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COVER STORY PAGE 32

AVL RACETECH female engineers Manuela Heinisch and Maria Santos.

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SOMEBODY DOESN'T HAVE A CLUE...

MOTORSPORT'S rule-makers are often the butt of jokes and barbed comments. But the turbulent events of the last few weeks, which were almost comical at times, have led me to revise my opinion of the great and the good who decide our destiny within the racing industry.

Reacting to the UK Prime Minister's predictable decision to delay the ban on the sale of new gasoline and diesel cars, Lisa Brankin, Ford UK Chair, pointed out that the Blue Oval has made a $50 billion commitment to electrification, launching nine electric vehicles by 2025. "Our business needs three things from the UK government," she said. "Ambition, commitment and consistency."

It struck me that motorsport's rule-makers have perhaps demonstrated all three qualities as they navigate the incredibly tricky minefield of the electrification of our industry.

Their reward has been the remarkable progress made in every direction. From the outstanding success of Formula E, to the introduction of sustainable fuels and now exciting strides forward towards hydrogen, the motorsport industry has come so far. All three technologies are featured heavily in this issue, with some fascinating remarks.

Among them were the observations of Avalanche Andretti Formula E team principal Roger Griffiths. He noted the mystification of some of the engineers who joined the FE program from Andretti's IndyCar squad. They are, he said, used to continuously changing ride heights, springs and damper settings in the quest for quicker lap times. But the Formula E team does very little of that. Partly because it doesn't have the time; also because those conventional tuning aspects are perhaps secondary to what can be achieved through powertrain control. And Griffiths should know: he has just helped deliver the US racing dynasty's first electric World Championship.

Another remark that struck me in this issue was the assertion from Martin Popilka, CEO of P1 Racing Fuels, that the introduction of synthetic fuels will not survive another 'Dieselgate'-style scandal. He warned that amid the euphoria accompanying motorsport's strides forward, we must beware the danger of "greenwashing".

Perhaps the biggest shame is that motorsport's green pioneers need not have bothered in the first place. Certainly not if you listen to the former leader of the 'free world', Donald Trump, who last month reiterated his belief that the climate crisis was a "hoax"! Warming to his theme (if you will excuse the pun), he asserted that "climate alarmists don't have a clue"…

Never mind worrying about a "greenwash". It's 'hogwash' we ought to watch out for!

Mark Skewis
EDITOR

PORSCHE STUDYING DEVELOPMENT OF DIRECT AIR CAPTURE TECHNOLOGY

DAC-extracted CO2 could be employed at Haru Oni eFuels pilot plant. By **Mark Skewis**

PORSCHE'S Haru Oni pilot plant, seen very much as a poster-child for the production of synthetic fuels destined for motorsport, could harness CO2 extracted from air for the production of eFuels.

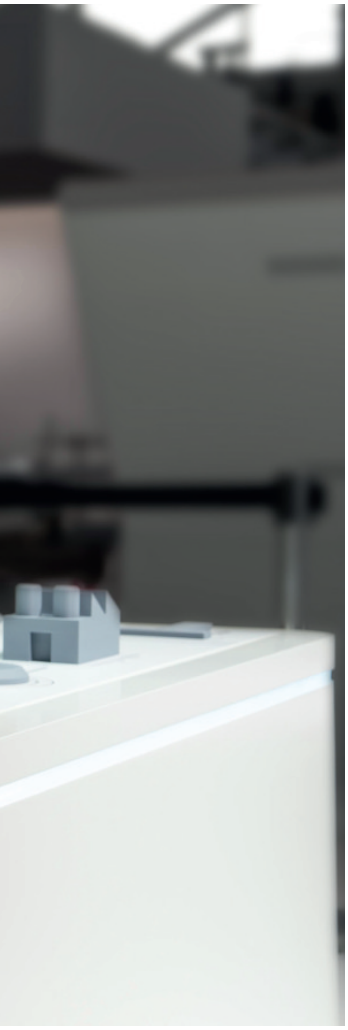
Porsche views direct air capture (DAC) as an important new technology, which is on the threshold of mass production. It insists that by extracting large quantities of carbon dioxide (CO2) from the atmosphere in an environmentally friendly manner, this technology can play a significant role in combating climate change.

Together with Volkswagen Group Innovation, the eFuels company HIF Global and MAN Energy Solutions, the sports car manufacturer is looking into integrating a DAC facility into the eFuels pilot plant in Chile. The facility could be used to extract, from the air, the CO2 required for eFuels production at the Haru Oni pilot plant.

"To slow global warming, it is essential to reduce emissions and remove CO2 from the atmosphere," said Michael Steiner, Member of the Executive Board for Research and Development at Porsche AG. "At the same time, we need CO2 as a raw material in many production processes. Why not combine the two? We're working on that.

RIGHT Synthetic fuels are a key pillar of the manufacturer's sustainability push

RIGHT Haru Oni: In the pilot phase, the facility should produce around 130,000 litres of eFuel a year



BELOW A model of a Direct Air Capture unit shown at the VW Group stand at the recent IAA Summit

"We want to put an industrial direct air capture, or DAC, procedure into series production. Together with the experienced team at Volkswagen Group Innovation, our established eFuels partner HIF Global, and MAN Energy Solutions, we are examining the integration of a DAC pilot plant at the eFuels plant in Chile. We regard DAC as a viable technology for the future because it can be used to extract the carbon molecules required for the production of many products in a sustainable manner. So, we are working on bringing the technology to a higher degree of maturity."

"In our view, DAC is an important new technology for the future – for energy extraction and particularly for the climate," added Barbara Frenkel, Executive Board Member for Procurement at Porsche.

"Pure CO2 can be used for industrial processes or permanently stored in the ground. It can also be used to produce eFuels – which we are planning to do as a first step. These eFuels are a useful complement to e-mobility, as there will still be many ICE vehicles on the road around the world for decades to come."

One major advantage of DAC technology is that CO2 can be extracted anywhere that there is renewable energy available to operate it. The technology is also scalable. The electricity for the filter system at the Haru Oni eFuels pilot plant could be generated using wind energy, so it would come from a renewable source. The required heat could be provided through the hydrogen generation process in the eFuels plant.

Porsche is drawing on the expertise of its partners, Volkswagen Group Innovation, HIF Global and MAN Energy Solutions. "The Volkswagen Group identified extracting CO2 from the atmosphere as an issue for the future back in 2019," said Nikolai Ardey, Director of Volkswagen Group Innovation.

How direct-air-capture (DAC) technology works

TO extract CO2 from the atmosphere, the ambient air is first cleansed of large dirt particles and directed through a pebble-like filter material. The CO2 deposited there is then extracted from the material and collected in a highly purified form for later use as a raw material. Water, a potential by-product, is drained off.

This CO2 extracted from the atmosphere can be used in a variety of different ways as part of a circular economy. In the future, it could be used as a raw material in the production of non-fossil-based plastics. This stores the CO2 long-term. It can also be used to produce fully synthetic fuels, also known as eFuels.

Porsche and HIF Global are studying whether and how DAC-extracted CO2 can be used at the Haru Oni eFuels plant in Punta Arenas, Chile, where CO2 is combined with hydrogen to form methanol. This is then made into synthetic fuel. Until now, the CO2 for Haru Oni has been taken from a biogenic source. As an alternative to the production of non-fossil products (CCU, or Carbon Capture and Utilisation), the CO2 can be permanently removed from the atmosphere and stored long-term (CCS, or Carbon Capture and Storage). RT

"Since then, we have extensively studied the concept with regard to suitable technologies and economic viability with international partners in the research and industrial sectors. Our research has found that scalable and commercially competitive direct-air-capture technology is possible. Together with Porsche and other partners, we now want to build a prototype plant and test the concept as a whole. We are already looking forward to the prospect of implementing this future-facing project in Chile."

"We are not waiting for solutions to come to us. We are finding them ourselves and moving forward," said César Norton, President and CEO of HIF Global. "We have proven that carbon-neutral eFuels can be a real solution for decarbonising the transport sector. In pioneering direct-air-capture technology, that enables efficient and low-cost CO2 capture, we are taking things a step further.

"We are delighted to be working with Porsche to operate this technology – the future of CO2 recycling – in the future at our plant in Chile and, in this way, make an active and timely contribution to fighting climate change." RT

Getty Images/NASCAR

Hendrick Motorsports engines earn milestone victories

THE engine department at NASCAR powerhouse Hendrick Motorsports has recorded two major milestones in quick succession: its 500th win, followed swiftly by its 300th victory in the top tier, the NASCAR Cup Series.

The achievements were delivered by Kyle Larson's win in the NASCAR Cup Series playoff opener at Darlington Raceway, and by William Byron at Texas Motor Speedway.

The engine shop rose to prominence after team owner Rick Hendrick's acquisition of Randy Dorton's company, Competition Engines, in 1984. Dorton became Director of Engine Operations and lead engine builder. His engines helped guide the team to nine NASCAR titles before his death in a plane crash in 2004.

The latest accomplishment for the organization comes just over two years after Hendrick Motorsports broke the all-time wins mark of 269 victories by surpassing Petty Enterprises with Kyle Larson's dominating triumph in the 2021 Coca-Cola 600. The Concord, North Carolina-based team stands alone as the lone premier series organization to cross 300 wins.

"300 is just such a milestone," team owner Rick Hendrick said. "When you put that distance on Petty's record (of 269) by a pretty good margin and at the rate we are going, we are just adding to it… I don't know where we are going to go and I am not going to set a goal because the goal for me is just winning.

"If we can win races every year and compete for championships, the numbers will come. 269 was in my brain for a long time and I didn't think we could ever get there. I just owe it all to the people here and the drivers along the way. It is unbelievable to be at 300."

The engine shop is the backbone of Hendrick Motorsports' campus. That was very evident to Jeff Gordon, a NASCAR Hall of Famer and the team vice chairman, before he even drove his first race car for the organization en route to become a four-time Cup Series champion.

"It's really special because when I came to Hendrick Motorsports, the thing that was evident to me right away, but especially after I drove my first Hendrick Motorsports car, was the engine shop," Gordon told HendrickMotorsports.com. "A lot of things in this company centred around the engine shop. The horsepower, the reliability and the pride that goes into that area of Hendrick Motorsports. I was right away at an advantage against my competitors when I was able to step on the throttle pedal and feel that kind of power.

Hendrickmotorsports.com

"I always loved hearing when the engine shop would come to me and say, 'Oh, we got you a couple more horsepower this time. I think you're going to like this.' It made my life and my job a lot easier. They always put a big smile on my face for that." RT

ABOVE & BELOW The Hendrick Motorsports engine shop celebrates its 500th win, courtesy of Kyle Larson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Flexi-aero back in the spotlight

RED BULL'S dominance at the Japanese GP dampened speculation that an FIA Technical Directive issued at the Singapore race had hobbled the reigning champions – but a number of teams are thought to have provoked the issuing of the Directive.

TD018 applied in particular to front and rear wings that, according to FIA Single Seater Technical Director Tim Goss, "try to get the most out of the boundaries that exist within the regulations".

"There are a lot of clever engineers out there looking to get the most out of the regulations and we have to make sure that everyone has a common understanding of where the boundaries are," said Goss. "And in recent times we have seen a little bit too much freedom being applied to the design details of aerodynamic components."

Goss said that the FIA became aware of a number of cases where bodywork designs (in particular, front and rear wings), comply with the requirements of Article 3.15 of the Technical Regulations, governing Aerodynamic Component Flexibility, but which could be deemed to contravene the provisions of Article 3.2.2, because they "exploit regions of purposely designed localised compliance and/or relative motion between adjacent components".

In layman's terms, as Goss explained, clearer guidance around how components are joined together needed to be given.

"For us, the important bit of Article 3.2.2 is that 'all aerodynamic components or bodywork, influencing the car's aerodynamic performance must be rigidly secured and immobile with respect to their frame of reference and that they must make use a uniform, solid, hard, continuous surface under all circumstances'," he explained.

"Now, quite clearly things cannot be totally rigid. So, we have a range of load deflection tests that define how much elements can bend and we've evolved those tests to represent what the teams are trying to achieve on track and to put a sensible limit on them. We play by those rules, while teams look to exploit the allowance in terms of deflection. That's normal. So the TD is just about making sure that we, the FIA, and the teams, all have a common understanding of where we will draw the line in terms of these design details."

And according to TD018 that line now exists at a point where, regardless of conformity with the load tests defined in Article 3.15, the FIA would consider any design which uses the relative motion between adjacent components of mechanisms in order to maximise aerodynamic deformation to be in breach of Article 3.2.2.

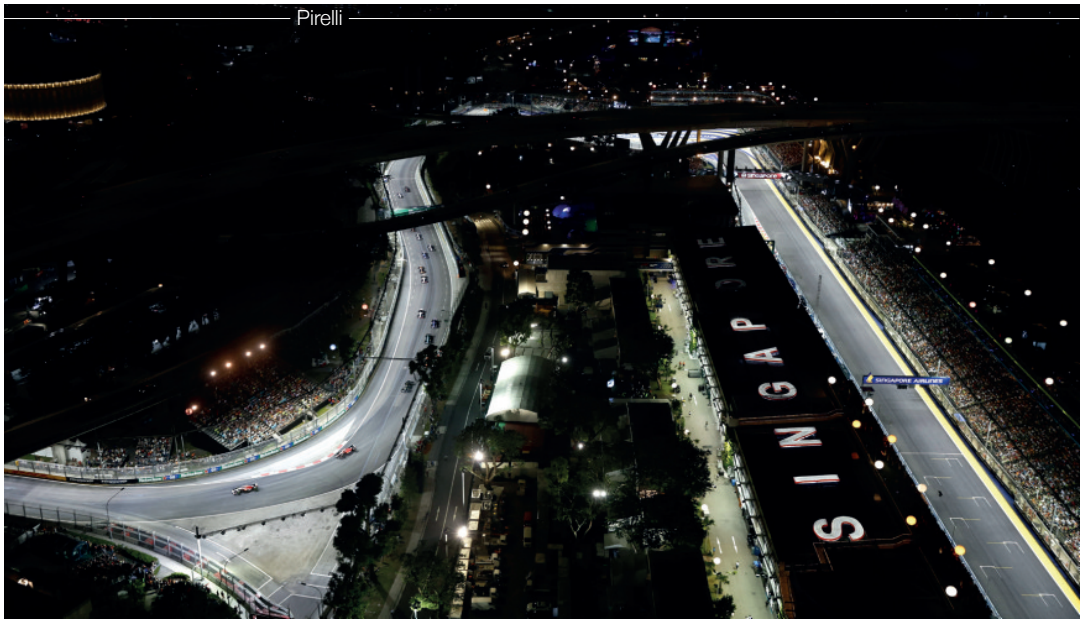
"What we don't want to see," said Goss, "as an example, is that the joint of a rear beam wing and an end plate is decoupled in any way such that it rotates about a pivot there, or that it can move laterally or up and down.

"It's not that we've seen any one particular car or feature that we've targeted, or an element that's been common across the whole grid," he said. "This is about where front and rear wing elements join the nose, join the rear impact structure, join the rear wing endplates. And there have been several instances where teams have tried to make the most of the deflection allowance by permitting some bits and pieces to start moving relative to each other.

"And if you've allowed one piece to be decoupled relative to another, the bodywork might have to have some degree of local flexibility at that location. And if there is local flexibility, we're saying, clearly, that's not compliant with being uniform, solid, hard and continuous. Under the TD, we have included various examples, designs which we consider are not permitted and exceptions which we consider are permitted."

To ensure further transparency going forward, the FIA is to also begin requesting additional drawings of the structural designs of areas of concern.

"Teams have to submit designs at the moment, they upload lots of information but now they will have to upload structural connections and that in itself helps to self-police it," said Goss.



LEFT Talk of flexi wings and floors has dominated since Singapore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World RX rises from the ashes!

FOLLOWING an FIA World Motorsport Council extraordinary e-vote, the 2023 FIA World Rallycross Championship season will conclude with drivers competing in RX2e-category vehicles.

The series has been on hold since a fire at Lydden Hill in July destroyed both Special ONE Racing RX1e Lancias, prompting the Stewards to end hat event prematurely on safety grounds.

The fire initially affected one of the cars but subsequently engulfed and destroyed both of the team's vehicles and transporter in spite of the actions of the local fire service. Video evidence showed that the fire was initiated at the battery of the car while it was in the team area charging, but it is not clear why this happened. It was evident that only extremely quick thinking by the team members saved them from injury.

Investigations into the root cause of the incident were initiated by the FIA with the co-operation of the Kent Fire service, the Lydden Hill track staff and the championship promoter.

With the battery manufacturer, Kreisel – which provides the kit that underpins all the cars in the top category – unable to provide an appropriate level of assurance in the system, the next three events were axed while investigations continued. Now, with the logistics timeframe of shipping cars to Cape Town, it has been decided that the drivers will compete in the single specification ZEROID X1 vehicles normally used in the RX2e ranks.

ABOVE The series will use single-spec RX2e cars to complete the season

The cars will then be relocated to China for the season-ending double-header, as World RX heads to the streets of downtown Hong Kong for the first time in the championship's history.

"We're really excited to be back racing in the World Championship again," enthused Team Principal, 14-time FIA European Rallycross Champion, Kenneth Hansen. "It's a huge effort from everyone involved – the promoter, the FIA and the teams – to pull together a solution after it looked impossible to continue this year.

"It's a huge achievement and so important that we are able to complete the season, and it's great that everyone will be using the RX2e cars for the final two events. We have great memories from Cape Town, where we won our first World RX Drivers' title in 2019, and we will see closer racing than ever with everyone running the same specification of cars.

"This also buys us more time to prepare for 2024 and beyond, where we will continue our growth as a sport in terms of a racing and commercial product and of course for us as a team within that. We are fully invested in moving forward with rallycross into an exciting future." RT

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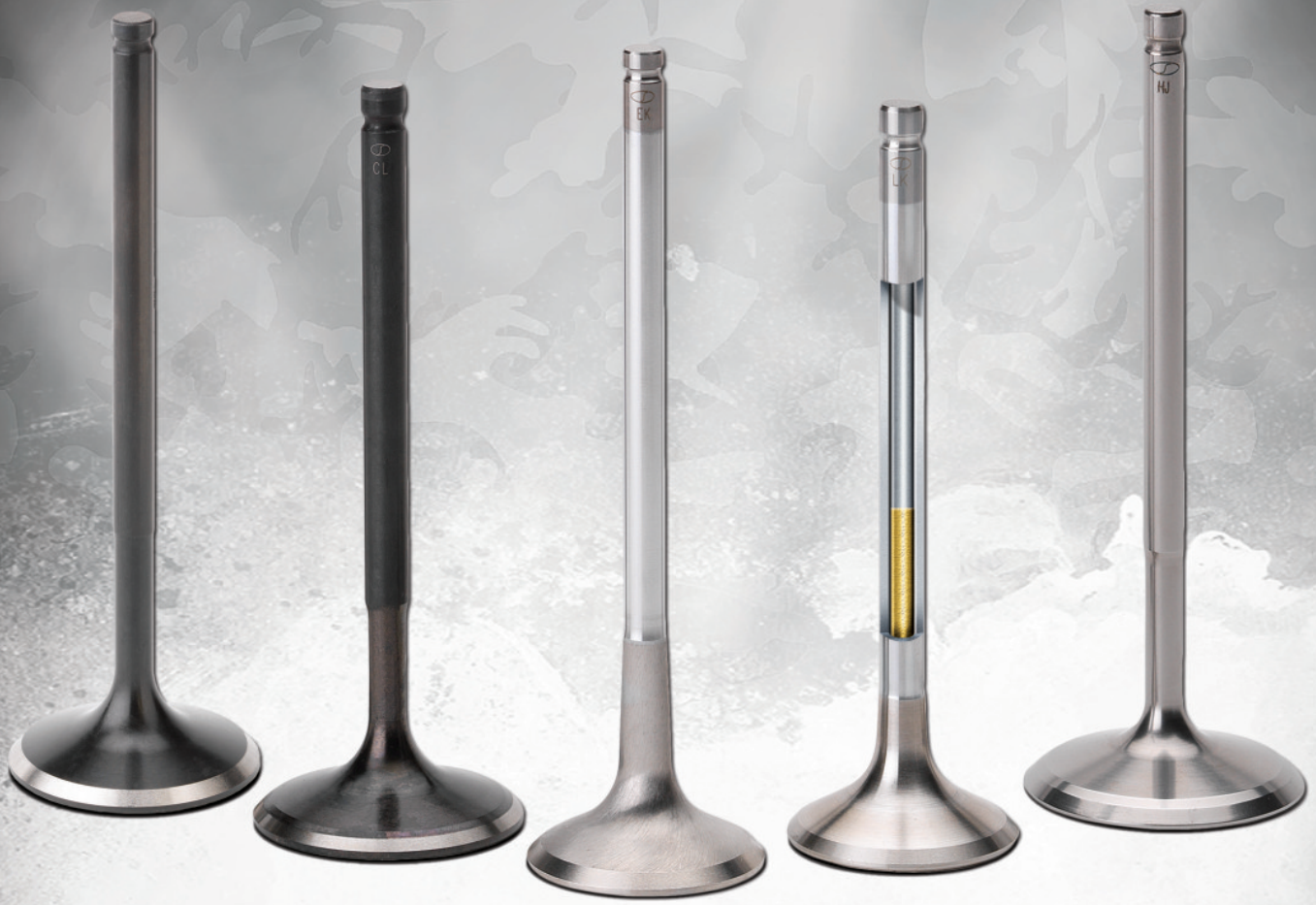

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Honda's US aces to join 2026 F1 push

HONDA Performance Development, the Japanese manufacturer's US racing arm, is to play an integral role in Honda's global motorsports programs, including its official return to F1 with Aston Martin.

Honda Racing Corporation (HRC) in Sakura, Japan, and Honda Performance Development (HPD) in Santa Clarita, CA, jointly announced that HPD will formally become Honda Racing Corporation USA (HRC US) starting with the 2024 motorsports season.

Collaborating as one global HRC entity, the two independent racing arms of Honda will combine their expertise and resources to strengthen Honda's overall motorsports capabilities.

"Our goal is to increase the HRC brand and sustain the success of our racing activities and we believe that uniting Honda motorsports globally as one racing organization will help achieve that," said Koji Watanabe, the president of HRC Japan. "Our race engineers in the US and Japan will be stronger together and I am so happy to welcome our US associates to the HRC team."

"Honda's racing heritage is unparalleled over the last 30 years and the talented men and women of HPD have contributed to that success in the US," said David Salters, president of HPD, who will become president of the new HRC US. "We are thrilled and very proud to join forces with our friends and colleagues in HRC Japan and represent Honda Racing as a global racing organization. We will continue to challenge ourselves in US motorsports activities even as we develop our people and technology to compete on a rapidly changing global motorsports stage."

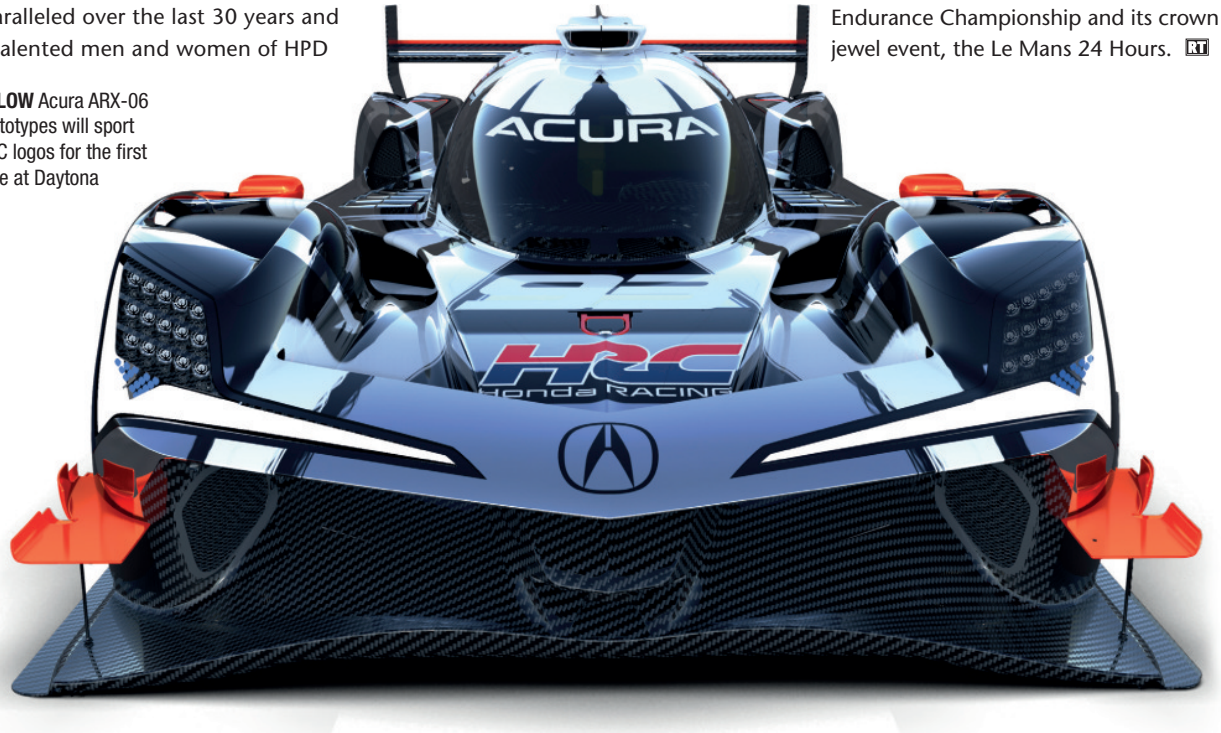
HRC was established in Japan in 1982 as Honda's motorcycle racing arm, and is recognized for more than 40 years of championship racing heritage in pinnacle global racing categories such as WGP/MotoGP, Superbike, Motocross, World Trial and the Paris Dakar rally. In 2022, HRC added auto racing including Honda's F1 program to its responsibilities, with the Sakura Center dedicated for auto racing and Asaka Center focused on motorcycle racing.

HPD was established by American Honda Motor Co Inc in 1993, as a separate racing arm to compete in the IndyCar series. For 30 years, HPD has competed in various racing series including IndyCar, IMSA, Baja Off-Road, Touring Cars, and Formula Regional America. Through HPD, Honda has 280 wins from 510 races in IndyCar competition, including 180 wins from 410 events with multi-manufacturer competitions. At the Indianapolis 500, Honda has won 15 times, nine with multi-manufacturer competition. Honda has won 13 Drivers' Championships and 10 Manufacturers' Championships in years with multi-manufacturer competition. HPD also has led the Acura brand to three consecutive wins in the Rolex 24 at Daytona, and three IMSA Manufacturers', Drivers' and Teams' Championships since 2018.

HRC's auto racing development centre in Japan currently supports Red Bull Powertrains for F1 power units. Starting in 2026, HRC will partner with the Aston Martin Aramco Cognizant F1 team as the official engine supplier. With three F1 races now in the U.S. (Austin, Miami, Las Vegas), the new HRC US will be involved in Formula 1 power unit development and race support starting in 2026.

The 2024 Rolex 24 at Daytona, scheduled for January 27-28, will mark the inaugural race for the new HRC US, with the defending champion Acura ARX-06 prototypes to sport HRC logos on their racing liveries.

The new role for Honda's US racing arm could ultimately pave the way for its IMSA GTP prototypes to contest the World Endurance Championship and its crown jewel event, the Le Mans 24 Hours. RT



BELOW Acura ARX-06 prototypes will sport HRC logos for the first time at Daytona

Pirelli exits WRC

THE World Rally Championship will have a new tyre supplier from 2025-2027 in the wake of Pirelli's withdrawal from the series. Michelin, Hankook and MRF are said to be in the frame to fill the void.

Pirelli won the previous tender, to supply tyres to all WRC categories from 2021-2024. The deal marked the Italian firm's return to rallying's top level for the first time since 2010.

Pirelli, which is present in more than 350 motorsport championships around the world, stresses that it remains committed to rallying. It will continue its participation in all the other rally competitions in which it is currently involved.

These include the FIA European Rally Championship, won this year by Hayden Paddon in a Pirelli-equipped Hyundai. The ERC is organised by the same promoter as the WRC, with a number of different tyre manufacturers taking part.

Pirelli is also present in more than 40 national rally championships worldwide, as well as a wide variety of other events for modern and historic rally cars.

The suggestion is that Pirelli's decision is not influenced by its commitment to F1, in which it is likely to pip Bridgestone to the next sole supplier contract. Instead, it is a case of 'mission accomplished' in rallying's top tier.

"We believe we got what we wanted in terms of being a part of the sport in the top class," said Pirelli motorsport director Mario Isola. "We will continue to develop products for rally because that is really relevant for our technology transfer on snow, ice and gravel, so we want to be involved in rallying. We are expanding our activity on historic rallies and some other championships."

ABOVE Pirelli is bowing out of the WRC

F1's biofuel initiative slashes carbon emissions by 83%

FORMULA 1 has revealed that DHL's new fleet of trucks running on biofuel reduced carbon emissions by an average of 83%, compared to fuel-driven trucks, across the European leg of the 2023 FIA Formula 1 World Championship.

Across the nine European rounds, the new 18 trucks were powered by HVO100 drop-in fuel (hydrotreated vegetable oil) and travelled over 10,600 km, transporting an average of 300 tonnes of freight per race.

The use of biofuel will continue into 2024 and beyond, with the data from this summer providing invaluable insight as Formula 1 and DHL explore further opportunities and sustainable innovations as the sport moves towards being Net Zero by 2030.

The biofuel-driven trucks maintain the same level of performance in terms of load capacity and travel distance as their diesel counterparts. All trucks in the DHL fleet are equipped with GPS to monitor fuel consumption and optimise more efficient routes.

In 2026, alongside the introduction of the next-generation hybrid engine, Formula 1 cars will be powered by advanced sustainable fuel, which due to the development from the sport's energy suppliers could have a hugely positive impact on the wider automotive and transport industry with drop-in capabilities. This year's F2 and F3 Championships have been powered by 55% sustainable fuel in partnership with Aramco, with the latter concluding at the Italian Grand Prix.

Ellen Jones, Head of Environment, Social and Governance at Formula 1, said: "It is great to see how our logistics operations can transform to achieve our Net Zero by 2030 goal. Reductions such as 83% with the use of the biofuel-powered trucks provide a fantastic platform to build upon, which we will analyse and then continue to deliver in our 2024 season, ensuring that these savings move from a single initiative to business-as-usual carbon reductions.

"Transport and logistics make up a significant portion of our carbon footprint in our sport, and it is crucial to have likeminded partners like DHL that are committed to working with us to drive these down and help us realise our Net Zero target."

Paul Fowler, Head of DHL Motorsports Logistics, said: "The introduction of 18 new biofuel-powered trucks this season marks a significant stride towards a more sustainable future for both Formula 1 and DHL. Achieving an 83% average reduction is a remarkable accomplishment, and we take great pride in it."

M-Sport UK reveals succession plan

M-SPORT UK has restructured, with founder Malcolm Wilson appointing a new leadership team to take the company forward under his management.

The move comes in the wake of the news that Commercial Director John Steele will be stepping down at the end of 2023. Steele has been with M-Sport for almost 40 years and has played a pivotal role in helping to build the company from its beginnings to the motorsport powerhouse it is today.

Malcolm Wilson remains chairman and owner. His new leadership team will comprise of existing company director Matthew Wilson, Technical Director Chris Williams, WRC Team Principal Richard Millener, Finance Director Paul McKnespiey and M-Sport Poland board member Maciej Woda.

Steele will continue as a director of M-Sport UK until the end of the year and will oversee the transition to the new leadership team. Thereafter, he will retain an advisory role.

Malcolm Wilson OBE, M-Sport Managing Director, said: "Firstly, I would like to thank John for everything he has done to help build M-Sport into what it is today – it wouldn't have been possible without him.

"He has found and developed some of the brightest minds in motorsport and will hand the reins to a new leadership team; two of which were first given an opportunity by him!

"As he steps back, the time is now right to progress our succession plan for M-Sport UK and in Matthew, Chris, Rich, Paul and Maciej we have five exceptionally driven individuals with the knowledge and insight to ensure our continued growth and success. We already have a close day-to-day working relationship, and I look forward to continuing and strengthening that over the coming years."

Since its inception in 1996, M-Sport has become the largest global manufacturer of Ford rally cars and is currently the only manufacturer to produce a rally car across every step of the FIA category ladder. The team has secured seven FIA World Rally Championships and 63 WRC victories.

The Cumbria, UK-based company is also the supplier of the TOCA British Touring Car control engine. It manufactures the new Mustang GT3 engine, and is the chosen partner to run the official Ford Dakar programme from 2024. RT

BELOW M-Sport is represented on every step of the rally ladder

Punching above its weight

FROM rallying to racing, combustion to hybrid, and the completion of a multi-million-pound Evaluation Centre, John Steele has been instrumental in the creation of a company which has constantly evolved and strengthened its capabilities.

He oversaw the growth of employee numbers from just four in 1985 to more than 250 pre-pandemic.

"The 38 years I have spent as part of the M-Sport family have flown by, and I take with me a great sense of pride in helping this once small family business grow into the global industry leader it is today," said Steele. "For that I sincerely thank Malcolm and Elaine for giving me the opportunity along with their help and trust all those years ago.

"M-Sport has always been and will continue to be about its people. They are what make the success possible, and I would like to thank every single member of staff past and present – all of whom have helped us achieve great things, always punching above our weight and setting standards others have followed – creating many fond memories and unforgettable experiences along the way.

"I'm looking forward to both the next chapter in my life and the next chapter in the story of M-Sport." RT

Getty Images/Red Bull Content Pool

IndyCar passes hybrid milestone

INDYCAR'S transition to its hybrid era, which commences in 2024, became tangible with the first track test of its 2.2-litre twin-turbocharged V6 engines paired with their hybrid components.

The successful exercise was conducted at Sebring International Raceway with a car from both Chevrolet and Honda present.

Using the eight-turn, 1.7-mile 'short course', Will Power (Team Penske Chevrolet) and Scott Dixon (Chip Ganassi Racing Honda) combined to pound out over 800 laps and approximately 1,400 miles during the two-day test.

Deployment of extra horsepower, which simulates the current overtake ("push-to-pass") system, came after the hybrid units were regenerated under braking elsewhere on the track. Manual and automatic regeneration techniques were tested.

The new hybrid technology will provide up to an additional 150 horsepower.

"I'm always excited to try something new," Power said. "I've been a big part of the testing of the new hybrid – running on the Indianapolis Motor Speedway road course without regeneration power like we're running here. It's going very smoothly. We've had no issues, and now we've added the regen to the power side of it. Everything is going as the engineers expected."

Turning laps in 90-degree temperatures and high humidity were added challenges successfully scaled by the new components. Both days also featured running in wet conditions after typical Florida afternoon rainstorms hit the track.

Dixon has helped to develop the 2024 powerplant since the autumn of 2022, with extensive testing behind the wheel.

"The ground floor is not always what it's cracked up to be," Dixon said with a laugh. "You come to some test days – especially at the start – and you sit around and try to figure out what's next and understand what improvements need to be made. You did very few miles then.

"Today is when you come in and run 600 miles on a street course or a road course, which is pretty hefty. It's in a great phase now."

Development of the 2024 engine package continues in a unique, collaborative effort between Chevrolet and Honda. The sound coming from the race cars is unchanged. The powerplant is unique to IndyCar, with a hybrid unit small enough to fit inside the bellhousing.

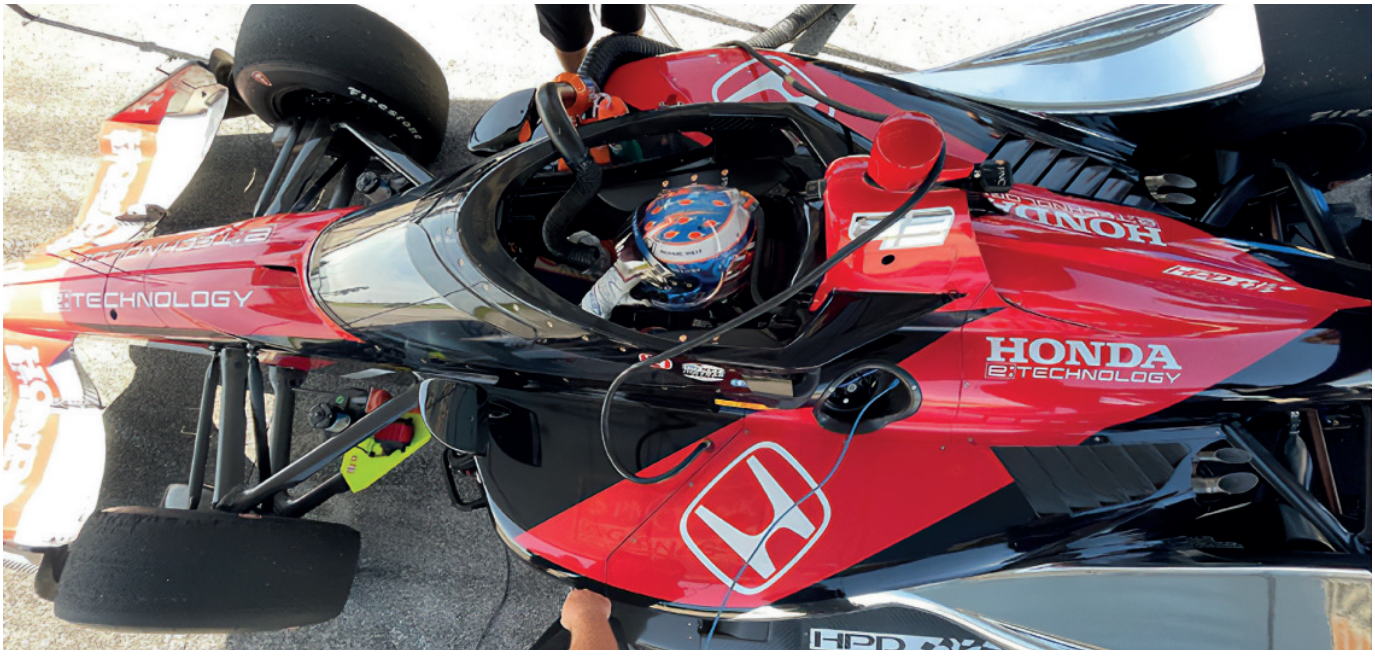
"For both manufacturers – I know for Honda – it's a huge push to be relevant to what they produce in their road cars," Dixon said. "This will bring in new technology that will trickle down.

"Much lighter, compact units, which will be better for the future. It's all about efficiency, to have less emissions and make it better for road cars."

Testing will continue throughout the fall and winter.

"A lot of things to be decided, but ultimately you can have more power all of the time, which would be good," Power said. "We all love more horsepower. I think you want the most regen that you can have and use the engine to its max. It's exciting."

"It will change the strategy," said Dixon, "especially if you have to regen and you're being attacked and it's going to be hard to regen. It's going to add a different dynamic. Not only from a strategy but for the person in the seat. You have to be thinking pretty quickly and making the right decision at the right time, which will make the racing even more spicy." RT



BELOW The 2.2-litre V6s were paired with their hybrid components on track for the first time

Extreme E extends broadcast deal with ITV in the UK

EXTREME E has extended its broadcast partnership with ITV, the UK's biggest commercial broadcaster, in a multi-year contract.

Fans in the UK will be able to watch the racing action free-to-air and live across ITV1, ITV4 and ITVX. Programming will also be available to catch up on demand on ITVX.

ITV has been a partner of Extreme E since the series' inception in 2021, and became the exclusive UK terrestrial broadcaster of live coverage in 2022 and 2023.

Ali Russell, Managing Director at Extreme E, said: "This gives us the platform to showcase our pioneering, gender equal championship – a world-first for motorsport – to a wide, engaged audience, and also raise awareness of the climate crisis and the need for sustainable solutions to climate change.

"Both Extreme E and ITV have a shared drive and commitment on this, and so this extension is a really important one." RT

WAE's hydrogen fuel cell EV platform targets sub-7m 20s laps at the 'Ring

WAE Technologies (WAE) revealed its latest hydrogen fuel cell electric vehicle innovation at this year's CENEX Low Carbon Vehicle (LCV) Show.

The ultra-high performance hydrogen fuel cell electric vehicle platform – EVRh – has been developed to demonstrate the potential of hydrogen (H2) powered powertrain systems through implementation in a high-performance vehicle application. Produced by WAE in Oxfordshire, EVRh combines WAE's extensive vehicle and powertrain engineering experience alongside a cutting-edge H2 fuel cell system, in one innovative package, allowing for end users to have zero tailpipe emissions driving.

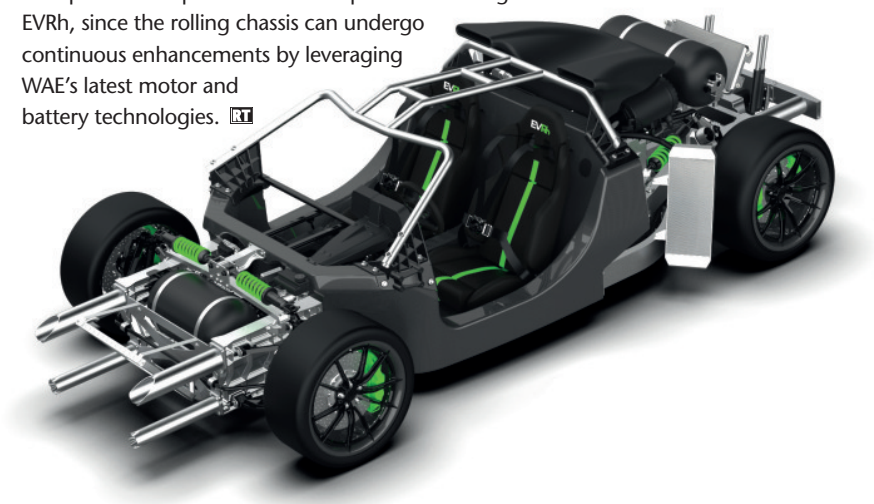
With its roots in racing, WAE's expertise is currently found at the heart of the LMDh sportscar package, the Gen3 Formula E car and in Extreme E. The latter is currently developing its hydrogen prototype for its Extreme H derivative, which is poised to receive World Championship status from the FIA.

The launch of EVRh came exactly one year after the reveal of its fully electric derivative, EVR. EVRh utilises an H2 fuel cell system, to produce electricity through a chemical reaction between hydrogen and oxygen in a fuel cell stack. Working with partners for the H2 fuel cell system, paired with WAE's systems integration and electrification technology, EVRh determines the potential of hydrogen powered performance systems, as a parallel-hybrid derivative of its EVR rolling chassis concept.

Featuring a lightweight composite structure, the high-performance H2 fuel tank and battery system are situated in the middle of the vehicle, optimising centre of gravity. The platform's design flexibility enables manufacturers to create multiple configurations from track-only vehicle, where power-to-weight is maximised, to road-going models of both open-roof Targa and fixed-roof GT style. This is made possible by the architecture's central tub which has been designed from day one to allow for such flexibility while still featuring the very latest performance technology such as active aerodynamics.

The powertrain has a state-of-the-art liquid-cooled FCEV battery pack at its core, capable of discharging 430 kW of power. Combined with the 120 kW hydrogen fuel cell, EVRh has a total output of 550 kW, enabling sub-2.5 secs 0-100 km/h acceleration and an estimated lap time of the Nürburgring in under 7 mins 20 secs. All-wheel drive and rear-wheel drive layouts are supported through multiple e-motor configurations.

The Hydrogen hybrid powertrain also brings multiple benefits to manufacturers, enabling an accelerated route to market, with the entire engineering and assembly completed by WAE, significantly reducing time and cost from development to market launch. Similarly, both OEMs and Tier 1s have the chance to incorporate new products into the powertrain using EVRh, since the rolling chassis can undergo continuous enhancements by leveraging WAE's latest motor and battery technologies. RT



BELOW The hydrogen fuel cell EV platform offers an accelerated route to market

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> "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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AWARDS 2023

Awards nominations now open

RACE TECH's Editor Mark Skewis and his panel of industry experts are looking for ground-breaking motorsport technology that enables a positive impact on the environment. If you believe that your product should be considered, **apply by 1 November 2023** with a short brief to sara.kimberley@kimberleymediagroup.com. A member of the team will then contact you for further information.

Nominees and winners will be announced at the World Motorsport Symposium Champagne Drinks Reception and Networking Awards Dinner on the evening of Wednesday 29 November 2023, to be held at Millennium Gloucester Hotel, London, Kensington, in front of key influential leaders in the motorsport and automotive industry.

WMS AWARDS CATEGORIES 2023

- Green Tech
- Most Innovative New Motorsport Product
- Race Powertrain
- Racecar Aerodynamicist

P1 Fuels


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"THIS TECHNOLOGY WON'T SURVIVE A 'DIESELGATE'-STYLE SCANDAL"

Is this make-or-break time for sustainable fuels? The CEO of P1 Fuels in candid discussion with **Chris Pickering**

MOTORSPORT enjoys a uniquely privileged position when it comes to new technology. The cars are looked after by the most capable engineers and mechanics in the world, they're driven by expert operators and, in many cases, replaced every season. If one idea doesn't work out, there's always another one to try.

For the rest of the world, that's not quite how it works. Globally, there are an estimated 1.6 billion combustion-engined vehicles on the roads. Even if every single application was suitable for electrification, and every single market was to head down that route, the likelihood is it would take decades to complete the transition.

Fortunately, motorsport can help here too. Or at least, that's the vision of Martin Popilka, CEO of sustainable fuel specialist P1 Fuels. The German company supplies the World Rally Championship (WRC) with a 100 per cent fossil-free blend. Along with high-profile demonstrations in historic motorsport with the likes of Sebastian Vettel, it has also begun supplying its fossil-free fuels to consumers.

"No matter how many vehicles we electrify, and how we increase the amount of EVs on the road, we still have that legacy vehicle fleet that will continue to pollute, if they don't have an alternative," comments Popilka.

Broadly speaking, sustainable fuels divide into two categories. There are biomass-derived fuels, which begin with the fermentation of organic matter, such as agricultural waste. These can be burnt as a pure alcohol in a suitably modified engine or further processed into an alcohol-free mixture that's a drop-in substitute for traditional gasoline.

The other route is power-to-liquid (PTL) to produce an e-fuel. As the name implies, this process uses power generated by renewable sources to combine hydrogen (ideally from electrolysis) and carbon dioxide (potentially captured straight from the atmosphere) to create synthetic hydrocarbons.

In theory, PTL and biofuels can be used interchangeably, mixed with each other or indeed with some percentage of fossil content.

"In an ideal world, we'd use a combination of both [biomass and PTL] methods, depending on the region," comments Popilka. "Second generation biofuels are fairly low carbon intensity fuels that don't require a lot of energy to process, meaning that they're relatively sustainable. What I see as the largest drawback to these fuels is that they're dependent on biomass waste, and there's only so much waste in the world that we can generate to convert into fuels. In my opinion, that means they're not very scalable."

> *"No matter how many vehicles we electrify, that legacy vehicle fleet will continue to pollute if they don't have an alternative"*

Second generation biofuels are defined as those which do not compete with crops for food production, but Popilka fears this could be open to abuse: "It's very hard to manage the supply chain in a way that guarantees second generation components. There's already a lot of first generation ethanol coming from Brazil and the United States that's derived from food crops and can't be considered sustainable, nor the right thing to do." ▶

LEFT The World Rally Championship has blazed a sustainable trail with its fossil-free fuel, but the message still needs reinforcement

Goodwood

ABOVE The company stages high-profile demonstrations in historic motorsport with the likes of Sebastian Vettel's 'Race Without Trace' campaign

Scalability

Standard pump fuel in the UK and Europe already has up to 10 per cent ethanol content, with the EU looking at scaling this up to 20 per cent. The concern is that there simply won't be enough second generation ethanol on the market to cope, although others have downplayed this, suggesting that we are still a long way from reaching that point.

So, PTL is the solution, then? Many sustainable fuel experts – Popilka included – believe this will ultimately be the better option, but it's not without its drawbacks.

"PTL has the advantage that you're essentially just using water and air, so it's not as sensitive to market fluctuations," he points out. "It's a slightly more energy-intensive process, but the real downside, at the moment, is the production capacity. Right now, there basically is none. In an ideal world, we would already have the capacity to bring enough e-fuel to the market, which we don't, but that's something that we're actively working towards."

P1 Fuels

BELOW P1's chemists benefit from the WRC's function as a high-speed laboratory

P1's ambition is to build an industrial-scale plant for e-fuel production, which Popilka believes could bring the technology close to price parity with fossil fuels. The company is already working on the design of a pilot plant to be based in Germany, which it aims to begin building during the second half of next year.

The technology to do this already exists, and the main thing that's required at the moment is upscaling to make it more affordable, says Popilka: "You can employ economies of scale with larger production facilities. When it comes to the technology readiness levels, the individual tech stack of an e-fuel refinery is well matured. The renewable power generation is already there. The cost of the electrolysis to produce green hydrogen is predicted to decrease over time. We did an in-depth technical analysis, and it's obviously more than fossil-derived grey or blue hydrogen, but even at current levels the costs are reasonable. The only technology that's not as mature currently is the direct air capture. That will require more investment to cut costs."

Direct air capture plants also exist, but they're operating on an experimental level currently. While this technology is maturing, P1 plans to use point-source carbon dioxide. This is where the gas is captured direct from industrial processes that would otherwise release it into the atmosphere, such as cement production. It's still ultimately released when the fuel is combusted, but this approach recycles carbon dioxide from other processes rather than adding its own.

"A lot of the technology related questions have been answered on a hypothetical level, and we aim to answer them on the working demonstrator plant that we plan to build next year as well. That will allow us to further investigate the costs and some assumptions that we have in the process technology. After that, we will immediately start engineering an industrial-scale plant," says Popilka.

Pure PTL

Currently, P1 Fuels uses a combination of PTL and biomass-derived chemicals for its fuels. One of the aims of the pilot plant is to optimise the processes behind e-fuel so it can take over as the primary fuel source, he explains: "One thing to bear in mind is that some of the sustainable fuel projects out there today, including some high-profile ones, actually output a really bad fuel. Some of them are down to 91 RON, with a very high content of heavy components. That's a problem for the high-performance markets we serve, so with this pilot plant we want to show that we can produce a clean, high RON fuel from one process without blending in fossil fuels or other components."

The key point here is that P1 is aiming to create a fuel that can be taken from the plant and put straight into the car without further processing. Popilka points out that some of the Fischer Tropsch fuels that are based on synthetic crude (or e-crude) require a significant amount of blending, and the additional components, which limits the scalability.

P1's aim is to produce e-fuels that meet standard road requirements straight out of the plant. This is significant as the additives used elsewhere in the fuel industry can be among the hardest components to substitute for fossil-free alternatives.

> *"We take the risk of 'greenwashing' very seriously – if we blow this now, the internal combustion engine won't survive"*

The fuels that P1 currently supplies for historic racing are said to contain no additives whatsoever, while we're told that those used in the company's other applications are in the order of parts per million, so their impact on the fuel's carbon footprint should be negligible. "We don't provide our fuels with those additives. It's up to the consumer to put them in if they need to, but that's not part of our core business," notes Popilka. ▶

Red Bull/Getty Images

BELOW P1 supplies the World Rally Championship with a 100 per cent fossil-free blend


Porsche

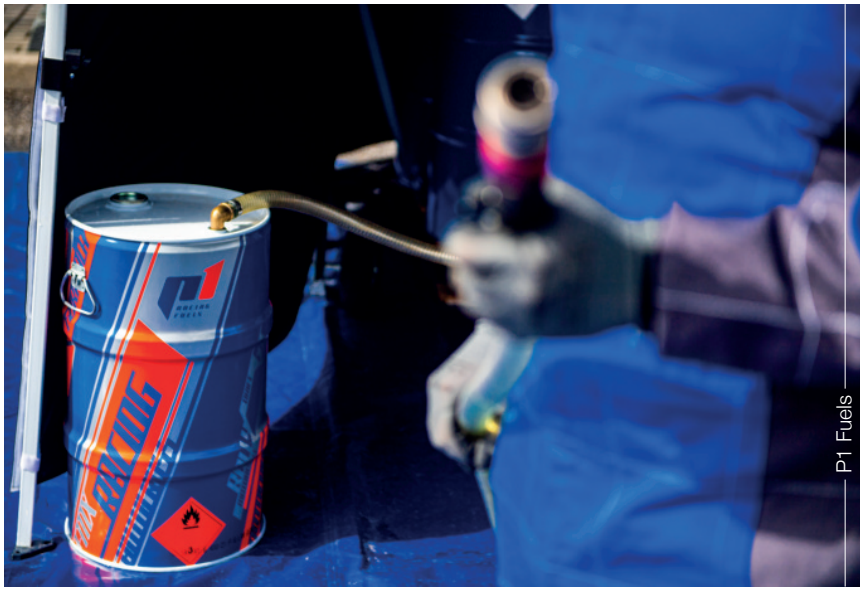
Traceability

The company says its fossil-free fuels already deliver CO2 reductions of around 80 per cent (depending on the exact formulation). It's hoped that this figure can be brought down to around 95 per cent with improvements to the supply chain, production and formulation.

As with the feedstocks used to produce ethanol for biofuels, there's a danger that unscrupulous suppliers could attempt to pass off grey or blue hydrogen (derived from natural gas) as fossil-free green hydrogen. To eliminate these risks, P1 plans to generate its own hydrogen on-site.

There are no less than nine different colour categorisations of hydrogen, each of which has differing environmental considerations. On top of this, of course, carbon dioxide can be captured from a variety of different sources – some greener than others. As with electric battery production, supply chain monitoring and traceability will be essential to understand the true impact of these fuels.

"The internal combustion engine has the potential to be every bit as green as battery electric over a full lifecycle analysis. The technology to do this is already there," states Popilka. "But what this technology will not survive is another Dieselgate-style scandal, and I don't think anyone is taking that risk seriously enough."


P1 Fuels

LEFT P1's fuels are proving themselves in hostile environments

RIGHT P1's mobile laboratory operates in the service parks and paddocks of world motorsport

ABOVE P1 plans to use point-source carbon dioxide while direct air capture technology is maturing. Porsche, whose DAC model is pictured, is one of the companies currently investing in researching the technology

Greenwashing

It's not just the potential for greenwashing around individual products or technologies, but the wider industry that produces them, he points out: "We have some of the largest fuel companies in the world marketing sustainable blends in motorsport championships, when 99.99 per cent of their revenue comes from extracting fossil fuels. Literally all of them are increasing their fossil fuel output every day, and then on the side they're promoting sustainable fuels in motorsport, with no industrialisation plans in sight. That's what differentiates startups like us, and it's why we take the risk of greenwashing very seriously – if we blow this now then the internal combustion engine won't survive in the future."

Fossil-free fuel may be the only viable option to decarbonise existing internal combustion engines – particularly when it comes to historic vehicles. For future engines and those currently in production, however, there's also the possibility of re-engineering them to burn hydrogen. This has the advantage that it requires less processing and significantly less energy input than producing e-fuel, but Popilka is sceptical about its practicality.

"The main problem is the logistics and ▶

ABOVE Benjamin Pochhammer (left) and Martin Popilka are founders of P1 Fuels and COO and CEO respectively

> *"Many consumers aren't even aware there are alternatives to electric vehicles"*

P1 Fuels

transportation," he comments. "Hydrogen as a gas is very difficult to transport and the infrastructure is non-existent. Meaning that even if you produce these fuels in locations that have lower costs of renewable energy, and you can guarantee that the energy is renewable, you still have a very hard time transporting them to the consumer."

The challenges are stark: "I mean, there's only one ship that carries hydrogen to Japan. Just one. So that logistics and transportation framework is a bottleneck, while derivatives of green hydrogen produced in, say, Africa, can be transported very easily with the current infrastructure. So, whether that green hydrogen is converted into ammonia or whether it's converted into synthetic gasoline, that liquid is very easy to handle and transport: you drop it into any tanker into any fuel station."

All of this, he adds, is part of a wider energy ecosystem, which is likely to include battery electric vehicles, hydrogen and possibly even methanol fuel cells. One of the challenges of this complex tapestry, as opposed to a heavily simplified one-size-fits-all narrative, is communicating it to consumers.

Issue of trust

"I think this is where we struggle the most, conveying this to consumers," comments Popilka. "People still have Dieselgate in the back of their minds, and re-building trust with the automotive

Red Bull/Getty Images

industry is going to be hard. We need to get a general buy-in [to sustainable fuels] from the car manufacturers, because right now, a lot of them are just promoting electric vehicles, and many consumers aren't even aware that there are alternatives. Apart from Porsche, none of the big OEMs are really communicating much about synthetic fuels."

P1 is hoping to change that through its involvement with high-profile championships like the WRC. And that work is also driving technical benefits too.

"In the WRC, you've got the freezing temperatures of Sweden, down to Kenya, where you have very hot temperatures. So we've learned a lot on a technical level with the manufacturers in the championship about how to increase the drop-in compatibility of these fuels," notes Popilka. "Based on what we've learned with this racing fuel formulation, we've developed a road-compliant EN 228 fuel, which is now being used in the historic cars we've supported."

> *"The internal combustion engine has the potential to be every bit as green as battery electric over a full lifecycle analysis"*

The challenges of upscaling sustainable fuel production for mainstream applications shouldn't be underestimated. But professional motorsport is a rather different case, with vastly smaller volumes and far less cost-sensitivity (at least for the race fuel itself, which generally accounts for a tiny percentage of a team's annual budget).

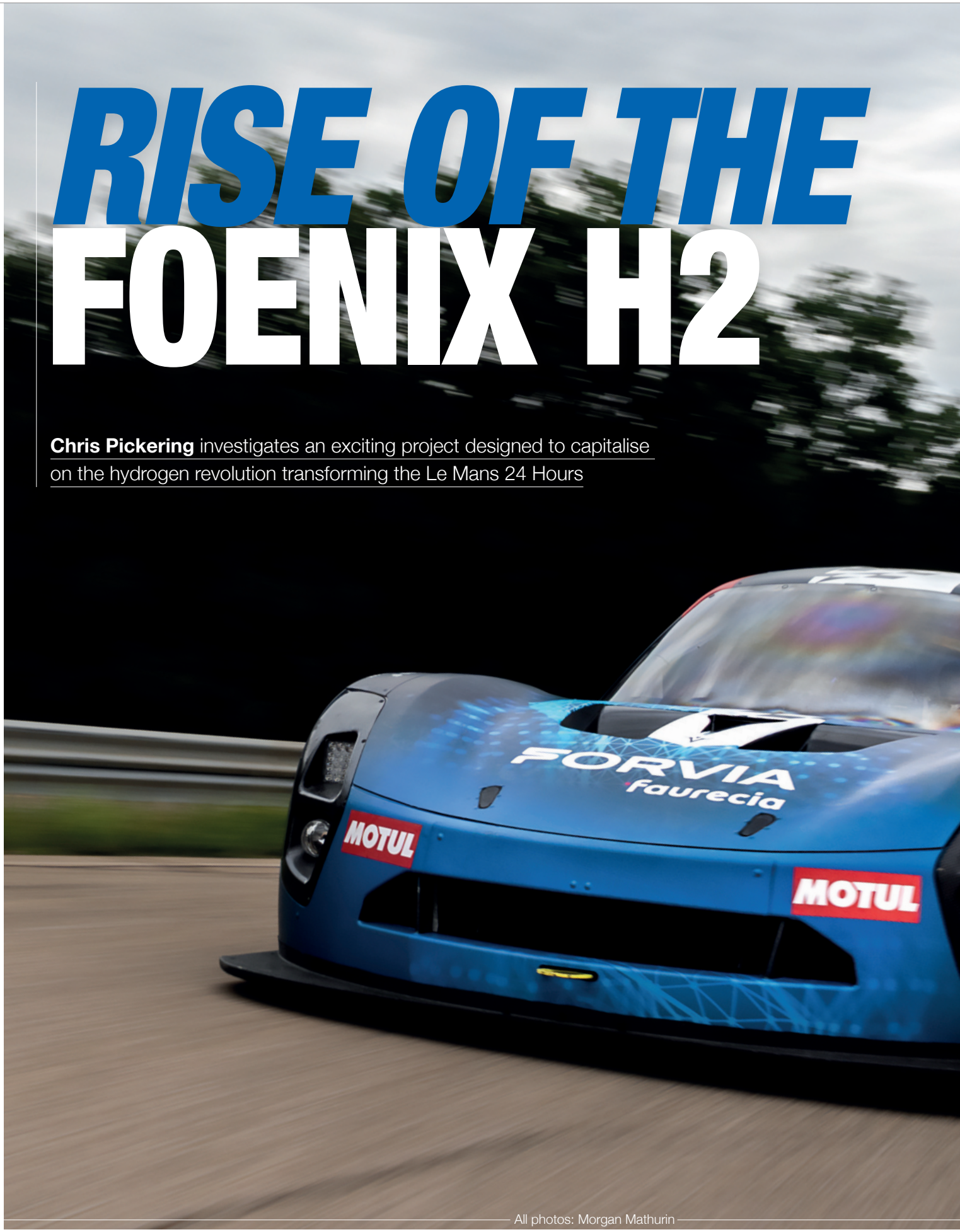
"Motorsport can either be part of the problem of global warming and emissions in the transport sector or part of the solution," concludes Popilka. "I think, as of today, no championship has any rational excuse to use fossil fuels. We supply six-year-old or seven-year-old kids in karting, through to the WRC and other championships. It's time for the wider motorsport industry to start exploring sustainable fuels in a more structured way and make that switch from fossil fuels."

ABOVE The historic market is increasingly waking up to sustainable fuel. At Goodwood the Fiat S70 'Beast of Turin' from 1910, with its 28-litre, four-cylinder engine, ran on P1 fuel. The team found that it started on the cranking handle easier, ran smoother, cooler and used less fuel than normal

LEFT Through its involvement with the WRC manufacturers, P1 has learned how to increase the drop-in compatibility of these fuels

RISE OF THE FOENIX H2

Chris Pickering investigates an exciting project designed to capitalise on the hydrogen revolution transforming the Le Mans 24 Hours



All photos: Morgan Mathurin

IT'S been a big year for the 24 Hours of Le Mans. After a century of innovation, the French classic remains at the forefront of motorsport technology, and top of the agenda at the press conferences taking place at this year's event was hydrogen.

Alongside news of hydrogen projects from Toyota and Ligier came the debut of the Foenix H2 from GCK. Developed by the group's recently-acquired subsidiary, Solution F, the car is a spaceframe-based GT racer with a 6.2-litre supercharged V8 adapted to run on hydrogen.

Not everyone will be familiar with Solution F, but there's a good chance you've seen the fruit of the company's labours. Founded in 1985 by engineer and rally driver Eric Chantriaux, the firm produced a series of engines used by Peugeot Sport/Citroen Sport in the customer versions of its 106 Maxi, Saxo kit car, 205 and 406 competition cars. It went on to produce the complete car for the Scandinavian Touring Car Championship, as well as the 3.5-litre V6 used in the Renault World Series from 2005.

The spaceframe chassis and V6 engine developed for "silhouette cars" went on to underpin the cars in the Scandinavian Touring Car Championship from 2013 to 2016, and many of these silhouette machines remain in action today with a variety of bodywork. With TCR starting to dominate touring car racing, Solution F took its silhouette concept over to GT racing with the original Foenix, powered by the Chevrolet LS family of engines.

Green energy group GCK already had divisions working on batteries and fuel cells, but it acquired Solution F in September last year to further its work on low carbon combustion engines. Both organisations have a long history in motorsport – GCK founder Guerlain Chicherit is a regular in both the Dakar Rally and the World Rallycross Championship – so a competition car seemed like the perfect way to demonstrate the potential of the technology.

First steps

The Foenix, with its GT3-style bodywork and easily adaptable tubular construction, would give the engineering team a ready-made platform to work on, but the first question was what sort of engine to use.

"The best way to optimise for hydrogen would be to build an engine from scratch," explains Hugues Baude, technical director of Solution F. "That way the thermal efficiency target could be upwards of 50 per cent: far more than most road car engines today, which are generally in the region of 35 to 37 per cent. But as a proof of concept, you want a quick solution, using an existing engine that's suitable for hydrogen."

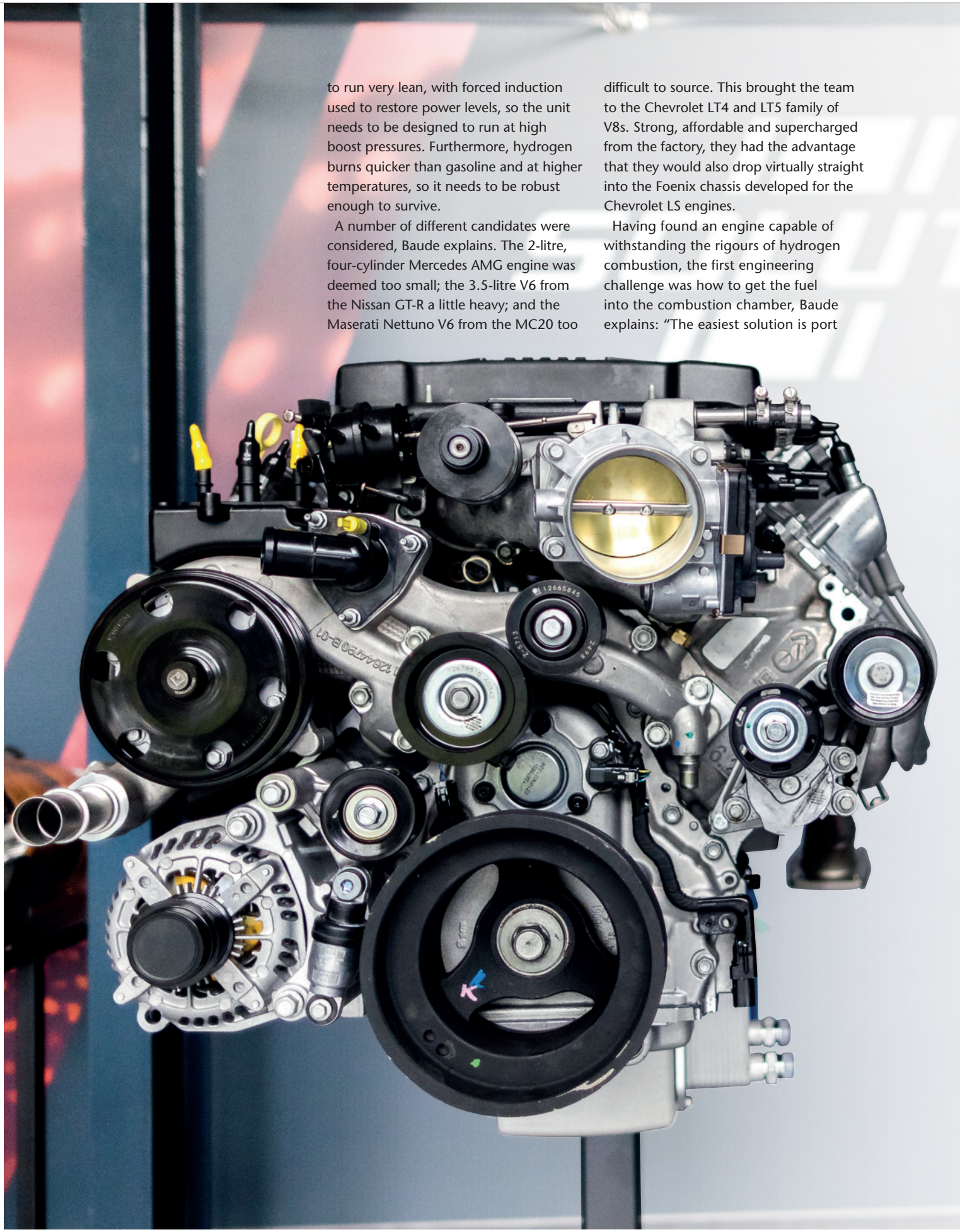
In theory, almost any engine can be adapted to run on hydrogen, provided that it is either supercharged or turbocharged. But finding one that will do so reliably at high power outputs is another matter. The main constraint is cylinder pressure. Hydrogen engines tend ▶

LEFT The Foenix H2 showcases Solution F's ability to convert existing combustion engines to hydrogen

to run very lean, with forced induction used to restore power levels, so the unit needs to be designed to run at high boost pressures. Furthermore, hydrogen burns quicker than gasoline and at higher temperatures, so it needs to be robust enough to survive.

A number of different candidates were considered, Baude explains. The 2-litre, four-cylinder Mercedes AMG engine was deemed too small; the 3.5-litre V6 from the Nissan GT-R a little heavy; and the Maserati Nettuno V6 from the MC20 too difficult to source. This brought the team to the Chevrolet LT4 and LT5 family of V8s. Strong, affordable and supercharged from the factory, they had the advantage that they would also drop virtually straight into the Foenix chassis developed for the Chevrolet LS engines.

Having found an engine capable of withstanding the rigours of hydrogen combustion, the first engineering challenge was how to get the fuel into the combustion chamber, Baude explains: “The easiest solution is port



injection, but there's a real risk of backfire when it goes into the intake manifold, because hydrogen is so easy to ignite. Additionally, because of this gaseous nature, hydrogen tends to occupy a high volume in the combustion chamber that reduces the potential power of the engine. With that in mind, we went for direct injection. Either way, you need specific hydrogen injectors and an ECU that's capable of driving them."

Hydrogen needs around twice as much oxygen to burn as gasoline, so the next consideration is air. The LT5's supercharger is a generous 2.65 litres in capacity. Baude and his colleagues found that they could get roughly the required mass flow simply by increasing the compressor speed on the standard hardware.

> *"The noise, the throttle response and the torque curve are very similar to gasoline"*

Once the oxygen is inside the combustion chamber, there's also the challenge of keeping it there. Hydrogen engines are prone to blow-by past the piston rings into the crankcase. This needs to be removed – not least because a mixture of air and hydrogen can explode if ignited.

In road car engines, a separate pump is likely to be used to accomplish this, but in the dry-sump race engine, Solution F takes a different approach.

"Crazy fast" scavenge pump

"We just run the scavenge pump crazy fast, so the flow is so strong that we have no hydrogen in there," notes Baude. "There's a separator going into the tank that separates the hydrogen and vents it to the atmosphere. It works on the same principle as a blow pump. The atmosphere contains hydrogen anyway, so there's no danger if you vent small amounts in low concentration."

Another challenge of allowing hydrogen to combine within oxygen in and around the engine is that it forms water. This can condense, resulting in corrosion and oil dilution. Solution F has been working with specially-tailored lubricants, suitable for high moisture conditions.

"Building the engine itself involved a similar amount of work to a conventional race engine. Maybe we were lucky, but we spent a lot of time working out the injector position in the initial design, and after that it was working. Optimising it on the test bench after that was where things got harder. We struggled with a lot of details, like the lambda sensor and the supercharger compressor, but the base engine worked first time," comments Baude.

The challenges were as much logistical as technical, he explains: "We're in the process of converting our own test bench to work with hydrogen, but at the moment there are perhaps only three or four facilities in France that you can use. To start with, the specification of the safety system depends on the mass flow of hydrogen that you're using, and with a high-performance engine that level is quite high. And everything else becomes more complicated too. For instance, after each test you have to clean the test chamber to make sure there's no residual hydrogen left in there."

ABOVE Developing a hydrogen-powered car is an awkward task with so few racing components currently tailored for the technology

Controlling the engine is equally tricky. Hydrogen combustion needs to be initiated within a precise time window to allow for the rapid flame speeds. Injection and valve timing also affects the risk of backfiring. And the complexity of all these challenges is compounded if you introduce features such as variable valve timing.

Ancillaries

On the hardware side, Baude reports that the ancillaries were as big a challenge as the engine itself. In particular, the high combustion temperatures mean that engine cooling is quite critical. Similarly, high boost pressures require a lot of charge cooling. "When it's on the test bench, you give the engine air and water, and it's no problem, but in the car it's a very different story," he notes.

The next big challenge is fuel storage. While hydrogen offers excellent energy density by weight, its volumetric density – even when compressed – is quite poor. As a rule of thumb, hydrogen requires around four times as much storage volume as the ▶

LEFT A 6.2-litre supercharged Chevrolet V8 has been adapted to run on hydrogen

equivalent quantity of gasoline. Part of this comes down to the tank construction, which needs to be particularly robust to cope with the pressures inside. Solution F has partnered with Forevia/Faurecia for developing H2 tanks for race application.

Dry, Baude points out, the hydrogen tanks in the Foenix H2 still weigh more than twice as much as the fuel tank in the standard car does when it's full. So light is the hydrogen, that the total mass of the car only changes by a few kilos when it's filled up.

Of course, it's not so much the chemistry of gasoline that gives it this advantage, but the sheer fact that it's a liquid. In theory, hydrogen can be stored as a liquid too.

Liquid storage

"Ultimately, I think liquid storage will be the way forward for hydrogen in motorsport," comments Baude. "When you're racing, you fill up, which brings the temperature down in the tank, and then you consume the fuel in maybe 30 or 40 minutes. That's not the same challenge that they face in aviation, where they need to cool the fuel throughout a long flight or on the runway during stopovers."

One of the challenges at the moment – particularly for cryogenic storage – is the lack of purpose-built components for hydrogen systems on a competition car.

"Whenever you look for something, it doesn't exist," comments Baude. "If you're building a hydrogen car, you have no hydrogen sensors or pressure regulators that are built to motorsport-spec. If something does exist, it's an industrial part that weighs two kilograms, when a motorsport part might be 20 grams. If you want to look at ▶

Jakob Ebrey

ABOVE Solution F is part of the consortium that has worked on the hydrogen refuelling rig developed by TotalEnergies for the ACO's hydrogen class

BELOW The car's easily adaptable tubular construction offered a ready-made platform for the engineering team to use

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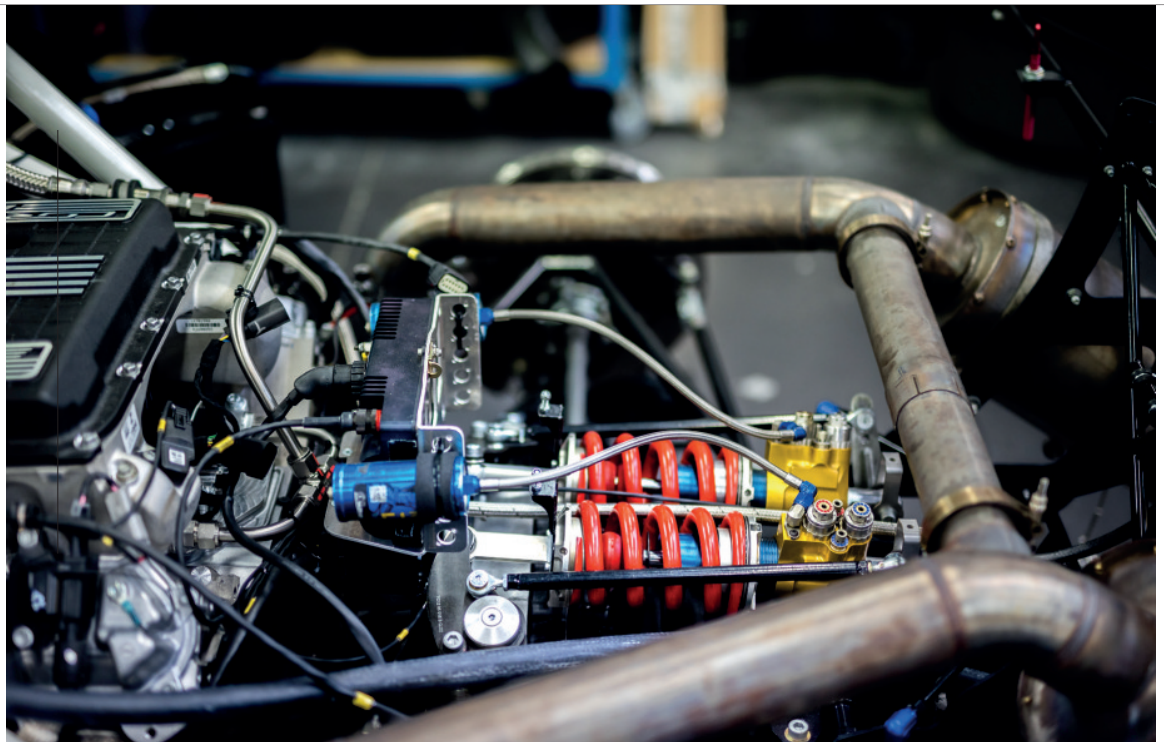


LEFT The V8 offered a base unit capable of withstanding the rigours of hydrogen combustion

liquid storage, it's the same situation but worse."

Solution F is part of the consortium that has worked on the hydrogen refuelling rig developed by TotalEnergies for the ACO's H24 class. The logistics and the regulations attached to that project are said to have been quite complex, and it's likely that liquid storage would make things harder still. In the long run, however, Baude believes it's worth the effort.

He's also optimistic about the prospects for the ACO's hydrogen class, which is set to debut in 2025: "I think that timescale is too soon for liquid hydrogen, but it's not crazy to think that we could have cars racing on hydrogen gas by that point, and refuelling at the track."

Different solutions

The big news surrounding the ACO's hydrogen class recently was that it has been expanded to include combustion-engined entries, not just fuel cells. This is a topic that's said to stimulate a lot of debate within GCK, with the group working simultaneously on both technologies.

"There's no universal solution," comments Baude. "At the moment, if you have a small road car, the best option is probably battery electric; if you want to convert a stationary engine, you probably use a fuel cell; and if you want to convert a big 500 kW diesel engine you probably aim to use hydrogen, even if you lose a little power along the way.

"The problem for motorsport is that the biggest fuel cells that currently exist are around 200 kW. At a track like Le Mans, the mean power consumption for an LMP2 car is about 330 kW. Obviously, with a fuel cell you have an electric powertrain, so you can generate maybe an extra 20 per cent through energy recovery, but that's still only 240 kW."

Another issue, he points out, is that the efficiency of a fuel cell tends to decrease when it is pushed to its maximum output. At mid-range they might achieve 50 per cent thermal efficiency, but that figure can tumble at higher loads.

> *"So light is the hydrogen, that the total mass of the car only changes by a few kilos when it's filled up"*

"It depends on the profile of the race," comments Baude. "For some competitions, I think a fuel cell could definitely work. For Le Mans, where you really need more than 300 kW, I think it would be a challenge. If you had two fuel cells, plus the battery, plus the electric motor and the fuel tank, it will start to get very heavy."

As an example, the fuel-cell-powered GreenGT H24 is understood to weigh around 1,415 kg. In contrast, the Foenix H2 tips the scales at around 1,200 kg with

BELOW The company has a strong racing heritage

a comparable fuel tank range, and it's said to be far from optimised at present.

Solution F has already begun testing the car, and the early indications are positive. "When you run the car, you can't tell that it's running on hydrogen. The noise, the throttle response and the torque curve are very similar to gasoline," comments Baude.

There's still plenty of work to be done. The next step is to refine the Foenix H2 to improve its lap times – the first target being to go faster than the fuel cell-powered H24. Since the H2 made its first appearance at Le Mans earlier this year the team has already redesigned the fuel lines. Baude notes that the fuel flow rate for a hydrogen combustion engine fluctuates far more than a fuel cell, which tends to run closer to steady state, and that the fuel system needs to be designed to withstand these fluctuations.

ABOVE Accommodating the storage volume required for the hydrogen is one of the chief packaging challenges

TOP When the car is running, it is hard to tell it is working on hydrogen

The team is also working to develop a more efficient cooling system, which will improve the aerodynamic performance of the car. At the moment, we're told, it has sufficient cooling capacity to demonstrate some fast laps, but not enough to complete a full race flat-out.

Cooling challenges

"Cooling a hydrogen combustion engine isn't easy, but it's a lot easier than a fuel cell," notes Baude. "Fuel cells run at about 40 degrees, so when you have ambient air at 30+ degrees in the summer it's very difficult to cool without destroying the aerodynamic efficiency of the car. If you have a combustion engine running at 100 degrees, it's much easier to get the temperature gradient."

Homologation is another point to consider. Although the Foenix is loosely built to a GT3 template, there isn't a specific set of regulations for hydrogen cars yet. Not all of the challenges relate to the powertrain, either. Although the original Foenix was homologated when it was first launched, this would need to be updated for the H2. Its tubular frame would be almost unique in modern endurance racing, but Baude notes that the Box 56 NASCAR entry at Le Mans this year was able to compete with a similar construction.

"We built the Foenix H2 to demonstrate Solution F's ability to convert existing combustion engines to hydrogen. It's a technology that could equally well apply to buses, trains or heavy duty," he says. "But when it comes to racing, the dream, for sure, would be to build hydrogen engines for a manufacturer."

Solution F isn't the only engine builder chasing that dream. But with a strong track record in motorsport and promising results from the Foenix H2, the dream may yet become a reality. RT

HOW ANDRETTI CONQUERED THE ELECTRIC REALM

Avalanche Andretti Formula E team principal Roger Griffiths gives **Chris Pickering** the inside story of the squad's triumph in the most action-packed Formula E campaign yet

NOWHERE does motor racing dynasties quite as well as America. The Unsers, the Pettys and the Earnhardts to name a few. But perhaps the most versatile of all these storied names is Andretti, with the Andretti Autosport team – founded by CART, F1 and Le Mans driver Michael Andretti – currently active in categories as diverse as IndyCar, LMDh, Extreme E and Australian Supercars.

The latest silverware added to the Andretti trophy cabinet comes from Formula E, after Jake Dennis clinched the Season 9 drivers' championship. To date, this marks a highpoint for the team in Formula E, having raced in the all-electric championship since its very first season.

It also comes as vindication, following a troubled start to Season 8, when the team was forced to strike out on its own after technical partner BMW abruptly left the series. Although the German manufacturer continued to work with Andretti as a powertrain supplier that season, its withdrawal from the day-to-day operations sent ripples through the team.

"BMW left the championship giving us next to no notice, which meant we had to react quickly," recalls Avalanche Andretti Formula E team principal Roger Griffiths. "We identified the gaps that would leave in our staffing and started a recruitment process to fill those. That meant that we weren't quite ready from a team operational perspective at the start of Season 8 – I think we were close, but we had typically relied on BMW to carry the weight on some of the more detailed aspects of the engineering, so we had to adapt to that shortfall."

By the end of Season 8, Andretti had bounced back with three podiums in the final four rounds. Better still, it had a new technical partner lined up for Season 9, in the shape of Porsche.

Formula E

RIGHT World Champion Jake Dennis celebrates with the Avalanche Andretti squad

BELOW Energy management was the key technological battleground as the season unfolded

"The Valencia test ahead of Season 9 was much later in the year than it is for the upcoming Season 10 test. We'd had time to get used to working with Porsche and the new powertrain, so we hit the ground running for the start of the season," recalls Griffiths.

The tie up between Porsche and Andretti sees the Stuttgart manufacturer developing all the powertrain hardware and software. Under the Formula E regulations, both the works Porsche 99Xs and the customer cars have to run the same basic code. A pair of Porsche engineers embedded within Andretti Autosport help to ensure that this rule is respected on both sides. Setup information and ideas are shared, but the two teams still have the freedom to optimise the cars within that framework.

"Our opportunity is how we run the car, from a setup perspective," comments Griffiths. "We try to operate with Porsche as a four-car team. We have a lot of discussions around the pros and cons of particular setup ideas, which can go as far as dividing up test opportunities over the race weekend so we don't duplicate the same work. At the end of the day, both programmes are resource-limited, so the best way to move forward is to combine the engineering capabilities of both teams."

Different approach

Energy management and race strategy have always been crucial in Formula E – perhaps more so than ever during the past season. This is one area where the customer teams have the opportunity to take a different approach.

"We run different simulation software to Porsche, which gives an interesting, parallel development path," comments Griffiths. "We've been using those tools for a number of years now, and we've become very proficient with them. Coming up to a race weekend we would look at the main sensitivities of that particular track. For instance, was it a powertrain-sensitive track? Or sensitive to weight or lateral acceleration?"

The findings from these initial simulations could then be used to put a run plan together for driver-in-the-loop simulation. Andretti's own simulator in Banbury ▶

> *"Conventional tuning aspects are perhaps secondary to what we can do with the powertrain control in Formula E"*

BELOW Dennis battles with the Jaguars, which were a threat throughout a dramatic season

in the UK wasn't yet ready at the start of Season 9, so the team travelled to Porsche Motorsport at Weissach to use the manufacturer's facility. Again, the data was shared from both teams' test runs.

Likewise, the off-car simulations were used to devise a test plan for the Valencia test, where one of the key targets was to understand the behaviour of the new Hankook tyres. Porsche and Andretti divided up tests like toe and camber sweeps between them for the event.

Alongside all the collaborative tests, both teams had the opportunity to carry out their own investigations. If anything, Griffiths admits, this perhaps plays into the hands of the customer teams: "I wouldn't say we had it easy, but as a customer team, we're not under the pressure to develop a powertrain while also running our own race team. We perhaps have a little more opportunity to concentrate on the go-faster stuff, but hopefully we're putting the benefits of that back into the programme."

Once the season kicked off, much of the work carried out independently by the teams focused on energy management. This has become particularly critical since the emergence of so-called peloton

LEFT Griffiths celebrates the squad's first electric world title

ABOVE One of the key targets was to understand the behaviour of the new Hankook tyres

racing within the series, where the cars tend to circulate as a pack to conserve energy before one car attempts to make a decisive break for the lead.

"If you go back to the early part of the season in Mexico and Hyderabad, I think it was quite straightforward. But then you saw a big shift around Berlin towards peloton racing," says Griffiths. "I think Portland was probably the most extreme example of that, where nobody wanted to risk expending too much energy until maybe two thirds of the way through the race, where they could make a break. On occasions, I think there was the possibility of maintaining the lead if you made a big enough gap, but you had to take the risk of expending that energy."

Front regen

Another major change with the arrival of the Gen3 era was the front powertrain – currently only used for regenerative braking. For the manufacturers, there was a huge control challenge in understanding how to blend mechanical and electrical braking safely and predictably. But there was also a big challenge in learning when and how to use the system most effectively, which applied equally well to the customer teams.

The first question is how much to use the front powertrain, and even that is far from trivial, Griffiths explains: "In theory, more regen energy is always good, but I think all the teams realised early on that if we used the front powertrain too much, it'd overheat and de-rate, whereupon its contribution starts to decay. And then you end up with a shifting brake balance. So, deciding when to coast, for example, ▶

> *"We would look at the main sensitivities of that track: was it powertrain-sensitive, or sensitive to weight or lateral acceleration?"*

Formula E


Spacesuit Media/Andretti Global

LEFT Teams have dramatically improved their understanding of the Gen3 car since the start of the campaign

BELOW Data is king in the battle for efficiency

can have a big impact. We did our own investigation into ways of keeping it on a consistent operating platform for as much of the race as possible, and throughout qualifying as well."

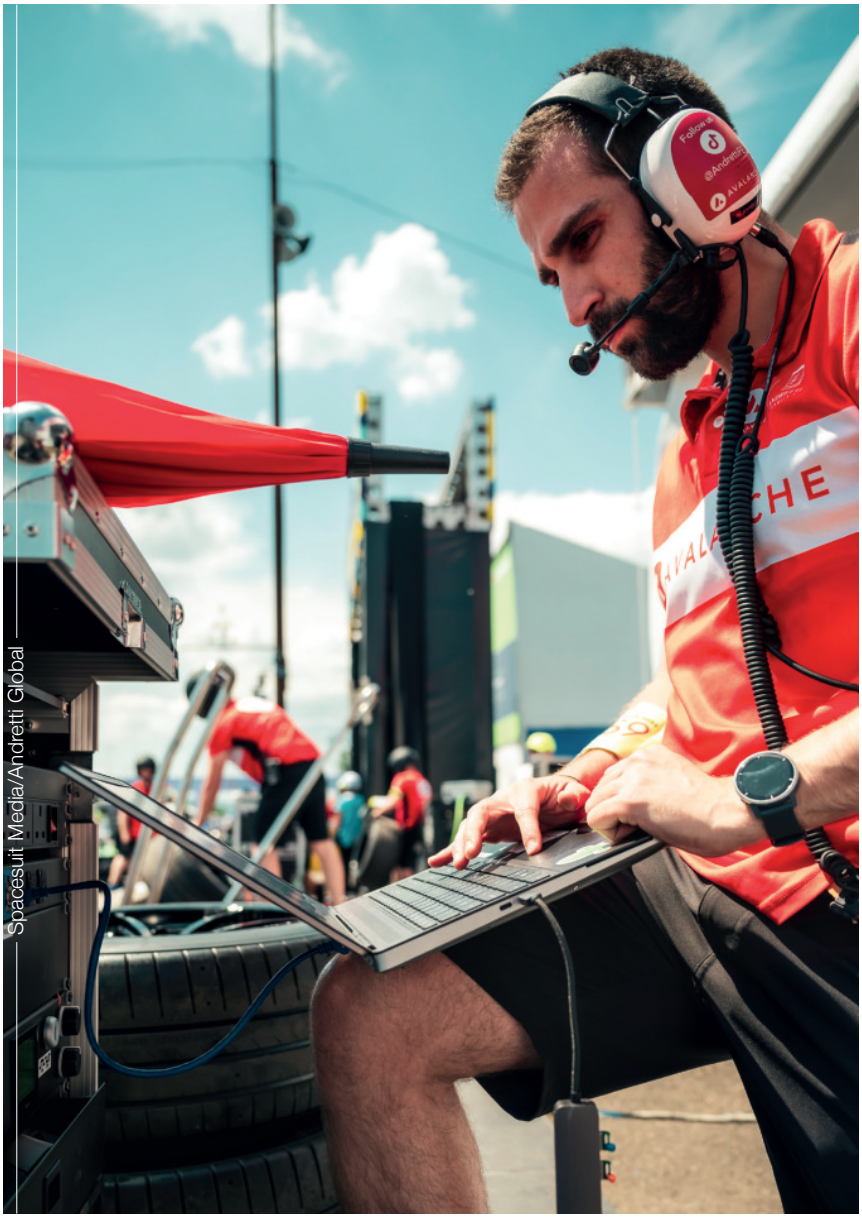
Formula E steering wheels are littered with buttons and rotary switches that allow the drivers, in consultation with their engineers, to tailor the car's energy consumption.

Tuning transformation

"It's interesting, when people come over from the IndyCar side, where they're used to continuously changing ride heights, springs, damper settings and so on," comment s Griffiths. "We do very little of that. Partly because we don't have time. And secondly, because those conventional tuning aspects are perhaps secondary to what we can do with the powertrain control in Formula E. We have so much more flexibility there. The overrun characteristics have a very consistent and very controllable impact on regenerative braking. That can have a big impact, for example, on how the differential operates. Those settings are a lot more powerful than two clicks on a front damper."

The general consensus in the Formula E paddock seems to be that the teams have all dramatically improved their understanding of the Gen3 car since the start of the season. However, Griffiths believes that there's still plenty of scope to further optimise the package.

"I think we'll see another significant step forward in lap times next year, particularly through the early part of the


Spacesuit Media/Andretti Global

> *"BMW left the championship giving us next to no notice, which meant we had to react quickly"*

season, which is revisiting the races that we've already done with more knowledge around the car," he comments. "Even just from understanding how to prepare the tyre ahead of qualifying. And all the time we're improving our off-car tools, which don't necessarily improve the best theoretical lap time, but they have a big impact on race pace."

Energy management was the key technological battleground as the season unfolded. Not only did the individual circuits have varying demands on coasting and regen, but the ambient conditions played a part too. Griffiths says there was a real danger of the teams having to de-rate the batteries in Rome this year, where trackside temperatures reached around 40 deg C. He believes that the efficiency of the 99X's powertrain gave the team an advantage there, as did the work that they'd done on thermal management.

It's interesting to look back at the shifting balance of power throughout Season 9. With the tribulations of Season 8 behind them, Andretti came out of the blocks strongly with a win in Mexico. Porsche's factory team then took the initiative for the next couple of rounds, before Jaguar and its customer team Envision emerged as the main opposition in the mid part of the season.

"The Jaguar always appeared to be one of the fastest cars in testing, so it was a little surprising to us that they maybe weren't as strong in the early part of the season," comments Griffiths. "They came on really strong later on, and we were playing catch-up to a certain extent, but we had a secret weapon in Jake [Dennis] who was able to overcome some of that deficiency."

Competitor analysis also played a part, we're told. Formula E teams use a variety of codewords to instruct their drivers over the radio, and there was a cat and mouse game along the pitlane to try and decipher these and better understand the strategies being deployed.

Looking ahead

For Andretti, one priority at the upcoming Valencia test will be settling a new driver into the team. Jake Dennis is staying on to defend his title, but Andre Lotterer is leaving to concentrate on his endurance racing commitments.

Instead, Dennis will be joined by Norman Nato. The Frenchman finished Season 9 in strong form, scoring a season-best result with second for Nissan in Rome and consecutive point-scoring outings in the last six races of the 2022/2023 campaign.

The three-day Valencia test is the only opportunity for the drivers to get on track ▶

Formula E vs Extreme E

FORMULA E isn't the only electric racing series that Andretti is involved in. The organisation also has an Extreme E team. Some of the personnel work across both projects, although technical crossover between the two is said to be minimal as the cars are so different.

The four-wheel drive Extreme E car weighs in excess of 1,800 kg and tends to finish a heat with 40 to 50 per cent of its battery capacity remaining, despite running without any brake regen.

In contrast, the aim for a Formula E car is to cross the line having squeezed every last drop of available energy out of the battery.

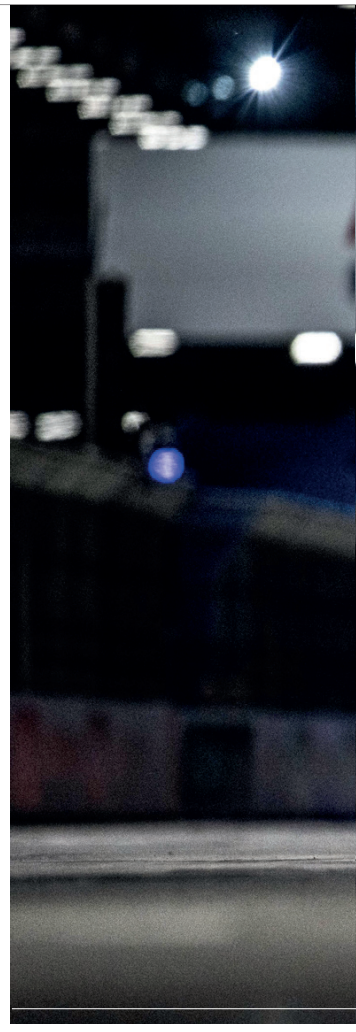
The Extreme E powertrain also plays a far more reduced roll, compared to dynamics, with the cars airborne for a significant proportion of the time. RT

Extreme E

LEFT There is surprisingly little crossover between the two electric disciplines


Formula E


Formula E



before Season 10 kicks off in Mexico in January, so it will be essential for them to log time in the car. During the past season, the team has also been compiling a 'Valencia list' of items that they haven't had time to investigate during the race weekends, with a view towards incorporating them into the test.

Perhaps the biggest question mark for Season 10 hangs over in-race charging. Currently, there's no official confirmation, but it's thought that the postponed Attack Charge feature will be introduced sometime in 2024.

"We've done a lot of work to see what in-race charging would mean for the strategy," comments Griffiths. "We also need to confirm the reliability, because only limited running has been done with the Attack Charge so far. Plus, we need to look at how we run the pitstop and what the roles of each individual would be during an Attack Charge stop. How do you minimise the stationary time beyond that which is needed to charge the battery and what does it mean in terms of where you come back out in the pack?"

In-race recharging would also have an impact on the battery management. With both the front and rear powertrains at their maximum regen capacity, the cars can already transfer energy at up to 600 kW. The original Attack Charge proposals saw the battery charged at the same rate, but for a full five seconds – enough to deliver around 4 kWh of extra energy,

ABOVE LEFT Dennis found himself isolated, surrounded by rival drivers and manufacturers, as he fought for the crown

ABOVE A new World Champion, crowned on home soil, emotions pumping after an intense season

Formula E

Formula E

ABOVE The Gen3 was the fastest, most efficient electric racecar yet built

and one and a half times the duration of the biggest braking zones in Formula E.

"It's going to have an impact on the battery," comments Griffiths. "How much of an impact will depend on the ambient conditions. Based off the strategic elements that we've seen, I think Attack Charge would be likely to go in quite early on in the race, where the battery is going to be cooler, but potentially at a higher state of charge. So there might be some balancing to be done there, but I don't see it as a major problem."

> *"You saw a big shift around Berlin towards peloton racing"*

Looking further ahead, there's tipped to be a Gen3 Evo update for Season 11, which could include new bodywork, new tyres and some degree of four-wheel drive capability from the front powertrain. It's thought that spec chassis constructor Spark will start testing with the front powertrain in propulsion throughout the coming season, with the teams unlikely to experience it before the Valencia test at the tail end of next year.

LEFT The team was among the quickest to get to grips with the new car, winning in Mexico

"It's going to be really interesting to see what comes with Gen3 Evo," admits Griffiths. "With the front powertrain, everybody is hopeful of having some record standing start times, but if you think back to this season's racing at somewhere like Portland, everyone wanted to get off the line as gently as possible to maintain energy. So the risk is that you do all this work to create a car that's super quick off the line and then nobody actually uses it."

Gen4 debate

There are other points to consider too: "It'd be exciting to have that front powertrain engaged, but is that actually taking away from what the next evolution of the car is going to be? What is the story going to be around Gen4? I'm curious to see how Gen3 Evo could impact the messaging for that.

"I think one of the other things that we have to be a little mindful of is some of the places that we race may no longer be available to us, because it would just be too fast. You know, if you think back to some of the tracks we visited in the past – Hong Kong and Paris, for example, tight twisty tracks – I'm not sure we could ever go back there. Just because we're becoming too quick. I think we'll see more stadium events and more on traditional racetracks."

Season 10, in contrast, looks set to follow an evolutionary path, building on the success of the existing Gen3 platform. The Avalanche Andretti squad will be aiming to make it two in a row, but they're sure to be facing stiff opposition. RT

THE STAR FACTORY GEARS UP FOR ANOTHER SHIFT

The new Formula 2 car is designed to be the ultimate one-make racing machine, preparing the next generation of single-seater stars for F1. **Damien Smith** reports

KEEPING pace and remaining in harmony with Formula 1 are essential tenets for the final stepping stone to grand prix racing. So it's no surprise that the brand-new generation of Formula 2 car, revealed in September at Monza and due for introduction in 2024, was conceived and built around two familiar key pillars: improved safety and an enhanced ability to race wheel-to wheel to hit the bull's-eye on spectacle.

But how should F2 raise its game to maintain its echo of the most intense, technically sophisticated and forever evolving form of motorsport without pricing itself out of reach for the 11 specialist teams invested in single-seater racing's second tier?

That tension, to strive for F1 standards within a confined and realistic efficiency, is at the heart of the challenge when it comes to F2 hitting its marks in the ultimate one-make racing formula.

Pierre-Alain Michot, known universally in F2 circles as PAM, took the lead on meeting that challenge when the FIA first started considering the next step for the feeder series in March 2022. The new car had its first shakedown at Varano in Italy on July 21, completing close to 100 km – "a good day in the office," says F2's deputy technical director, who Race Tech caught up with at Magny-Cours where development of the new car was continuing apace.

"It's been in our DNA for quite a while to put on good racing and this car is a step forward in that regard," asserts PAM on the subject of that central pillar. "We have worked on the aerodynamics to allow the cars to follow each other more than what they can do at the moment. One key element was to make sure the car doesn't create so much dirty air, so a target was for us to 'clean' the air at the back of the car." As he points out, one key advantage of the single-spec premise is that teams face far greater restrictions ▶

Formula Motorsport Ltd

ABOVE Dallara, Aramco, Pirelli and Mecachrome were key partners in the project

than those in F1 when it comes to unpicking regulators' good intentions in this regard…

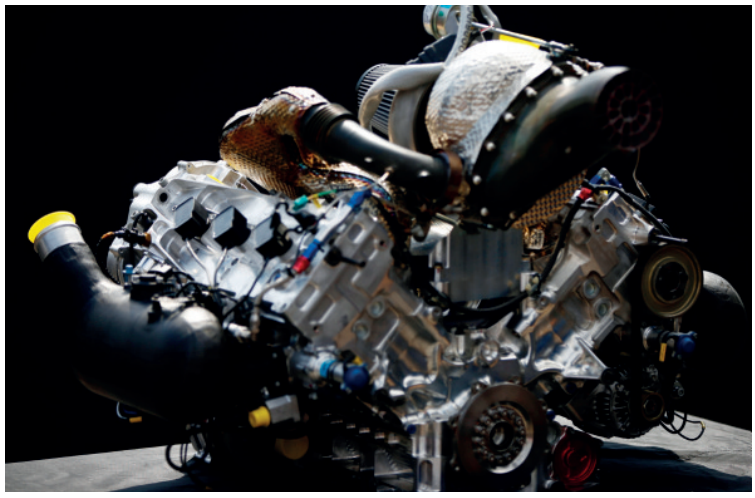
"In the end we were able to push quite high, which is why we have some visibly different wing concepts than what we have in F1. You'll have seen a lot of comments on the look of the rear wing and it's part of that concept to clean the air."

The sculpted, minimalist 'perch seat' rear wing is the clear and obvious visual signature that differentiates the new F2 car, which is designed to serve the formula through the next three seasons. "In terms of concept there is a lot of carry-over from the current car," says PAM, "but in terms of parts it's 75-80% new."

Once again, the car is designed and built by Dallara featuring a survival cell made from a sandwich carbon fibre/aluminium honeycomb structure with Zylon anti-intrusion panels and Kevlar honeycomb bodywork. Remarkably, the car hasn't seen a windtunnel. "It was designed 100% by CFD," PAM reveals, "and we did some aero tests on track to validate the numbers, which is the most accurate means. Windtunnels are accurate too, but on-track validation is more important."

Power remains consistent from Mecachrome's 3.4-litre single turbo V6, which pushes out 620 hp at 8750 rpm with maximum torque of 570 Nm at 6000 rpm. There's more continuity on the transmission through Hewland's six-speed longitudinal sequential gearbox featuring electro-hydraulic command via steering wheel-mounted paddle shift, and a ZF carbon clutch. "The clutch is the same and the gearbox has an upgrade on the casing to sustain the new loads in the FIA's safety regulations," says PAM. "In Hewland we have a long-term partner that has been able to give us a reliable gearbox. The concept of the engine was similar so the gearbox could remain similar as well."

What *is* different is the already accelerated evolution of synthetic fuel, the vital element for F2 to meet the FIA and F1's key sustainability targets, as PAM explains. "While a lot of components are similar, with this engine we prepare for 2025," he says. "Already



ABOVE With cost control so important, the 3.4-litre turbocharged Mecachrome engine has been retained. It now includes some new features to accommodate the Aramco synthetic fuel that will be introduced in 2025

Getty Images/Red Bull Content Pool

LEFT Aramco 55% bio-sourced sustainable fuel was successfully introduced for the 2023 campaign

> *"It's been in our DNA for quite a while to put on good racing and this car is a step forward in that regard"*

RIGHT The design philosophy of the new car is to give young drivers the best preparation, by making it as close to an F1 car as possible in terms of safety, look, systems, performance, sustainability and accessibility, all at reasonable costs

this season we are using 55% bio-sourced sustainable fuel, and in 2025 we will have 85% synthetic fuel. In anticipation of that we have made a pre-upgrade of the engine and the final upgrade will come in 2025. Then we will do another third step in 2027 – although we'd like to do it earlier if we can – to 100% synthetic fuel.

"Aramco is our partner for this and we are working closely with them to make sure we have both performance and reliability, which is the case this year. We have had the same performance we had with the previous fuel, in terms of power on the dyno and on track the lap times were the same."

Aramco is investing in two pilot productions in its synthetic fuel programme: one in the company's native Saudi Arabia and another in Spain. An increase in the quantity of molecules made by synthetic process is the target, to create the type of 'clean' fuel upon which F1 is banking for its own future through and beyond this decade.

When it comes to safety, the new-spec F2 not only matches the FIA's exacting standards for 2024 but also exceeds them. "The monocoque has been upgraded quite a lot so it can sustain higher loads," says PAM, "and cockpit safety is a big focus of the new car. We have a big step forward because we have the same safety standards as F1 for 2024, and even a little bit further for the roll hoop safety specification which is made to 2026 standards. Remember we were designing the car for more than one year, so on safety we are quite far ahead. It's always a challenge to make sure the car is still light and safe enough. It's a difficult pressure, but a good pressure when you see all the big incidents we have had, not only in F2 but in other categories, and that drivers have been able to walk away safely from."

The now ubiquitous cockpit 'halo' device was intrinsic to the design and is made by Dallara. "With all the incidents we have ▶

Formula Motorsport Ltd

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LEFT The wraps come off the new car at Monza

BELOW The car systems, which include items such as the Virtual Safety Car (VSC), have been devised to get the drivers used to the myriad controls they will be confronted with in F1

had on the track in past years we cannot disagree with the halo," says PAM. "It is a big part of the safety and design of racing cars now."

The onboard electrically operated extinguisher system is new, in accordance with the latest FIA standards, and continues to be supplied by FEV, the small family-owned fire suppression specialist based near Arundel in Sussex. FEV is also a supplier to all 10 F1 teams.

Driver functionality is key to fully prepare F2's rising talent for the step they all aspire to. "In terms of driver ergonomics, we've made sure that it can be driven by a driver of any stature, from the shortest to the tallest and anyone who might be involved in the championship in the coming years," says PAM.

> *"The evolution of synthetic fuel is the vital element for F2 to meet the FIA's key sustainability targets"*

There is also a new non-assisted rack and pinion steering system featuring a new XAP steering wheel with dashboard, gear change, clutch and DRS paddles, marshalling and Virtual Safety Car [VSC] display, plus DRS hydraulic activation identical to that used in F1. "We have a lot of switches," chuckles PAM. "About 10 buttons and three rotary switches, and one big one in the bottom of the wheel with a touch screen. It's important for drivers to be able to, let's say, play with the steering wheel in the same way as they do in F1. They'd have to adapt to the marshalling system, so they have VSC and all the functionality for that, plus they can change the mapping for the throttle ▶


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ABOVE Detail of Dallara's sculpted F2 2024

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BELOW The aerodynamics, developed in CFD, have targeted improved racing

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and clutch to adapt to conditions."

Electronic features include a new Marelli Marvel VCU 480 ECU/GCU including a data logging system, a new Marelli FOX 442 power supply management unit and CAN data acquisition pre-equipment.

Focus on cost

The car is suspended on pushrod-operated double steel wishbones, with twin Koni dampers and torsion bars at the front and spring suspension on the rear. Ride height, camber and toe are fully adjustable, as are the anti-rollbars front and rear. Again, tried and trusted suppliers are key. "Yes, but it's not only that," says PAM. "It's also a question of cost. When you have a complete new car and system the teams have to start again from scratch and spend a lot of money. In the end we want them to concentrate on pure racing, make sure we have a reliable car and something efficient. It's important to have continuity."

F2 cars will continue to run on OZ Racing magnesium rims and Pirelli's slick and wet-weather tyres – 18 x 12" on the front, 18 x 13.7" on the rear. The Texense tyre pressuring monitoring system fitted to all cars is another carry-over and remains a key safety feature, says PAM. "It means we can monitor at any time the tyre pressures to make sure we don't have any leak or puncture, and can make the driver aware. There's a light on the dash which flashes when they have a puncture. Also, we are sticking with a choice of four different compounds across the season and we are working closely with Pirelli to develop this 2024 tyre, to make sure we can still have good racing."

RIGHT Deputy Technical Director Pierre-Alain Michot, known universally in F2 circles as PAM

Formula Motorsport Ltd

Braking is via six-piston monobloc Brembo callipers, with Carbon Industrie carbon-carbon brake discs and pads. How close is F2 braking to F1 standards? "It is a specific system that has been developed for F2," answers PAM. "We are


Aramco

not pushing the boundaries as F1 does because we need to have something affordable for the teams – but this is really the same kind of technology in terms of materials. In the end the drivers get a taste of F1 performance, in the last step before F1."

PAM needs to get back to the test. Before he signs off, we ask what he's most proud of with this new car. "The big step was in terms of aero, not just in how its looks but also in terms of performance as well," he answers. "We do have a little bit more downforce which will make it more efficient for the drivers to find the limit. It's good to give the drivers a car that can prepare them properly for the next step – and it's an important milestone for us."

ABOVE Aramco is developing the next generation of scientists as well as drivers

BELOW The launch of this next generation of FIA Formula 2 car marks the start of an exciting new chapter for the championship

> *"It's important for drivers to be able to play with the steering wheel in the same way as they do in F1"*

The build of the car will be finalised in the next month before the teams each take delivery of one chassis mid-December, with the second following mid-January – giving them just enough time to prepare for the first race of the new F2 era at Sakhir in Bahrain on February 29-March 2.

Biggest challenge

"The biggest challenge, as always, is being able to have everything on track at the expected date," smiles PAM. "We are still OK for that, but it is one of the main challenges to make sure everyone is in line and on time, to comply with all of the FIA requirements in terms of safety and F1 design. It's always a challenge to get a race car on track." RT


Formula Motorsport Ltd

TURMOIL... AND A TITLE

Unconventional, flamboyant and ground-breaking, Benetton defied perceptions as the rebels of Formula 1. In this extract from his new book, **Damien Smith** investigates the controversial 1994 season when the team broke through F1's glass ceiling

Motorsport Images/LAT

RIGHT Schumacher and the colourful Mild Seven-sponsored Benetton B194. After years of McLaren and Williams domination, there was a new sheriff in town

SOMETHING had changed. From the first tests in 1994, the Benetton Formula 1 team had somehow evolved, and it went far deeper than the colour-swap from Camel yellow to Mild Seven blue. The rebel F1 team, the outsider tilting at the established order, suddenly shed its old perennial 'nearly' status.

There was nothing nearly about the new B194. It hit the track in early January – and flew from the start. What made the difference? How had the team shifted from contender to clear and obvious pacesetter at the start of a new 'passive' era, now active suspension and so-called driver aids had been banned?

"There were a couple of things that contributed to that and funnily enough the 1993 active car was definitely one of them," says [former technical director] Pat Symonds. "To get what we did out of the active car, we had to do a lot of vehicle modelling and I think it's a bit like when ground-effect cars were done away with [in 1983], people said we wouldn't need wind tunnels anymore. It's not like that, you need things more.

Active lessons

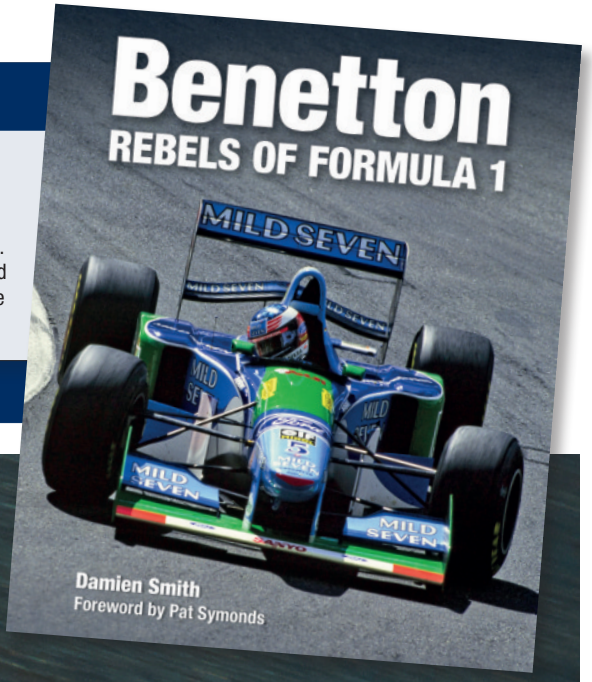
"In developing the 1994 car we knew that the active systems were going from Canada 1993 onwards, so from June that year we just turned all our attention to the next challenge. Apart from the four-wheel-steer project, the rest of the vehicle performance department were working on modelling passive cars.

"We had in our mind why the active car was good and how close we could get to it with a passive car. There were some quite neat little systems on there. We had this system using Belleville washers that controlled the ride heights. We had programmes we'd written, a bit like the active car, where we could say this is the ride height we want at this

speed and at that speed. A lot of that technology hadn't gone, it had just been reapplied.

"In conjunction with that we knew we needed to do something different on aerodynamics because we weren't controlling the car anymore. We needed to go back to some of the things we were thinking about before we went active, on aerodynamic sensitivities and what have you. We did a damned good job on that. We had a car that had a really good chassis, it had a very driveable engine" – the new Ford Cosworth Zetec-R V8 – "which definitely wasn't as powerful as the Renault, as we'd find out in 1995. ▶

Extract taken from:
BENETTON – Rebels of Formula 1
Written by Damien Smith. Evro Publishing. Foreword by Pat Symonds. UK price £60 hardback



But it was very driveable and you could build a very nice car around it. And the aerodynamics were benign, so it was dead easy to set up.

"I talked before about how the 1985 car was easy to set up – the 1994 car was the second in that regard. You could tune it to the circuit very quickly, it looked after its tyres. It really was a good car. When you're trying to make your aerodynamics benign – by that I mean not very peaky or sensitive – you often have to give away a bit of downforce to do it. But actually the 1994 car had as much downforce, if not more, than any of its contemporaries. It was just a damned quick car."

Meanwhile at Williams, the dominant force through the 1992–93 'active' era, the transition back to passive thinking was proving bumpier. Expectations had blown through the roof with the arrival of Ayrton Senna, who'd finally got his hands on the best car on the grid – only to find the FW16 was anything but. Suddenly, Benetton had the advantage.

"Exactly," says Symonds. "Where we thought, 'What did we learn from active, how can we turn it into passive?', I almost think Williams just did everything the same as they had the year before. The Williams did have a lot of downforce but it wasn't a very driveable car. With Ayrton in it, at the first race in Brazil when he spun off, it was just because he was having to wring its neck to keep up with the Benetton."

Rory Byrne [chief designer] picks up

Motorsport Images/LAT

on the theme. "As far as the car was concerned, I concentrated on two things: first, getting the centre of gravity as low as possible, which I put a real big effort into. In fact the car was about 15 kg underweight, so we had that amount of ballast on the floor, which makes a sizeable difference to the centre of gravity and lap time, especially in the race in terms of tyre usage.

"The other big thing is I put a big effort into making the aerodynamics very benign in terms of pitch, roll, that sort of thing. In terms of Benetton/Toleman in F1, that is the best car I designed. A lot better than the 1995 car. Everything I'd learnt, including from John Barnard, was all relevant."

LEFT Refuelling returned at the Brazilian GP, adding new complication and jeopardy to the lives of pit crews. The refuelling rig was supplied by a company called Intertechnique, a name that would soon be thrust into the media spotlight

The B194 broke cover in the hands of test driver Allan McNish at a cold Silverstone in mid-January, much earlier than new Benettons usually ran – necessarily so in the wake of the active-to-passive regulation change. As pre-season testing ramped up, it quickly became obvious the team had stepped up a gear.

At Barcelona in February Michael Schumacher lapped under Alain Prost's 1993 pole-position time and was fastest on all four test days, a full second clear of Damon Hill's Williams. So were Michael and the team immediately aware just what they had under them for the new season?

"Yes and no," says Symonds. "We had a huge problem pre-season, a massive problem. The new Zetec engine kept breaking cranks. We weren't often getting through a day on an engine in pre-season testing, we were normally doing an engine change at lunchtime. The first race was in Brazil and we were shipping the cars out at the weekend.

> *"The dark cloud of suspicion over the illegal use of traction control was never far away"*

"Just before that final weekend we went to Silverstone with the last chance we had of fixing this crank problem. We had to do a race distance on the south circuit and it was bitter, so cold. There were no pits, we were working out of an awning. There was one little hut we hid in to do the timing. And we did a race distance that day, the first we'd done pre-season. Heading to Brazil we knew we had a very good and competitive car, but not whether it would last. But we didn't have any more problems with the crank. Cosworth solved it."

Crash trauma

There was also a degree of trauma over who would be joining Schumacher in the second Benetton. JJ Lehto, a highly rated Finn with a decorated junior record behind him, was plucked from Sauber where he had endured a largely disappointing 1993 at the new Mercedes-backed team. After seasons at Onyx and Scuderia Italia, Lehto had paid his dues and now was rewarded with a top drive. But the dream turned into a nightmare almost immediately when he suffered a huge crash at Silverstone during a January test.

The Benetton went off at Stowe travelling at 140 mph and backed into the barriers. Knocked out in the impact, Lehto was rushed to Northampton General and then on to a London hospital with serious back injuries. He'd been lucky to escape paralysis.

"That was bizarre actually," recalls Symonds. "It was close to the end of the day and no one quite realised ▶

how serious the accident was. It was one of those things, he'd gone off, everyone was packing up. He'd been taken to hospital. OK, let's see what's going on. He had actually fractured his vertebrae.

"It was a bit surreal: shit, this is quite serious. It was a real shame because he never really came back from it. Of course he did come back, at Imola where he had the infamous start-line accident. But we did nothing to make things better. I think that testing accident spoilt quite a promising career. JJ wasn't going to be a world champion, but he was a very competent driver. And it got Verstappen in, didn't it?"

Jos Verstappen, of course, future father of world champion Max. Verstappen Sr was 'the next big thing' in early 1994. His stellar junior career had been capped with a dominant run to the German F3 Championship and victory on home turf at the Zandvoort Marlboro Masters, but it was a cameo test performance for Arrows that really made him hot property. Now Flavio Briatore swooped, signing the 21-year-old to a reputed six-year contract!

> *"We had 100 bhp less than Williams. But we had Michael"*

He was supposed to be test driver in 1994, much to the surprise of McNish, who soon quit his role to focus on racing, but in the wake of Lehto's accident Verstappen suddenly found himself promoted to what turned out to be the second-best seat on the grid beside Schumacher.

"He was a character," smiles Symonds. "What do you call people like him? A rough diamond. He was quite quick but would never think the same way as Michael. Michael was highly intelligent and Jos was… not as intelligent."

Did Briatore sign him just because he was in demand among other teams? "That's probably true actually! Typical Flav. Let's face it, Jos wasn't bad. And of course with JJ having his accident quite late it wasn't as if we had a whole load of people to call on. He settled in, got on all right with the guys."

Interlagos and Aida: light and shade

"The consequences for any team or driver found cheating will be mind-blowing. The drivers are included in this because, while they may be unaware if their cars are underweight or even running over-sized engines, there is no way they could not be aware of the operation of a traction-control system." ▶

Motorsport Images/Sutton Images

BELOW Joan Villadelprat catches up with Gerhard Berger. The forthright team manager drilled his pit crew to a point of excellence as refuelling returned. The new style of sprint-stop-sprint racing suited Benetton and Michael Schumacher perfectly

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FIA president Max Mosley set out the governing body's imposing stall early in 1994 as it faced policing the ban on driver aids. The cars were supposed to be passive in the new era but little else was as F1 embarked on a season of deep trauma, tragedy and dispiriting controversy. We'd never seen anything like it, haven't since and hopefully never will again. As for Mosley's words, reported in January, they would echo through the season, and most pertinently in relation to those 'noisy neighbours' at Benetton.

Mosley repeated his warning, in no uncertain terms, on the eve of the new season: "All the teams know exactly what the rules are and on all the difficult or grey areas they know exactly what the FIA's view is," he said. "Although our view is not necessarily the view of the stewards it would probably be quite persuasive. Anyone who wants to go to Brazil with an uncontentious car can. So I think the chances of problems are small – and if there are problems, I have to say it will not be our fault.

Threat of draconian penalties

"If you demonstrate that somebody deliberately cheated; not that they interpreted the rules differently to you, or that there is some debatable point which they may be wrong about – but if somebody *deliberately* does something like, say, fits a traction-control system, then I think draconian penalties are completely correct. After all, it's a deliberate attempt to gain an advantage by completely unfair means.

"If somebody was caught with traction control, they could certainly expect to be out of that year's championship, and possibly more. In the end it would be a matter for the FIA tribunal, but they could expect a severe penalty. However, I hope it won't come to that."

ABOVE Schumacher turns the heat on Ayrton Senna as Jean Alesi's Ferrari shadows at the 1994 season opener. Two-stopping Schumacher took the lead in the pits and cruised to a win after a rattled Senna spun while in pursuit. This was new

As the season began, the inkling that F1's world order had changed was confirmed in sensational fashion as Schumacher and Benetton tore through the early races. Sure, Senna was on pole in Brazil, yet he had no answer to Schumacher in the race and spun lamely into retirement as he struggled with a Williams running on a handling knife-edge. Although Michael couldn't pass the Williams on track.

Instead, he used a two-stop pit strategy aided by a returning feature that would fundamentally shape F1 for the rest of the decade and deep into the next: mid-race refuelling had returned for the first time since 1983, all in the name of spicing up the show – while adding expense to team budgets and jeopardy to the lives of intrepid pit crews. The sprint-stop-sprint era was here, and Benetton immediately embraced the challenge.

> *"We had in our mind why the active car was good and how close we could get to it with a passive car"*

"We prepared for 1994 better than anybody else," says Joan Villadelprat, the bullish team manager who ruled Benetton's pit with steely authority. "I brought some wheel guns from Dino Paoli in Italy that used fully controlled pressure to do up the nut. I did 1,000 practice pitstops in the factory and another 1,000 ▶

over the year. I kept filming the crew and showing them to see how we could improve. People didn't take it seriously, but we took it seriously. We improved everybody in the stops and that's how we managed to win: beating Senna in Brazil and so on. That's why Benetton had the record for [fastest] pitstop for many years. Now the guys who have the record are the guys who came from me: Jonathan Wheatley at Red Bull, Rob Marshall and more. That was me, not Ross [Brawn] or anyone. It was me pushing the kids heavily.

"We had 100 bhp less than Williams, with the Cosworth engine. But we had Michael who was in this explosion, this brilliant moment. And the car was bloody good, aerodynamically, in weight, with a team that was able to recover a few seconds in every single pitstop. So we started winning."

"We were measuring pit-ins and pit-outs long before anybody else," says Greg Field, the 1980s Benetton veteran who Villadelprat had pulled back into the fold at the start of 1994 as team co-ordinator. "Michael would come in on morning warm-ups and go straight through to see how quick it took. And there was no pitlane speed limiter before Imola 1994. The cars were coming in flat out. On our track walk, we'd always look at the pit entrance and how you could approach it, especially after the speed limit came in. At Aida Michael said, 'I could cut across the grass here.' I said, 'Be careful not to hit the barrier.' 'Yeah, but the wheel is coming off anyway,' he replied. Good point well made, Michael!"

Schumacher was tailor-made for F1's refuelling era, as Frank Dernie explains. "You had to be able to drive a qualifying lap every lap up to the pitstop. If you had track position after the final pitstop, that was it. A reasonably good driver, as long as nothing goes wrong, would win the race if he's in the lead after the final stop. It suited Michael being that much fitter than everyone else. He was miles ahead in that respect."

> *"Schumacher was tailor-made for F1's refuelling era"*

Round two, Aida in Japan. Senna was on pole, but found himself wiped out at the first turn, leaving the path clear for a dominant Schumacher to make it two-nil.

"Confidence builds and you start to believe in yourself," says Symonds. "I'd like to think we never got cocky, but we really were starting to believe in ourselves. Pre-season testing, we'd been quick, we had reliability concerns, but in Brazil seeing Ayrton go off trying to keep up… Wow. Williams was acknowledged as *the* car, Ayrton was acknowledged as *the* driver and we seemed to be able to play in the same game. It gave us a hell of a lot of confidence. And the team was really gelling then."

After all those years as the rebel outsider, striving and falling short… How did it feel for you and Rory to find yourselves finally on top? "It was wonderful, it really was," says Pat. "Rory is just brilliant. One of the most underrated people in F1. Doesn't self-publicise at all. Still at it too. He's mad, but then so am I! Ross Brawn was a huge influence on the team as well. We just had really good people. All the mechanics. It really did come together."

Not everything went to plan. Verstappen made his F1 debut in Brazil, just his 53rd race in a car, and ended it in a barrel roll triggered by Eddie Irvine's Jordan. That evening the team also survived a protest from Jordan over aerodynamic 'barge boards', which by now were sprouting behind the front wheels. And the dark cloud of suspicion over the illegal use of traction control was never far away, although it was Ferrari rather than Benetton that first found itself

Motorsport Images/LAT

LEFT Take that! A picture that says it all from the 1994 Brazilian GP. Schumacher and Benetton would win six of the first seven races

RIGHT Schumacher beats pole starter Senna to the first corner at the Pacific GP. The Williams is about to be punted out by Mika Häkkinen's McLaren. What Ayrton then saw watching trackside fuelled his suspicions over the legality of Schumacher's Benetton

Motorsport Images/LAT

under scrutiny. In Aida there was talk of the red cars running a 'power-reduction system', while driver Nicola Larini was reported to have let something slip to the Italian media when he mentioned turning off the traction control…

On race day the FIA released a statement: "It came to the notice of the FIA technical delegate that during the free practice sessions on Saturday cars number 27 and 28 were fitted with a device which in certain circumstances limited the power of the engine. As the FIA technical delegate was not satisfied that the device complied in all respects with the sporting and technical regulations, Ferrari were advised not to use it. This advice was complied with."

Traction-control denials

Schumacher's strong start off the line had also raised suspicions, to an extent that an annoyed Brawn was forced into traction-control denials. Later in the season, another lightning start at Magny-Cours further fuelled speculation that Schumacher had electronic 'help' getting away as he darted in front of Hill, despite the short run to Turn 1 at the French circuit. But insight from Dernie on this subject offers a possible explanation. "Michael was absolutely shit at starts," he states. "We'd often be quick in practice and qualifying, but if you look at the races in 1993 half the time he came around the end of the first lap in sixth because he'd made such a shit start. Part of it was because we had a very low crank centre height and the clutch diameter was restricted, but mainly it was because he needed more practice. So I produced a system where we used to do a practice start every time he left the pits, until eventually he got good. Which was another reason why people thought we had traction control because all of a sudden Michael could make good starts."

This writer has heard paddock insiders talk about Schumacher stopping out on track during 1994, as if he was resetting something on the car – an inference to a launch-control system. Symonds and Dernie claim they can't recall. But was this just Michael working on his getaways, as Dernie had taught him? "We practised because our starts were poor," says Frank. "People assumed we were testing a traction-control system." RT

Transforming… ‘THE JUNK IN THE TRUNK’!

How a rusty diesel Mercedes, with ballast in the boot, morphed into an innovative home-built hybrid rallycross challenger. By **Hal Ridge**

INNOVATION is one of the core elements of motor racing’s DNA. But, in an era of vehicles being created for single-specification series, to limit costs and keep competition close, genuinely innovative projects are increasingly rare.

When they do emerge, they stand out from the crowd. Take a brief look back at history and it’s Audi’s quattro, Brabham’s BT42 fan car, Brawn’s BGP 001 double-diffuser and Mercedes’ DAS systems that tug on the minds and hearts of motorsport fanatics.

> *“YouTube inspiration led to the implementation of what is effectively his own active suspension system”*

But, those examples were all ultra-high-budget, top-level efforts. The thing with motor racing is, with the potential of competing at any level, innovation is often just as rife off the radar as it might be at the highest echelons.

Engineer Viktor Johansson hails from the north of Sweden. He has been heavily involved in the development of the unique hand control system used by paraplegic rallycross Supercar racer Mats Ohman. Undeterred by a life-changing snowmobile accident, Ohman has been racing with hand controls since the start of the millennium and was winning events in 2023. While Race Tech covered Ohman’s unique system several years ago, Johansson works with his compatriot to constantly fine-tune the elaborate concept.

As it happens, in the series in which Ohman raced this year, RallyX in Scandinavia, Johansson was also competing. But while Ohman is in the top-flight four-wheel-drive Supercar class, Johansson competes in the Open 2WD category of the Nordic-based series. In fact, Johansson won the Open 2WD title in 2022, driving his somewhat unconventional Mercedes 190e Hybrid.

Born from the relatively free Supernational regulations in rallycross, the Open 2WD category has perhaps the loosest rule set of any high-profile motorsport series. Each day of RallyX 2023 had over 30,000 live views on YouTube, and the Open 2WD class – where the rules essentially stipulate a requirement for the car to be 2WD – is one of the fan favourites.

Creative fire

Having previously competed in the single-specification four-wheel-drive Supercar Lites category, in 2020 Johansson decided that he wanted to feed his creative fire. He set to work on a two-wheel-drive project, initially for the

Supernational category in Sweden before switching to the RallyX Open 2WD.

"I built the car from scratch. It was a dark blue rusty diesel Mercedes when I got it," he laughs. "Then we raced it for the first time in the Swedish Championship in 2021, I was driving in the 2400 (cc) Supernational category, but the car just had an old really bad Volvo 240 four-cylinder engine, so I had to buy a new engine for the second year."

Brainwave

He sourced a 2.5-litre engine, bored to 2.9 litres with a different crankshaft, uprated inlet and exhaust manifold, in his home town of Elspen to mate to his Sellholm five-speed sequential gearbox and Volvo 940 rear axle. Johansson eyed stepping up a class on the engine capacity ladder, but a passing brainwave made for a change of direction.

"I did a local race at home to just try out the new engine ahead of the 2022 season," he recalls. "In the 2400 category you had to have a weight distribution of 55% on the rear, so the car was pretty light compared to how it is now, and I had to put a lot of 'junk in the trunk' to get the tyres to stick to the ground. We needed to add about 100 kilograms, and then it was working really well. My wife at that time had a Volvo V60 plug in hybrid. I was driving it home from work one day and started thinking, 'Maybe I can take a battery and use it instead of the lead I had in the trunk of the Mercedes, and then I could put an electric motor on the rear axle.' Even if it added five horsepower, ▶

BELOW The home-built hybrid Mercedes is one of the most innovative rallycross machines to appear in years

ToniGraphs

it would be more return for the weight than with just the lead."

With a deadline of the opening RallyX round at Holjes, Sweden, in mid-May, Johansson started researching how he could deliver one of the most innovative rallycross machines seen for some time.

"I bought the parts from a junk yard at home: a BMW battery, motor and control unit from a Mini. It has the same base as a BMW 225 hybrid. But pretty soon we realised it was hard to connect the electric motor to all the CAN bus signals and make them communicate, so I kept the BMW battery, but bought an after-market motor with a control unit from a company in Poland that sells kits to convert your everyday car. You just go on the website and put however many volts you want, so I went for 120," shrugs the Swede.

> *"The first bespoke hybrid rallycross car for an international series"*

And so it began. Johansson and his team embarked on creating the first bespoke hybrid rallycross car for an international series. As planned,

Viktor Johansson

ABOVE The hybrid system also acts as a traction control-type system when conditions are difficult

LEFT Better than ballast: the 'junk in the trunk' now contributes to the car's performance

Qnigan

the BMW battery was housed in the boot, while the motor was also packaged in the rear of the car, offset to one side with a chain from a motorcycle to drive the input flange into the rear differential, behind the Sellholm gearbox.

"We didn't know so much in the beginning or if it was going to work or not," admits Johansson. "We had a discussion with my father, who is a big part of the project, about where to put the motor. In front of the gearbox or after it? But we thought it would be easier to put it after the gearbox because if there's a little delay on the electric engine, it would be hard to shift gears. It was all pretty easy: there are three wires between the electric motor and control unit, positive and negative to battery and then it's just a TPS (throttle position sensor) that controls the electric motor."

That electric motor TPS is joined under Johansson's right foot by a second sensor for the ICE throttle in the front of the car. Johansson has since spent time developing the harmonisation of the deployment of each propulsion system, although the initial setup worked from the outset.

"You feel the kick"

"I've tried changing the curves on the throttle (map), where the motor is producing the most power, but it's pretty easy when the motor is so small compared to the ICE," he says. "You feel the kick when the motor is on or not but I was afraid of how the power curve when we started would be, but it's just the same, it just adds 100 bhp all the way through the revs on the ICE. It's pretty linear. I have the curve on the throttle now so up to 35/40% throttle the electric motor is working pretty little, then after 40% it's almost full."

Not only does the home-built hybrid system offer increased outright performance, it also acts as a traction control-type system when conditions are difficult.

"When it's slippery, you are under 40% throttle finding the grip, and when I have the grip I just put it down then I have all the power," he says. "At the track in ▶

Denmark for example, I was starting at 4,000 rpm and made awesome starts. If I didn't have the electric motor, it would just bog down – usually you have to start at 5,500-6,000 rpm when only using the ICE, and it revs to 8,500 rpm."

Johansson says that adding the hybrid hasn't required specific geometry changes. The output at the rear wheels has increased by 100 bhp with the addition of the motor, making for 450 bhp in total, with 500 Nm torque.

Just as in the current World Rally Championship, where Rally1 cars are driven through some sections on electric power only, or indeed out of stages if they have had a problem, Johansson has that option too, by putting the gearbox in neutral and just using the motor. In 2022 he finished heat races in two different events with electric-only power on his way to the title.

At the 2023 finale in Sweden, the electric system almost made for a fairy-tale finish. In the opening free practice session, Johansson's engine blew. Needing to complete two heat races before he could even consider securing another ICE, Johansson contested the heats on electric-only propulsion. An all-night effort to source and replace the ICE kept his title hopes alive, but he ultimately lost out to rival Fredrik Tiger. Arguably, the result mattered less than the effort, with the rest of the paddock looking on in admiration at what Johansson's car was capable of.

Viktor Johansson

ABOVE An after-market motor and control unit helped sort early communication issues in the makeshift hybrid system

BELOW The improvised system has contributed to some demon starts

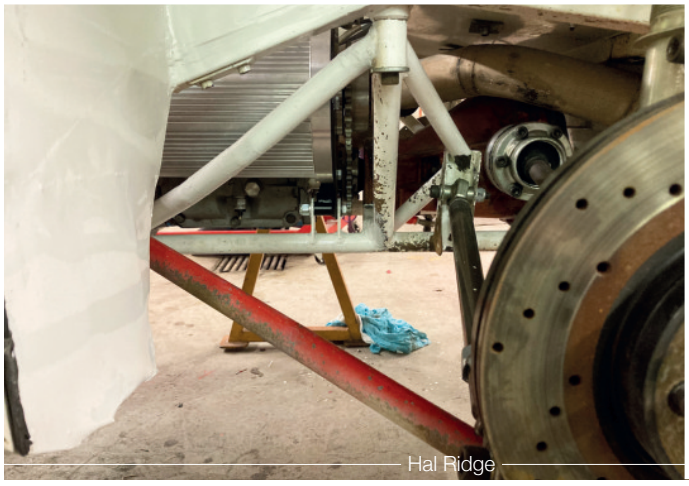
Dash with a difference

The Mercedes hybrid machine also has a surprise for anyone looking in the driver's door, the dashboard coming with its own story. "This sport costs a lot of money," says Johansson with a smile. "I had bought the electric motor and all that stuff, and was looking for a dashboard. An AEM dashboard is about €1,000 for example, and with the MaxxECU we

Jan Kare Rafoss


Viktor Johansson


Viktor Johansson


Hal Ridge


Hal Ridge

ABOVE The motor is also packaged in the rear of the car, offset to one side. A chain from a motorcycle drives the input flange into the rear differential

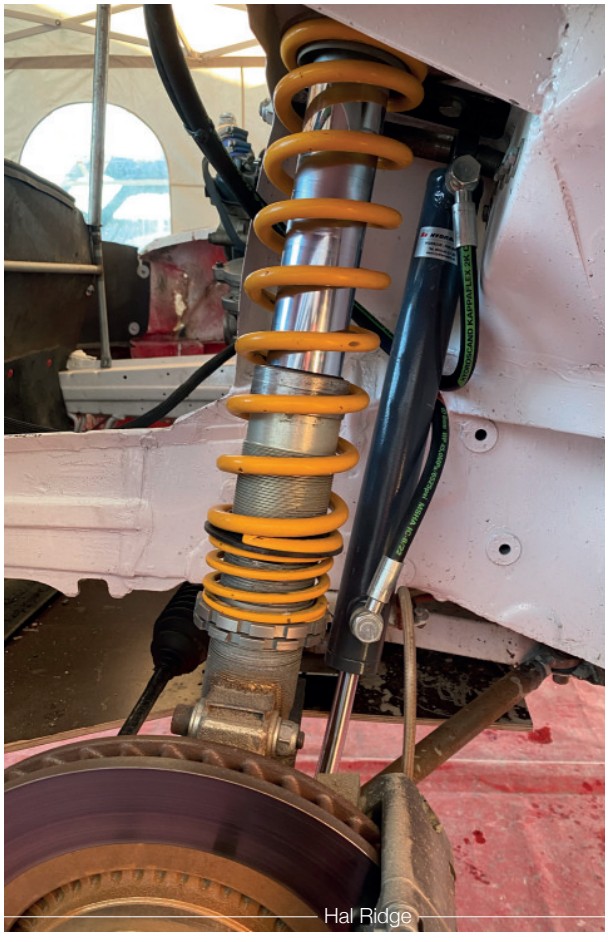
use, that has the opportunity to have a Bluetooth connection to a phone.

"I was eating dinner with my mother-in-law one evening, and asked if she had an old phone. She said yes, so I asked if I could have it. It's a Samsung with a really, really bad battery, so it's always plugged in. But I used that as the dashboard and it works great. I think there's still some flower pictures and stuff in it there also!"

> *"It adds 100 bhp to the ICE all the way through the revs"*

As the famous Pirelli marketing slogan has always reminded us, power is nothing without control, and while, for the time being at least, most rallycross series run on crossply Cooper rubber, it's an important reminder that even with an extra 100 bhp from a hybrid unit, that figure is futile unless you can put it on the ground.

By its very nature, rallycross is a constant compromise of surfaces and in the rear-wheel-drive world, decades of refinement has been put into making high-powered, composite-clad Supernational, and now Open 2WD cars work. It's a real art to make a car soft enough to put power on ▶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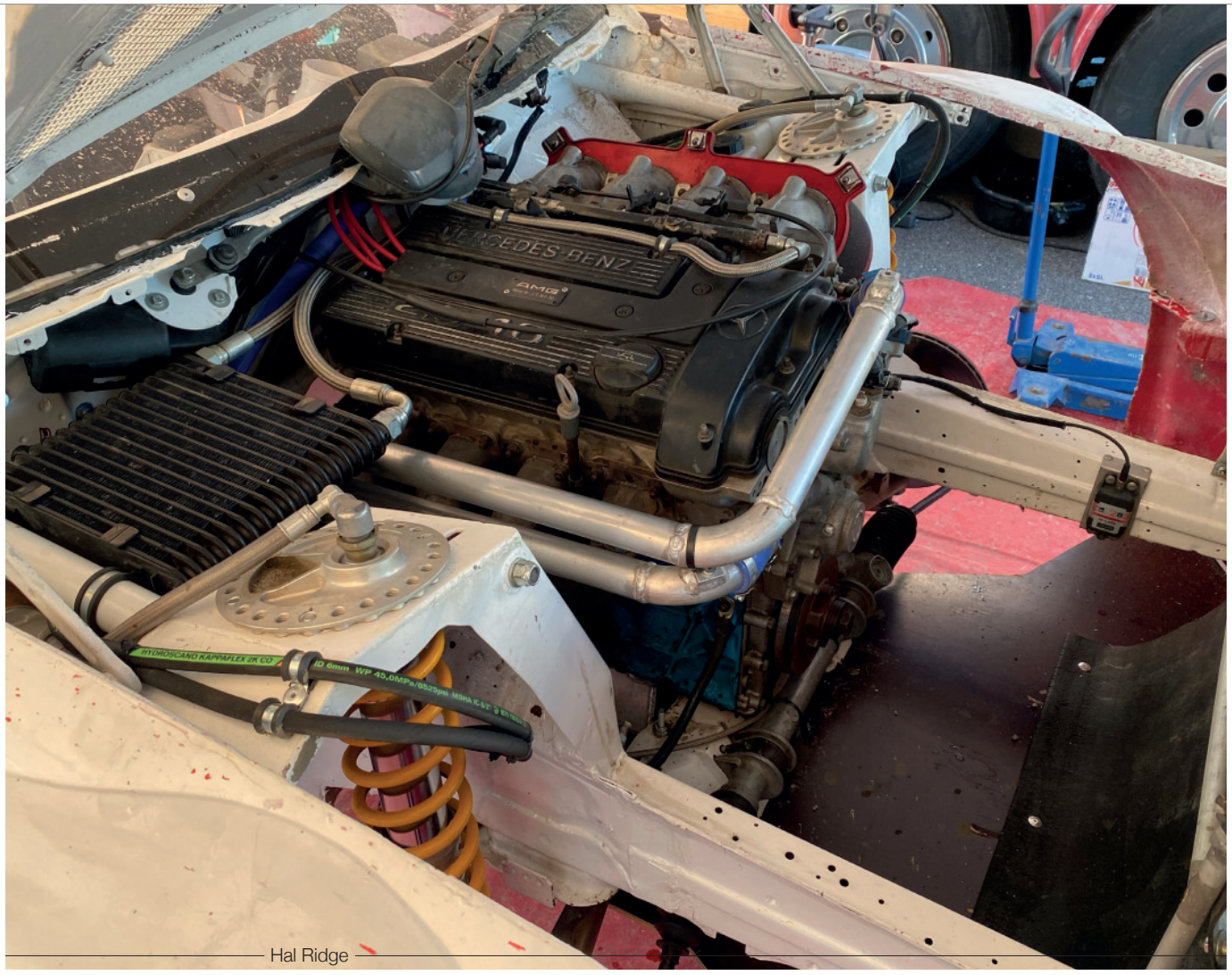
RIGHT Active suspension? No problem, we can do that too!



Hal Ridge

the ground, while making the chassis stiff enough to deliver lap time on the Tarmac as well as the loose.

"It's a balance that I don't think many other motorsports have," says Johansson. "Like sometimes when I talk with someone who does circuit racing

> *"One of the most innovative rallycross machines seen for some time"*

and I say we have just put in 100 kgs of junk in the trunk and they are like 'what!'. I tried many things; we have this concept and it works. I can't say so much more than that! The weight distribution is 62% on the rear now. They have copied the Open 2WD rules in the Swedish Championship now too so that is fine for us and we have moved the water cooling to the rear to help cooling and for the weight. The total weight with me in the car and fully race-ready is 1,300 kgs. There's no minimum – I've tried to have a lighter car, but you need to have some mechanical grip in the slow corners and acceleration. It depends on the track. Some tracks you would maybe benefit from having a lighter car, but I think we have found the balance."

But, Johansson isn't done there. While the hybrid system came into its own in 2022, some off-season YouTube browsing gave him fresh inspiration for 2023. This led to the implementation of what is effectively his own active suspension system to accompany the Öhlins dampers at each corner.

"My father has a tractor workshop and after seeing some videos I built a hydraulic anti-roll bar system," says Johansson. "They're just normal hydraulic cylinders that are cross-connected, so when one wheel is moving up, the oil is flowing on the other side and lifting the other wheel. Then I have a hydraulic accumulator that we fill with gas pressure. So if I have a little bit of pre-charge, instead of lifting the inner wheel, the oil will go to the accumulators. They're connected front to rear too."

Active ride

Asked how complicated the system has been to set up, Johansson shrugs modestly: "It was a few hoses and connectors. I think a lot. But we have not tested the car so much, just in races, so I want to make a proper test and try different pressure settings to see how the car behaves. And maybe, I don't know how I will do it yet, I can control

ABOVE The Merc's ICE is complemented by the hybrid system above 40 per cent throttle

the pressure while I'm driving. Maybe on the fast corners we can make it stiffer and softer in slow corners. But this is what I love. I drove Supercar Lites for two seasons and it was fun, but I love to be in the garage with my mates doing stuff like this. That's a big part of why I do it."

Interview almost over, the final question. What's next? Johansson's main mechanic is first to chip in. "4WD" he says immediately. Johansson is quick to respond. "Ah, I don't really know right now, my head is pretty full with what I'm doing here – there is always something you can do."

What the Swede and his tiny family team has achieved is remarkable. Motorsport would be a greater place with more projects like Johansson's Hybrid Mercedes. And now he's proven the concept, hopefully the 4WD Hybrid Rallycross Supercar will come along in the future. This writer will be the first on the plane to northern Sweden if that happens.

BELOW Johansson's ingenuity has been rewarded with impressive performance

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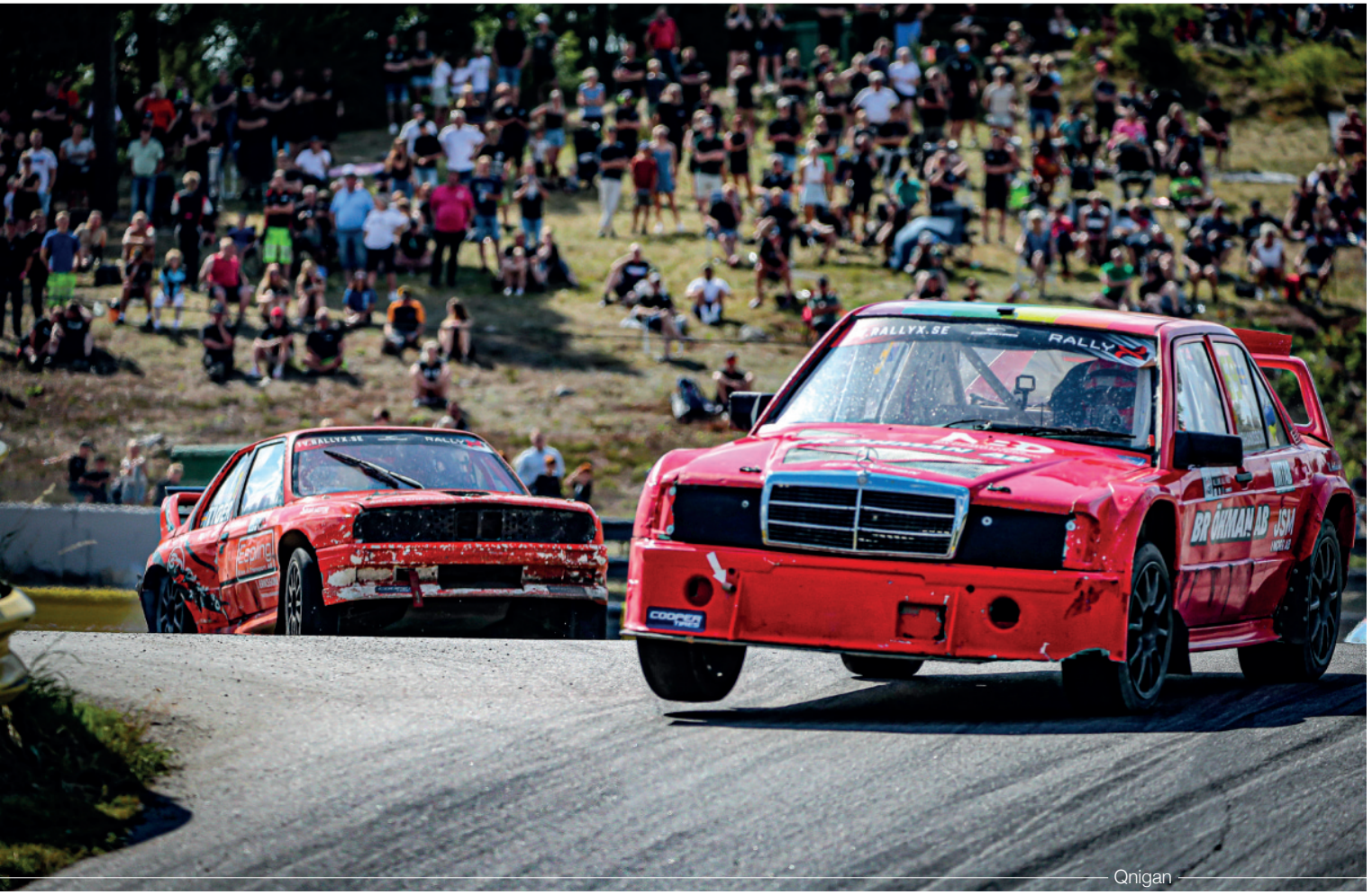

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BORN TO WIN

Sergio Rinland reflects – with increasing disbelief – on F1's vetting procedure for new teams

I **READ** with some amusement that the new teams aspiring to enter F1 have to demonstrate not only that they are financially sound, but present a plan of how they propose to be sustainable to achieve net zero by 2030. Which is a good thing. But on top of that, they have to commit to staff diversity and achieve a positive social impact.

Those last two conditions are a bit abstract and esoteric.

Motorsport, Formula 1 in particular, has always been inclusive and diverse since the early days. It is in its DNA. We only have to remind ourselves of the gender, nationality, ethnicity and religion of the long list of heroes who have graced the sport to prove that point.

Motorsport never needed a 'condition' for a team to exist that included a certain percentage of gender and ethnicity in its workforce. Motorsport is the archetypical example of meritocracy: if you are good at your job and hard-working, the doors to success are open to you. I for one am living proof of that!

Rising to the challenge

Positive social impact? What *is* that? Motorsport fans are and have always been a well-behaved crowd, knowledgeable about the sporting and technical aspects. Motor racing has always inspired youngsters to enter technical careers or to adhere to a very tough discipline to get into the sporting side. What other sport has such a positive social impact?

The same goes for sustainability and low emissions. Save for a few exceptions over the whole history of motorsport, the activity has always been about efficiency, how the get the most from a given amount of energy and resources. Give us the challenge, and we rise to it.

But now, it appears that you have to present a 'plan' of how to achieve all that we have been doing for more than a century. It looks as if new teams have to present a list of personnel with x% of gender equality, y% of ethnic minorities, and z% of certain nationalities. Also, present a plan of how many kids in the grandstands the team is planning to inspire to go into a technical school or apprenticeship.

What about asking the teams for their background in motorsport? What success records can they show? In what series/formulas do they participate? Those are questions to ask.

We need teams who want to win, not just to turn up and eat a slice of the cake, as some seem content to do. I was once given a stinging reprimand by a team boss because I said publicly that I was designing the team's F1 car with the ambition of winning races. 'We can't go saying that,' he insisted. We don't need those kinds of teams.

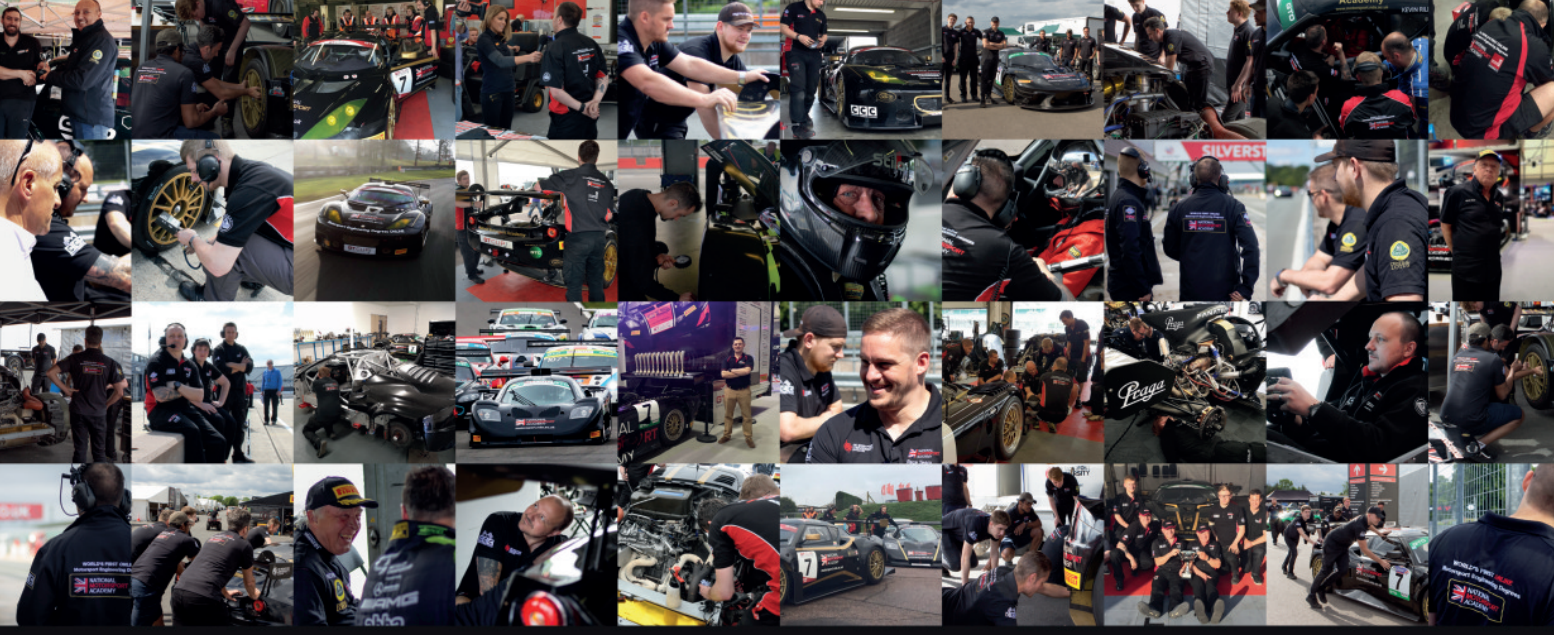
We have talked before of the existing squads' resistance to the possible addition of Andretti Global. But there's a team that, in my 'motorsport book', ticks all the boxes.

The most important aspect of a Formula 1 team is to be competitive and win races if they are good enough. Be located where the team can benefit from the highest quality supply chain, of components, materials, and people. It is not racial discrimination that most of the F1 teams are located in the UK's Motorsport Valley – don't make me laugh! Drivers come from all over the world; always have. Mechanics and engineers come from all over the world; always have.

I teach Race Engineering and Simulation in the Motorsport Master's degree at Oxford Brookes University. Only a small percentage of students are from the UK or even Europe: a prime example of diversity! When they graduate, they are hired because of their skills and qualifications, not by the colour of their skin or gender.

So don't tell me about inclusivity. We don't need anyone to come after 130 years to tell us, hard-core motorsport fans, to be inclusive. Just show us your motorsport credentials and make sure you have the money to do it right. RT

BELOW Andretti, which has just won its first electric world title, wouldn't enter F1 just to make up the numbers



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