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TO LEAD OR FOLLOW?

MOTORSPORT has reached a stage where it has to lead or follow. Most engineers would strongly argue that it must be a leader.

It was a sign of the times that the Motorsport Industry Association's recent Energy-Efficient Motorsport Conference (EEMS), which offered us a few clues to the future, had to be held in a virtual format.

It hosted many fine speakers, giving their thoughts on what the future of motorsport is going to be like. Much of the discussion centred on the type of fuel we will be harnessing. F1's chief technology officer, Pat Symonds, stated that one of the difficulties in promoting low carbon fuels is the terminology used, such as sustainable fuels, e-fuels and biofuels, and sometimes it's difficult to subdivide them.

However, it was former Audi Motorsport chief Ulrich Baretzky, recently retired, who came up with the most radical ideas, his theory being to expect the unexpected and never say never when it comes to any potential technical solution.

Two-stroke engines for the next generation of F1? The comment might have provoked nervous laughter, but the idea is not as outrageous as you might think.

He went on to say that battery electric vehicles and maybe hybrids are seen by many manufacturers and governments as the powertrain of the future for cars, but they come at a cost. He said that in the future, motorsport will play the most important role ever, showing the possibilities of what can be environmentally friendly, but warned that e-fuels need energy to be created.

Many people therefore argue that a better use of energy is in battery electric vehicles and hybrids, but solar power is far more efficient, he maintains. He suggests that a three-hour burst of sun every day for four days would give planet Earth 100% of its energy needs and that we should be clever enough to harness it.

Hydrogen, too, will have a major role to play in future transportation, including ships, lorries and even planes. With slight modifications to the crankshaft, he reminded us, cars could run hydrogen in existing engines.

We are at a technology crossroads and there is no easy answer. New fuels, new propulsion systems, financial costs, environmental costs are all part of the equation and it's a question of finding the right solution for the vehicle involved. Altogether, though, as the engineers at EEMS agreed, it's a tremendous chance for the motorsport industry to excel.

Bill Gates in his book has said that achieving net-zero will be humanity's greatest ever achievement. It will require innovation on a scale the world has never seen and his key comment is that the solution isn't to stop driving, flying and doing all the things that society expects, but to innovate – at which point the motorsport world has a great opportunity with its skill to design and develop.

William Kimberley
EDITOR

"WE NEED INNOVATION, NOT PLANTING TREES"

Mercedes engine guru says climate crisis presents motorsport with a great opportunity to lead the way. By **Mark Skewis**

ANDY COWELL, the former MD of Mercedes-AMG High Performance Powertrains, has urged motorsport's key players to set ambitious targets in order to survive a turbulent period for the industry, saying: "We need innovation, not just planting trees."

Speaking in the Motorsport Industry Association's Energy-Efficient Motorsport Conference (EEMS), Cowell acknowledged that motorsport must react to the global climate challenge. But he suggested that it is well placed to play a leading role in identifying solutions – for wider industries, as well as motor racing.

"I think there is a great opportunity for this industry," Cowell stressed. "The great thing about this industry is that we shoot for the stars. If you hit a target first time, it's probably because it was set too low; as motorsport engineers, we don't do that. We are looking for breakthrough technology. We make the impossible, possible."

The conference was held against a backdrop of uncertainty over the future direction of the automotive industry. Although Formula 1 has committed to continued use of "emotive" internal combustion engines, there is presently no one clear technology pathway: many governments once encouraged hybrids but now champion Battery Electric Vehicles, while hydrogen and e-fuels are also touted as solutions.

A recurrent theme amongst the speakers was the recognition that the future direction is currently being dictated by political considerations, rather than technical ones.

Cowell told the conference he was inspired and encouraged by the challenges facing the industry.

ABOVE Just when you thought you were done with Zoom, the MIA conjured an impressive array of speakers

"Bill Gates said that achieving net-zero will be humanity's greatest ever achievement," he said. "It will require innovation effort on a scale the world has never seen. His key comment was that the solution wasn't to stop doing all the things we do today in our society, it is to innovate. At which point the motorsport world has got a great opportunity, because it is all about quick, competitive innovation."

In his role with Mercedes-AMG, Cowell was instrumental in F1's march towards the impressive figure of greater than 50 per cent thermal efficiency from its V6 hybrid engines.

"I've heard people refer to the V6 and ERS powertrain as 'miraculous'," Cowell said. "They are not miraculous. There is no 'unobtainium' within them. They are created from relentless and obsessive hard work.

"The motorsport industry is a mighty innovator of energy-efficient systems. The real magic is turning those crazy ideas into real hardware that fits together, works efficiently.

> *"We are looking for breakthrough technology. We make the impossible, possible"*

"The F1 innovation environment is fuelled by that innate, primal desire to be a winner and the desire to survive, to create lap time-reducing ideas that are developed and successfully raced quicker than your opponents," he noted. "Every aspect is obsessively studied to gain understanding, to generate ideas that help improve efficiency and reduce those dreaded losses."

Cowell noted that while the wider automotive industry is coming to terms with electrification, Formula 1 engineers now have more than a decade's experience of hybrid technology. He admitted that the challenge of those first KERS systems, introduced to the sport back in 2009, had been "immense" for a generation of engineers who at that time had zero experience of working with high-voltage systems. At the same time, he said, the manner in which teams had tackled those problems was indicative of the strength of the industry.

He related a tale of his time at Mercedes-AMG, which has dominated the hybrid era with seven successive drivers' and constructors' titles, revealing how the engineering team would always challenge itself to reach new heights with the 'BHAG' slogan: setting a "Big Hairy Audacious Goal".

Addressing the part motorsport could play in helping solve the wider climate crisis, he insisted the BHAG philosophy had a role to play. "Right now, we need a big achievement," he said, "because we are in a race against time." RT

"Set teams a CO2 target…"

PICKING up on Andy Cowell's opinion that motorsport rules should be more imaginative, former Audi engine supremo Ulrich Baretzky produced one of the boldest suggestions of the EEMS conference: "Set teams a CO2 target!"

"Andy said we should have rules that work for every demand, be it electric, e-fuel, whatever," said Baretzky. "So why not give an amount of CO2 that you can use for your racecar every year – it may be on the track, or in its production.

"Then it's up to the teams to use it wherever they want, but at the end, the overall amount is limited.

"This will lead immediately to very interesting technologies," he predicted. "Expensive, yes, but the money would be very well invested." RT

BELOW It was pointed out that the obsessive nature of motorsport's finest brains could and should be tackling the technical solutions required amid the climate crisis

Impact Data Recorder to revolutionise grassroots motorsport

THE FIA has developed a new low-cost Impact Data Recorder (IDR), a major advancement in its effort to reduce fatal accidents around the world and improve safety in grassroots motor sport.

Developed by the FIA Safety Department in collaboration with AiM Technologies in the UK, the new IDR is a fraction of the price of the current Accident Data Recorder (ADR), which is used in top-flight championships such as Formula 1 and the World Rally Championship. Due to the cost of ADRs, they are currently only fitted to less than one per cent of racing cars around the world.

The FIA is encouraging all National Sporting Authorities (ASNs) to incorporate these devices into their grassroots championships. Graham Stoker, FIA Deputy President for Sport, said: "This is a remarkable opportunity to improve safety in grassroots sport worldwide. We have created an affordable data recorder using modern technology that can be used in any championship and we want everyone in the pyramid to fit this to their competition vehicles. Ultimately using an IDR has to become part of the safety system in the vehicle, like putting on gloves or wearing a helmet."

One of the primary objectives of the FIA Safety Department is to learn through the study of serious accidents how best to reduce the risk of fatal injuries. To do this, researchers rely on data to determine the most effective way to improve survivability.

Worldwide accident data collected by the FIA shows that 99 per cent of fatal accidents occur in amateur-level motorsport and contain no accident data recording. This makes it very difficult to attain a detailed understanding of the crash sequence and to learn from an accident to improve safety for the future.

This is why the FIA Safety Department developed a product that can easily record data to analyse accidents but at a very low cost to the competitor. It was also designed to be easy to install and can be operated without the need of special technical support.

> *"Using an IDR has to become like putting on gloves or wearing a helmet"*

The result is a small and novel device, measuring just 6 cm and weighing 12 grams, that will not interrupt drivers. Housed in a smart polymer casing, the IDR requires no wiring or mounting with its simple 'fit and forget' adhesion installation. It requires no maintenance and its internal battery is capable of recording over 80 incidents during its two-year lifespan. The device instantly records all high G impact data and is also programmed to capture all secondary impact data.

The IDR is part of a system that will include a secure access mobile application, allowing impact data to be downloaded from the IDR, stored securely on a cloud server and then distributed to the owning ASN. The app enables the user to not only download the impact data but also submit supplementary information such as driver details, vehicle details, incident photographs and additional information. The reporting functionality offered by the app allows the ASN to gain a better perspective of every incident through more thorough incident reporting and accompanying impact information, all being held in one database.

IDRs offer many benefits to ASNs, circuits and drivers, including the possibility of reduced insurance premiums, more track time and identifying trends that may lead to the refinement of cars, circuits and safety equipment.

Adam Baker, FIA Safety Director, said: "By utilising recent advancements in consumer electronics we have been able to achieve a very low-cost device, making it possible for widescale adoption in grassroots competition. We encourage all ASNs to integrate this innovative new data recorder into their range of safety devices." RT

ABOVE The IDR is part of a system that could transform the way accident data is reported

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Audi poised for WRC comeback

AUDI'S legendary Quattro could return to the FIA World Rally Championship in a new project spearheaded by former DTM and World Rallycross Champion Mattias Ekström.

Ekström's newly-formed EKS JC team is developing a Rally2-specification Quattro A1, which would be suitable for the WRC2 and WRC3 support categories.

The car has been built to FIA regulations in co-operation with South African company Rally Technic and the team confirmed it would be eligible for WRC competition.

"When the new generation of Audi A1 was launched, we knew we wanted to build something out of it," said Ekström. "And since everyone knows my passion for rallying, it quickly became clear that we would build a rally car.

ABOVE & BELOW
The Quattro name could enter rallying's second tier using a 'Rally2 kit'

"The car is ready. It's just the set-up work left. We need to do some test kilometres and gather the information. There is no real set date for it, but it is quite clear we will see the car in some competitions in spring/summer.

"For now, this car is just for our own use, but when we will be satisfied with its performance, we will offer it for rent or purchase to other competitors," he added.

The four-wheel drive Quattro A1 has a 1.6-litre turbocharged engine which puts out 263 bhp and is paired with a five-speed sequential gearbox. The project is thought to use a version of French firm ORECA's original FIA R4 kit concept.

EKS JC team manager Joel Christoffersson said testing would begin on snow and gravel before switching to asphalt. Former FIA Junior WRC champion Emil Bergkvist will be the development driver.

"The Rally2 kit provides a unique price-performance balance for competitors," said Rally Technic director Chris Coertsee. "But it is also combined with a legendary brand and a glorious body kit."

Ekström has long-been associated with Audi in motorsport. He drove an S1 in the FIA World Rallycross Championship from 2014 to 2019. He won the title in 2016 and finished runner-up the following two seasons.

The Swede made a WRC return at last month's Arctic Rally Finland after almost 15 years away. He finished fifth in WRC3 in a Škoda Fabia.

Audi revolutionised rallying in the early 1980s with its turbocharged four-wheel drive Quattro. When the fire-breathing Group B era was introduced in 1982, the 370 bhp A1 was soon at the forefront of the new generation.

It made its WRC debut in 1983 at Rallye Monte-Carlo but only started four rallies as a works car before it was succeeded by the A2 version. Hannu Mikkola drove it to wins in Sweden and Portugal and went on to win the drivers' world title that season.

Audi and its Quattro departed the WRC as a factory team in 1987 after scoring 24 wins from 58 rallies. The Quattro remains probably the most important rally car in WRC history. RT

LEFT Push-to-Pass scenarios were simulated running in a pack at IMS

IndyCar

IndyCar tests ahead of hybrid switch

THE NTT IndyCar Series has stepped up its preparation for an engine configuration change in 2023, which includes hybrid technology, by testing a Push-to-Pass system at Indianapolis Motor Speedway.

Push-to-Pass, used in IndyCar on road courses and street circuits since 2009, gives drivers a short horsepower boost that assists with overtaking. It has never been used in an oval-track race and while it has been tested three times over the years at such venues, this was its first experience at the iconic 2.5-mile IMS.

Four drivers, led by six-time champion Scott Dixon, participated in the simulation of how Push-to-Pass could be used with the new 2.4-litre, twin-turbocharged V6 powerplant that will debut in 2023.

IndyCar President Jay Frye reiterated this was one of many tests to be held before the engine configuration is used in competition.

"When we came into (this test) we thought this would precipitate more questions than answers, and that's probably what happened, which is fine," Frye said. "We're looking at how (racing) could look in 2023 with the new hybrid system coming in."

The hybrid component features a Kinetic Energy Recovery System (KERS) that generates, stores and repurposes energy, which will be used for Push-to-Pass on road courses and street circuits – and maybe even ovals if that's deemed the path to take.

The drivers spent more than two hours running in a pack to simulate race conditions. They were given different variables for each 20-lap run, with some Push-to-Pass durations choreographed to span as little as five seconds, others more. Each duration changed the speed at which the cars reached the end of IMS' long straightaways, with ranges from 230 mph to 236 mph, Frye said in an example.

The drivers reported that they could feel the difference. "It's interesting," Alexander Rossi said. "You really feel (Push-to-Pass) deactivate, but you *certainly* feel it come in. It's pretty cool. It's like, 'I'd like this power all of the time.'"

Frye said the drivers preferred the shorter durations, which was good information to learn.

"SOME 'OH CRAP' MOMENTS!"

"It's a lot of power, and some of the durations were quite long," Dixon said. "Ten seconds of (it is) probably 50, 60, 70 horsepower, especially on a car that's trimmed out, and your average lap speed can jump by several miles per hour. With the draft, you arrive at the corner 10 mph faster than normal, and I think we all had some, 'Oh crap!' moments because it's not what we're use to.

"I'm not a big fan of overtake on a super-speedway because we're all very vulnerable and sometimes crazy situations (arise) that aren't necessarily good and might make the racing worse. It's going to raise the speed and abuse the tyres, so there are lots of questions to answer."

IndyCar Series cars are in line for a horsepower increase in 2023 as the new engine can produce an estimated 100 horsepower more than the current 2.2-litre configuration. The KERS system can add another 100 horsepower, although Frye stressed all that increase might not happen at once.

"We tried to simulate how it could work," Frye said, adding that testing on the new engines is expected in early 2022.

Previous oval Push-to-Pass tests were held at Pocono Raceway, Phoenix Raceway and World Wide Technology Raceway, but those were with a previous generation of the Push-to-Pass system.

Josef Newgarden said this is one of the many options IndyCar has for the future: "The horsepower bump is (adjustable) – you can turn the boost up or down. So, that jump in performance off the corner can be bigger or smaller, and the length of (the Push-to-Pass) is adjustable. We ran through a couple of scenarios, a couple of configurations. It's definitely noticeable.

"It's just a matter of preference and what's the right configuration to give to the field. That's the type of info we were trying to arm IndyCar with, and now it's on to them to dissect that information and see what we do in the future." RT

GCK to develop its own fuel cell system

FRENCH company Green Corp Konnection (GCK) has chosen to join forces with FEV – a leading engineering supplier globally – to design, develop and integrate its own high-performance fuel cell system.

Its capacity will be showcased in motorsport before being deployed across other industrial areas.

This announcement reinforces GCK's commitment to playing a key role in the transformation towards zero emission mobility.

The two companies will develop an onboard fuel cell system with an output of 200 kilowatts (kW), one of the most powerful on the market. Green Corp Konnection will be the first user of the latest generation of stacks produced by EKPO Fuel Cell Technologies, a joint venture between ElringKlinger and Plastic Omnium specializing in the development and industrialization of hydrogen fuel cells for mobility.

The GCK fuel cell system will, it says, offer a unique level of power and energy density, even enabling its integration into the lightest vehicles. With cooling, compression and voltage conversion solutions adapted to this power level, the fuel cell system is aimed at meeting the growing needs for hydrogen systems in all sectors across the mobility market, from trucks, to buses and industrial equipment.

For over 20 years, FEV has demonstrated its experience in fuel cell system development on various major projects. The company's services include the development and design, build, vehicle integration, commissioning, calibration as well as testing of components and complete fuel cell systems. Their application can range from passenger cars to commercial trucks and railroad trains.

ABOVE & BELOW Fuel cell development is a key part of GCK Motorsport's ambitious Dakar plans

The fuel cell system development is a key component to GCK Motorsport's breakthrough project, launched during the Dakar Rally last January. Led by Guerlain Chicherit and now supported by FEV, GCK's sport and media flagship will become the first team to present a hydrogen-powered cross-country vehicle at Dakar 2022 before competing in the race in 2023, thus supporting Rally Dakar organizer ASO in its desire to promote an environmentally sustainable event.

Eric Boudot, CEO of GCK, commented: "We are delighted to have a leading partner in FEV to join us on this huge challenge. This historic step in the life of our company perfectly illustrates our mission to develop technological solutions to meet the growing demand for the integration of green energy in the field of mobility."

"Thanks to more than 20 years' experience in the field of hydrogen related technologies, FEV is driving numerous projects on a European and global level when it comes to the transformation of the mobility sector towards CO2-neutrality," said Nadim Andraos, Executive Vice President for FEV in France, Spain and North Africa.

"We are facing one of the great human and technological adventures and will make sure to support GCK's participation in the Dakar Rally with a hydrogen-powered vehicle with all our passion, expertise and infrastructure."

Porsche AG

"Track-to-road" boost for Gen3

FORMULA E's transition to its Gen 3 era has been boosted by commitments from Porsche and Nissan.

However, it wasn't just the manufacturers' pledge that was important, so much as their explanations for the move. Where BMW caused a stir before Christmas, announcing its withdrawal because it had 'exhausted' the R&D opportunities offered by the all-electric series, Nissan and Porsche sounded a very different mood music.

"We entered the sport with a 'road-to-track' technical transfer approach, and by extending our racing programme through the Gen3 era, we have the opportunity to close the circle with 'track-to-road' technical transfer," explained Tommaso Volpe, Nissan Global Motorsport Director.

ABOVE Porsche and Nissan both endorsed Formula E's ability to act as a proving ground for tech transfer

"We believe that, as one of the most global manufacturers involved in the ABB FIA Formula E World Championship, this sport is the perfect platform to promote our expertise in electrification and demonstrate our commitment to more sustainable mobility solutions."

As part of its goal to achieve carbon neutrality across its operations and the life cycle of its products by 2050, Nissan intends to electrify all new vehicle offerings by the early 2030s.

Porsche was similarly pointed with its comments, insisting that it "believed" in the future of Formula E.

"From our point of view, it offers the most competitive environment to advance the development of high-performance vehicles with a focus on eco-friendliness, energy efficiency and sustainability," said Fritz Enzinger, Vice President Porsche Motorsport and Senior Vice President Group Motorsport Volkswagen AG.

"It was important for us that the DNA of Formula E, which has made the championship so successful, was preserved. That's happened. At the same time, we see potential to take Formula E to the next level from a sporting and technological point of view."

"Ahead of another important technical milestone for the ABB FIA Formula E World Championship, I'm glad that Porsche has committed to the next era," said Jean Todt, President of the FIA. "Being lighter, more powerful, with faster charging, the Gen3 race car will further establish the discipline as the pinnacle of electric racing. It's also the confirmation that Formula E is the right platform to promote manufacturers' expertise in electrification and demonstrate our shared commitment to more sustainable mobility solutions." RT

Grosjean accident to drive research

RESEARCH into new technologies that can improve fire extinguishing media and firefighting equipment are among a raft of recommendations to emerge from the investigation into Romain Grosjean's fiery crash at last season's Bahrain Grand Prix.

Analysis by the FIA, the governing body, identified more than 20 areas in which safety can be improved. These include changes to the cars, barriers, circuits, driver safety equipment and medical response.

While the impact force was higher than the FIA initially suggested in the immediate aftermath of the accident, at 67G compared to 53G, the actual impact speed turned out to be lower, at 119 mph rather than 137 mph.

The report said that the force of the impact caused the middle rail of the barrier to fail, and "significant deformation" of the upper and lower rails.

The fire was caused by fuel escaping as a result of the dislodging of the fuel hatch on the left-hand side of the chassis and the fact that the engine fuel supply connection was torn from the tank's safety bladder.

Grosjean was immersed in the flames for 27 seconds.

FIA President Jean Todt said: "Important learnings have been drawn from these investigations that will drive our continuous mission to improve safety in Formula 1 and global motorsport. The enduring commitment of the FIA, particularly the Safety Department, on reducing risks associated with motorsport enabled Romain Grosjean to maintain consciousness and survive an accident of this magnitude. Safety is and will remain FIA's top priority."

FIA Safety Director Adam Baker said: "Incidents involving fire of this scale are thankfully rare, so it is very important to learn what we can, including the interaction with the [car's] high-voltage system."

Among the areas where changes will be made are: the geometry of the front of the car's survival cell and additional load tests; head restraints aimed at ensuring they do not impede driver egress; engine mounting and fuel cell installations; reviews of barrier design and positioning; and updating medical intervention equipment, including fire extinguishers.

There will also be further research into a number of areas including warning systems, and improving existing barriers and fire equipment, as well as new barrier systems. RT

Race Of Champions to showcase new tech

THE 2022 Race Of Champions will see stars from different race disciplines go head-to-head in both electric and biofuel rallycross cars.

The Race Of Champions was the first major international motorsport event to introduce electric race cars back in 2010, and is aiming to be fully sustainable and carbon-neutral next year.

As such, the multi-discipline event's bill will feature the new FIA RX2e Championship car, developed by Olsbergs MSE and QEV Technologies.

"From what we have seen during the first tests, this brand-new electric rallycross car has very impressive torque and overall performance," said Fredrik Johnsson, President and Co-Founder of the event. "I'm confident that the RX2e car will be a spectacular addition. The many star drivers at Race Of Champions will love pushing this electric car to its limits as they compete head-to-head to prove that they are the fastest!"

During testing, the RX2e car – built around a spaceframe chassis and incorporating two independent powertrains alongside a 30 kWh battery – has routinely wowed drivers with its instant torque and power.

It was recently announced that AP Racing has been selected to supply front and rear braking to the FIA RX2e Championship, which will support the FIA World Rallycross Championship at six European events in 2021.

For the first time in the event's history, the Supercar Lites rallycross cars – a regular feature on the bill –will run on 105 Octane 100% fossil-free biofuel. The move is the result of a collaboration between Olsbergs MSE and P1 Performance Fuels.

Martin Popilka, CEO, P1 Racing Fuels, said: "We have been working on this exciting project together with OMSE for many years, and to see it finally come to life is immensely rewarding. Like the automotive industry and the world in general, motorsport needs to move with the times and that means adapting for a more sustainable and environmentally-friendly future."

Pite Havsbad in Sweden will play host to the event for the next five years on a specially-designed circuit built on the frozen Baltic Sea, just 60 miles south of the Arctic Circle – making the forthcoming edition Race Of Champions' first venture onto the ice.

BELOW The RX2e car will be a spectacular addition to the Race Of Champions

Electric and ICE to race together in British rallycross

ELECTRIC and Internal Combustion Engine cars will go wheel-to-wheel on the same racetrack in the British Rallycross Championship 5 Nations Trophy, which is introducing electric cars into its top-tier Supercar category.

The series is adopting the STARD kit, developed by former WRC star Manfred Stohl's operation in Austria, which underpinned last year's inaugural Projekt E series on the World Rallycross Championship's supporting bill.

The Andros Trophy winter series was the first to successfully integrate electric and ICE cars into the same race and last year Stohl won rounds of the Austrian Rallycross Championship in a STARD-built electric Ford Fiesta ERX. Holten Motorsport campaigned a similar machine in Norwegian Rallycross Championship rounds. The concept is also being adopted by national championships in Germany, Hungary, Italy and elsewhere.

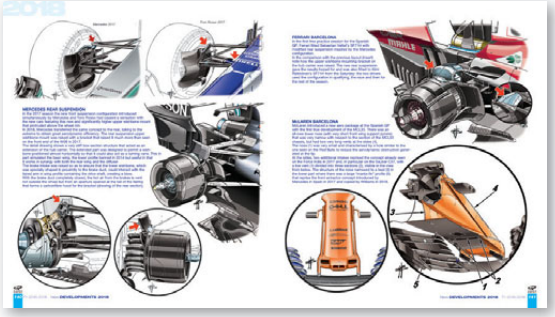
The four-wheel-drive, three-motor, 450 kW, 1,000 Nm torque machines deliver comparable performance to existing 600 bhp Supercars. But they will face stiff competition in a UK series acknowledged to be one of the strongest domestic championships. The STARD ERX powertrain has been designed to be retro-fitted to existing Supercars.

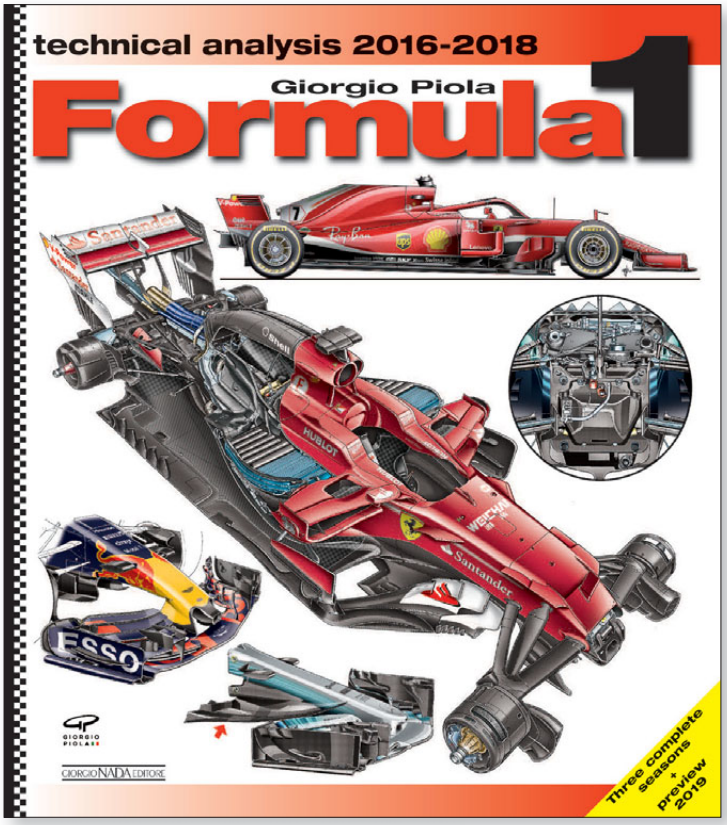
"Rallycross lends itself so well to the next era of motorsport," said Championship Coordinator Hannah Rynston. "To be the first in the UK to combine the two types of power is very exciting."

Giorgio Piola

NEW

FORMULA 1
2016-2018 Technical Analysis
(with 2019 preview)





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THE last edition of an automotive literary classic: the technical analysis of Formula 1 penned by Giorgio Piola. After 25 years of publication, the historic draughtsman brings the curtain down on this experience with a volume that examines the last three seasons, from 2016 to 2018, as always reviewing the principal technical innovations in the spheres of chassis and engine design. This three-year analysis is appropriately completed with a retrospective of some of Piola's most important drawings from a 50-year career that began back in 1969.

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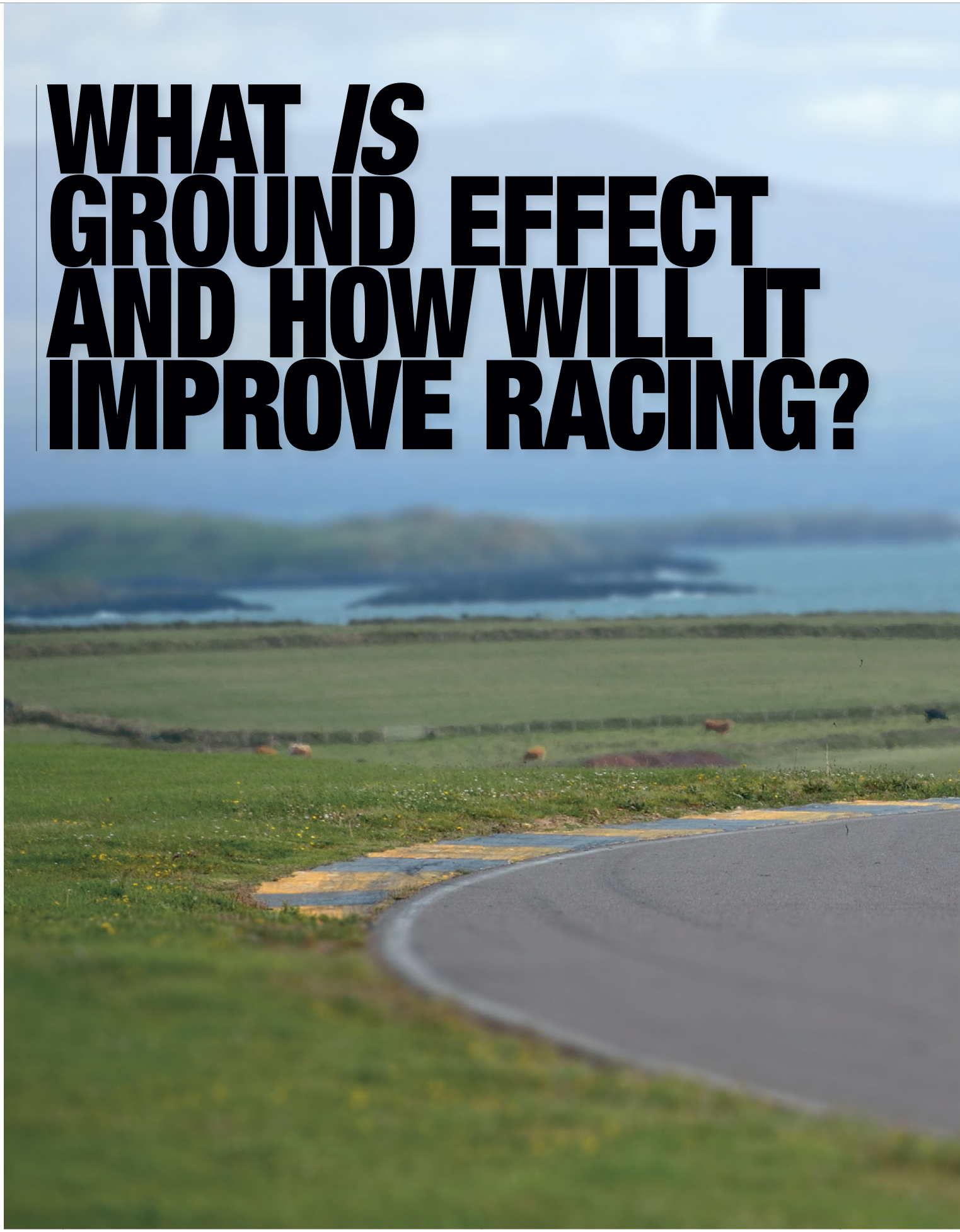
WHAT *IS* GROUND EFFECT AND HOW WILL IT IMPROVE RACING?



Ground effect returns to Formula 1 next season, in a new generation of cars conceived to deliver more overtaking. Renowned F1 aerodynamicist **Willem Toet** explores the ramifications

GROUND EFFECT was used to great effect in the late 1970s and early '80s. The shaped sidepods that took advantage of it, however, were banned during the '80s with the introduction of 'flat floor' regulations. The phenomenon returns to F1 in 2022 as part of an aerodynamic overhaul of the sport.

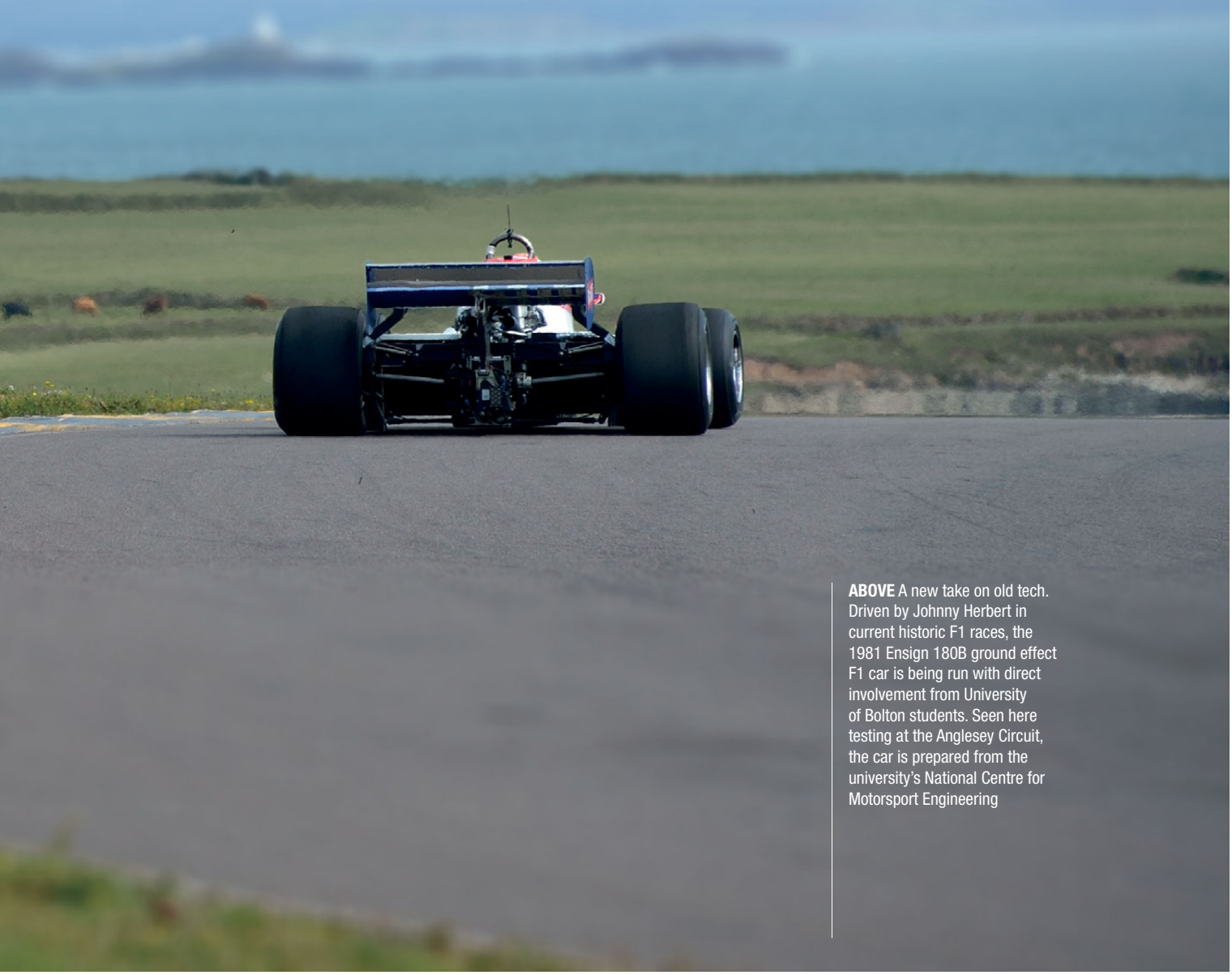
To get our heads around ground effect properly, we first need to understand some properties of air. Air molecules move around a lot and interact with one another. On average they travel fast – about 1,000 mph – and they travel over 200 times their "interaction" size before bouncing off another molecule. Molecules are tiny: their direct sphere of influence stretches to about $3 * 10^{-10}$ metres (0.0000003 mm).

In truth, individual molecules don't move very far – they tend to bounce around close to home – but there is significant mixing created by the large (relative) distances the molecules move between interactions. The speed of sound is related to both the speed molecules travel and the time/distance between interactions. The speed of travel is related to temperature. So, air is simple in some ways and deliciously complex in others.

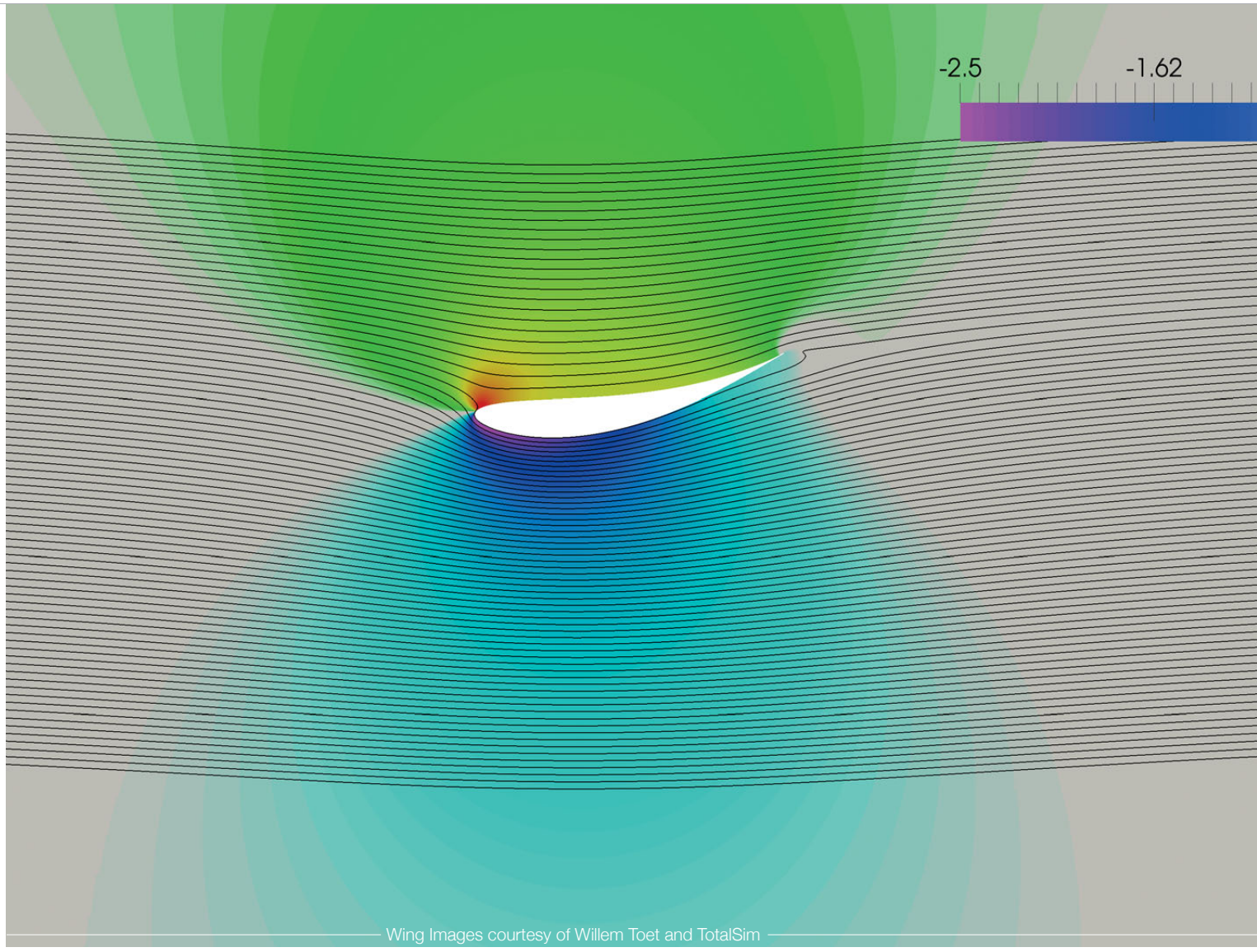
PUNCHING THROUGH AIR

When a body punches through the air, it deflects tiny parcels of air and that deflection influences what the air is doing quite far from the body. Tiny parcels are much bigger than molecules and behave in a smoother, simpler manner in still air.

Let's start with an aerofoil. Now I'm a motorsport person, so my aerofoil may be upside down if you are into aeroplanes… ▶



ABOVE A new take on old tech. Driven by Johnny Herbert in current historic F1 races, the 1981 Ensign 180B ground effect F1 car is being run with direct involvement from University of Bolton students. Seen here testing at the Anglesey Circuit, the car is prepared from the university's National Centre for Motorsport Engineering

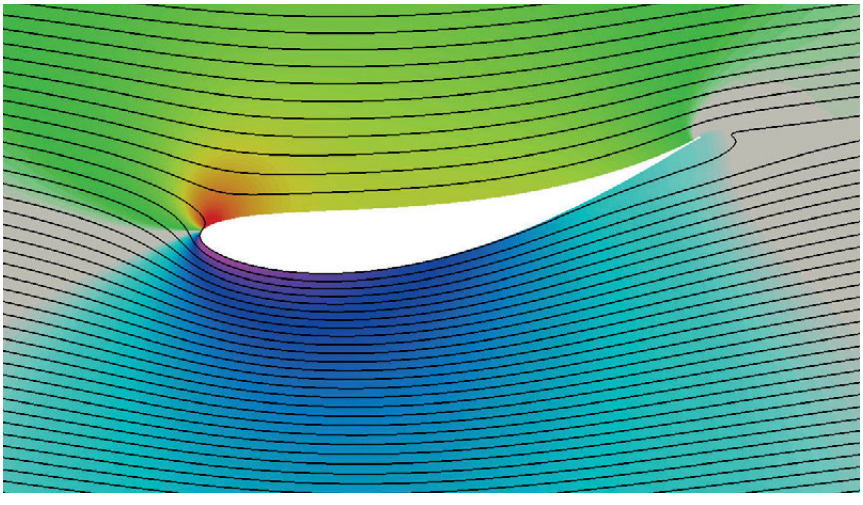


Wing Images courtesy of Willem Toet and TotalSim

Each black line (**above**) represents where the air will travel relative to the wing if you follow it over time. The lines are hard to see but you do see that even those furthest away from the wing are still being influenced by it. The colours represent the change in pressure relative to ambient pressure far from the wing.

So, from the pressures too we see that the air very far from our wing is affected. Green to red represents an increase in pressure, while blue to purple represents a reduction in air pressure.

Zooming into the picture (**below**) shows the curvature of "streamlines". There is a lot of free space in all directions around the wing (and this image of it).



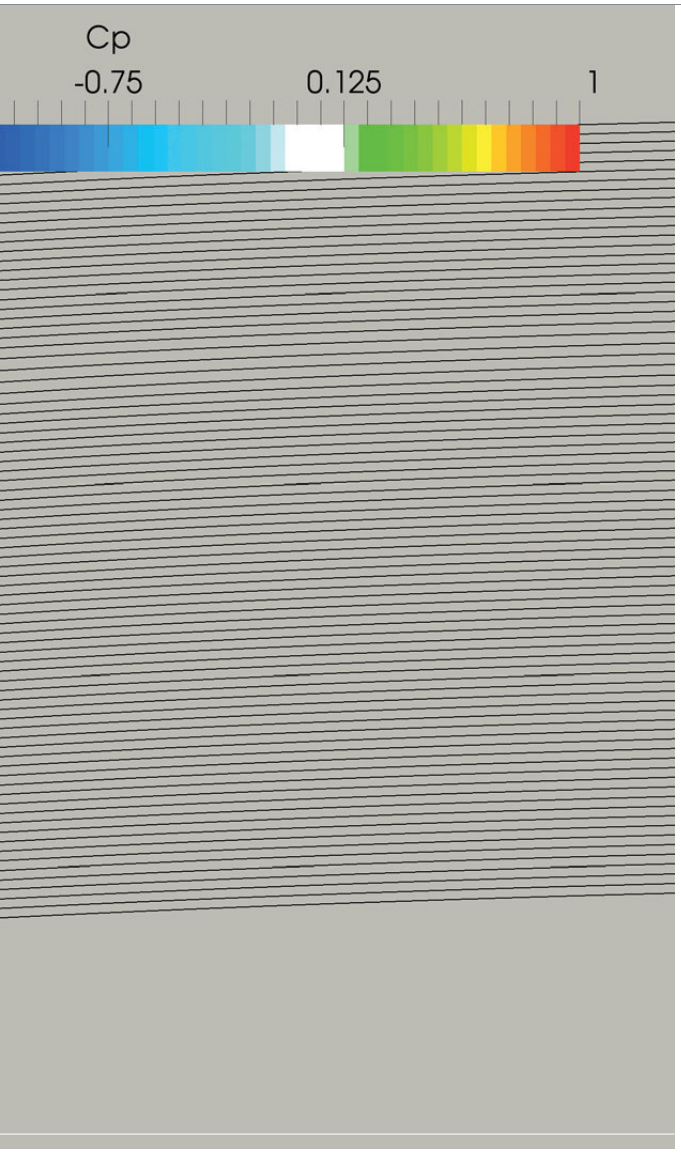
If, rather than moving this wing in air far from the ground, we move it along close to the ground, the air cannot move as it did in "free stream" conditions.

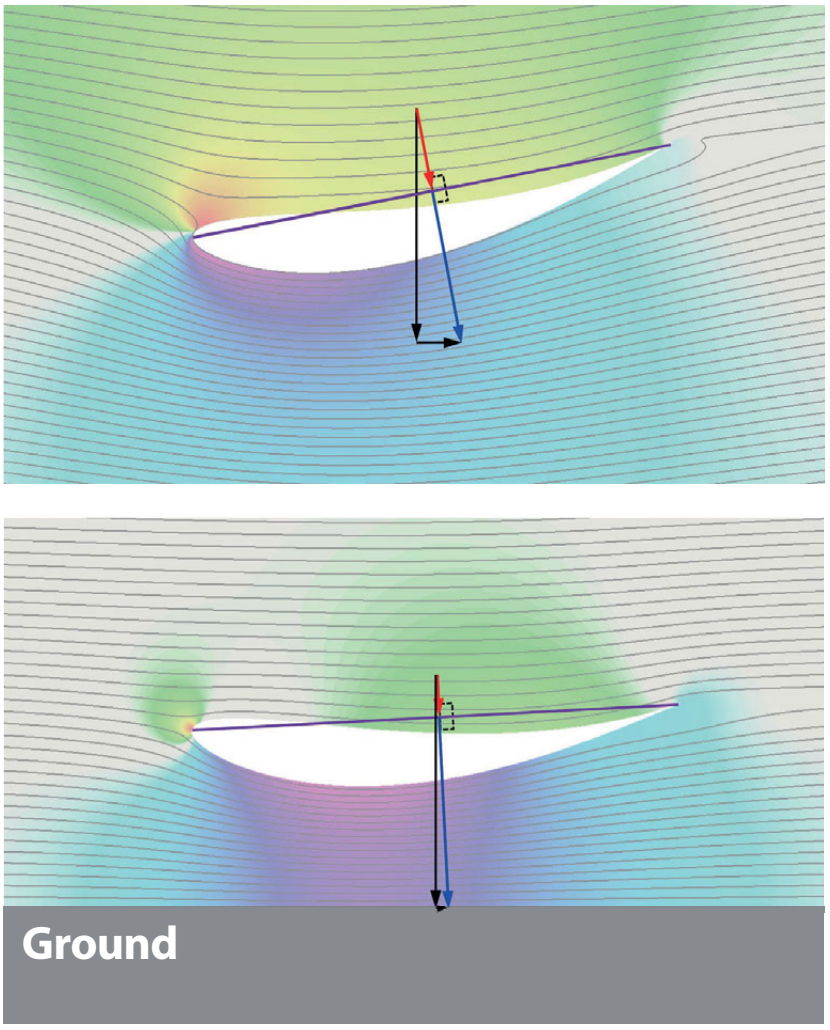
A wing at the same angle but now close to the ground (zoomed and the ground is the bottom of the picture, **opposite**) shows that there is a change in the pressures acting on and around the wing.

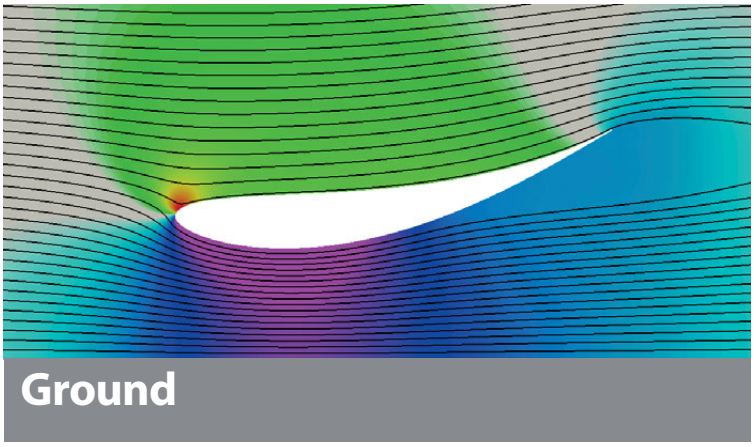
When a body moves close to the ground the air is squeezed and, in this case (shape-dependent), accelerated more than in free stream, so more pressure-induced force is created.

SAME DOWNFORCE, LESS DRAG

We can take advantage of this fact. To produce the same force as our wing in free stream, we can take the same wing, reduce its angle, and run it close to the ground. We have the same downforce but less drag. Why? Well, the net forces







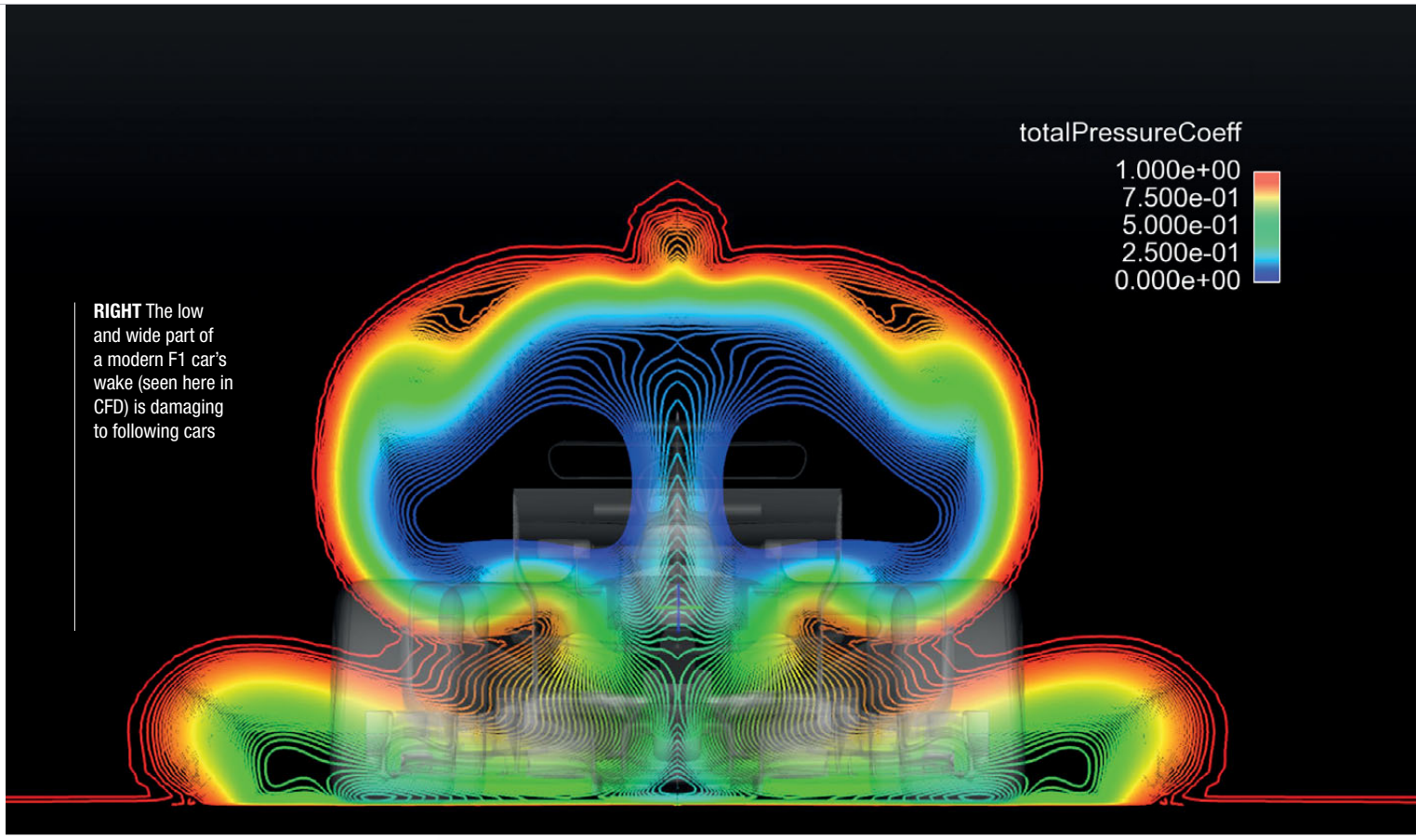
act in a different direction. The resistance to motion of our wing (aerodynamic drag) comes from two main sources. One is like a friction force (the wing rubbing against the air), but we will focus on the other. That is pressure drag and comes from the sum of all the pressures acting on the wing.

Mathematically we can integrate (add up) all the pressure forces acting on the wing and express them as a single force vector. To picture this, let's simplify our wing shape and the pressures acting on it. We won't worry about where the force is acting, as the impact of that can be managed and it does not change our discussion.

If we pretend that our wing is a thin flat plate, then pressures can only act on the upper and lower surfaces and normal to the surfaces (in the direction of the surface). The resulting force vector can be divided into the part creating vertical (downward) force and the part creating horizontal force (drag). This wing is in free stream. You can see the curved flow lines at the bottom of the cropped image (**top**).

The same wing, at a lower angle working in ground effect, (**above**) has less pressure increase above it and more pressure reduction below. It produces the same downforce but generates less drag force, which you can see from the force vectors. This, in a nutshell, is ground effect. For racecars this means that downforce generated by the surfaces facing the ground is more efficient than, for example, a rear wing which is "far" from the ground.

If you flip the wing back to the "correct" way up for aircraft and for birds, there is the same conceptual benefit in terms of lift-to-drag improvement when operating close to the ground. Heavy birds use it to take off more efficiently when taking off over water; aircraft also use it to assist with take-off. ▶



RIGHT The low and wide part of a modern F1 car's wake (seen here in CFD) is damaging to following cars

HOW WILL GROUND EFFECT HELP?

But how will ground effect help F1 and can we learn something from the earlier ground effect generation?

F1 rules have been changed many times over the years. Any amendments relating to aerodynamics have usually attempted to limit the downforce being produced.

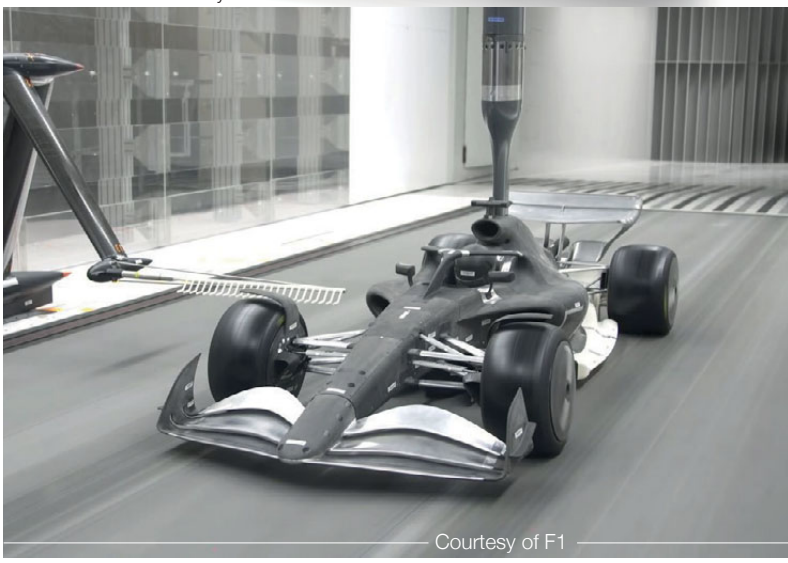
Rule changes for 2019, and also alterations coming in for 2021, are part of the "normal" trend trying to reduce downforce (or at least reduce the rate of increase of downforce). It hasn't worked in the longer term – aerodynamic forces make such a massive difference to the performance of F1 cars that teams have invested ever more resource into aero research.

One rule change that went the other way and taught us a lot was 2017. More freedom was given to teams in areas such as the volume beside the middle of the chassis (bargeboard area). Those of us able to look at the impact saw a big improvement in performance but a widening of the dirty air wakes of the cars. We all knew this would happen; research done in the past, which led to the removal of large bargeboards in 2009, showed exactly this trend.

Aerodynamics allow F1 cars to increase average speed around a lap of a typical F1 circuit by more than 25%. However, in so doing they are creating such a mass of "dirty" air (disturbed and dragged forward by the car) that a ▶

Courtesy of F1

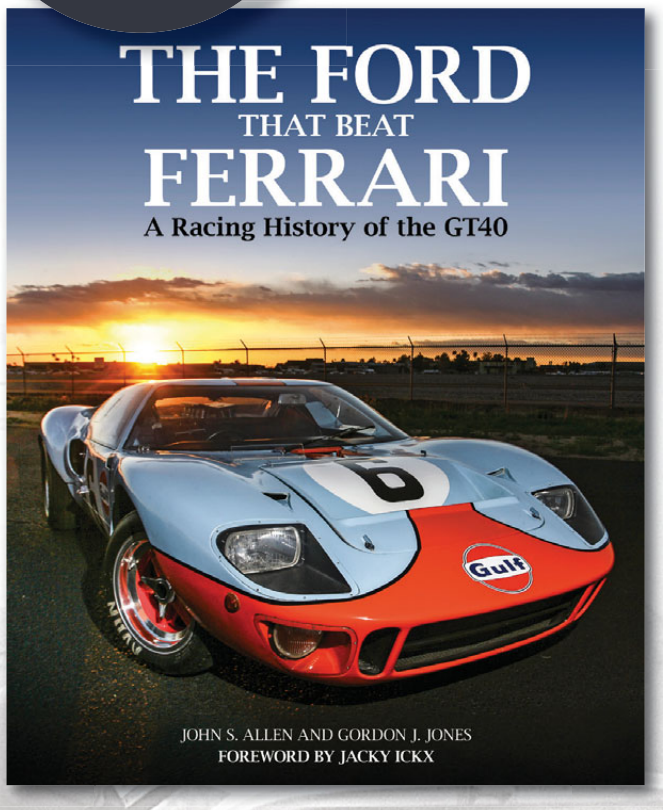
ABOVE The next generation of cars could look spectacular



RIGHT A wind tunnel model of a car designed to the proposed 2022 regulations

Courtesy of F1

The Ford That Beat Ferrari



THE Ford GT40 was without doubt the most impressive of all Ford racing cars, a car which caught the imagination of everyone during the 1960s and subsequent years – a classic car from the Golden Age of sports car racing.

The racing history of every GT40 chassis is traced in pictures between 1964 and 1971. We see the development of the first works cars at FAV, Shelby and Alan Mann, the rise of the 7 litre Mark II and its successes followed by the all-conquering Mark IV.

The works car, though, are only half the story. The majority of cars were raced by private teams and every major team and private entrant is portrayed.

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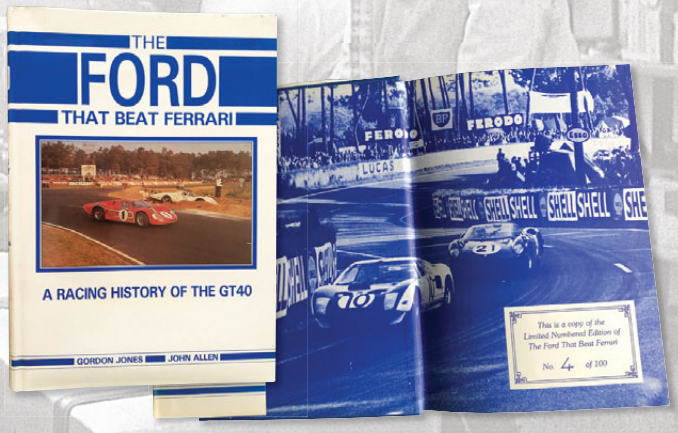

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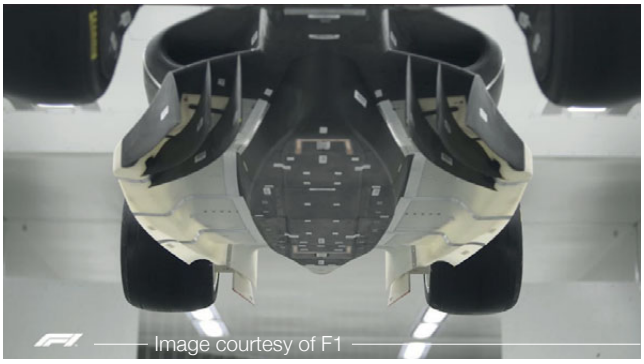
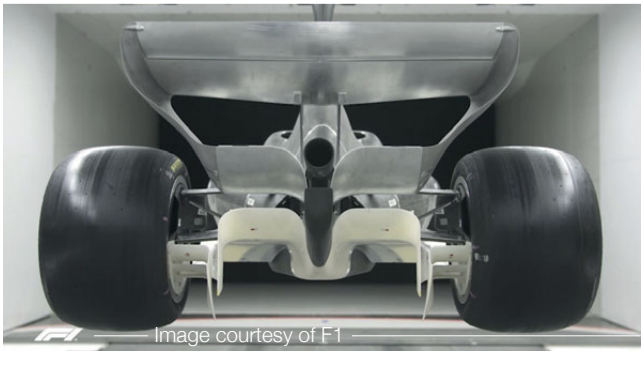
following car cannot pursue closely in corners. There, benefit on the straights cannot make up for the losses in corners.

2017 saw more freedom for aerodynamic parts on F1 cars. The result was that cars were faster, but a big part of their wakes was sent low and wide. The image at the top of page 24 shows the shape of the wake at 6 metres behind the car (which is ghosted into the image to give size and location information). The upper mushroom, influenced by upwash from the rear wing, will continue to move upwards as it dissipates. The low part hangs around and can be felt by following cars. This wide part of the wake is the main problem which makes overtaking so difficult in F1 – it has made it really challenging to get close to another car in the corners that lead to overtaking straights.

So, F1 management have, over a period of years, conducted extensive research into ways of reducing the impact of one car in front of another. Reducing downforce dramatically achieves part of the objective but would make the cars much slower.

The new rules coming in for 2022 aim to take the "wake" of the cars and direct it upward, with clean air filling the void behind the car like an elongated teardrop





ABOVE Many heavy birds use ground effect while gathering forward momentum to then eventually be able to fly

LEFT A glimpse of the 2022 model from beneath the front of the car

LEFT Looking at a model of the 2022 regulations F1 car from behind. Outwash tricks used in current F1 cars will not be permitted from 2022

LEFT Current cars have flat undersides from the rear of the front wheels to the middle of the rear wheels. These flat sections are on two levels with a 10 mm flat skid under car centreline. The new rules allow a completely three-dimensional underside

shape in plan-view. There will be a reduction in the ability to get a slingshot past another car on straights, but that will be more than compensated for by being able to race closer behind in the corners.

Ground effect as such would not help overtaking. However, reversing the banning of ground effect shapes, F1 has been able to maintain a high level of downforce and efficiency without the wide wakes induced by less direct methods of creating downforce.

Over the years, rules intended to reduce downforce were effectively circumvented with research, creating huge wakes. The new rules prevent teams from kicking airflow outward, while allowing more upwash which sends almost all of the dirty air upwards. So that is how ground effect will help future F1 cars.

This means aero teams in F1 now have a whole new area of performance to explore and exploit.

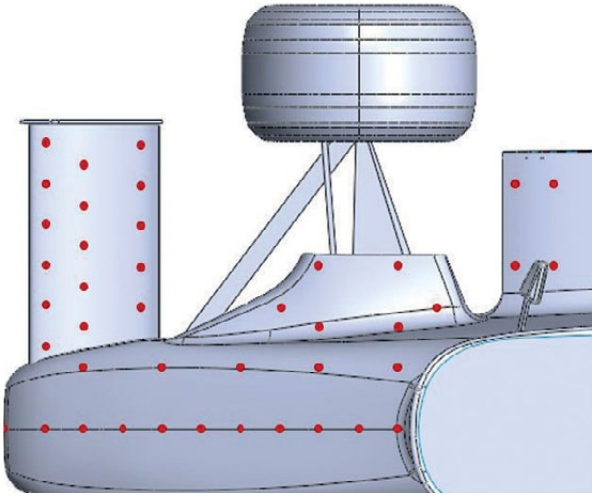
It's not just present-day aero departments who are taking a close interest in the resurrection of ground effect, but also the aerodynamicists of tomorrow. Getting original aerodynamic data from historic ground effect cars is close to impossible. However,

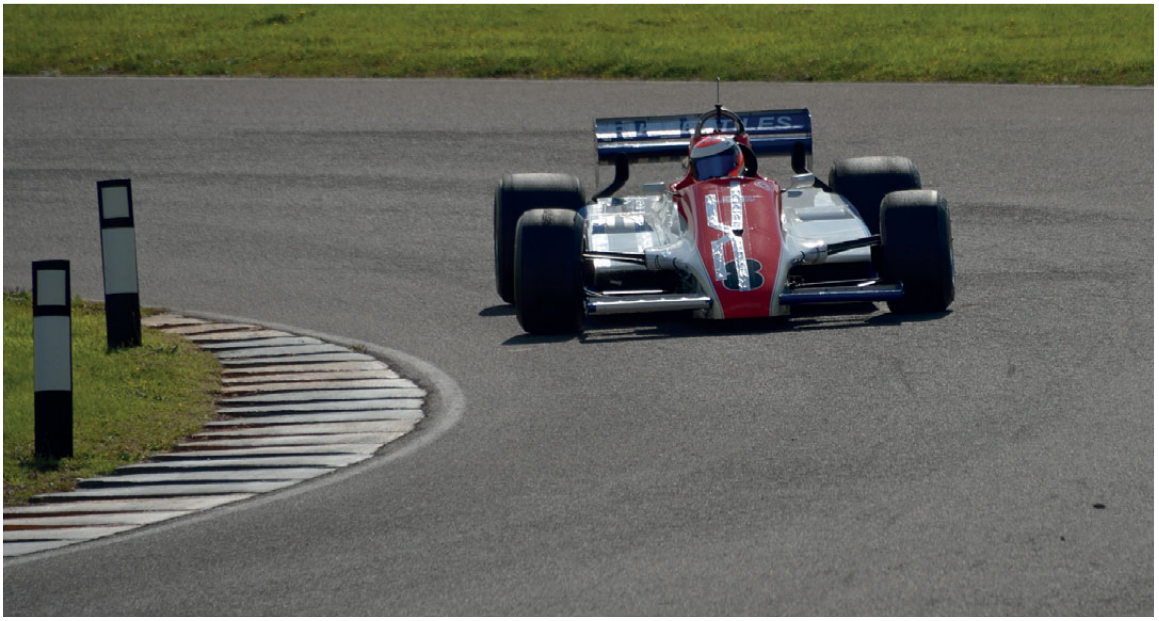
> *"A reduction in the ability to get a slingshot past another car, on straights, will be more than compensated for by being able to race closer behind in corners"*

at the University of Bolton's National Centre for Motorsport Engineering (NCME), students have scanned an Ensign 180B which is in their workshops so that a CAD model can be created. This model will then be run in CFD to gather information about flow patterns, wake structures and aerodynamic efficiency.

This may be a golden opportunity to learn from past research many of us will have forgotten. One day they hope to compare this data to cars of the 2022 generation.

And what will those new cars look like? Stunning, we think! RT





ABOVE & RIGHT NCME students are working hand-in-hand with experts to prepare and race the Ensign 180B ground effect F1 car. With the post-scanning CAD work partially done, a series of desired pressure measurement points was agreed. Sensors loaned by Evolution Measurements were then fitted to all of them for a test at Anglesey

OUT OF THE BLUE...

Chris Pickering finds out how Ricardo has responded to a request for help with a unique project that could prove a major milestone in autonomous vehicle development

THIS year could see the start of something remarkable. The Indy Autonomous Challenge, scheduled for October 23, promises to get a group of driverless cars racing wheel-to-wheel around the famous Indianapolis Motor Speedway for a top prize of $1 million. If successful, it will be the first event of its kind in the world and a major milestone in autonomous vehicle development.

The cars will all use the same mechanical package, developed by Dallara in collaboration with Clemson University's International Center for Automotive Research (CU-ICAR). This is based around the current Dallara IL-15 Indy Lights chassis, but it features a number of significant changes – enough to warrant a new chassis designation: AV-21.

Most obviously, the driver will be replaced by a set of drive-by-wire systems controlled by an onboard computer. Alongside this, comes a suite of sensors to help the robotic car find its way around the course (RADAR, LIDAR, cameras, ultrasonic and infrared sensors are all under consideration and it could well use all five).

Other links to the outside world will include car-to-car and car-to-infrastructure

ABOVE It's Indianapolis, but not as we know it. The Indy Autonomous Challenge pitches universities against each other to create software that enables self-driving Indy Lights race cars to compete in a head-to-head, high-speed autonomous vehicle race at IMS

RIGHT A familiar setting, but unfamiliar technology: the autonomous Dallara AV-21 at Indianapolis Motor Speedway

communications systems. Each of the student teams will use this package as the hardware platform for its own software, which will drive the vehicle.

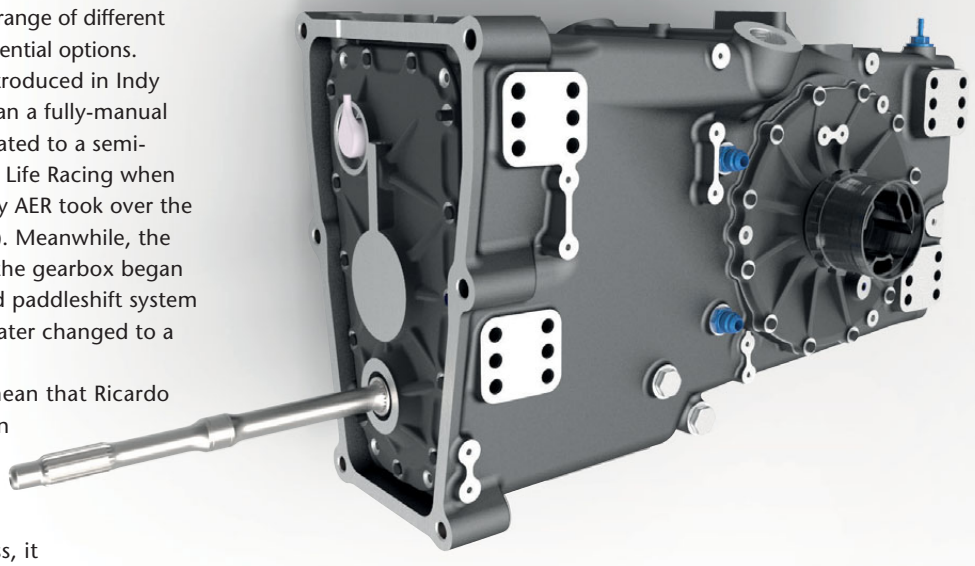
The powertrain is in for some changes too. For a start, the 2-litre turbocharged four-cylinder AER P63 engine is being swapped for another (as yet undisclosed) internal combustion unit. The standard clutch will also be replaced by a centrifugal design from ZF, similar to that which racing legend and double-amputee Alex Zanardi used in his BMW M8 GTE at Daytona in 2019.

Power will be transmitted through a variant of the same six-speed Ricardo transaxle unit found in the standard IL-15, but this too has been somewhat re-engineered for the new application.

"Around a year ago we were contacted by Dallara, who had started working with Clemson on an automated version of the IL-15 Indy Lights chassis," recalls James Oakenfull, Ricardo's Head of Motorsport. "It came somewhat out of the blue, but we were fascinated by the idea and it's been a really interesting project."

The basis for the transmission remains Ricardo's 500Nm Single Seater Gearbox unit. This is a well-proven design that began life as an oval-only transmission in Indy Lights in 2002 and has since seen action in half a dozen other applications, including Formula Renault 3.5 and the Japanese Super Formula series.

The secret to accommodating all of these different applications lies with the Ricardo gearbox's modular design. While the casing remains the same, it has ▶



been designed to accept a wide range of different gear sets, shift systems and differential options.

When the gearbox was first introduced in Indy Lights in 2002, for instance, it ran a fully-manual sequential shift (which was updated to a semi-automatic paddleshift unit from Life Racing when the English firm's sister company AER took over the engine supply contract in 2015). Meanwhile, the Formula Renault 3.5 version of the gearbox began life with a hydraulically-actuated paddleshift system from Magneti Marelli, but was later changed to a pneumatic system from Shiftec.

All these different iterations mean that Ricardo has amassed a sizeable parts bin of interchangeable options, from which most of the components for the IAC car have been plucked. Nonetheless, it still represented a unique project.

"Dallara introduced us to Clemson, and we provided them with the data that they needed to redesign the rear of the car for the new engine. We've taken their lead on what they want to do with regards ratios," explains Steven Blevins, project manager for high performance transmission products at Ricardo.

The Indy Lights cars already run the longest final drive ratio that Ricardo produces for this gearbox – an 11:33 – so the decision was taken to stick with that. The Clemson engineers then picked a ratio set that would provide the correct spread between pulling away in first gear in the pitlane and topping 200 mph on the banking.

"We're running combinations of parts that we've never done before," comments Blevins. "It's the lowest first we offer for this gearbox with the highest sixth that we do and the longest final drive. It helps that we've been able to pick some of the other components from the parts bin too, such as the mounting bracket and the lever for the shift system. The only new part that we've had to engineer from scratch is the clutch shaft – the rest is a question of using existing parts in slightly unconventional combinations."

At present, the challenge is being run as a one-off event on the banked oval at Indianapolis, but the updated gearbox has been designed to futureproof the autonomous AV-21 against the possibility of running on road courses at a later date.

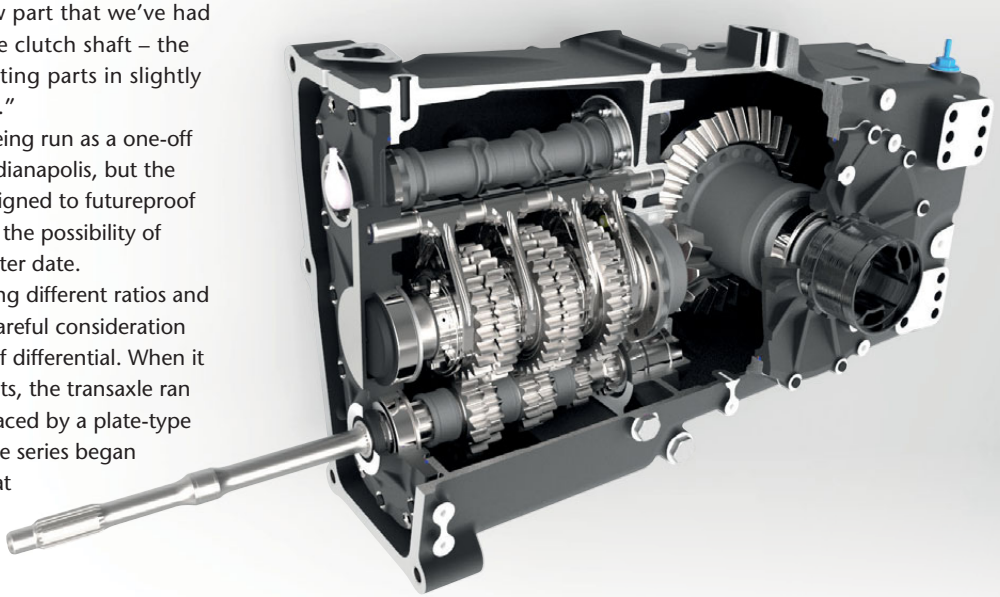
As well as the option of running different ratios and final drive units in the future, careful consideration has also gone into the choice of differential. When it was first designed for Indy Lights, the transaxle ran a spool, although this was replaced by a plate-type limited slip differential when the series began visiting road courses. For now at least, the autonomous cars will revert to a fully-locked differential, but this will be a modified version of the plate-type LSD, featuring an internal locking piece rather than a conventional spool. As such, it would be a simple operation to convert the cars back if they were ever to compete on road courses.

ABOVE & BELOW
The modular design of Ricardo's gearbox, enabling a wide range of different gear sets, shift systems and differential options, has been the key to its success

NEW SHIFT SYSTEM

Another significant change, relative to the standard IL-15, is the switch to a Shiftec pneumatic shifter system. This is similar to the design that Ricardo had already worked with in Formula Renault 3.5, so most of the required parts were once again available from the parts bin. ▶

> *"Nothing will break a gearbox quicker than a mis-timed gearshift system"*



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Physically speaking, the control of the transmission is relatively straightforward. Shiftec does produce a variant of the system that includes a pneumatically-operated master cylinder for automated clutch control, but the decision was taken to go with the ZF centrifugal clutch instead. Once the car is moving, a pneumatic actuator pulls or pushes the selector mechanism to go up or down one ratio. This lends itself quite well to automation, Blevins notes, because the system is largely mechanical – as soon as the air pressure is released, the actuator is free to move and a spring inside the selector mechanism sends it back to its resting position.

"The actuator changes gear, but it's the gearshift mechanism that returns the actuator," he comments. "With a pneumatic system it essentially has to push the actuator back and vent the pressure to the atmosphere, so the spring has to be strong enough not just to reset the internal mechanism, but also to re-centralise the pneumatic actuator. It isn't a big drag, but if the spring is too weak it can take too long for the system to reset itself for the next gearshift. We had to consider a similar issue with the hydraulic actuator that was used on the original system on the Formula Renault 3.5s – you have to move a lot of oil to reset the actuator, which comes down to the spring."

ABOVE Clemson University's students at work integrating autonomous vehicle technologies into the latest variant of Dallara's Indy Lights challenger

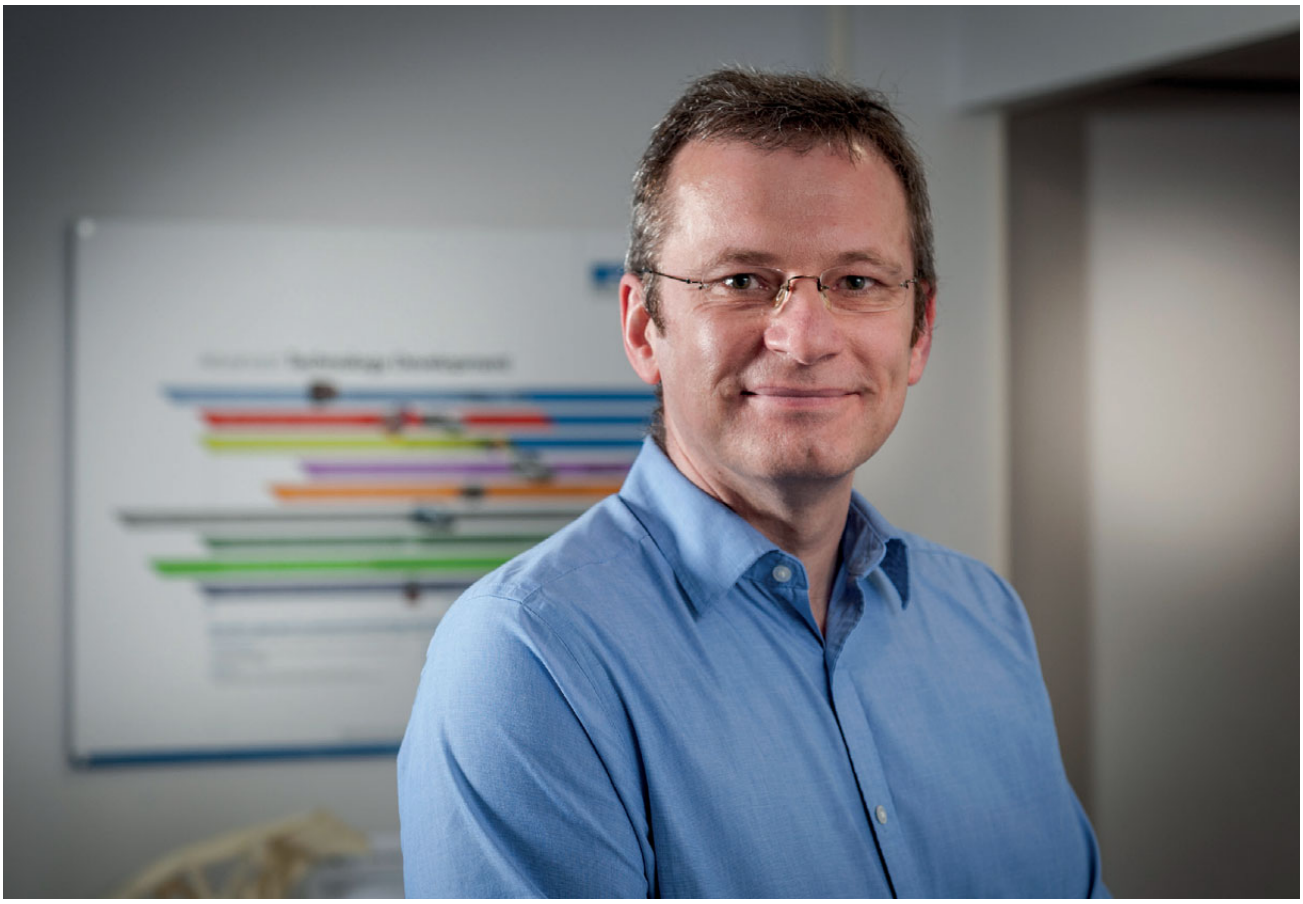
QUESTION OF TIMING

The shift process itself is all a question of timing, he explains: "One of the things we worked on quite a lot during our time on the Audi LMP1 programme was selector fork design. There's always a danger that you'll get a dog-on-dog contact during a gearshift. Our forks are designed to be flexible enough to allow the barrel to continue (almost to its end position) even if you get a dog-to-dog situation initially. Once the dogs have passed each other, that spring loading action in the fork brings the clutch ring into gear."

In its crudest form, a paddleshift actuator just fires to its maximum pressure and it's up to the selector mechanism inside the gearbox to actually make the shift work; the shifter system maintains pressure for ▶

ABOVE The successful Le Mans programmes with Audi helped Ricardo progress in many areas, including selector fork design

Audi AG



a certain length of time to ensure that the shift is completed, but it's purely time-based, with no feedback from inside the gearbox.

"It's a completely open loop control system, but the timing is very important," notes Blevins. "If you get the timing wrong, you could theoretically bounce from one dog to the next and never actually go into gear. And there's nothing that will break a gearbox quicker than a mis-timed gearshift system."

COUNTDOWN TO THE RACE

A long road lies ahead for the student teams hoping to race at Indianapolis. They have to progress through a series of gateways, including demonstrating their work on an existing autonomous vehicle and taking part in a virtual race sponsored by engineering simulation company Ansys.

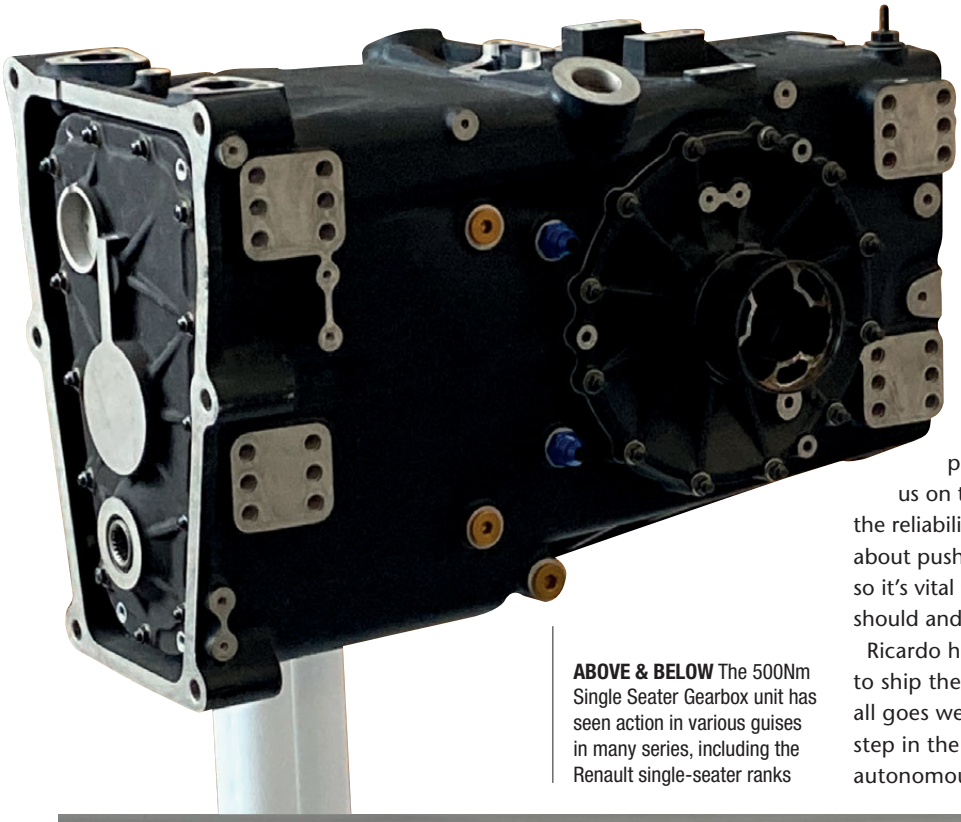
It won't be until the fourth stage of the competition that the surviving teams actually get their hands on a real AV-21, with practice days scheduled for June, September and October. After that, there's a final qualifying event on October 21-22 to determine which teams go through to the race on October 23 and where on the grid they will start.

> *"This challenge is all about pushing autonomous vehicle development, so it's vital that the spec hardware all works as it should"*

The race will begin with a rolling start. All being well, the vehicles will then accelerate towards their top speed and stay close to that for most of the race, meaning that the hardest part for the transmission will already be accomplished.

"The duty cycle for the gearbox will be a little different to a conventional Indy Lights car," comments Blevins. "Fifth and sixth gear are normally very close in Indy Lights. The drivers generally use fifth in clean air and sixth when they're drafting someone to give them a little bit of extra speed. The ratios for the autonomous car aren't set up like that, so I think they will accelerate up through the gearbox and then stay in sixth for most of the race. I don't think the gearbox will do a great deal of shifting if the autonomous algorithm works well."

ABOVE As project manager for high performance transmission products, Ricardo's Steve Blevins has worked in close collaboration with Dallara on many occasions



ABOVE & BELOW The 500Nm Single Seater Gearbox unit has seen action in various guises in many series, including the Renault single-seater ranks

The individual race teams won't have any control over the gearbox hardware or the transmission control software. As part of a spec mechanical package, it's intended to work quietly in the background and support the main aim of developing autonomous racing cars.

"Standing on the inside of Turn 1 at the speedway and watching a field of 10 autonomous cars whip past at 200 mph will certainly be an eye-opening sight," comments Blevins. "We're very pleased that Dallara chose to work with us on this project and I think that highlights the reliability of the gearbox. This challenge is all about pushing autonomous vehicle development, so it's vital that the spec hardware all works as it should and allows the teams to get on with that."

Ricardo has so far built one gearbox and plans to ship the rest to the US by the end of May. If all goes well, this will be a small but important step in the road towards the world's first fully autonomous race.

MESSAGE IN A BOTTLE?

Is it possible to bottle the spirit of the Autosport International Show in the midst of the pandemic? ASI Connect gave it a good go, as **Luke Ramsey** reports

THE first ever edition of Autosport International (ASI) Connect debuted last month, attracting an audience of motorsport industry professionals during the two days of online networking and discussions.

While difficult to compare directly with the long-established Autosport International at the NEC, organisers managed to replicate the buzz of the event and provide countless opportunities to network, chat and learn.

The show's vast array of debates and discussions covered all corners of the motorsport industry, bringing members of the industry together on a fully integrated online platform to network, advertise their businesses and engage with the packed schedule of panel discussions.

According to Oliver Ciesla, Motorsport Network's Chief Operating Officer, the first running of the fully digital show was a great success. "We're delighted with the outcome of the first edition of ASI Connect and I would like to thank all speakers, participants and colleagues who contributed to this success," he said.

"The feedback from our guests, speakers and exhibitors shows it was a valuable opportunity for networking, doing business and debating the sport. We're excited for ASI Connect to become a powerful complement to Autosport International, which is scheduled to return to Birmingham's NEC on 13-16 January 2022."

The show's debates and discussions brought together 53 high-profile speakers across 13 thought-provoking panel discussions, that covered everything from the future of Formula 1 and electrification of motorsport to club racing and historic motorsport. The online format successfully bottled the spirit of the NEC show's diverse array of disciplines, personalities and interests into a COVID-appropriate format.

ABOVE & RIGHT Changing times: PURE ETCR's Series Director Xavier Gavory (above) was a member of the Future Power panel. The series' cars, such as Hyundai's Veloster N ETCR, feature 500 kW electric powertrains, making them the most powerful and fastest-accelerating touring cars ever built

All of the debates were streamed live on the ASI Connect online platform, which will remain online year-round, allowing attendees to return and watch discussions on-demand, as well as continue networking with exhibitors and other visitors. Registration is still open so members of the motorsport industry can still sign up and access the platform, even if they missed the live event.

"LIFE IS CHANGING. ACCEPT IT"

Some of the event's key debates included a look at the Future Power of motorsport, with fascinating insight from electric championship bosses Alberto Longo (Formula E) and Xavier Gavory (PURE ETCR) along with synthetic fuel entrepreneur Paddy Lowe and motorsport green power provider Guerlain Chicherit. Longo and Gavory discussed the plans their businesses and championships are working to, while Lowe and Chicherit explained their businesses' plans to provide different types of power to the motorsport industry.

"We all love the noise of V8 and V12s, but life is changing and we need to accept that," explained Chicherit during the Future Power panel. "The question we ask is not only if the car needs to be electric or hydrogen, it's how we provide pure energy." Chicherit's company Green Corp Konnection works with different partners to create solutions for producing and providing electric energy to motorsport, having won FIA tenders to become the exclusive supplier

Hyundai Motorsport

of electricity and recharging infrastructure for the electric World Rallycross Championship and its junior categories. The company is also working with a Saudi Arabian solar energy leader to find a solution for powering EVs at the Dakar Rally.

One panel, The Future of Historic Racing, was hosted by Race Tech's sister publication *Historic Racing & Technology*. Moderated by Adrian Goodsell, the panel included voices from across the country's historic and classic motorsport scene. Brian Sims represented the Historic Racing Association, John Waghorn joined on behalf of Nicholson McLaren, while Prof Steve Sapsford for SCE and Dr Mark Busfield from the University of Bolton also took part.

The discussion looked at the steps the historic motorsport market can take to remain relevant in a world shifting its focus to electrification and clean power, as well as how to engage a younger generation in the technology of the past. With today's student engineering courses geared towards electrified machinery, a focus needs to be made to preserve the racing greats of the past.

> ***"If you go back 20 years, historic motorsport was a man in a shed. Now, it's big business"***

Busfield explained the opportunities that this part of motorsport offers to engineering students: "Historic motorsport, if you go back 20 or 30 years, it was a man in a shed. Now, it's big business. The owners of these cars are High Net Worth Individuals, and they're very expensive to run, so therefore it has to be done properly. It's a good opportunity for many students to go into."

Photos: Jeff Bloxham

Students will have found ASI Connect's discussion about education and Finding New Talent to be particularly interesting, with advice and inspiration from key educators at Oxford Brookes University and Cranfield University along with professor and F1 aerodynamicist Willem Toet.

Genevieve Gordon shared details of the National Motorsport Academy's innovative Business of Motorsport degree, too: "We differ from the engineering and technical side. The programme that I run and wrote is reflecting the business side of motorsport. We have drawn on conversations that I have had in the past with various motorsport organisations, looking at how they could engage people with a more business-focused interest in the motorsport environment."

Amid the other high-profile speakers was legendary F1 engineer Rob Smedley, who shared details on

ABOVE & BELOW
Historic motorsport has evolved to become big business

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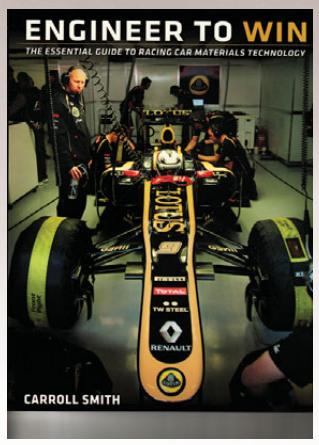

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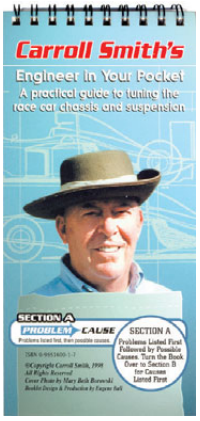

Store all the answers in your hip pocket! This handy pocket guide written by racing professional Carroll Smith suggests realistic solutions to common race car handling problems. Formatted listing causes and possible effects, and problems and possible causes. Spiralbound, 3 1/2"x 7 3/4," 32 pgs.'

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ABOVE Processes have had to change, at every level, in order for motorsport to recommence

his Electroheads e-kart project, which aims to democratise grassroots motorsport to make it accessible to all. Costs shouldn't be a barrier to getting into motorsport, he says. Inspired by F1 electrification technologies, Smedley's e-kart aims to make grassroots motorsport "cleaner, fairer, cheaper and faster". The ultimate aim? To put driver talent ahead of budget.

The Electroheads e-kart example is just part of a theme that was prevalent throughout ASI Connect: addressing the question of diversity. Putting talent ahead of budget opens the door to people from different backgrounds who might have more barriers to break than a typical motorsport audience. Widening the talent pool and removing these barriers to minorities and women is vital to the future of the sport.

> *"The sport had analogue admin in a high-tech world"*

Driven by Diversity's Lindsay Orridge led a specific discussion about Diversity in Motorsport, featuring W Series CEO Catherine Bond-Muir, Racing Pride's Richard Morris, Wavey Dynamics' Jahee Campbell-Brennan and presenter Ariana Bravo. The panel discussed the steps we can all take to tap into a wider wealth of talent by making motorsport a more inclusive place.

An event highlight was a one-on-one interview with Yath Gangakumaran, Director of Strategy and Business Development at Formula 1. Speaking to James Allen, Motorsport Network's President, Gangakumaran revealed details of the renewed #WeRaceAsOne initiative that forms the Environment, Social and Corporate Governance (ESG) policy of Formula 1 through the championship's commitment to diversity and inclusion, sustainability and community.

At a national level, the UK's tracks and clubs have taken a hit during the pandemic. ASI Connect's opening discussion combined input from BRSCC chairman Peter Daly, BARC CEO Ben Taylor and Gold Track's Calum Lockie. Between them, the three speakers provided well-rounded insight into the challenges facing clubs, tracks and track day operators amid the current circumstances, but also the opportunities open to them. This discussion was hosted by Racing Mentor Jess Shanahan, and provided an engaging opener to the two-day event.

As part of this national motorsport discussion, the panel explored a positive outcome of the pandemic: an improvement in processes caused by restrictions on in-person mixing. "Pushing a car across a paddock to join a queue for scrutineering was replaced with a much more customer-friendly system,"

explained BRSCC's Daly, while BARC's Taylor added that "the sport, at all levels, had analogue admin in a high-tech world". The digitisation of processes at all levels of motorsport is certainly a welcome change for many involved.

This balance between national and international racing, from BRSCC to Formula 1 and everything in between, showed the reach and relevance of ASI Connect and its in-person sister show Autosport International. The franchise successfully gives opportunities to all aspects of our sport to discuss and debate.

PRAISE FOR ONLINE FORMAT

Autosport International organisers say feedback from attendees, exhibitors and speakers was overwhelmingly positive, with 93 percent saying they'd attend again later in the year and 92 percent saying they'd recommend ASI Connect to a colleague or friend. The integrated online platform was received well, too, with 87 percent of attendees remarking it was easy to use and navigate.

Anonymously collected testimonials included feedback that attendees used ASI Connect to network and discuss in an innovative way, in a period when many have been unable to visit the racetrack or other in-person motorsport events.

One visitor said ASI Connect was a "highly useful and informative event with a great selection of speakers and tools to network with others in the industry," while another reckoned there was a "superb quality of speakers that came together, the likes of which you would be unlikely to find elsewhere in one place".

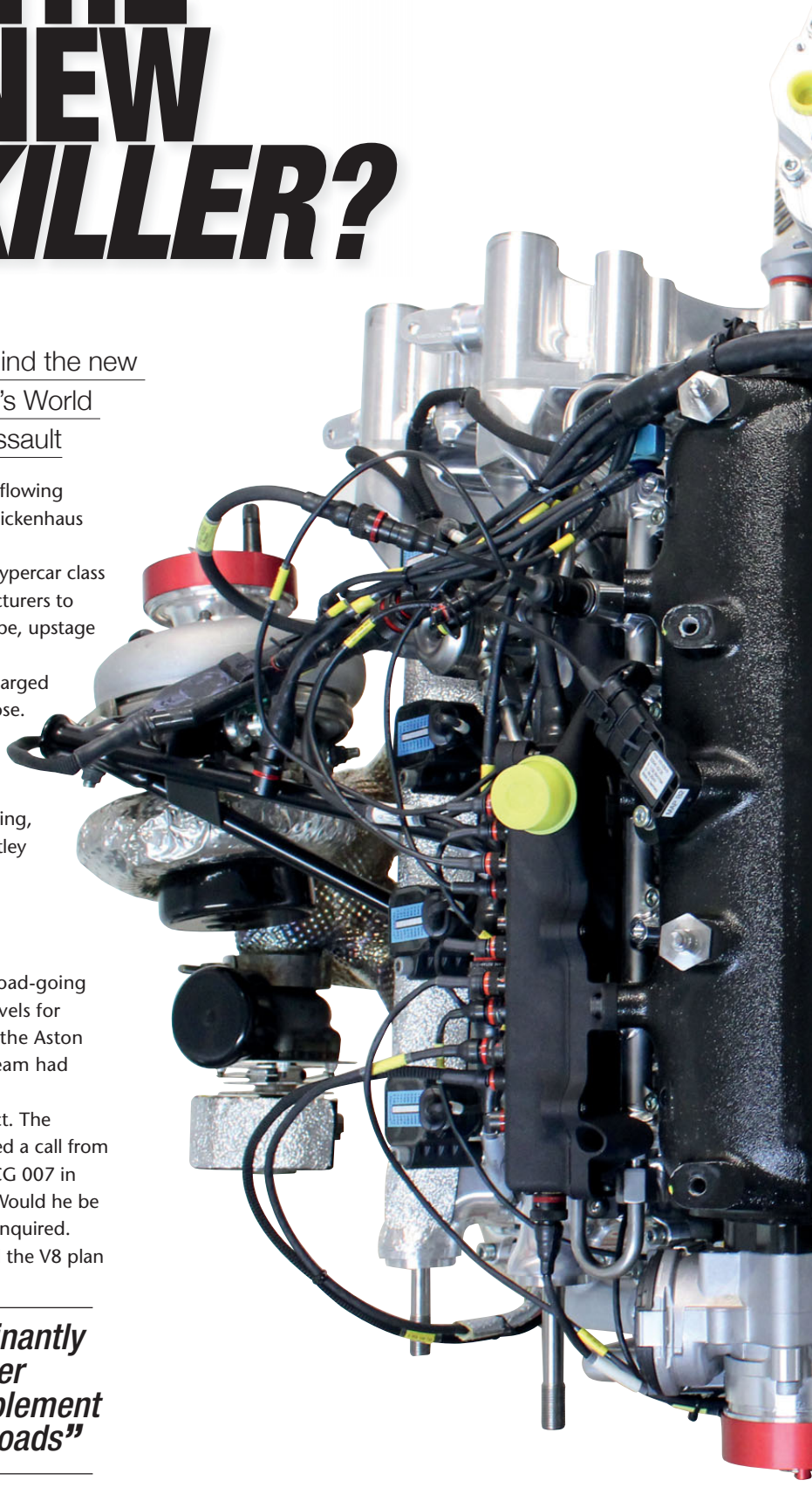
It is certainly a challenge to replicate the buzz and atmosphere of the NEC show but ASI Connect definitely felt like a community coming together. The platform's features to book meetings with exhibitors and fellow attendees, plus the instant contact features and 'Coffee Break' chatroom all managed to alleviate some of the issues that come with other online events. The added bonus of not having sore feet at the end of the day or paying £15 for parking helped, too.

RIGHT Remember this? The plan is for ASI to return next January

BELOW Guerlain Chicherit discussed Green Corp Konnection's showcasing of green technology

IS THIS THE WEC'S NEW *GIANT-KILLER?*

Chris Pickering talks to the man behind the new V8 engine that will power Glickenhaus's World Endurance Championship Hypercar assault



IF looks are anything to go by, the clean lines and flowing curves of the SCG 007 from Scuderia Cameron Glickenhaus (SCG) surely make it a winner already.

Team founder Jim Glickenhaus described the new hypercar class as "a magical opportunity" for boutique car manufacturers to take the race to the big OEMs. And maybe, just maybe, upstage them in the process.

The heart of the SCG 007 is a 3.5-litre twin turbocharged V8 from Pipo Moteurs, built specifically for the purpose. It's the first time that the French firm – best known for its four-cylinder rally and rallycross engines – has built its own V8 from scratch. However, the company has a proven track record in endurance racing, having developed production-based engines for Bentley and Morgan in the past.

SECOND THOUGHTS

Originally, the plan had been to use Alfa Romeo's road-going Ferrari-derived V6. However, as the target power levels for the Hypercar category went up (originally to allow the Aston Martin Valkyrie to race with its 6.5-litre V12), the team had begun to have second thoughts.

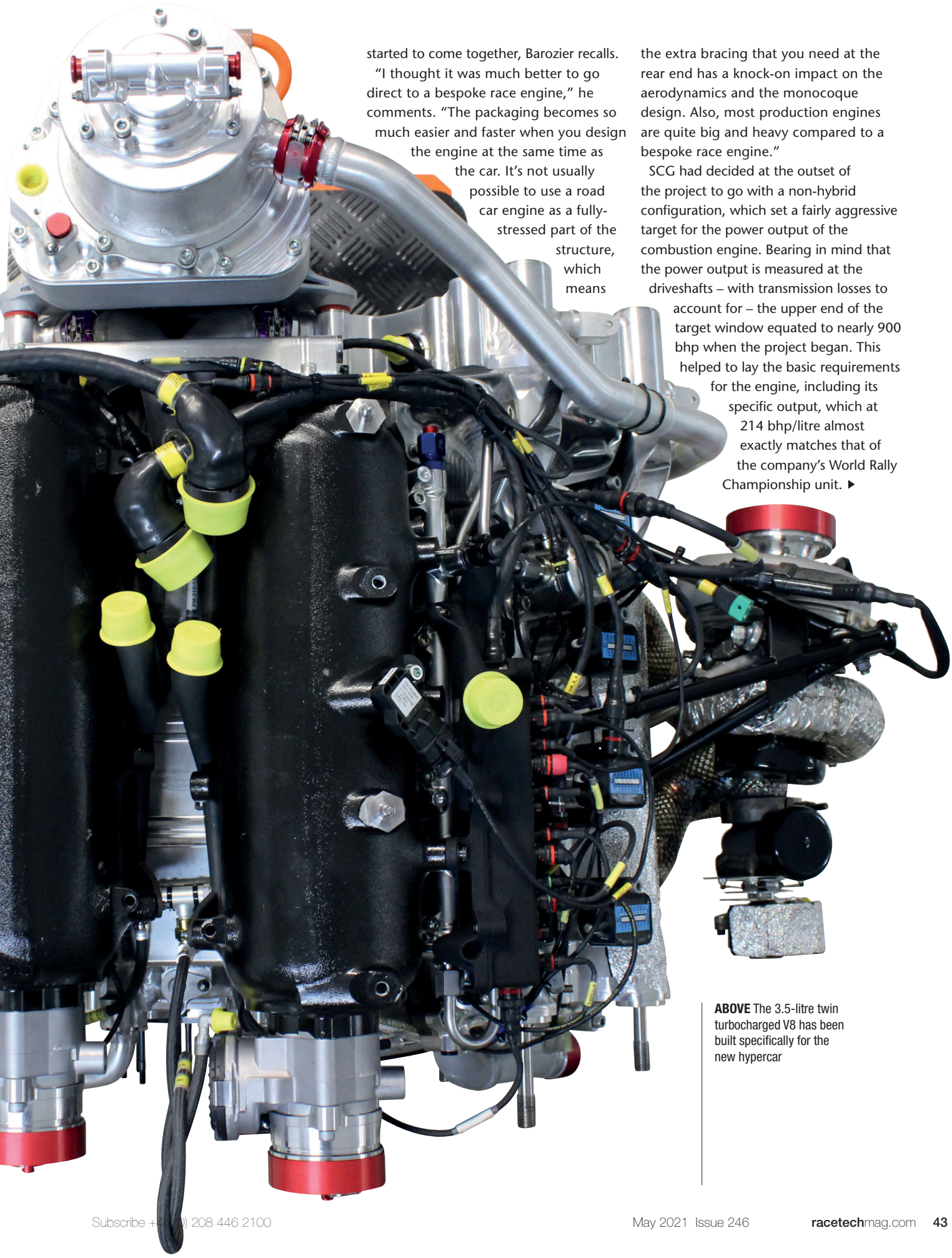
It was around this time that Pipo entered the project. The company's general manager Frédéric Barozier received a call from Podium Advanced Technologies, which builds the SCG 007 in collaboration with Scuderia Cameron Glickenhaus. 'Would he be interested in building an engine for Le Mans?' they enquired.

A few days later they met to discuss the project and the V8 plan

> *"The engine runs predominantly on direct injection at lower loads; port injectors supplement that at high speeds and loads"*

started to come together, Barozier recalls. "I thought it was much better to go direct to a bespoke race engine," he comments. "The packaging becomes so much easier and faster when you design the engine at the same time as the car. It's not usually possible to use a road car engine as a fully-stressed part of the structure, which means the extra bracing that you need at the rear end has a knock-on impact on the aerodynamics and the monocoque design. Also, most production engines are quite big and heavy compared to a bespoke race engine."

SCG had decided at the outset of the project to go with a non-hybrid configuration, which set a fairly aggressive target for the power output of the combustion engine. Bearing in mind that the power output is measured at the driveshafts – with transmission losses to account for – the upper end of the target window equated to nearly 900 bhp when the project began. This helped to lay the basic requirements for the engine, including its specific output, which at 214 bhp/litre almost exactly matches that of the company's World Rally Championship unit. ▶



ABOVE The 3.5-litre twin turbocharged V8 has been built specifically for the new hypercar

Pipo already had a solid starting point in its family of four-cylinder competition engines. A V8 was the obvious solution to meet the hypercar power requirements (minus the hybrid assistance found in its competitors' V6 designs). This raised the prospect of grafting two of the four-cylinder engines together, although the reality has turned out to be somewhat more complex.

99 PER CENT NEW

"I would say 99 per cent of the engine is new. At the start, the idea was to use the experience and some parts from the four-cylinder, but once we began work on the design we realised that nearly no parts were transferable," comments Barozier.

Nonetheless, there are similarities. The cylinder heads were loosely based around the company's rallycross engine, with which it shares the same 85 mm bore diameter and bore spacing; the valvetrain also uses the same chain drive concept seen on the four-cylinder engines. Parts such as the tensioners and guides are identical between the two banks (as are the fuel rails and the intake manifolds) to control costs.

"The four-cylinder engine was based on the dimensions laid out in the FIA's Global Race Engine regulations. We kept those basic dimensions for the V8," comments Barozier. "For instance, the camshaft design is similar, even though the profiles themselves have changed. The cylinder head bolt pattern is identical too – you can fit the new head designed for the V8 directly onto the four-cylinder."

While the 3.5-litre V8 was on the ▶

ABOVE The V8 block is a whole new design, machined from a single billet of aluminium

BELOW Packaging becomes easier and faster when the engine is designed at the same time as the car, as with this project

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drawing board, Pipo also set about designing a new 1.75-litre four-cylinder that uses essentially the same cylinder head design. This is intended principally for the new 1,750 cc regulations in European hillclimbing, where it produces more than 600 bhp.

NEW CHALLENGES

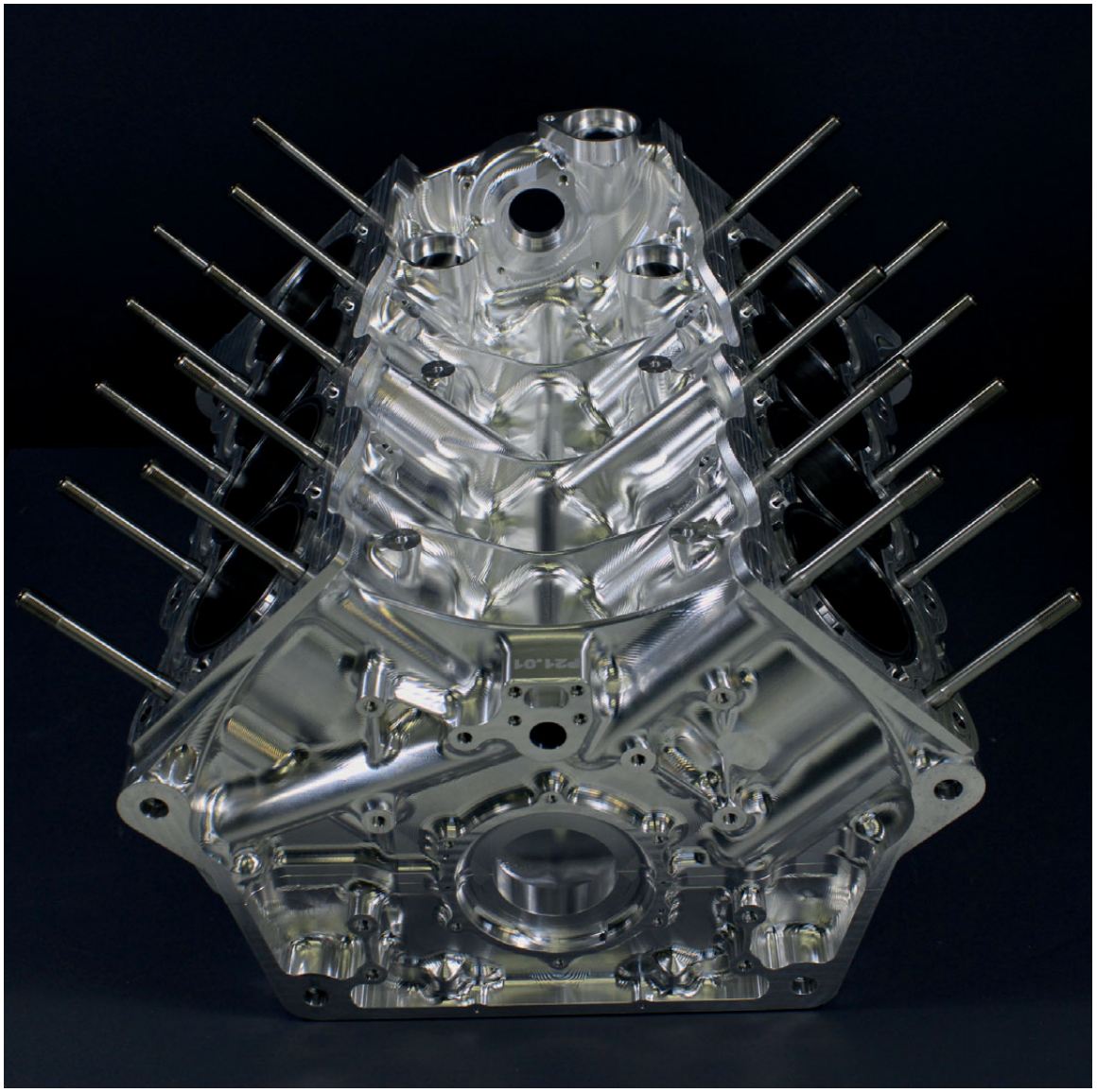
Despite the similarities, there are also some notable differences to the four-cylinder engines. Most obviously, the V8 block is a whole new design, which is machined from a single billet of aluminium. Finding a supplier with a milling machine capable of accommodating such a large chunk of metal wasn't easy, but a local firm was eventually found, which had the added benefit that the Pipo engineers could visit them for weekly meetings. This allowed the machining company to play an active role in the design – regularly reviewing changes to ensure that they wouldn't impact the manufacturing process.

Before that, however, Barozier and his colleagues had to lay out the initial design of the block. This began with the major attachment points – 20 head studs (10 on each side) and another 20 studs used to locate the five main bearings.

That might sound straightforward, but things rapidly become crowded when you're trying to package eight cylinders into a compact race engine, he points out: "If you're designing an inline engine the studs are all parallel to each other, but with a V8 you have all of these bolts running at 45 degrees to each other and you have to locate the oil galleries in the same space, so eventually it becomes quite tricky to fit everything in."

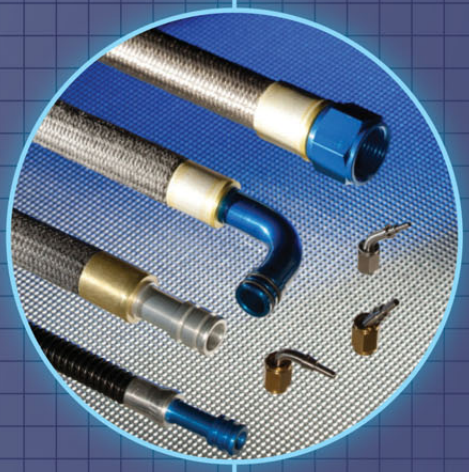
> *"Things rapidly become crowded when you're trying to package eight cylinders into a compact race engine"*

The flat-plane crankshaft – manufactured by Arrow Precision Engineering – borrows heavily from the design of the four-cylinder item, although it was another area where packaging was to prove crucial. Pipo has carried over the same spacing between the main bearings, which meant that there were now twice as many connecting rods to accommodate in the same space. This meant that particularly ▶



LEFT With the head studs running at 45 degrees to each other and the oil galleries vying for space, packaging the V8 is a challenge

INTELLIGENCE CONNECTED



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ABOVE & BELOW A 3D printed exhaust ball joint is one of the products of a fruitful partnership with French specialist Poly-Shape

careful attention had to be paid to the rod bearings and the crank design to ensure adequate stiffness.

"This was the first time that we had designed our own V8 crankshaft, so we did a lot of simulation work around the torsional vibration to ensure we were well away from the resonant frequencies," comments Barozier. "We spent a lot of time looking at bore and stroke to find a good compromise between the crank throw, the stiffness and the engine capacity."

Efficiency has always been a major factor in endurance racing, and the Hypercar class is no different. Compared to the four-cylinder engines, the intake port geometry has been re-designed to improve tumble at the expense of outright flow. This increases combustion efficiency and allows the engine to run leaner.

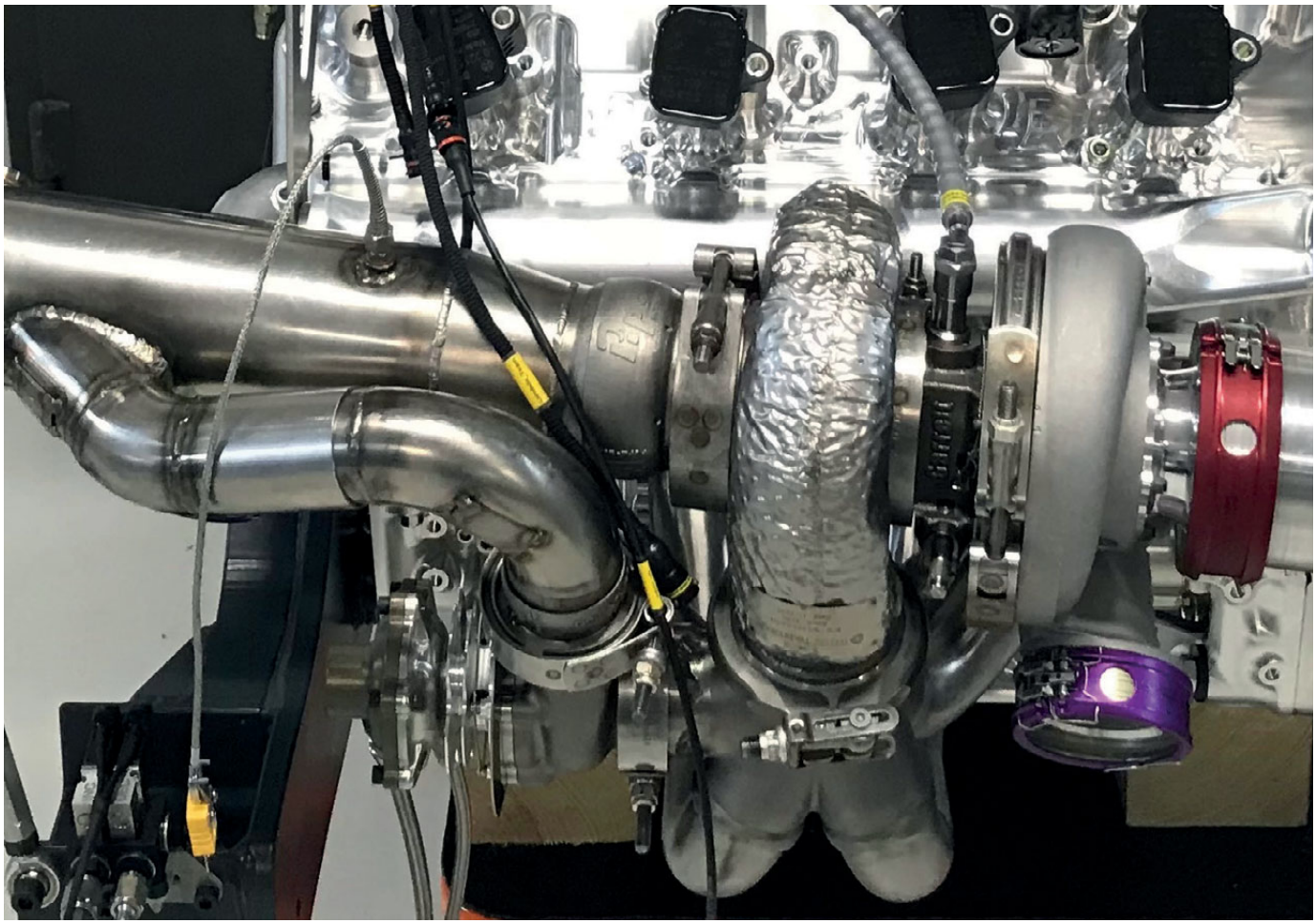
As part of this, the injector spray pattern has also been reworked. There are now two sets of injectors, with the engine running predominantly on direct injection at lower loads, while a set of port injectors supplements that at high speeds and loads.

The decision to go with a twin turbo setup was partly an extension of Pipo's philosophy of pairing two four-cylinder engines. This way, each turbo can be controlled separately based on the four cylinders that it feeds.

REVERSE ROTATION DESIGN

Given that the specific output of the 3.5-litre V8 is so close to that of the company's World Rally Championship engine, the decision was taken to use the same basic Garrett turbocharger design, albeit with revised dimensions.

The two turbochargers are mounted low on either side of the block, primarily to aid packaging for the rear end aerodynamics. One turbo is a standard unit, while the second is a reverse rotation design, giving a fully symmetrical layout that simplifies the pipework and results in equal-length pipes between the two turbochargers. ▶

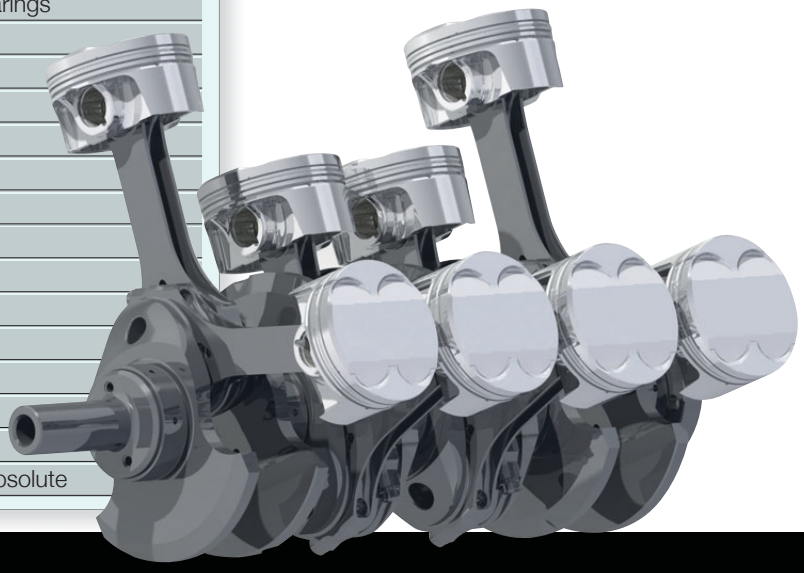


Glickenhaus by Pipo Moteurs Spec sheet

Model	P21
Cylinders/bank angle	90° V8
Bore	85 mm
Stroke	77 mm
Block material	Billet aluminium
Head material	Casting aluminium
Liner material and/or cylinder bore coating	Steel with Nikasil
Main bearings	5 plain bearings
Crankshaft material	Steel
Connecting rod material	Steel
Piston material	Aluminium
Number of rings on each piston	3 rings
Type of timing drive	2 chains
Number of valves per cylinder	4 valves
Number of spark plugs per cylinder	1
Port and/or direct injection	
Included valve angle	39°
Intake valve diameter	34 mm
Exhaust valve diameter	29 mm
Compression ratio	11:1
Maximum engine speed	8,000 rpm
Maximum plenum pressure	2.3 bars absolute

MANUFACTURING APPROACH

Pipo made extensive use of 3D printing during the production of the engine. Numerous parts including the oil tank and the water pipes were produced in aluminium using additive manufacturing by the Bölinger Group in Germany. Various bits of bracketry were 3D printed in plastic, while the 4-into-1 collectors on the



ABOVE & BELOW
The crankshaft was another area where packaging was to prove crucial. Arrow Precision Engineering manufactured both the crank and connecting rods

LEFT Data collected from the test sessions will be harnessed to run lap simulations on the company's dyno

exhaust manifolds and the turbocharger wastegate housings were 3D printed in Inconel by French specialist Poly-Shape.

"Creating the tool to cast these parts would have been a huge investment for a small number of engines, so we decided to go with 3D printing instead," comments Barozier. "You can send the design off as soon as the 3D model is complete and then you receive the working parts maybe two weeks later, so it's a very time-efficient way of doing things."

One particularly interesting concept to come out of the partnership between Pipo and Poly-Shape is a 3D printed exhaust ball joint. As the name implies, this is a spherical joint that provides a degree of flexibility within the exhaust, allowing the joints to rotate ±10° in any axis. The practical upshot of this is that it relieves stress on the joints that could otherwise lead to fatigue failures, while using the differential expansion between the inner and outer layers of the joint to provide a gas-tight seal. First developed for rallycross applications in 2018, the whole design is printed in temperature-resistant Inconel in a single process.

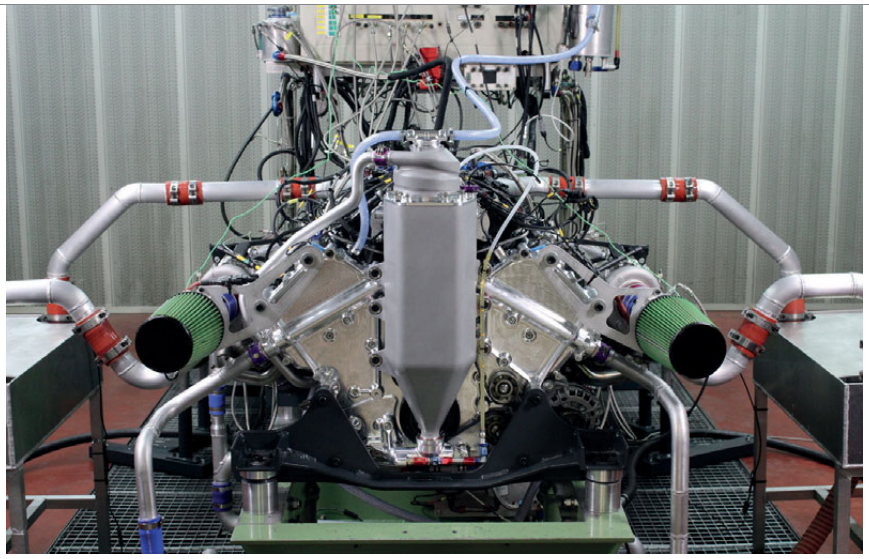
> *"3D printing is a very time-efficient way of doing things"*

Pipo also employed a distinctly modern approach to sourcing some of the components. When it came to finding oil filters, for instance, the company put a request out on its LinkedIn page inviting suppliers to come forward.

"Within a few hours we'd received several ▶

Glickenhaus by Pipo Moteurs Key suppliers

Cylinder head casting	Barbas & Plailly
Cylinder head machining	Project Mecanique
Block/crankcase	Serre Mecanique
Liners/bore coating	Capricorn
Oil pan	Serre Mecanique
Crankshaft	Arrow Precision
Camshafts	Scam
Timing drive components and auxiliary drives	Pipo
Tappets	Xceldyne
Pistons, rings and pins	Mahle
Circlips	Mahle
Connecting rods	Arrow Precision
Big end bearings	Mahle
Main bearings	Mahle
Fasteners	ARP
Valves	Xceldyne
Valve seats and guides	Pipo
Valve springs	PSI
Ignition system	Bosch
Spark plugs	NGK
Fuel injectors	Bosch
Engine management system	Bosch
Sensors	Bosch
Data acquisition	Bosch
Throttle	Bosch
Oil pumps	Dailey Engineering
Oil filter	Purflux
Oil tank	Böllinger Group
Turbochargers	Garrett
Wastegates	Pipo
Exhaust	Pipo
Intake manifold	Loire Fonderie
Air filter	Green
Fluid lines	FHS
Fuel pumps	Bosch
Oil supplier	MOTUL
Pipo's in-house dynos supplied by	FEV



LEFT Two engines have already completed 30-hour durability tests on the dyno without problems

RIGHT A bespoke racing engine was preferred because the bracing required with a production engine would have had a knock-on effect on the monocoque and aerodynamics

proposals," reports Barozier. "It turned out to be a very good way to find people who were interested in the project and capable of supplying good parts for us. Ordinarily, when you're browsing you might email someone and then end up calling them a week later to get a response. For this project we had a lot of suppliers come to us via the internet."

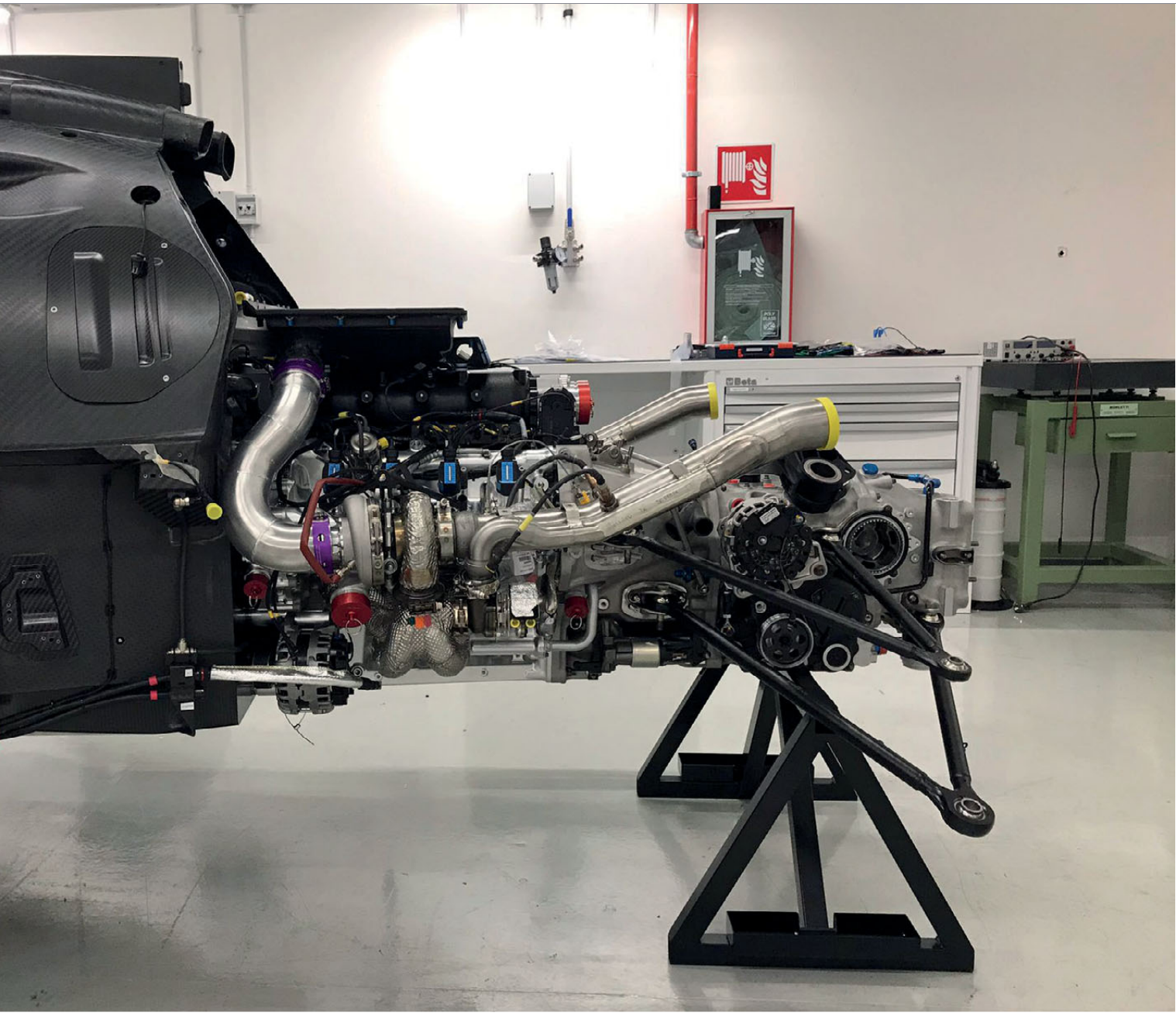
HITTING THE TRACK

There is still plenty of work left to do, although the first stage of the project is now drawing to a close. The SCG 007 had its first test at Vallelunga at the end of February, with further running at Monza during March and a 30-hour track test planned for mid-April. Engine testing also continues behind the scenes at Pipo, using data collected from the recent test sessions to run lap simulations on the company's dyno. The main task currently is fine-tuning of the calibration, Barozier explains.

Two engines have already completed 30-hour durability tests on the dyno without any issue. As with most top-tier sports car engines, the planned rebuild life is based around a complete race week at Le Mans, which equates to around 6,000 km, although the team will go beyond this in testing.

"We've had no technical issues so far," notes Barozier. "It's important to

LEFT The engine has performed well in initial tests in the SCG 007



> *"Re-configuring the engine for LMDh would be straightforward"*

keep testing now in the car as this can sometimes highlight problems that you don't see on the dyno."

At present, the engine is only being used by SCG, but Barozier says he's keen to talk to other potential customers – including those racing under IMSA's LMDh category. In this form, the total system power would remain the same (at 500 kW or 671 bhp), but the internal combustion engine would be somewhat detuned to run in combination with IMSA's standard (50 kW or 67 bhp) hybrid system.

"The lower power output in LMDh would allow us to extend the rebuild life right out, making it very cost-efficient for the teams," notes Barozier. "Re-configuring the engine for LMDh would be relatively straightforward. We would need new turbocharger geometry and new calibration, of course, but most of the hardware would carry straight over.

"One of the benefits of using a twin injector setup (DI and port injection) is that we can be quite flexible on the power target. When we designed the engine we were also aware that we might need to go to synthetic fuels or ethanol in the future, which would require specific flow characteristics."

The intention is for the new V8 to become a long-term part of Pipo's product line up, although its origins lie very much with the SCG 007.

"The hypercar been a really good project to work on," comments Barozier. "When you're dealing with a project for a large OEM, part of the decision making is often driven by politics or marketing, whereas here we have been able to concentrate on the best technical solution without any of those constraints."

With the World Endurance Championship's season-opener at Spa now just a few weeks away, it won't be long before we get to see how the SCG 007 and its new V8 engine stack up against the competition.

ZERO TOLERANCE!

World Rally Championship squads are used to the white-hot heat of competition. But how did they combat the challenges posed by temperatures of minus 20 degrees C as they prepared for the Arctic Rally? **Anthony Peacock** reaches for his Survival Kit…

IF you get into your car at Helsinki and drive pretty much due north (although it's not a direct route as there are a few lakes in the way) you'll eventually reach the town of Rovaniemi, after about nine hours on the road.

Some might call it a monotonous drive: the predominant tones being snow white, hints of brown and green from the never-ending snow-covered forests, and the occasional flash of red from painted log cabins.

These are known as 'summer houses': places where Finns often go to contemplate life and *sisu* – that untranslatable Finnish word epitomised by rally drivers, which loosely means 'courage in the face of adversity' – through an introspective haze of sauna steam. ▶

RIGHT The Arctic Rally threw up a number of challenges crews and suppliers weren't used to dealing with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WRC/Red Bull

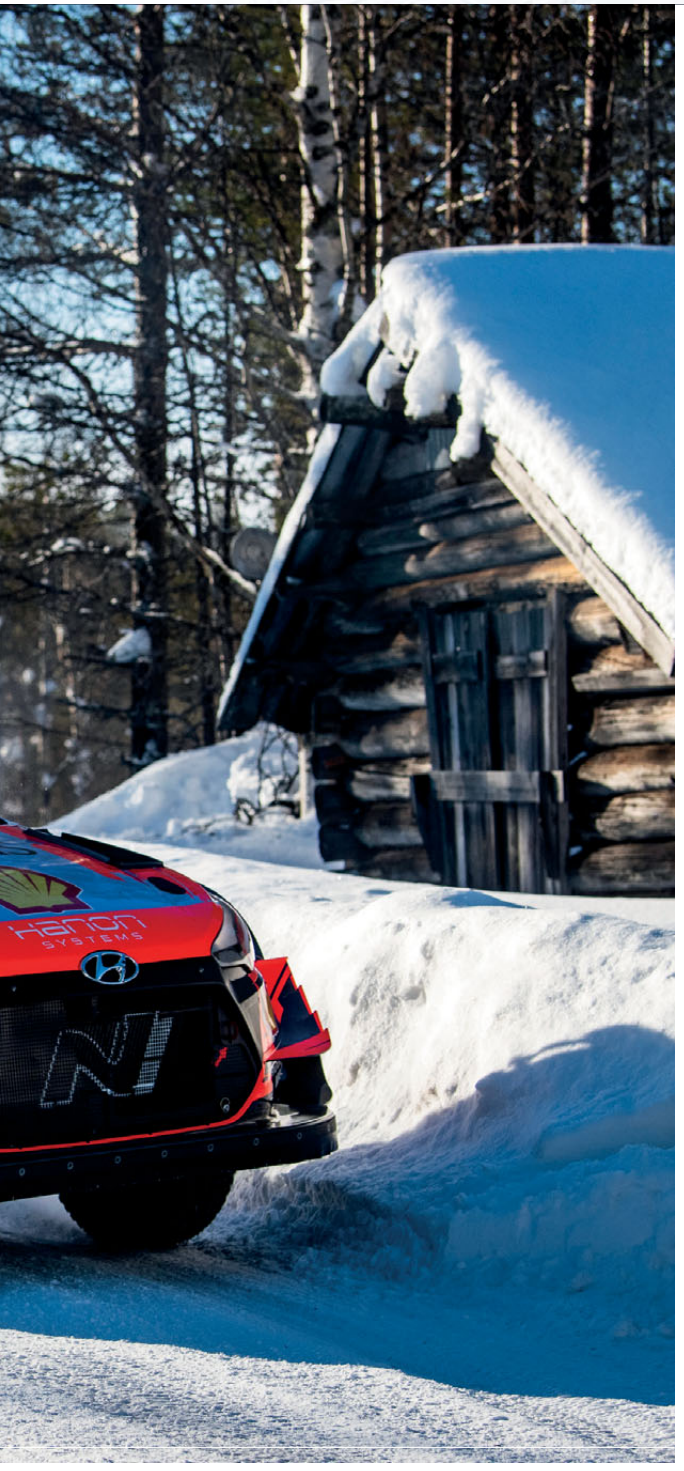
It's the sort of reverie you can easily find yourself in after many hours at the wheel on those dark and deserted Finnish highways, with only logging trucks for company. But letting the attention wander isn't advised: those snowy forests can hide some hefty reindeer, who occasionally feel the need to jump out into the road to test their *sisu*.

The journey is worth it though as Rovaniemi is a magical place that's also the home of *Joulupukki*: or Santa Claus. The Santa Claus Village is open for business all year round, disgorging coachloads of tourists even in the height of summer. He's got a hotel complex, restaurant, post office, and even a dog-sledding school.

One of Santa's other jobs this year was presenting the prizes at the Arctic Rally Finland: a last-minute replacement on the World Rally Championship for Rally Sweden, dropped due to COVID restrictions. Rovaniemi, just inside the Arctic Circle, is around 1,000 kilometres north of Rally Sweden's base in Karlstad as the crow flies. This also addressed one of the recent issues around Sweden's round of the world championship: a frequent lack of snow and cold temperatures.

In the weeks leading up to the Arctic Rally,

> ***"The ice and snow that can build up in the wheel arches and louvres can add up to 55 kilograms, practically the weight of an extra co-driver"***



WRC/Red Bull

ABOVE & LEFT Ott Tänak's stage times with the reindeer might not have frightened his rivals, but he was unbeatable at the wheel of his Hyundai

BELOW With COVID precluding the presence of spectators, crews carried snow shovels and ice picks to enable them to dig a stranded car out of a snow bank

and during testing, temperatures hovered around minus 20 degrees or lower (nothing unusual, as the event has been run as part of the Finnish championship in temperatures colder than minus 30 before). For the rally itself, it warmed up unexpectedly: which presented teams with a different problem, as the conditions they faced were different to those in which they had tested.

START DIGGING...

But how do you even set up a car – and team – to operate in winter conditions that are frankly inhumane?

Some things are mandated by the rules. Crews have to carry snow shovels and survival blankets, just in case they go off somewhere remote (even more hazardous this year, due to the lack of spectators – banned because of COVID – to offer help).

Every situation is different, but the more switched-on crews practice how to dig cars out of snowbanks most effectively in advance and take advice from locals who are well-versed in the art of doing so.

Those hints and tips aren't just limited to how to wield a shovel. The most important thing, if you're ▶

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trying to drive your car out of a snowbank, is to lock the centre diff. If you just go straight for reverse, you risk digging a bigger hole. Reverse gear on a modern World Rally Car is a delicate one: if you just bang it in, there's a risk of breaking it. And then you really are screwed.

Other equipment carried in every car on the Arctic Rally includes ice picks and scrapers. The amount of ice and snow that can build up around a World Rally Car, especially in the wheel arches and louvres, can add up to around 55 kilograms: practically the weight of an extra co-driver. That's actually less of a problem when it gets very cold, as in Arctic temperatures the snow is more like a fine powder, clinging less to the car than it does when conditions are merely sub-zero.

> *"Battery-heated socks to keep their feet warm"*

M-Sport

ABOVE Some drivers prefer yellow-tinted glasses to help them pick a route through the glare of the landscape

BELOW A lot of attention is paid to the lighting, to avoid snow crystals dazzling the drivers

The cars themselves are considerably different even before they arrive at the Arctic Rally, as Jamie McMillan, engineer to M-Sport driver Gus Greensmith, explains.

"You can get rid of a lot of the cooling, as in those temperatures the cars simply don't need it," points out McMillan. "So we don't use the gearbox cooler, and we blank off the brake cooling and the differential cooling as well."

All the associated ducting can be removed too, which helps reduce weight and can also benefit aerodynamics. But there's plenty of extra equipment ▶

M-Sport

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added to the car, so the overall weight difference tends to balance itself out. In the end, an Arctic Rally car is only around five to 10 kilograms lighter than a standard rally car, if that.

HEATED WASHER JETS

The battery capacity is increased and there's an additional slave battery as well, just in case the car needs some help to fire up after a chilly *parc ferme*. A heater matrix is installed, directing hot air towards the driver's feet. This is also used on Rallye Monte-Carlo and occasionally on Rally GB, depending on what time of year the event is run. Some roof insulation goes in, to stop too much warm air escaping, while there's more heavy-duty screen wash and a heated washer jet to dispense it onto the windscreen.

Drivers have to carry heavy coats as well as their survival kits, plus overshoes to slip on top of their delicate driving shoes every time they get out of the car. Despite all that, it's still very cold inside the cars on the stages – or "blue balls time" as the inimitable Colin McRae poetically described Rally Sweden.

Some drivers such as Marcus Gronholm used to wear battery-heated socks to keep their feet warm, while in the boot there are also heavy-duty gloves, so crews don't lacerate their hands on the densely studded tyres every time they change a wheel.

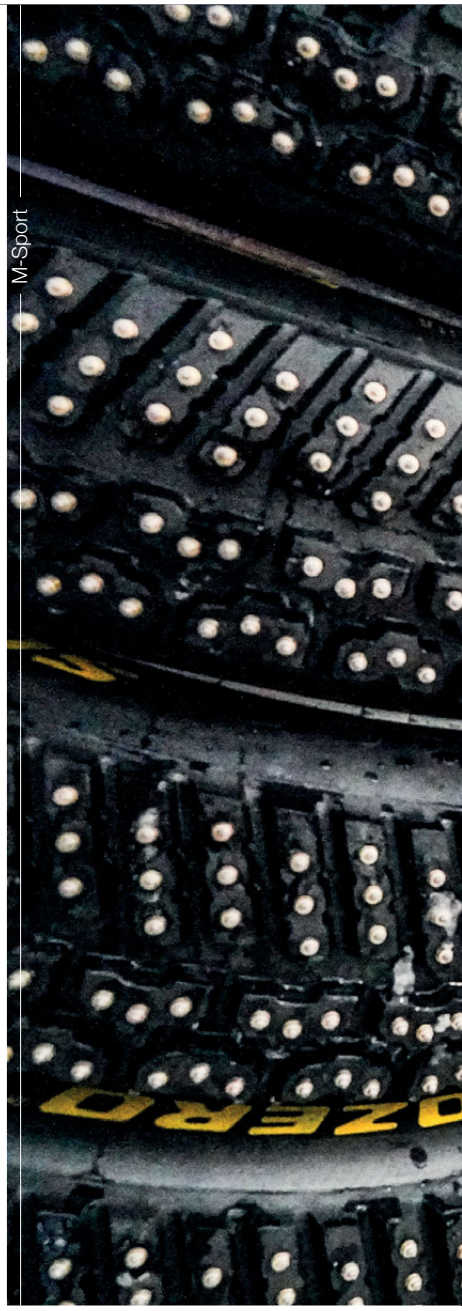
"One of the things we developed was a specific snow box ahead of the radiator," explains McMillan. "On a snow rally, there's obviously a big risk of a car going off into a snow bank, and the snow box is there to trap the snow without it clogging up the radiator, which would obviously lead to overheating."

A special low temperature oil is used in the dampers for winter conditions. Attention also has to be paid to the problems caused by ice forming on moving parts.

One expert we talked to warned: "Never underestimate the problems caused by low temperatures. You might think heat was the biggest enemy, but low temperatures cause all sorts of issues!"

Cars also have heated side screens, and toggles on the steering wheel so that drivers can flick the spotlights on and off: vital when driving through a snow storm, as white snow crystals reflect the light. That's the same reason why some drivers wear yellow-tinted glasses on the Arctic Rally. These are designed to put a bit of perspective on the flat white landscapes, making it easier to discern the road layout. The same technology has extended to lamp pods: some crews like to run yellow headlamps, a bit like French motorists in the 1970s, as they believe it helps them to see better. And on the ultra-fast icy roads of the Arctic Rally, which paradoxically offer more grip than gravel, confidence is everything. This is why the

> *"It can get to the point where you're not able to finish a job because you lose all feeling in your hands"*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ABOVE Pirelli's Sottozero Ice J1 tyres featured close to 400 tungsten studs, each one protruding a maximum of seven millimetres out from the tread. Much of their total length is hidden out of sight within the tyre, locked into place during a patented process of vulcanisation

Toyota GAZOO Racing

BELOW Special equipment was mandated for drivers who might have to brave the conditions to complete work on the car

RIGHT M-Sport developed a 'snow box', ahead of its radiators, to trap snow and prevent overheating

drivers work very hard to find precisely the right snow set-up during the pre-event test.

"In the end, that's pretty much all you can do because modern homologation standards are so strict, there's very little scope to do something different," adds McMillan. "The days when you would build specific cars for specific events are gone: these cars have to do everything."

EXPOSED TO THE ELEMENTS

The pre-event tests are often more challenging than the events themselves: especially for the mechanics on this year's Arctic encounter. As Keiron Bowness, M-Sport's head event technician, points out: "You don't have all the tents and equipment that you would have on a rally ▶

M-Sport

ABOVE The louvres that form part of the WRC cars' aero package are vulnerable to picking up large amounts of snow

M-Sport

ABOVE Conditions put extra pressure on the service arrangements

BELOW A picturesque setting, but behind the scenes the rally threw up problems rarely encountered by the teams

Toyota GAZOO Racing

> *If it's hot, you can generally work around it; but there's absolutely nowhere to escape from that sort of cold"*

at the test: often it's just you crawling under the car on a thin plastic sheet, exposed to the elements! It can get to the point where you're not really able to finish a job because you lose all feeling in your hands."

The mechanics prepare for it by kitting up in thick thermal over-suits on top of their usual overalls. But that also slows the whole process down. When two or three burly people are crammed together under a Fiesta, there's barely space to move, let alone perform a millimetre-perfect job under intense pressure of time.

The equipment also suffers with the cold: battery-powered tools can run themselves down almost instantly, while the oil in the jacks becomes thick and sluggish. It's a bit like trying to service a car while wading through treacle. Naturally, there's a psychological toll as well, with the cold and inconvenience putting tempers closer to the edge in what's already a tense situation.

"Because of all those things, I think the Arctic Rally is probably the most physically challenging event of the year," concludes Bowness. "If it's hot, you can generally work around it; but there's absolutely nowhere to escape from that sort of cold."

It was a double points finish on the Arctic Rally for M-Sport though, with the factory Fiesta WRCs ending up in eighth and ninth places thanks to Teemu Suninen and Greensmith respectively.

They would have been followed home by the privateer Fiesta of Janne Tuohino, but on Saturday night, with just two stages left to go on Sunday, the Finn slipped in the sauna and dislocated his shoulder. Try as you might, there are some local hazards in Finland that you just can't prepare for.

M-Sport

ABOVE The undulating landscape passes at a remarkably high speed, with studs perversely offering drivers more grip than they would expect on pure gravel

DAKAR'S HYDROGEN PIONEERS

Hal Ridge examines GCK's ambitious plans for a hydrogen fuel cell-powered assault on the legendary Dakar Rally

FOR most companies or teams making a switch to competing in motorsport using alternative energies, one project is more than enough.

But for GCK (now rebranded Green Corp Konnection) – which is known foremost for fielding radically-designed Renault Meganes in the World Rallycross Championship for the last three years – its latest endeavour isn't just a single entity: it's a vision tied heavily to seismic changes in the rally-raid discipline. And things are moving so fast that GCK's latest creation, the e-Blast 1, launched in November and demonstrated at the Dakar Rally in January, is now as good as obsolete in its current guise and will soon be replaced by its younger sibling.

That's because the firm is over two years into a five-year plan, with the end vision of competing in the Dakar Rally with an electric-hydrogen hybrid machine using in-group developed components. This is alongside plans for supplying customers, and providing energy systems to the entire event [see sidebar]. If it sounds ambitious, that's because it is.

EMISSIONS MISSION

Dakar promotor ASO revealed plans in January to include an alternative energy class in 2022 for electric, hybrid and hydrogen-powered vehicles. From 2026, competitors in the elite car and truck classes will have to meet the required ultra-low emission standards, while in 2030 the target is to have all cars and trucks using

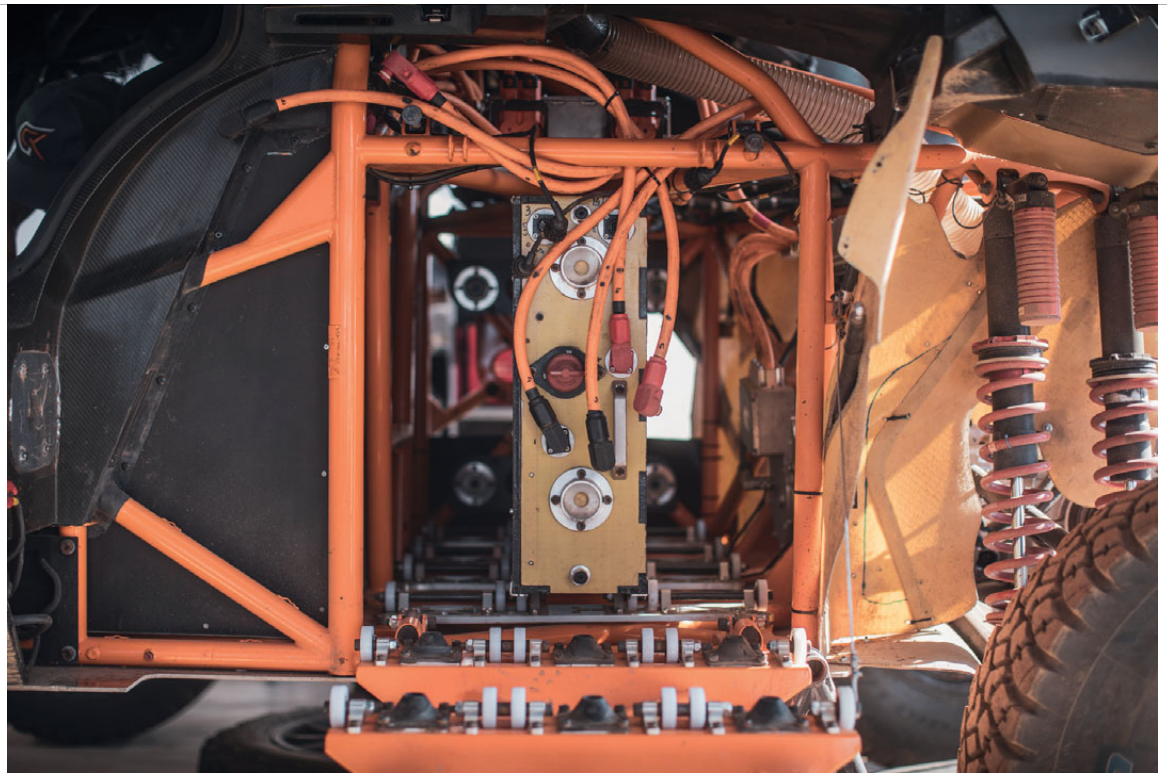
BELOW The first public outing of GCK's fully-electric off-road racer, the e-Blast 1, was timed to coincide with the revelation that Dakar organisers are pursuing a greener future

> *"Without turning green, there was a risk of the death of the Dakar"*

alternative energies.

In conjunction with that announcement was the public outing of the e-Blast 1, GCK's fully-electric off-road racer. But, while the French outfit has implemented the powertrain and associated systems into its latest creation, the chassis isn't new. GCK owner Guerlain Chicherit, an experienced rally, rally-raid and rallycross driver, bought four 3008 DKR chassis from Peugeot Sport when the French marque axed its programme. The tubular spaceframe machine has made the perfect platform for GCK to utilise for the first steps on its multi-year journey.

Peugeot's DKR iterations won the Dakar in the hands of Stephane Peterhansel in 2016 and 2017, and Carlos Sainz the following year. For that final assault, in 2018, the 3008 DKR was updated with an increased track width by 10 cm each side, new upper and lower arms in the double-wishbone suspension layout and new rear track rod ends, all in a bid to aid stability. With the V6 bi-turbo diesel engine now benched, but formerly located in the rear section of the spaceframe, the balance of the car will have inevitably changed. ▶



LEFT & BELOW LEFT
The 150 kWh batteries, manufactured by Ion Battery Systems, have been designed to facilitate quick changes

But GCK Motorsport has recognised the benefit of using a chassis developed on a huge budget like that of Peugeot's works effort.

"We decided two years ago now to launch this programme. We have decided to take steps and not to go directly from clean paper to the race," explains GCK CEO and head of GCK Motorsport, Eric Boudot. "The first step was to concentrate our efforts on the powertrain, that is key. And then after the development, after we have validated all the technology, we'll have the time to think about making a new chassis and changing the car.

"We had the opportunity at that time to purchase the fleet of Peugeot, that won the Dakar in 2017 and 2018, so we have the four cars and for us it was better to start without having in mind the problem of the chassis and the suspension. At that time it was the best car in the world in rally-raid, and it is still one of the best cars in the world for this competition, so it permitted us to just focus our efforts of

> *"Making enormous fuel cells is something that is more at the level of R&D, and more 'R' than 'D'"*

development on the electrification of the vehicle."

From within the GCK Group – consisting of seven different companies, all geared towards sustainability – the 150 kWh batteries fitted to the car have been manufactured by IBS (Ion Battery Systems). Likewise, the rear-mounted 250 kW motor, that delivers 1,000 Nm torque, is an in-house creation, developed together with undisclosed partners.

HUGE INVESTMENT

"We changed a lot of things on the car," says Boudot. "What is similar to the Peugeot I would say is the suspension and the chassis. Then we cut the chassis in two and all the rear has been redeveloped and redesigned, all the tubes at the rear to accept the motor, the battery and the gearbox. The link to the ground has been maintained and was huge investment of Peugeot, so for us it was a lot of time that we save by taking those parts."

The chassis retains its twin three-way adjustable dampers per corner, one of each pair accompanied by a steel coil spring and having 460 mm travel. The BF Goodrich tyres clad magnesium one-piece 17x8.5 OZ Racing wheels which house Alcon four-piston callipers and 355 mm vented discs all round.

To overcome the vast range of terrain that makes up the Dakar challenge, the e-Blast 1 is fitted with a two-speed paddleshift transmission – unlike many electric race cars, which are single-speed. "You cannot drive the ▶

LEFT The current car features Alcon four-piston callipers and 355 mm vented discs all round

BELOW The rear of the Peugeot chassis has been redeveloped and redesigned to accept the motor, battery and gearbox

same in the sand, gravel, on the flat zones so we have a new gearbox developed specially for this vehicle, and it was important that it could be made for the position of the motor in the vehicle [too]," explains Boudot.

The interior is effectively all-new, adapted for fully-electric use. The first iteration of the car was running 12 months before its Dakar outing in January, with much of the testing executed by development driver Kevin Abbring, a former works Hyundai World Rally Championship campaigner.

"We have developed and implemented new technologies for the driver as well: they can now brake using the regen system, they can force the regen by hand, which Kevin has been very positive about," says Boudot.

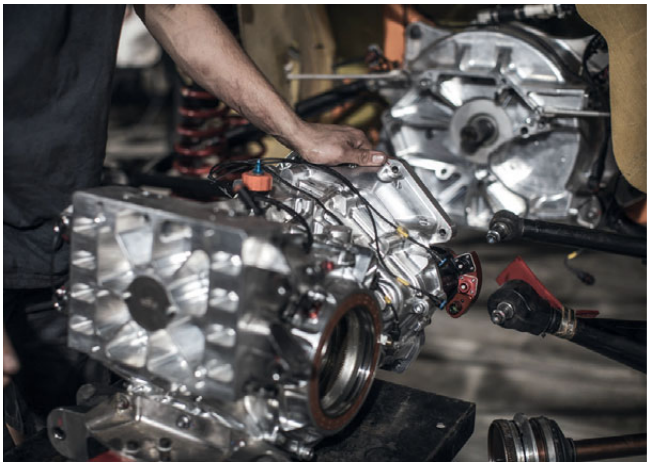
REGEN CHALLENGE

Developing effective brake regeneration systems in low-mu, loose surface conditions is one of the biggest challenges engineers face in off-road electric competition vehicles. While GCK is coy about revealing specific details throughout on the e-Blast 1, Boudot openly admits that evolving a regen system on the car is a two-part programme.

Abbring is already using the existing system as a driving-aid, but for the car to be able to complete stage durations of over 450 competitive kilometres, sometimes part of over 800 total km sections on the Dakar, the car needs to harness and store a lot more energy than it currently does. ▶

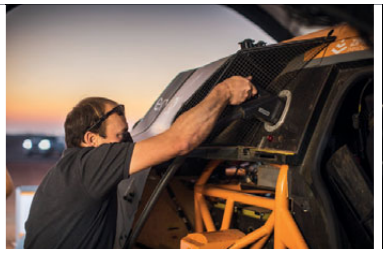
ABOVE The tubular spaceframe 3008 DKR offers a perfect platform for the team's first steps towards its hydrogen objective

BELOW LEFT & RIGHT The rear-mounted 250 kW motor delivers 1,000 Nm of torque



While packaging of the battery packs in the e-Blast 1 has been designed to facilitate quick battery changes, the car can currently achieve between 120 to 130 kilometres of range.

The plan isn't for this machine to remain as electric-only, though. As you read this, the French squad is working on returning to the Dakar for a second public debut next January. This time it will feature a bespoke hydrogen fuel cell powered by 25 kg of 700-bar hydrogen, delivering 120 kW of energy, coupled with a reduced-capacity 60 kWh battery pack, set to be cooled by a new system integrated to allow faster charging. The car will be renamed the e-Blast H2.



ABOVE The e-Blast 1 is charging into a sustainable future

HERE COMES HYDROGEN...

"We're keeping a bit less than half the battery capacity of the vehicle, and we will replace the other half with a fuel cell and hydrogen tanks. That will permit us to have a pure hybridisation," says Boudot. "We're not in a ratio of having a fuel cell with a small battery, we are having a big fuel cell with also a big battery. And with that we have calculated it will permit us to have two times 250 km in one stage, with refuelling in the middle."

While electric motor racing is still relatively new, it's positively old hat compared to hydrogen competition. As such, there is a lot to learn for those heading down that path in the near future, especially tied with the ASO's plans.

"A lot of things are completely different and even more if you speak about hydrogen," admits Boudot. "For sure the Dakar is about autonomy, but also the conditions: the outside conditions and temperature, but also the dirt, the G [force] impacts in different situations. I think that rally-raid is the most difficult category for the technology today when you switch to green."

Such technologies are advancing at a fast rate, though. GCK embarked on this five-year plan over two years ago. Back then, hydrogen was much more of a black art than it is today. While the squad's batteries are being developed in-house under the GCK umbrella, the hydrogen fuel cell side of the ▶

> *"Hydrogen was much more of a black art two years ago than it is today"*

RIGHT The project is viewed by GCK very much as a showcase for technology aimed eventually at the mass market

project will entail a partnership with FEV (see news). The plan is for that phase of the project to be completed this year, ahead of the car's next run in the Saudi Arabian desert, again in demo mode.

In 2023 the ambition is to begin competing. Whether that's in the full event or selected stages, is as yet unknown. In 2024, GCK is hoping to run a two-car effort on the Dakar competitively.

But this effort isn't just about making a race car and team: the whole project is being created with wider objectives in mind. "We decided to focus on the hybrid [concept] with big batteries and big fuel cell and that was dictated by a lot of considerations, including the calculations of range and the average power [needed] in the race, and also because of the technology maturity," explains Boudot.

"Today, making enormous fuel cells is something that is more at the level of R&D, and more R than D, and we have to keep in mind the philosophy of the GCK Group. Motorsport is our communication, our marketing, and to technologically improve the parts, but we are building an industrial group of different companies."

LEFT GCK was best known for its rallycross exploits prior to this project

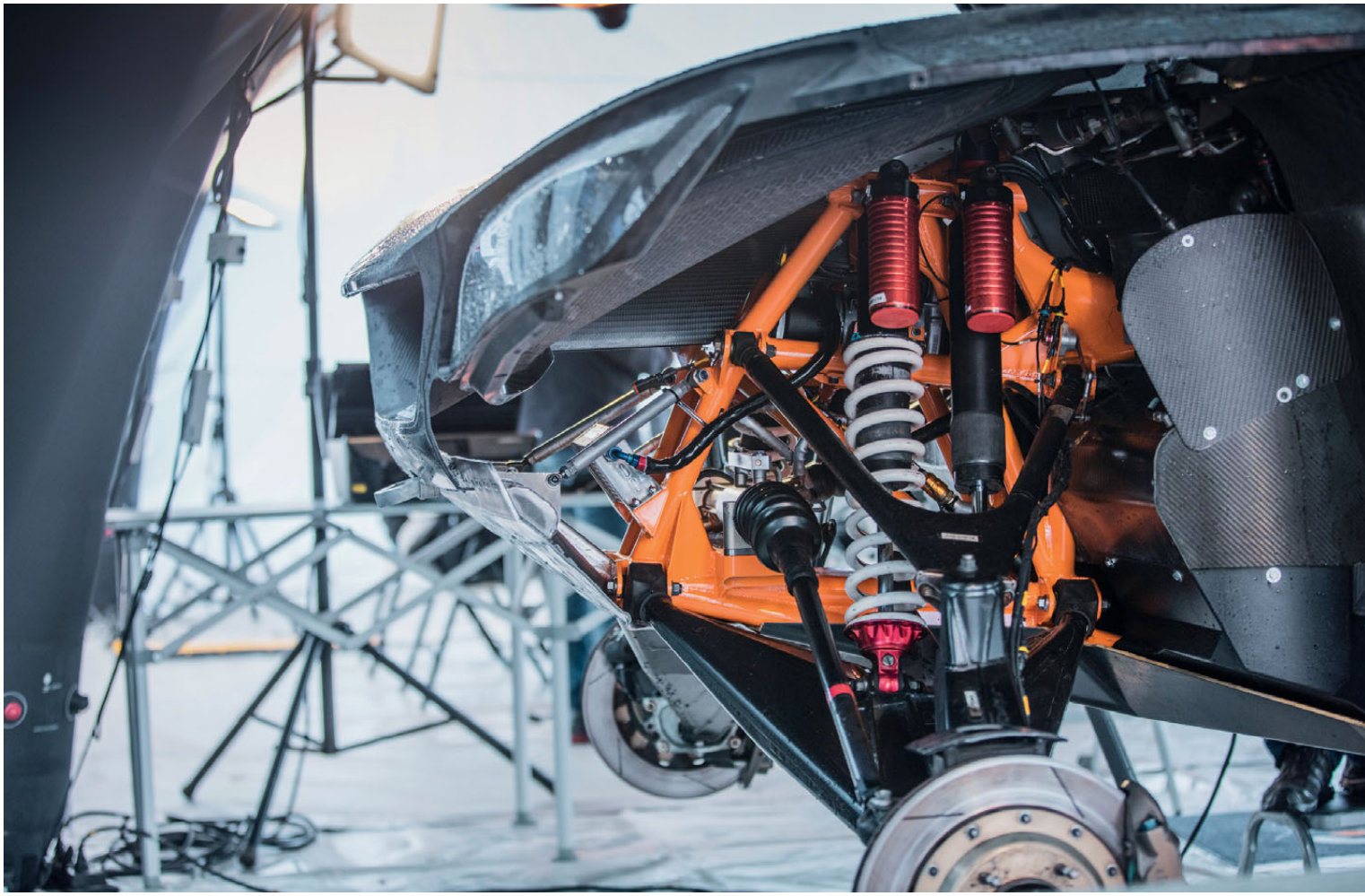
BELOW Retaining the Peugeot's suspension, which was good enough to scoop three successive victories on the event, enabled more focus to be given to the electric powertrain

MASS MARKET TARGET

One of these companies is GCK Industry, which is now targeting the market of retro-fitting ICE [internal combustion engine] vehicles to electric with batteries or with hydrogen [under the GCK Exclusiv-e banner].

"The Dakar should be the window for the technology, and we should also be able to transfer what we develop in motorsport to the mass market," says Boudot. "Even if it's a niche market in our case today, we cannot make a fuel cell or a component that is 10 times the price of the mass market acceptability, or that is 10 times what it should be for a standard vehicle. So this is a good compromise, one with performance and also reliability.

"That's always the problem with motorsport: you have to compromise between products that are more ▶



Powering the Dakar's future

Efforts to strive for a greener future aren't confined just to the cars

ONE of the significant challenges for the Dakar Rally compared to other motor sport disciplines is the lack of a centralised paddock or service area.

The event's tour between bivouacs makes the challenge of using alternative energy greater still. But, along with its efforts to produce a car to compete on the event, GCK is also well involved with powering the Dakar's future.

In a tie up between GCK Energy and Saudi solar energy leader, Desert Technologies, GCK is working on the transformation to a 'green bivouac' for the Dakar.

This year, it provided green energy to the media centre and TV wall to showcase a fully integrated charging solution for electric vehicles. That included 630 solar panels covering 1,200 square metres, producing between one and two Megawatts (MW), using GCK Energy's bespoke mobile photovoltaic solution along with the containerised solar field delivered by Desert Technologies.

A mobile storage system, manufactured together with another industry partner, Socomec, collected and stored between 300 kW and 600 kW during the day, before delivering the power to the bivouac after dark. This included charging GCK's e-Blast 1 for its demonstration programme.

The concept is in line with the ASO's plan to have a fully autonomous bivouac by 2024. In future the vision, which is also now a necessity, is to also provide power for hydrogen-run vehicles.

ABOVE & LEFT
A 'green bivouac' was trialled this year

in D than R, keeping in mind that it should be a bit R also because we have to be in advance of the market."

As yet there are no confirmed regulations for the Dakar Rally's future concept. It's a work in progress between the FIA, ASO and technical working groups. Dakar Rally director David Castera's announcement during the 2021 event revealed fairly open rules in the first instance of introducing new technologies, allowing cars to run either two- or four-wheel-drive from next year.

OPEN TO CHANGE

GCK is involved in discussions about the regulations, and is more than open to the possibility of changing or rebuilding its current chassis to suit new rules.

Inevitably, perhaps, the rule-making process will be partly shaped by the clout of Audi, as was the case for so many years at Le Mans. The German marque will take on the Dakar next January with a hybrid machine, using a "high-voltage battery, which can be charged as required while driving via an energy converter in the form of a highly efficient TFSI engine [believed to be based on its DTM engine]."

"What is important for us is the powertrain," stresses Boudot. "In the future we want to also be a partner of other teams as a provider of powertrains in hydrogen, electric or whatever."

There's no denying that GCK's aspirations are ambitious, but the Dakar organisers'

plans are equally so. With all other top-level motorsport heading for a greener future, there seems little option, and the progress is perhaps a little overdue in the rally-raid world.

"I think this [the ASO's objective] is ambitious but also imperative," notes Boudot. "The decision being taken by ASO is challenging, but it is very good to fix some dates. We all know without this change, without turning green, there was a risk of the death of the Dakar. It's very difficult to promote a competition in the desert with such fabulous surroundings and still pollute when we can do it another way."

GCK isn't alone in its new venture. Audi Sport will be present at the Dakar next year with its hybrid machine, while explorer Mike Horn and multiple motor cycle Dakar winner Cyril Despres are aiming to start the 2023 event with a Gen-Z hydrogen-powered car. There are also hydrogen-powered truck projects in the works from Gaussin Group and Kolen Industries.

The event has long been regarded as one of motorsport's last great adventures. The next few years for GCK and its counterparts, breaking new ground in Dakar technology, will be an even greater challenge still, and a fascinating one at that. RT

ABOVE The interior of the Peugeot has been adapted for fully-electric use

BELOW Maintaining a low centre of gravity was a key objective that drove the packaging

MOTORSPORT MUST LEAD, NOT FOLLOW

The Energy-Efficient Motorsport Conference persuaded motorsport's leading lights to share their insight into the direction of the industry – without leaving their living rooms. **Sergio Rinland** fires up the computer

AFTER 18 years of successful running, the Motorsport Industry Association's Energy Efficient Motorsport Conference (EEMS) was forced online for the first time this year.

It was, nevertheless, very well presented and prepared. The conference featured many prestigious speakers who offered an insight into what leaders of the automotive industry and motorsport are thinking, and how they are responding to the challenging times in which we live.

As ever, MIA chairman Chris Aylett was full of optimism, suggesting that these difficult times offer a unique opportunity for the motorsport industry, from whichever angle you look at it. I agree. Every cloud has a silver lining and for motorsport – a discipline which has a 'can-do' attitude and refusal to give up running through its very DNA, and is well-versed in striving to find any possible means with which to beat the opposition – this is a great opportunity.

Since the early days, at the end of the 19th century, motorsport has been all about efficiency: how to get the most out of a Joule of energy. Hence, currently, where the rest of the world has woken up to the fact that our resources are limited and our contribution to global warming is unsustainable, motorsport is – like the old Boy Scouts motto: 'Be Prepared' – always ready to respond.

There can be a tendency for us to be apologetic about the excesses of Formula 1. But, as Andy Cowell reminded us at EEMS, achieving an internal combustion engine with more than 50% efficiency is outstanding to say the least.

The conference threw up some very interesting comments, many of which will resonate with any regular readers of this column. Cowell also suggested, and I would agree 100%, that the current trend of restrictive rules goes against the motorsport grain and doesn't necessarily save the money it was intended to.

FREE FORMULA

It was a breath of fresh air when he proposed a free formula, one where the limitation is in energy consumption. Let teams find the best possible solution, he said, rather than the rule-makers second-guessing where the automotive industry will be in a few years' time. The latter route dictates which technology to promote, sometimes without all the information at hand.

The argument of EVs vs Carbon Neutral Fuels also resurfaced during the EEMS debates. The conclusion was very much of 'horses for courses'. There is no doubt that for city mobility and transportation there is no option but electric, even disregarding how the electricity is generated (albeit far from populated areas!). We must clean the air in cities. No argument there.

As for the rest of transportation and particularly for what we care about most, motorsport, the jury is still out.

The VW Group is progressing relentlessly towards carbon neutral fuels by CO2 capture. Porsche and Siemens, meanwhile, are developing and implementing a pilot project in Chile that is expected to yield the world's first integrated, commercial, industrial-scale plant for making synthetic climate-neutral fuels (eFuels).

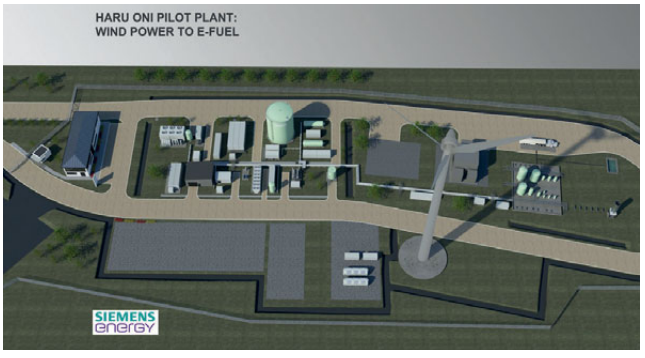
So, we expect that ICE will be with us for a few years to come. For motorsport (and for Ulrich Baretzky, always one of the leading and most charismatic figures in these debates), that is pure music.

There were some concerning comments to emerge from the conversations, however. F1 Chief Technical Officer Pat Symonds disclosed that F1 is looking more and more into standardization of components, albeit with a tender process. I believe that will work to the detriment of the industry, as well as closing the door for future developments. Who said there is no more to come from braking systems, gearboxes or indeed batteries?

More than ever, we need motorsport to contribute by developing new technologies and processes to then be applied in other industries. Standardizing components only creates monopolies, restricting further progress. As we have been saying for many years, and the proof is out there for everybody to see, control formulas and standardized components do not make motorsport any more economical. On the contrary, if we look closer.

Where I do agree with Pat is the fact that for motorsport, and Formula 1 in particular, its prime objective is to provide a good spectacle. Without that, every other discussion is irrelevant.

As for the motorsport industry, going carbon neutral, as suggested by Baretzky and Jost Capito, is a must, as it is for every other industry. Well-to-Wheel efficiency and carbon neutrality should be our main target. RT



LEFT Porsche and Siemens Energy are leading climate-neutral eFuels development with the "Haru Oni" pilot project in southern Chile taking advantage of wind power

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