig. The key to the project's ultimate success? Top quality equipment, for sure, but also experience, passion and perseverance.

"From a technical standpoint, what we developed was a hybrid system for these race cars. But what we really developed was a high-performing team," insists Jacob Bergenske, Director of Bosch Motorsport North America. "That's not what people see on the outside, but it's the story on the inside."

The successful advent of LMDh has been a pivotal moment. For the first time in over 20 years, manufacturers and teams can use the same car to compete for the overall victory in the FIA World Endurance Championship and the IMSA WeatherTech SportsCar Championship.

The result will be a Le Mans 24 Hours grid where the LMH ranks of Toyota, Ferrari, Peugeot and, soon, Aston Martin will compete with the likes of Porsche, Cadillac, Acura, BMW, Alpine and Lamborghini. These are halcyon days for the sport and Bosch has been one of the driving forces behind that success.

McLaren Applied

Nominated for its VCU-500

THE VCU-500 is McLaren Applied's latest generation integrated motorsport Vehicle Control Unit and Data Logger. It's effectively the electronic brain for any vehicle.

Leveraging a 30-year heritage in Formula 1 and other world-class series, McLaren Applied is adapting and applying much of its motorsport expertise to other industries. But the company remains a key player in motorsport as teams and championships grapple with the electrification of the sector. This powerful yet lightweight unit, manufactured at its state-of-the-art production facility at the McLaren Technology Centre, in Woking, UK, typifies that trend.

The unit has a vast array of inputs, outputs and communication interfaces such as CANFD with the provision to log 2,000 parameters at a thousand times a second to its onboard logging memory. Engineers can run multiple applications on the latest generation 64-bit quad-core microprocessor, with application code automatically generated from MATLAB/Simulink models.

The VCU integrates with the McLaren Applied suite of user-friendly software tools including System Monitor, ATLAS and McLaren Control Toolbox, its proven toolchain widely used in F1, NASCAR and IndyCar. This allows customers to define their own control strategies, optimise their performance and partner with other organisations. Co-developing on the VCU-500 is made possible by leveraging McLaren Applied's patented Reduced Data Access (RDA2) and Parameter Discovery functionality, enabling multiple parties to develop code in separate applications, and restricting data access between applications whilst protecting their Intellectual Property. This reduces the number of units on the car, potentially achieving a competitive advantage over others on the grid.

Launched this year, the VCU-500 was raced in the Formula E World Championship by customers and secured several podiums and wins. In 2024, the unit will debut on the inaugural season of the E1 Series, the new electric powerboat racing series running in multiple cities beginning in Jeddah. RT

RIGHT The VCU-500 integrates with the McLaren Applied suite of user-friendly software tools

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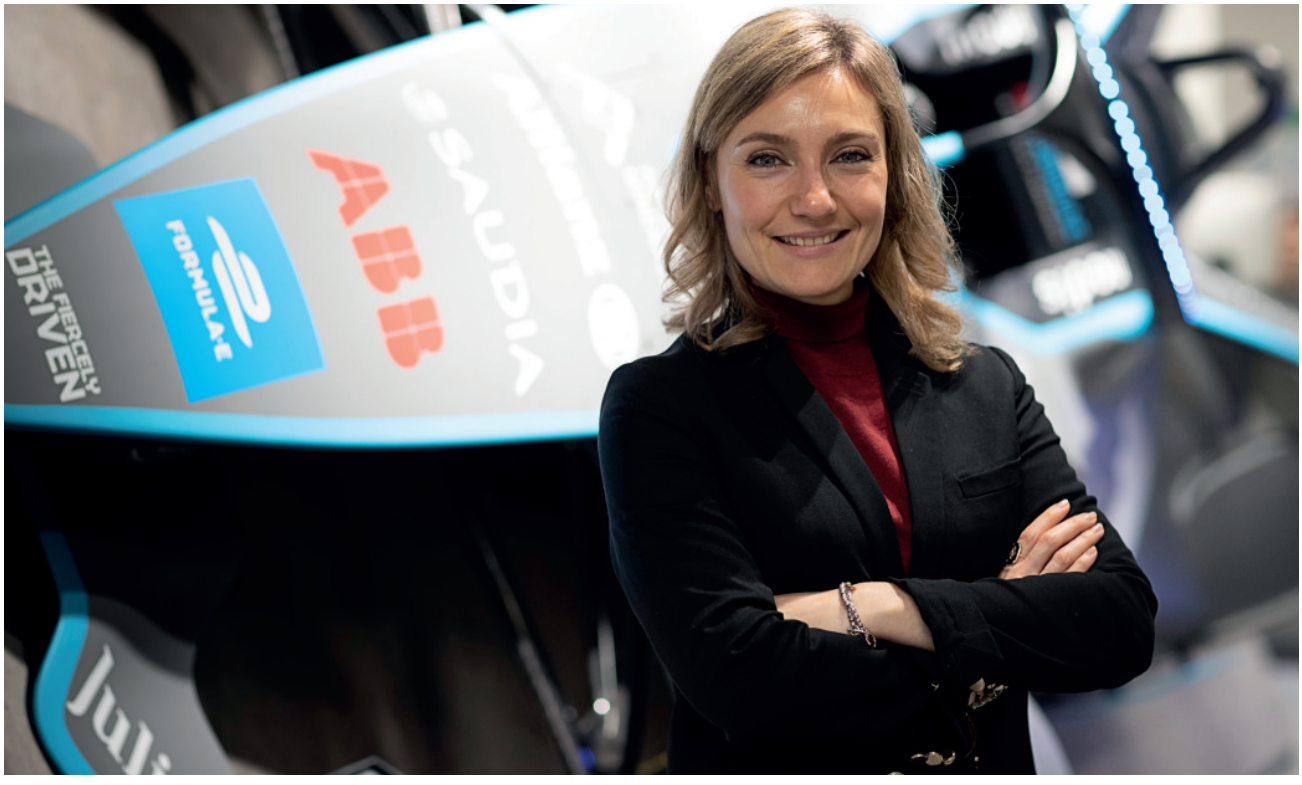
FORMULA E'S SINGED AND SUSTAINABLE RACE FORWARD

Formula E's pre-season testing offered a glimpse into the future of electric racing – and the obstacles that come with it. By **Olivia Hicks**

BLACK smoke billowed out of the Circuit Ricardo Tormo on a Tuesday afternoon in late October. The fire, however, wasn't from a fuel leak or an engine failure typical of gas-guzzling motorsport series. Instead, the blaze began as a rare electric battery blast.

Formula E had barely started pre-season tests when the DS Penske of rookie test driver Robert Shwartzman slowed on track. After just three hours, on-track action for the next 36 hours ceased when the glittering gold car's battery exploded and sent the Mahindra Racing garage up in flames.

"It's nice to be back in a kind of familiar environment," Nyck de Vries, the former AlphaTauri Formula 1 driver and returning Formula E champion, managed to say just before the media centre was evacuated. In a continuous stroke of bad luck, De Vries' side of the garage held melted and waterlogged tech.



All photos: FIA/Formula E

ABOVE The climate change awareness is a central pillar of the all-electric series

LEFT Julia Pallé, Formula E's vice president of sustainability, draws inspiration from sectors as disparate as sailing, aviation and professional tennis

The incident fuelled sceptics' concerns over the electrification of motorsport – a debate plaguing the electric vehicle industry since its inception – but it also pointed to a heightening struggle between balancing sport and sustainability.

Speculation swirled around the paddock about the potential consequences if the fire stemmed from a larger issue with an incompatible battery and this season's debut supercharger. The gossip was quickly squashed as testing resumed on Thursday afternoon and the car batteries were deemed safe to compete, according to the Fédération Internationale de l'Automobile (FIA).

Pit stops are back

Despite sharing the same car generation and location as last year, 2023 Formula E testing had a different star. The ABB Formula E Race Charger, allowing for top-off pit stops, adds a new sporting format. The charging infrastructure, designed to deliver up to 600 kilowatts of power, had Friday's crowd of spectators leaning over the guardrails to catch a glimpse of the new technology.

This time last year, Formula E unveiled the Gen3 race car in Valencia, Spain. The new edition of the first 100% electric single-seater upped the ante compared to the previous generation of vehicles. Two powertrains, balanced in the rear and front of the 856-kilogram car, set the fastest speed in Formula E's history and featured double the energy regeneration and power of road electric vehicles. While gasoline-powered vehicles have a 40% fuel efficiency, the Gen3 car leaps ahead with 95%.

> *"In its nine-season lifespan, Formula E had only witnessed two large-scale issues with batteries"*

"It's the fastest racing car we've ever had, going faster than 320 kilometres per hour, which is wild, to be honest," Julia Pallé, Formula E's vice president of sustainability, says.

As the first car of its kind equipped with four-wheel-drive and boost charging, the Gen3 car is a powerhouse with an extra 100 kilowatts thrown in ▶

there. Affectionately dubbed a "power station on wheels" by the series, the car produced nearly twice the previous year's Gen2 energy recovery. From the limited-range first-generation race car – requiring drivers to pit mid-race and jump into another car to make it across the checkered flag – to the record-breaking Gen3, the series has made significant progress in less than a decade.

"The big step was in battery technology and range," Florian Modlinger, director of factory motorsport for Tag Heuer Porsche Formula E, says. "With this additional front powertrain, which is now in the car to recuperate energy during the braking manoeuvre, we regenerate more than 40% of the race energy we spent."

Not only are the batteries pushing the limits of electric possibility, but Formula E also credits the cells as the "most advanced, sustainable batteries ever made." Batteries, supplied by WAE, the electric engineering company grown out of the Williams Formula 1 Team, are granted a second chance post-Formula E. As of 2022, roughly 95% of the metals within the batteries can be extracted for other purposes and 40% of the batteries are recyclable.

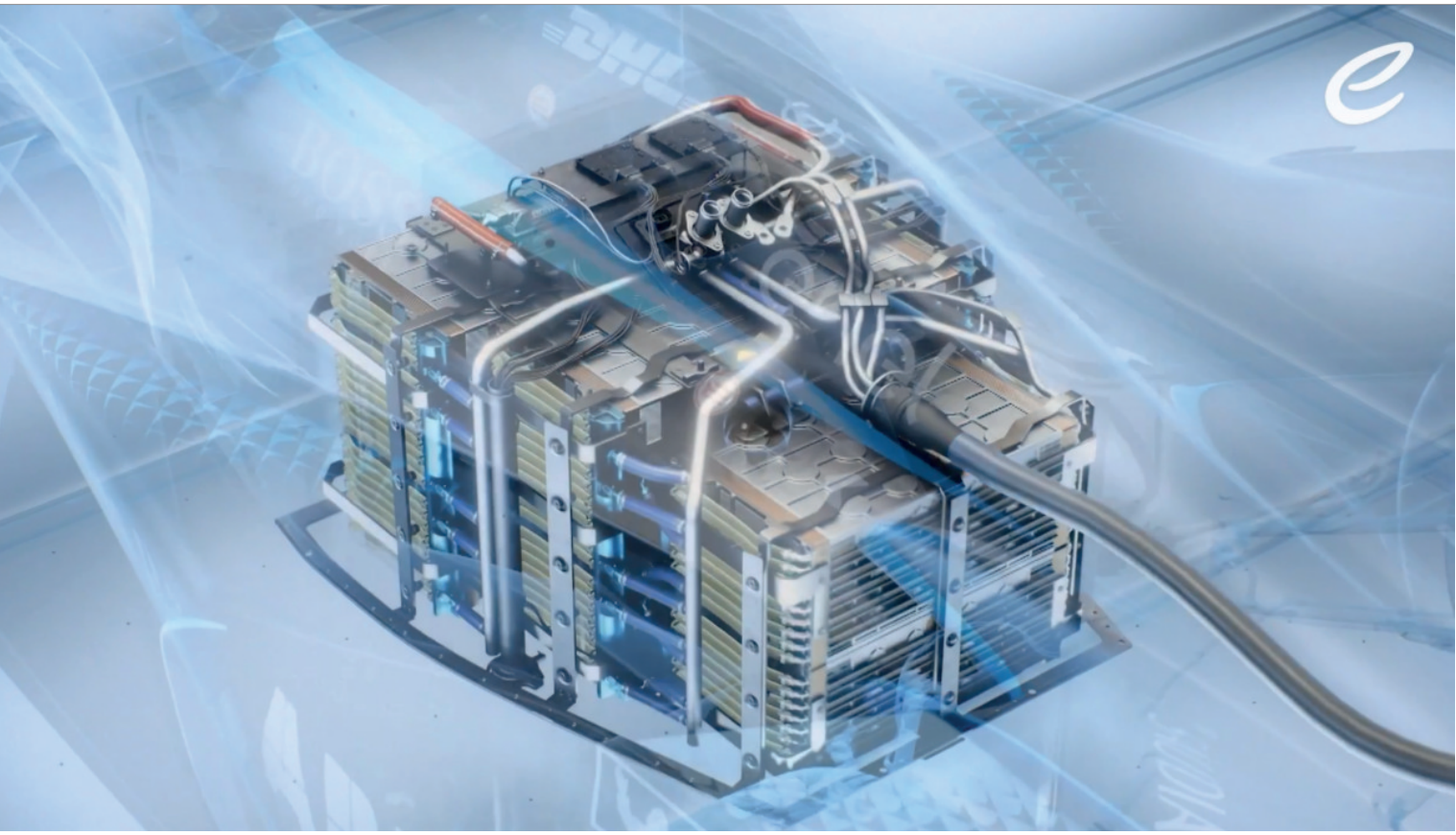
The electric and low emissions identity of the Gen3 powertrain isn't the end of the sport's sustainable story. Body source materials include linen and repurposed carbon fibre from the previous second-generation cars – the first time previous bodywork has been used in a formula series' car – and 26% of the Hankook tyres are sourced from recycled rubber. When this season's tyres are spent and the Gen4 car is eventually premiered, the Gen3 will be recycled to reduce material waste and the tyres will have a second life as an industrial fuel source or flooring material.

ABOVE Formula E monitors impact on a race-by-race basis

BELOW The sport has worked with carbon footprint experts from the very beginning to assess the footprint of the championship

"They are the only racing cars in the world that are consistent with sustainability KPIs (key performance indicators) using the principle of circular economy," Pallé says.

The electric series is an innovator in the motorsport space, but it isn't shy about crediting its muses. Pallé eagerly points to the sailing industry's reuse of carbon



fibre in constructing race-ready sea vessels as a source of inspiration, along with the recycled materials used in aviation and the eco-conscious event management structure of professional tennis.

The Gen3 race car and supercharger may steal the spotlight, but off-track is where treading lightly in carbon emissions is most important. While the cars make up less than 1% of championship emissions, packing up and moving equipment from one continent to the next over seven months accounts for 73% of carbon output, according to the Season 8 Sustainability Report.

Formula E has cut operational and transport emissions significantly by prioritizing rail and sea transport, but there remain logistical impediments to sustainability as the race calendar grows. For example, regionalization and race calendar optimization have become a topic of concern as freight travel accounts for roughly three-fourths of emissions. Despite a 7,500-ton reduction in cargo emissions between 2018 and 2022, the upcoming 2024 calendar jumps from the Western Hemisphere to the East and then back again twice.

As new race host countries are added to the schedule, such as China and Japan that join the 2024 lineup, Formula E is stretched between operational strain and constantly reducing its environmental trace.

"We have the aspiration to continually grow the championship to more races, while at the same time doing it in a much more efficient way where we continually decrease the carbon footprint," Pallé says. "It's not that the world needed another racing series. The world needed a racing series that would address climate change."

Formula E sets out to do just that.

The series' resume as an eco-trendsetter is seemingly never-ending. From leading the professional sports world as the first with an initial net-zero carbon footprint, to helping found the United Nations Convention on Climate Change Sports for Climate Action programme, to holding the title as the most sustainable sport in the world, its list of accolades is full of firsts. ▶

ABOVE The lifecycle of the cars and their batteries (a Gen2 unit is seen here) is taken into account

BELOW LEFT The series invests in leading climate protection projects around the world

BELOW Every effort is made to offset the series' footprint

Lifecycle emphasis

The electric racing series plays a major role in achieving the FIA's 2030 carbon-neutrality status and was the first of seven series to meet the FIA's environmental accreditation standards. By 2025, the ruling body aims to award all world championships with three stars across promoters, organizers, teams, circuits, suppliers and manufacturers. Formula E's foundation of carbon neutrality and life-cycle emphasis sets a lofty standard for the rest.

It comes as no surprise then that there is a buzz about the series – and it isn't just the hum of the cars.

The ever-evolving race format allows for an exciting – albeit constant rulebook refreshing – experience that is reflected off the track as the organization partners with manufacturing giants, global sustainability committees and cutting-edge companies that provide the series with renewable fuel "literally from your French fries into the tank of generators," as Pallé puts it.

Technology that may be available in electric cars in two, three or five years' time is right around the corner, hidden protectively in the notebooks of engineers and collected in the data of debrief rooms. With that comes an infectious jolt of innovation.

That inventive malleability is Formula E's greatest asset in ushering in a green tomorrow, but it's also the sport's greatest downfall. From the garages to the press conferences, the importance of sustainability without sacrificing seed became a mantra. Pulled between its function as a testing ground for the future of electric vehicle technology, the pioneer of eco motorsport technology and a serious professional sporting championship, Formula E is at risk of an identity crisis.

"Road relevance. That's something which motorsport throughout its generations has been keen to harness and that's no different from Formula E," Ian James, team principal of NEOM McLaren Formula E Team, says. "What we have here is an opportunity to, I suppose, harness that connection through demonstrating how we can use fast charging. But at the same time, there is a sporting element to it as well."

The superchargers lie at the intersection of this tug-of-war. For the first time since the Gen3 car was introduced, drivers will pit for 30-second boosts of ▶

BELOW Freight, business travel and operations are all reviewed regularly

BOTTOM The Gen3 racecar meets DHL's world-first electric cargo plane. Both can be replenished by the same charger

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electric charge. Like hitting a golden coin in Mario Kart, the extra attack charge hurdles the 22 drivers forward but also adds a logistical reformatting.

A one-tyre strategy to save on space and reduce carbon emissions and a shuffling pit stop procedure may sound alarm bells for motorsport traditionalists. Disrupting the norm is never digestible for the masses, especially those accustomed to cheering on cars sporting the various numerals succeeding "V." It may be an uncomfortable reality that sustainable engineering has a permanent place in the formulas rather than serving as a science project, but Formula E is proving that adaptability is necessary to move forward. And when performance comes into question? Well, that doesn't seem to hold the series back if the Guinness World Record holder for the fastest indoor land speed, NEOM McLaren's Jake Hughes, has anything to say about it.

ABOVE Optimisation of a round-the-world calendar is an issue. With the spectacular Table Mountain as a backdrop, Cape Town became the first sub-Saharan African city to host a Formula E round

RIGHT Formula E took its reductions even further in 2021 by becoming the first sport to get its CO2 reductions verified by the science-based targets initiative

BELOW Hankook's race tyres will have a second life as an industrial fuel source

Risk to reputation

Last season, notably absent of pit stops, showcased just how uncertain and entertaining spec series can be. Seven different drivers stood on the top step of the podium across 16 races.

"If it's done in the right way, that's something that is going to add more excitement, more strategic elements into the sport," James says.

If priorities skew, the race risks its reputation.

With a surging audience, surpassing NASCAR last season to become the fourth most-followed motorsport series globally, Formula E can't take any chances. Maintaining that balance is at the forefront of everyone's minds. "You have to find the right compromise," Norman Nato, a racing driver for Avalanche Andretti Formula E, adds.

The series remains cautious and realistic about championship format and scale limitations when considering new technologies. Formula E's finger-on-the-pulse tech pursuit becomes tricky with a round-the-world calendar. While new tech may be rolling out quickly and accessibly in one country, the infrastructure may not be there in another. Hydrogen fuel cells, a

renewable electricity source Pallé says the series is closely monitoring, offer a road to net-zero mobility in the automotive industry. The technology, however, is far from widespread.

"At the moment, it's not really yet at scale for the needs that we have," Pallé notes. "The aspiration to power, ultimately, the cars and the championship is through [green] hydrogen sources. The challenge for us is that we have to be able to race and deliver in countries that have a very, very different level of maturity from a technological perspective."

The battery explosion only amplified this debate.

Formula E sceptics may bemoan the signature screech of the cars or insult it as little more than a "F1 reject" series, but it's difficult to point towards the battery fire as a legitimate tick against the sport.

"The record speaks for itself," Luke Skipper,

communications director for the FIA, says. In its nine-season lifespan, Formula E has only witnessed two large-scale issues with batteries, one in Long Beach in 2015 and the other in Montreal during the 2017 season.

"Motoring in an ICE car is also something that is highly flammable and can explode," Pallé argues. "So, ultimately, there's no place with a car where there is zero risk. That's the reality. We've been racing for 10 years with exceptional crashes, which have proven that the battery was more than reliable."

Battery fires are a parroted argument against electrifying the automotive industry, but the limited data available suggests electric vehicles are less of a fire hazard than those with Internal Combustion Engines. In a U.S. research study conducted by the National Transport Safety Board and compiled by AutoInsuranceEZ, gas-powered vehicles had an average of 1,529.9 fires per 100,000 cars sold. Electric vehicles, in comparison, had only 25.1.

"We here in motorsport, we are the most extreme case," Modlinger contends.

Formula E's status as a young series tasked with forging the future of electric mobility means hurdles come with every 100 metres of technological success. The battery fire was just one of the constant trial and error processes. For Modlinger and Pallé, the incident proved that the safety measures and systems in place were working.

"The level of professionalism that has been shown is there to showcase that it was managed super quickly and efficiently," Pallé says. "But also, the learnings have been taken straight away to make sure that they will do all the tests and so on. Ultimately, there's really nothing to be worried about. The risk [of] zero never exists. You cross the street, and you can be run over by a car, but it's not because of that you stopped crossing the street."

> *"It's not that the world needed another racing series. The world needed a racing series that would address climate change"*

Running a 17-round professional motorsport series with a fanbase of 344 million people with a strict sustainable strategy isn't an easy feat. Despite its hiccups, Formula E isn't deterred. The electric racing series will continue to juggle high-speed performance, all while heralding the environmentally friendly future of racing.

"The beauty of sustainability is that it's a series of constant challenges," Pallé says. "I think we've always been very open with the fact that we're not doing this to pride ourselves or pat ourselves on the back. We're here to try and really showcase and create movement towards electrification." RT

BELOW The electrification of the automotive industry, allied to the championship's sustainability goals, have lured a stream of manufacturers to the series. Note Andre Lotterer's Porsche 99X Electric Gen3 in the air!

VIRTUAL RACING MEETS REALITY

The shared vision behind the development of the Artura GT4 steering wheel

RENVALE, Ascher Racing and McLaren have revealed details of their collaboration to develop a high-performance steering wheel for the brand-new Artura GT4 supercar.

The Artura GT4 is McLaren's latest supercar, developed to compete and win in various GT4 series around the world. It features a super light carbon fibre tub, advanced aerodynamics and a 585 bhp 3-litre, 6-cylinder engine. With a focus on ultimate driver engagement, one of the highlights inside of the Artura GT4 is the steering wheel developed and engineered by Renvale and Ascher Racing.

Renvale and Ascher Racing collaborated on logistical, electrical, mechanical, and electronic development to produce a race-ready steering wheel for the McLaren Artura GT4 project.

Renvale is a key player in the world of bespoke wiring harness systems, with decades of experience in designing and manufacturing solutions for motorsport, creating products that have contributed to winning 50 world titles, with success spanning F1, FE, MotoGP, Le Mans and WTCR.

Ascher Racing is globally recognized for its state-of-the-art virtual motorsport steering wheels. It is the first wheel-only manufacturer to form a true partnership with a real car producer such as McLaren.

"Being an avid sim racer and currently using the Ascher Racing sim wheel on the simulator, I've had experience using various sim racing wheel suppliers, so I suggested that having a collaboration with Ascher Racing would be a good fit for Renvale," said David Meenan, Business Development at Renvale. "Functionality and quality are on the same level as Renvale, and that's what's expected in the highest echelons of motorsport."

Renvale has an established relationship with McLaren, which spans over 35 years from designing and manufacturing the wiring harnesses for the all-conquering MP4/4, the 1993 McLaren F1 road car, right through to the present day with the Artura. Although the competition was fierce, as a preferred supplier, Renvale gained the contract for the all-new GT4 wheel.

"Renvale has managed many steering wheel projects in different guises, but typically with the client providing the hardware and Renvale adding the manufacturing expertise," reflected Anthony Moss, COO of Renvale Group.

Thinking outside the box and recognising the gap between SIM and real-world racing was now so close, Renvale thought why not try and bridge the gap, quickly concluding there was only one name to work with on such a project: the renowned SIM enduro racer and creative talent, Martin Ascher of Ascher Racing.

McLaren was impressed by the tried-and-tested hardware solution, grip technology, gear shift paddles, and precise quality. The challenge was to combine high-performance parts from virtual motorsport with complex real-world motorsport technology.

Renvale and Ascher Racing therefore embarked on a journey to create a cost-effective, plug-and-play, race-ready wheel. "Taking a sim wheel, which typically uses Bluetooth or USB interfaces and creating a bespoke CAN-based electronics package to integrate into real-world motorsport was an enormous task," said Darren Burden, Renvale's Engineering Manager.

Complex work

As the Artura platform uses a hybrid powertrain, McLaren had challenges in de-hybridising the car to comply with GT4 regulations. This meant the transmission and accompanying control units had to be changed. Developing a CAN module to integrate with its various motorsport and road car control units to give full functionality of Ascher Racing's existing sim hardware was very complex. It took a lot of expertise, plus the proverbial blood, sweat and tears, but Ascher Racing and Renvale achieved their mission. They delivered a beautiful, fully functional, low-cost steering wheel on time and were rewarded with fantastic feedback from both Mclaren and the drivers alike. RT

BELOW The collaboration embraced a fusion of advanced sim racing wheel technology and real-world motorsport expertise

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TIME TO TAKE THE BULL BY THE HORNS?

With Red Bull's superiority overwhelming and TV figures underwhelming, is it time to rein in Red Bull? The dilemma prompts **Sergio Rinland** to recall an encounter with Bernie…

A COUPLE of months ago we expressed our horror that some sort of Balance of Performance was being discussed after one of the F1 teams had thrown its toys out of the pram.

Just when it appeared that everybody had seen sense and dismissed such a silly idea, there is now a groundswell of opinion that – with F1 TV viewing figures slightly down from last year – something must be done to halt Red Bull's domination. Perhaps we should point out here that FOM has kept increasing its revenue year after year since taking over F1 from Bernie Ecclestone...

The current situation, with the almost embarrassing level of superiority enjoyed by Red Bull and Max Verstappen, reminds me of an anecdote from when I was Brabham's Chief Designer. Bernie came into the office we used to share with Chief Engineer Charlie Whiting (before he became the master of F1 policing and regulations) and saw us going through a series of spy pictures of the all-conquering McLaren of the time. 'What are you doing?' he enquired, to which we answered, 'Looking at McLaren pictures to figure out what they are doing that makes them so quick'.

With typical Bernie pragmatism, he responded: 'They are not doing anything special; it's all the rest of you doing it wrong'. Or words to that effect. Except maybe a bit less polite.

He was spot-on, of course, and I would say that the same applies to Red Bull these days. Or to any other team of decades past.

What amuses me now is that anyone should even be considering the idea of changing the rules to cancel out Red Bull's advantage! If hundreds, or even thousands, of engineers in the other nine teams are struggling to find an answer to Red Bull's superiority, how will the small technical team at the FIA know what to change to counteract such an advantage?

We are all speculating on what the advantage is, but in reality, none of us know for certain. The stepped underfloor? The anti-dive front suspension? The rear suspension damping? The DRS effect on underfloor drag? Or perhaps a combination of all of those and a few more we haven't thought about.

When a team finds that "unfair advantage" (as Mark Donohue put it so well) and on top of that has a driver at the top of his game, firing on all cylinders, it is very difficult to know where the advantage lies. I even heard of someone suggesting Red Bull drop Checo Perez for someone who could challenge Verstappen. There's probably a reason that didn't happen in the years of Schumacher or Hamilton domination too… Ridiculous.

Improving performance in F1 is more difficult now than ever due to the restrictions put on development in the quest to reduce spending. A cleverer formula has to be found to achieve both: curbing spending and allowing teams to develop their cars.

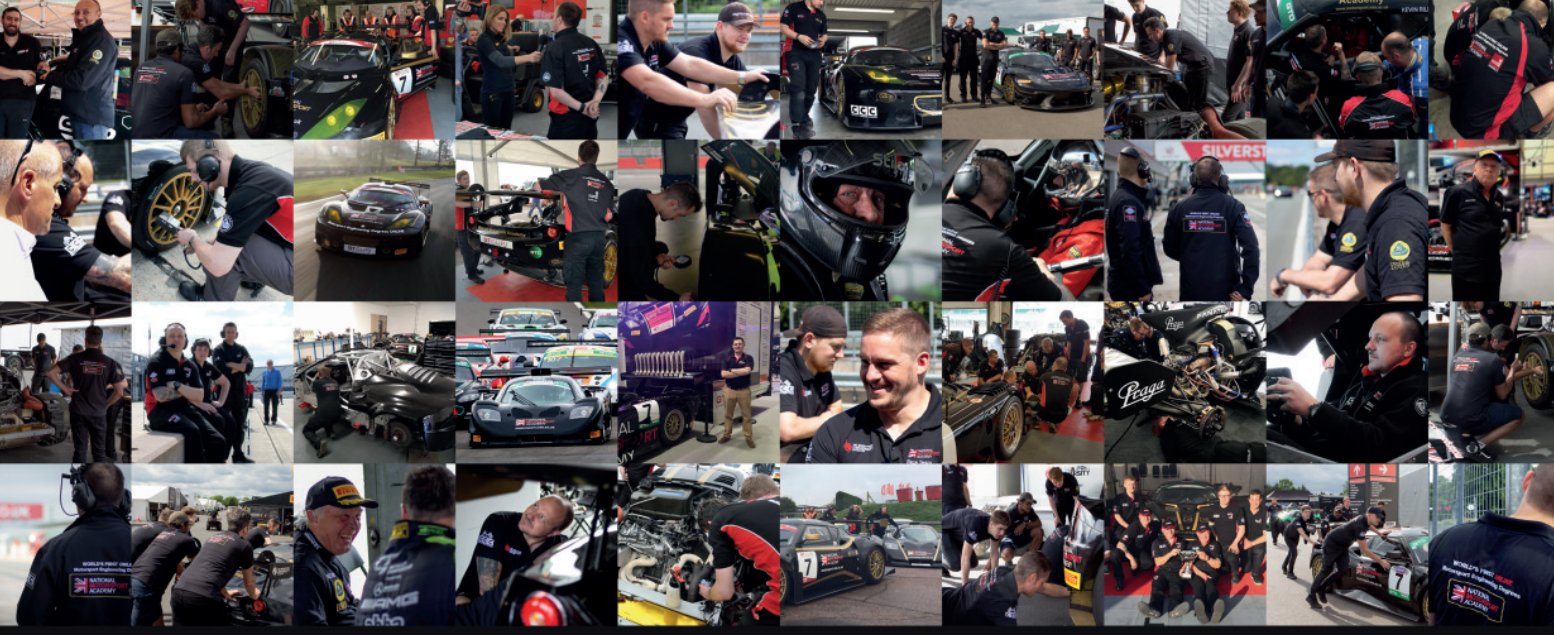
One thing is certain: Formula 1 is, and always has been, a meritocracy. As such, you will always have someone doing it better than the others. If spectators are slightly down from last year, so be it. We have 20 cars in F1, and there is plenty of action behind Verstappen.

I say do not mess with it. The new rules are doing what they were set up to do. Perhaps cancel DRS or allow it to be free? (With these new rules it is not necessary). I am sure that will spice up the show. But don't penalise someone who is winning. That is why they do it: to win. And if they take a lap off everybody, hats off to them.

And by the way, if Checo Perez is having a difficult time right now, it has more to do with Verstappen's exceptional communion with the Red Bull RB19 than any other consideration. It's no different from any other wonderful driver/car combinations in the past: Fangio/Mercedes; Clark/Lotus; Stewart/Tyrrell; Senna/McLaren; Schumacher/Ferrari; Vettel/Red Bull; and Hamilton/Mercedes. Leave it as it is; on one hand it doesn't make for the best viewing; on the other, it's Formula 1 at its best. RT

Getty Images/Red Bull Content Pool

BELOW Max Verstappen is in the sweet spot with Red Bull's RB19. Should we legislate against them?



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