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Volume 27 Issue 11
Published September 2020
The next issue will be published
in early October 2020
ISSN 1356-2975

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Overseas copies are sent via air mail
Special offer 12 issues for the price of 10
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Race Tech (ISSN: 1356-2975) is published monthly by Kimberley Media Group Ltd.

Cover image: Toyota Gazoo Racing

Design & Production:
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LE MANS 2020

Different month Unique challenges

COVER STORY PAGE 36

481.576 MPH

9 Hot Rod Trophies

3,156 HP

1 Fastener

The Speed Demon Racing Team relied on nothing but ARP fasteners to earn the Hot Rod Trophy for a record 9th time with a top speed of 481.576 mph, while setting a new piston-engine, wheel-driven land speed record at 470.015 mph.

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MOTORSPORT at the highest level is all about pushing technical boundaries. We have seen time and again through the years how technologies and processes developed in the heat of competition can be fed into other industries.

Aerodynamics, brake systems, electronics and microelectronics, data capture and storage, simulators, telemetry, IC engines, energy storage units and the advancement of materials have all changed beyond recognition in the last few years in all forms of motorsport where regulations allow, with many of the lessons learnt being used in other industries. Many top teams have now created separate entities to sell their knowledge to other industries. One of the most recent stories is Williams Advanced Engineering using the expertise it gained in Formula E to develop the world's largest hydrogen-powered mine truck for global mining manufacturer Anglo American.

As you will see elsewhere in this magazine, McLaren Applied Technologies has been working with Swiss company Bcomp, the sustainable lightweighting specialist, to develop a natural fibre racing seat for Carlos Sainz and Lando Norris. It is the first F1 car part to be made of renewable textile fibres. By optimising the mechanical properties of flax fibres through fabric architecture, it has been possible to make a seat with the required strength and stiffness, but with a 75% lower CO2 footprint compared to its carbon fibre counterpart.

What all this goes to show is that the motorsport engineer is a most innovative person with boundaries there to be broken. While it is essential to have regulations in place to stop runaway development, they must not be so tight that they stifle all innovation. It is a tough call for the organisers and sanctioning bodies.

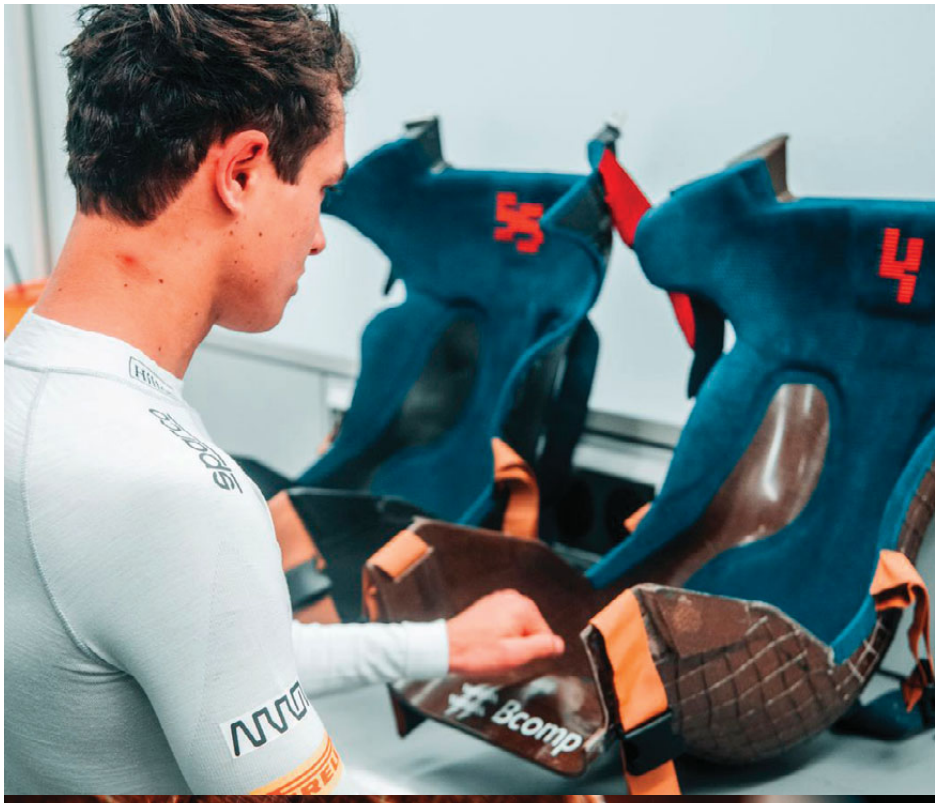
On a different note, it is very good news that all 10 Formula 1 teams have now signed the Concorde Agreement, which takes us through to 2025. This includes Haas, which was rumoured to be pulling out of F1 but has now committed for the next five years. Also, as I write this, the news has come through that Williams F1, which was put up for sale in May, has been bought by US-based investment firm Dorilton Capital. It will still race under the same name and remain at its English base. You can read the thoughts of Sergio Rinland, who assisted on one of the squad's finest designs, in our Last Lap column.

Finally, and sadly, I am very sorry to report that Deputy Editor Alan Stoddart is leaving us. He has been offered a journalistic job in the healthcare sector, in which he has a lot of experience, and he goes with our blessing. However, we will miss him, his commitment, his good sense of humour, his work ethic and his passion for writing. RT

William Kimberley
EDITOR

F1 RACES INTO THE FUTURE

McLaren pioneers use of sustainable composites in F1



McLAREN has revealed that it is collaborating with Bcomp, a Swiss sustainable lightweighting specialist, to develop F1's first natural fibre composite racing seat.

McLaren changed the face of the sport in 1981 when, in conjunction with aerospace expert Hercules, it introduced the first carbon fibre composite monocoque for its MP4/1. Now, carbon fibre accounts for around 70% of a modern-day F1 car's structural weight. But what if, in this age of economic uncertainty and environmental responsibility, there was a cheaper and more sustainable alternative?

The natural fibre racing seat developed for Carlos Sainz and Lando Norris is the first F1 car part to be made of renewable textile fibres. By optimising the mechanical properties of flax fibres through fabric architecture, it's been possible to make a seat with the required strength and stiffness, but with a 75% lower CO2 footprint compared to its carbon fibre counterpart.

"The use of natural fibre composites is the latest example of pioneering, composite materials innovation at McLaren," said McLaren F1 team principal Andreas Seidl. "Not only does this solution provide equivalent performance to carbon fibre, it represents another step forward in our evolving sustainability programme, while underlining our commitment to helping F1 turn its ambitious sustainability strategy into action."

"For decades, F1 has been an innovation lab for technology that has transformed not just motorsport, but the automotive industry and beyond," added McLaren F1 technical director James Key. "The sport must continue down the road of getting to an increasingly environmentally friendly set of conditions, and our development and application of natural fibre composites is an example of how we're accelerating this journey, as well as the ongoing evolution towards cleaner mobility."

Since 2019, the seat has constituted part of the driver's weight budget. This offered McLaren the opportunity to use additional bio-composite material, if necessary, to

LEFT The seat is seen as just the start for the use of natural fibre composites

ensure sufficient strength and stiffness in this safety-critical component.

The original carbon fibre seat design was reverse-engineered by Bcomp, then the new design was optimised and manufactured. The seat was run in pre-season testing without any problems and the Bcomp flax seats could be raced in the near future. With so many potential applications, the natural fibre composite racing seat is seen as just the first step in a process to identify other components that can be replaced with a sustainable alternative that has equivalent weight and performance.

Bcomp started as a garage project in 2011 with a mission to create lightweight yet high performance skis. The bCore were launched and successfully adopted by some of the biggest names in freeride skiing. The founders, material science PhDs from EPFL, used flax fibres to reinforce the balsa cores and improve shear stiffness. Impressed by the excellent mechanical properties of flax fibres, the development to create sustainable lightweighting solutions for the wider mobility markets started.

Today, Bcomp is a leader in natural fibre composites for sustainable lightweighting. Its solutions are found from sports and motorsports to automotive interiors, luxury sailing yachts, bridges and satellite panels.

"Sustainability and decarbonisation is a global issue, and it is fantastic to see motorsport embrace carbon alternatives, paving the way for widespread adoption within large-scale mobility application," said Bcomp CEO and Co-Founder Christian Fischer. "McLaren has always been a pioneer within the sport, in terms of both composites and sustainability, thus it feels like the perfect match and a great honour to collaborate with such a prestigious brand." RT

How McLaren broke new ground - Page 20


PUTTING NATURAL FIBRE COMPOSITES IN THE DRIVING SEAT

F1 RACES INTO THE FUTURE

Williams saved by sale to US investment firm

WITH Formula 1's new Concorde Agreement in place, the sale of its last remaining family-owned team, Williams, has underlined the sport's move into a fresh era.

The Grove-based squad represented the last bastion of the past, having repeatedly rejected the overtures of manufacturers. It had also bucked the trend of seeking the backing of a consortium, or a Haas-style partnership with a bigger team. However, its Advanced Engineering division was sold last December and it was announced last month that Williams Racing has now been acquired by Dorilton Capital, a private investment firm headquartered in the United States.

The deal received the unanimous support of the Board of Williams, including its founder, Sir Frank. Dorilton Capital is said to appreciate the importance of respecting and retaining Williams' heritage and culture and is committed to maintaining its identity. The team will continue to race and compete under the Williams brand, with the chassis name remaining unchanged. Dorilton has no plans to re-locate the team from Grove, its traditional home.

The new Concorde Agreement is set to transform the sport. The hope is that it will help address the historical challenges that Williams has faced as an independent constructor, by reducing the financial and on-track disparities between teams.

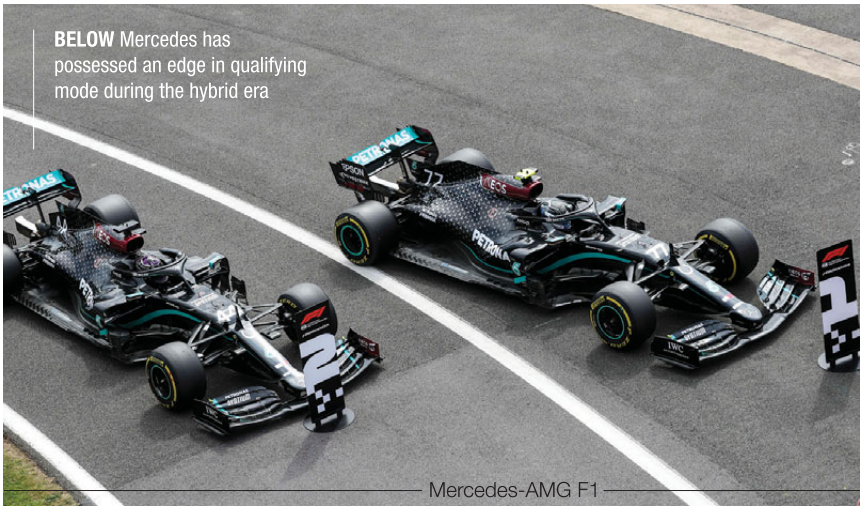
"We wanted to find a partner who shared the same passion and values, who recognised the team's potential and who could unlock its power," commented deputy team principal Claire Williams. "In Dorilton we know we have found exactly that.

"As a family we have always put our team first. Making the team successful again and protecting our people has been at the heart of this process from the start. This may be the end of an era for Williams as a family-owned team, but we know it is in good hands. The sale ensures the team's survival but most importantly will provide a path to success."

Matthew Savage, Chairman of Dorilton Capital, commented: "We believe we are the ideal partner for the company due to our flexible and patient investment style, which will allow the team to focus on its objective of returning to the front of the grid. We look forward to working with the Williams team in carrying out a detailed review of the business to determine in which areas new investment should be directed." RT

LEFT Williams has been saved from extinction

'Party Mode' ban could backfire, says Merc



BELOW Mercedes has possessed an edge in qualifying mode during the hybrid era

Mercedes-AMG F1

MERCEDES F1 boss Toto Wolff has suggested that the FIA's attempts to restrict the use of special engine modes could backfire, improving the World Champions' race performance.

A technical directive was originally considered for the Belgian GP, requiring teams to operate their engines in the same mode for qualifying and in the race. But the ruling, which effectively bans the use of engine "party modes" in Q3, was delayed.

The move is intended to curtail the dominance of Mercedes in qualifying. But Wolff insisted that he only expected his cars to lose a couple of tenths of a second, and that rivals would also be affected.

"We have a good quali mode and we are able to give it a little bit more power in that last session," he admitted. "But if that is not possible anymore because everything needs to be smoothed out over the race, then it's not a deficit for us. On the contrary, we think we can translate it into more performance in the race."

Wolff explained that any surplus of power deployed in qualifying requires a relative cutback on race day to keep an engine's reliability in check. "If you can avoid damaging your power unit in those few qualifying laps that you have available in Q3 and then the odd lap in the race, the damage metrics goes down dramatically," he said.

"So five laps of quali mode not being done gives us 25 laps of more performance in the race. We are always very marginal on what we can extract from the power unit, and if we were to be limited in qualifying modes, then well, we will be stronger in the race." RT

Gulf back in top flight with McLaren

GULF Oil International Ltd is to return to motorsport's top tier with McLaren.

The multi-year strategic partnership will encompass McLaren Automotive's supercars as well as branding carried on the McLaren Racing F1 squad.

The deal reunites two companies that have a longstanding and successful history together. Gulf's link with McLaren started in 1968 and continued until the end of the 1973 season, with Gulf and McLaren enjoying success in both Formula 1 and the Can-Am series, in which the partnership won over 40 races. They united again at the Le Mans 24 Hours in the 1990s, with the McLaren F1 GTR running in Gulf colours throughout the decade.

"We're delighted to welcome Gulf back to McLaren and reunite two iconic brands in a new and exciting partnership," said Zak Brown, Chief Executive Officer, McLaren Racing. "Gulf is part of McLaren's history and are well-known for their innovation and technical excellence in the industry, which aligns with McLaren perfectly."

"This is a very exciting partnership that brings the Gulf brand back into elite motor racing," said Mike Jones, Chief Executive Officer, Gulf Oil. "The history books are full of remarkable tales that tell of what Gulf and McLaren have achieved in the past. Now we are together once more to write the next chapter of this unique partnership.

"We're proud to be working alongside a brand that shares our future aspirations and our ambition for innovation both on the road and on the track." RT

BELOW To launch the partnership, the Gulf brand is being integrated into the F1 team

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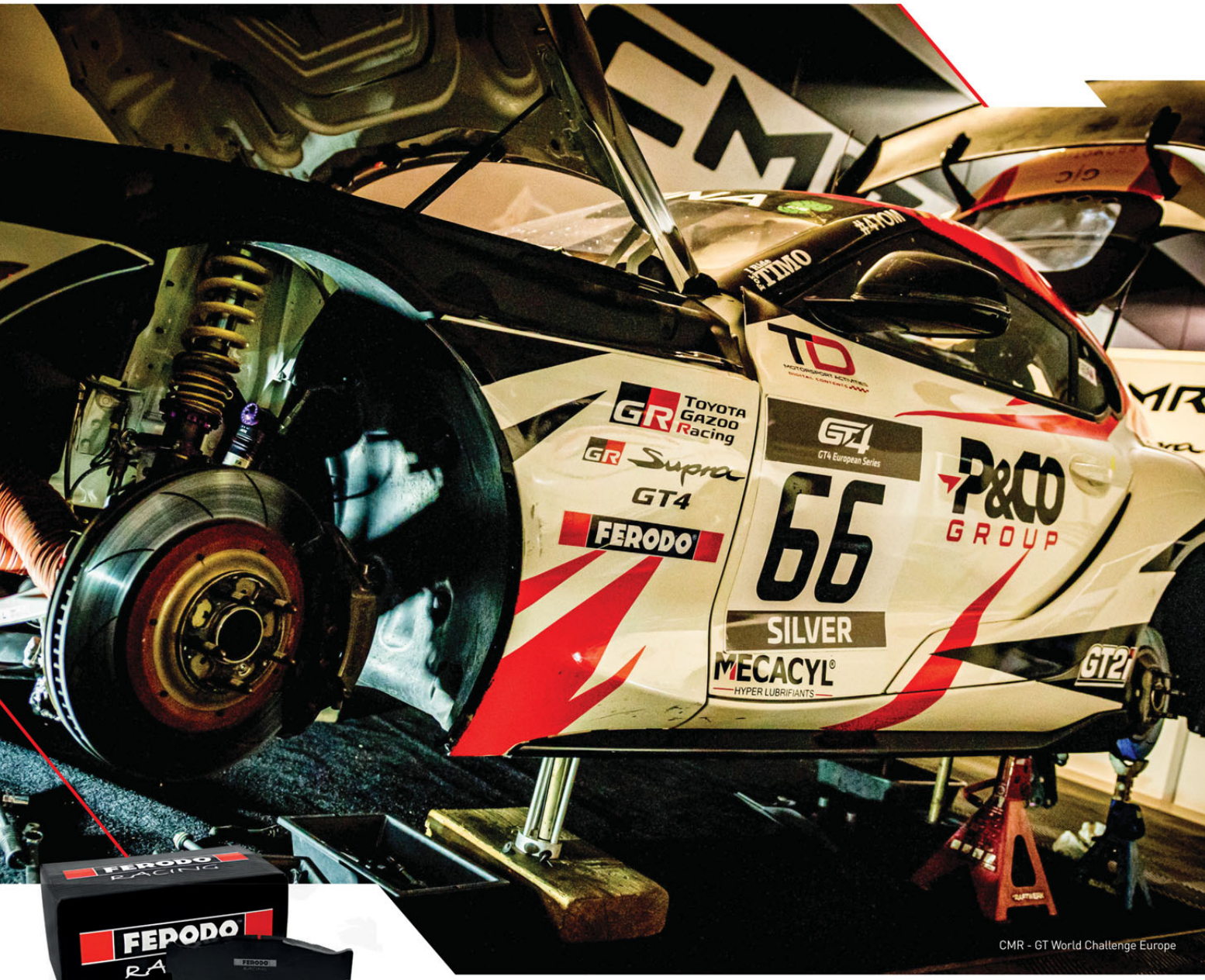

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MAHLE partners with FE Champions

MAHLE has signed a technical partnership with reigning Formula E champions DS TECHEETAH.

MAHLE will use its many years of expertise in e-mobility to support the racing team, while taking advantage of the rigours of the motorsport environment to gain a wealth of new insights that can be applied to series production development. As a driving force behind sustainable mobility, MAHLE has pioneered a host of core e-mobility technologies including developments in battery cooling.

"As one of the technology pioneers in the field of e-mobility, we're delighted to be working with DS TECHEETAH – one of the very best teams in Formula E. It's a partnership of equals," said Fred Tuerk, Vice President, MAHLE Motorsports.

"MAHLE Motorsports has been a strong partner to the most successful teams since the early days of racing. For us, motorsports are like a development lab. This new partnership in Formula E gives us the opportunity to test out our e-mobility solutions in the tough motorsports environment and to develop them quickly and consistently for use in series production."

Keith Smout, Chief Commercial Officer DS TECHEETAH, said, "We consider our new partnership with MAHLE extremely important for the future development of our team and we are beyond excited to have them on board. We have proved that we have the best technology and the best people in the business as it stands and, with the addition of MAHLE expertise, there is no end to what we can achieve. With such a great partner, we are certain to stay at the top of the Formula E Championship. We are pleased that such a well-established manufacturer like MAHLE recognizes the value of a relationship with our team and the importance of a sport like Formula E for the future."

MAHLE Motorsports has been a developer and systems partner on the international motorsports scene – including Formula 1, DTM, MotoGP and NASCAR – for several decades.

The solutions developed and produced by MAHLE for e-mobility cover a wide range of areas, including battery, powertrain, and cabin temperature control. MAHLE also offers electric drive motors and auxiliary components as well as solutions for control and power electronics, not to mention software and engineering for electric vehicles. RT


FIA/Formula E

LEFT The partnership with the double Formula E champions could spawn tech developments that can subsequently be put into series production

Le Mans Hypercar lure for Ferrari

THE holy grail of a factory Ferrari assault on Le Mans remains an option as the World Endurance Championship's new Hypercar category takes shape.

The Italian manufacturer has revealed that a factory return to the top flight of sportscar racing for the first time since 1973 is one of the options being evaluated.

"All the doors are still open," Antonello Coletta, who heads up Ferrari's sportscar racing activities, told Motorsport.com. "The interest in the top class is still there and we are scanning all the opportunities."

LEFT Ferrari is a mainstay of the GT ranks but is now evaluating the top category

Ferrari has already ruled out the new LMDh category, because its effort must be based on its own chassis rather than piggyback an LMP2 monocoque. However, the ability to race in both WEC and IMSA with its own road car-based hypercar design remains a lure.

Coletta stressed that the coronavirus pandemic had put a hold on the decision-making process. "After COVID we stopped everything because we had other priorities," he said. "But I hope to restart discussions after the Le Mans 24 Hours [in September]."

Ferrari was a participant from the start in the discussions that led to the publication of the LMH prototype rules in December 2018. RT

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BTCC squad's aero boost

THE Toyota Gazoo Racing UK BTCC team has revealed that it has benefited from D2H Advanced Technologies' computational fluid dynamics (CFD) modelling expertise this season.

The manufacturer-backed team, run by Speedworks, approached Buckingham-based D2H last December to help develop its Corolla. Work commenced in January, with data from a vehicle scan, and completed bodywork was delivered, two days ahead of schedule, in mid-March.

"Speedworks knew there was significant potential for aero performance improvement after the 2019 season and approached us to undertake complete analysis, design and bodywork manufacture in a very short timeframe," said Chris Hebert, D2H aerodynamics engineering director. "We used a combination of ANSYS solver and in-house D2H software to boost resolution and shorten timescales. We've found our approach is highly effective, and it enabled us to deliver on time for Speedworks."

Over the past few years, D2H has been challenging the perception of effective CFD being expensive and time-consuming when developing external aerodynamic performance. Hebert explained: "Unfortunately high resolution CFD is often seen as a very expensive option which can eat up time, whereas more affordable CFD alternatives are frequently unable to provide useful results. Our strategy from the start has been to develop methodologies and systems which enable high quality CFD within tight deadlines."

D2H has been using ANSYS CFD software for a number of years. "We view ANSYS as being the fastest, most accurate CFD solver on the market, while offering us the broadest options," Hebert says. "But this is only part of our strategy – we've also developed our own complementary software such as CAD-Check to give us control of the process while crucially enhancing both speed and quality of the analysis. Our high level of quality versus the cost of the process is at a ratio not seen elsewhere in the market, and routinely surprises new clients."

ABOVE D2H's aero work is one of a number of off-season improvements the team has made

D2H's CAD-Check software rapidly checks CAD data for viability and ensures higher precision results and fewer downstream delays from CAD errors. Hebert said it was an important factor in delivering Speedworks' bodywork on time.

Another key element in D2H's strategy is the use of larger mesh sizes which, in this case, are 20 times larger than those used by key rivals. The end result, it claims, is a 0.75-second reduction in average virtual lap times when the Corolla is tested over a number of UK circuits, which has translated into immediately improved race performance.

"D2H was able to offer us a combination of accurate CAD source data, high-quality CFD coupled to aero design, and an ability to manufacture the resulting bodywork design, all within a very tight timescale," explained Christian Dick, Speedworks team principal. "This end-to-end process was the ideal solution for Speedworks, enabling us to advance the Corolla's performance ahead of the 2020 season.

M-Sport expansion on course

PROGRESS on M-Sport's state-of-the-art Evaluation Centre continues at pace, and the multi-million-pound facility at the firm's Dovenby Hall Estate in Cumbria remains on course for completion this autumn.

The facility is considered integral to the future of the Cockermouth-based business, and once complete will safeguard existing jobs as well as creating new skills in the area.

Northern Developments' team of expert constructors have put in the hours over the summer months, and the building is now fully clad and watertight.

All internal pre-cast concrete walls have been installed, and initial partitions to separate the 10,723 m² workshop from its various departments are starting to take shape alongside mechanical and electrical installations.

The external concrete road is being laid, and structural glazing that will form the front of an impressive showroom at the front of the development is now also being installed.

ABOVE The Evaluation Centre is key to M-Sport's response to the pandemic

The project was made possible with investment from the UK Government's Regional Growth Fund (RGF) as well as Growth Fund investment provided by Cumbria Local Enterprise Partnership (CLEP), and will allow M-Sport to develop a one-of-a-kind facility in the UK.

"It's important that we move forward with an operational facility to attract new business and protect existing jobs as well as new skills in the area," said M-Sport Managing Director Malcolm Wilson. "These are particularly challenging times for so many businesses, but once the Evaluation Centre is up and running I'm confident that we can come out the other side and continue to provide for Cumbria."

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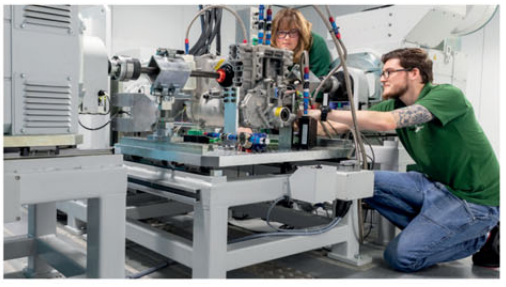

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IndyCar

Team behind Aeroscreen wins Schwitzer Award

THE engineering team behind IndyCar's new Aeroscreen won the 54th annual Louis Schwitzer Award, announced at the Indianapolis 500.

The awardees included Ed Collings, Red Bull Advanced Technologies; Antonio Montanari, Dallara; Stefan Seidel, Pankl Racing Systems; Craig McCarthy, Aerodine Composites; Brent Wright, PPG; Marco Bertolini, Isoclima; and Bill Pappas and Tino Belli from IndyCar.

BorgWarner and the Indiana Section of the Society of Automotive Engineers (SAE) International gave the award, along with a $10,000 prize, to the engineers. The award recipients have decided to donate the prize money to SeriousFun Children's Network.

The Louis Schwitzer Award honours engineers who innovate new concepts to improve competitive potential, with a focus on new technology with applications in the engine, powertrain, profile, chassis or safety. Judges aim to recognize advancements that increase performance, safety or efficiency.

"A lot of the emphasis for the Indy 500 is put on who will take home the coveted Borg-Warner Trophy, but we think it's just as important to highlight the significant efforts of the engineers behind the scenes who continue to innovate impressive technologies for the NTT IndyCar Series," said Frédéric Lissalde, president and CEO, BorgWarner Inc. "With safety being at the forefront of everything we do at BorgWarner, we're pleased to see this group of award winners honoured for bringing a creative and functional safety solution to the racing industry."

Implemented by IndyCar for the 2020 season to protect the driver from airborne debris, the Aeroscreen is designed to withstand up to 28,100 lbs (125 kN) of vertical and lateral static loads and survive the impact of a 2.2 lb (1 kg) projectile fired at 220 mph (354 kph). A key benefit of the technology is that it has no optical distortion and does not interfere with the driver's sightlines. Additionally, it allows for 'straight up' driver extraction in case of a back injury and is interchangeable with all Dallara DW12 chassis systems.

Consisting of an additive manufactured titanium top frame, a titanium-reinforced carbon fibre lower frame and a clear laminated polycarbonate screen, the top frame prevents large objects from entering the cockpit. Similarly, the lower frame stiffens the cockpit opening and provides attachment points for the top frame and screen, and the screen deflects smaller debris away from the cockpit.

The Aeroscreen is the result of a worldwide engineering collaboration between IndyCar and Red Bull Advanced Technologies (UK) for the structural design; Dallara (Italy) for the aerodynamic design; manufacturers Pankl Racing Systems (Austria) for the top frame; Aerodine Composites (US) for the lower frame; and PPG (US) and Isoclima (Italy) for the screen.

"Since the first call to Red Bull Advanced Technologies to the implementation of the Aeroscreen, there has been a dedicated group of engineers both internally and at our partners working tirelessly," IndyCar President Jay Frye said. "The countless hours that the entire team and paddock put into making our drivers safer on the racetrack have already paid dividends as we saw last month in Iowa. Thank you to BorgWarner and the Indiana SAE for their long-time and continued support of this prestigious award." RT

Mountune seeks investment

MOUNTUNE, the race engine and road-car performance specialist, is looking for a buyer or investment partner for its UK operation, after its founder resigned from his role as director. The firm has appointed Big Four firm KPMG to manage the sale process.

Mountune has 40 years of experience providing race engines globally. It has enjoyed success in the WRC, BTCC, WTCC, World RX, Formula Ford and many other series. As a robust aftermarket performance parts business, meanwhile, the firm is one of only a few which can tweak Ford Focuses and Fiestas without sacrificing the manufacturer's warranty, as an official partner of Ford. With a head office in Brentwood, the firm also has a facility in Los Angeles, California.

The UK's car market was already on a downward trend before the COVID-19 lockdown decimated new car sales. Matters were made worse still when founder and technical director, David Mountain, left his position in July. Mountain remains on Mountune's payroll on a part-time basis, while Andrew Williams has subsequently taken over as director and the company has opened itself up for investment.

Mountune released a short statement confirming that KPMG had been appointed to help organise its affairs, and find a backer – either in the form of a full sale or as capital investment into the current structure. RT

WAE to supply eSC

WILLIAMS Advanced Engineering is to supply the eSkootr chassis, battery system and powertrain for the Electric Scooter Championship's first two seasons.

WAE has already begun development of a high-performance electric prototype. It is capable of achieving speeds of more than 100 km/h (60 mph) and accelerating faster than most road cars.

Track testing will commence in September before all entrants are supplied with models for the 2021 launch season.

"Make no mistake, this is a very high-performance model," said Iain Wight, WAE Business Development Director. "Some of the cornering and acceleration figures that we've simulated are really quite extreme. It's like nothing that's ever been seen before." RT

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Murray rewrites the supercar rulebook

Coming to a racetrack near you soon? Gordon Murray reveals spiritual successor to McLaren F1

WHEN the all-new Gordon Murray Automotive T.50 supercar made its public debut last month, car enthusiasts around the world were rapt. Every single part of the car was scrutinised, including Cosworth's 3.9-litre V12 engine, which GMA describes as "the most engaging, characterful and driver-focused V12 engine ever produced."

The T.50 is the spiritual successor to the McLaren F1. Murray described it as: "a car created to improve on the F1 formula in every conceivable way. With 30 years of technological and systems advancement, now, the time is right to design the greatest analogue driver's car."

The aerodynamics, developed in conjunction with the Racing Point F1 team, are touted as the most advanced of any road car. That is in part due to a unique 400 mm rear-mounted fan that, says Murray, makes the infamous Brabham fan car that won the 1978 Swedish GP look like "a blunt instrument" by comparison.

The fan and its associated ducting system improve on conventional ground-effect systems by actively managing both underbody and overbody airflow. This boundary layer control ensures the most effective interaction of airflow on top of, and below the car, balancing drag and downforce at all speeds.

This same fan-assisted aerodynamic enhancement was first used for the road on Murray's F1 supercar. Few realise that two fans had been employed to pull air from under the car as these, far smaller, fans were hidden beneath each of the F1's rear haunches.

The underbody airflow system not only enhances performance, but also allows purity of design for the car's upper surfaces. Air flows over the top of the car undisturbed by unsightly vents, ducts, or flaps. The fan interacts with a pair of active spoilers at the rear, which can contribute to downforce or reducing drag, as required.

The fan is driven by a lightweight 48-volt motor, spinning at up to 7,000 rpm. The unit's design and underbody ducting does away with the need for a 'skirt' – like that used by Murray's Formula 1 BT46B Fan Car. Vertical inlet ducts fitted with filters ensure no road debris can pass through the fan.

The T.50 features six different aero modes that optimise performance for different scenarios to balance traction and outright performance.

ENGINEERING ART

Sitting prominently at the rear of the car, the fan is just one example of 'engineering art' on the T.50. Another, about which Murray feels passionately, is the engine.

"To be truly remarkable, an engine needs to have the right characteristics: highly-responsive, an amazing sound, engaging torque delivery, free-revving, and it has to be naturally aspirated," said Murray. "For all those reasons, the engine in the T.50 was never going to be anything other than a V12."

The 3.9-litre T.50 engine delivers maximum power (663 PS) at 11,500 rpm, on its way to a 12,100 rpm redline. The T.50 has the highest power density (166 PS-per-litre) of any road-going V12. It is also the lightest ever made thanks to a combination of exceptional design and lightweight materials (aluminium, steel and titanium) resulting in a total engine weight of just 178 kg.

With a focus on driver engagement, the T.50's engine will be the highest-revving and most responsive naturally-aspirated engine ever fitted to a production road car.

Fed by a roof-mounted cold-air ram induction inlet, the T.50 powerplant delivers 71% of its peak

"The greatest analogue driver's car"

ABOVE At 986 kg total vehicle weight, the T.50 is lighter than a typical supercar by almost a third

RIGHT Cosworth's 3.9-litre T.50 engine: the greatest road-car V12 ever made

torque from 2,500 rpm. The maximum torque figure of 467 Nm is produced at 9,000 rpm, while the pick-up is a record-breaking 28,400 revs per second.

Packing this amount of power into the world's lightest road car V12 required yet more innovation. To achieve the weight target, the block is made from a high-strength aluminium alloy and the connecting rods, valves and clutch housing are titanium.

Focusing again on the driving experience, Murray strived for the engine to have very compact external dimensions and the lowest possible centre of gravity. Here, reducing the F1's 125 mm crank height was the goal, a feat more than achieved by the Cosworth team – the T.50's crank sits just 85 mm from the bottom of the engine.

Beneath the car's two rear gullwing openings, Murray's motorsport heritage influences the appearance of the Cosworth GMA V12. Inspired by race car engines, it uses gear-driven ancillaries for lightness, with the added benefit of a clean and uncluttered engine bay. Murray was determined that the engine should be devoid of unsightly belts. All of the ancillaries are carefully positioned out of sight, leaving the block heads, primary exhaust manifolds and inlet trumpets centre stage.

As well as effectively being an engineering work of art, the T.50's engine is semi-structural, providing much of the rigidity and weight saving found in a race car, without compromising driver comfort and cabin refinement. The semi-structural layout saves weight and increases stiffness while avoiding the noise, vibration and harshness penalties typically found with fully structural units.

As part of the early development process, the team surpassed efficiency and emissions requirements and completed plans for two engine maps. These driver-selectable modes ensure the T.50 is not only the ultimate driver's car but is equally at home as a GT or a daily driver. While the engine offers usability and high-performance in either mode, 'GT mode' limits revs to 9,500 rpm and with 600 PS available, making the car even easier to drive around town.

If the driver selects 'Power mode', the full breadth of the car's ability is unleashed, utilising all 663 PS, and accessing the engine's full 12,100 rpm rev range. In this mode in particular, it promises to be one of the best-sounding road car engines ever made – achieved partly through the extensive rev-range, but also influenced by the car's Direct Path Induction Sound engineering, which channels the sound of the fabulous V12 into the cabin.

The launch made no mention of any racing plans for the T.50, but Murray revealed last year that he has potential customers interested in racing the car. He is known to have had discussions with the ACO, the organisers of the Le Mans 24 Hours, with one eye on its forthcoming hypercar regulations. RT

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THOMAS KRAEMER, Director Motorsport Quality Management, Porsche Motorsport

Motorsport innovation drives our future. It's a unique environment that develops cutting edge technology and inspires next-gen talent. The powerful combination of science and sport can entertain, excite, engage and educate… These core principles shine through at the World Motorsport Symposium which provides an essential snapshot of the year's achievements balanced against exceptional future insights on the direction of every major motorsport category."

BRYN BALCOMBE,
Chief Strategy Officer, Roborace

In a changing world it is important to get unbiased thoughts from leading suppliers, manufacturers, engineers and trend-setters… The World Motorsport Symposium offers insight into different technologies from many different angles – it is a great initiative by RACE TECH to bring key people into the same room to share information and thoughts – this is extremely important for the continuing development of future energy for vehicles."

ANDERS HILDEBRAND,
Managing Director,
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"It was a pleasure to attend the WMS this year. As always, the quality of delegates and papers was excellent. This combined with the ever-professional running of the event made it a great success."

RICHARD BARDWELL, Director, SHARC
MARK GALLAGHER, Director, SHARC

"We really enjoyed the event and have thought a lot about it during the last few weeks. It is one of the best events of the year to strengthen our network and to be a part of shaping the future of the motorsport industry – very valuable!"

PETER WIRTZ, Customer Account,
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PUTTING NATURAL FIBRE COMPOSITES *IN THE DRIVING SEAT*

Chris Pickering discovers how McLaren and Bcomp are pioneering the use of sustainable composites in Formula 1

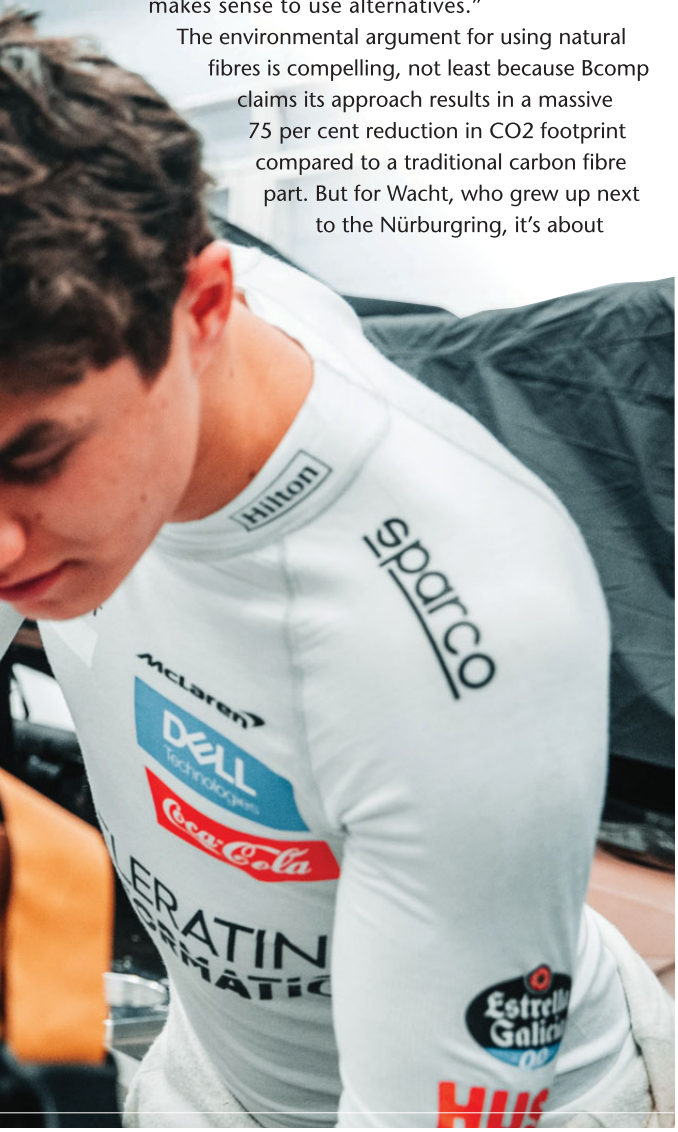
All photos: McLaren Racing

WHEN McLaren introduced the MP4/1 in 1981 its carbon fibre monocoque ushered in a whole new era for motorsport. Within a matter of weeks the other teams began clambering to adopt the new wonder material, with its exceptional strength-to-weight ratio, and 40-odd years later carbon fibre remains the default option in professional-level motorsport.

But is it time for a new generation of composite materials? Natural fibre composites are rapidly gaining acceptance in the lower formulas due to their safety, sustainability and cost benefits. Now, appropriately enough, it's McLaren that has been the first to bring these new materials into Formula 1, in partnership with Swiss composites specialist Bcomp.

"The use of carbon fibre is deeply ingrained within motorsport," comments Johann Wacht, motorsport manager at Bcomp. "If you can produce the same part in carbon fibre the assumption is that it's fundamentally better, but in a lot of applications it's simply overkill. With a move towards more sustainable motorsport it makes sense to use alternatives."

The environmental argument for using natural fibres is compelling, not least because Bcomp claims its approach results in a massive 75 per cent reduction in CO2 footprint compared to a traditional carbon fibre part. But for Wacht, who grew up next to the Nürburgring, it's about offering a material that delivers genuine performance advantages as well: "Sustainability is a massive factor, but natural fibre materials offer their own benefits in terms of physical properties. On top of that there is a safety benefit, so they tick all the boxes."



> *"The environmental argument for using natural fibres is compelling, but it's a material that delivers genuine performance advantages as well"*

ABOVE Flax fibres are nine per cent lighter than any equivalent carbon material

LEFT The seats for Lando Norris and Carlos Sainz are the very first F1 car part to be made of renewable textile fibres

DIRECT SUBSTITUTE

Flax is a natural plant fibre that is carbon neutral to grow and doesn't compete with food crops. Broadly speaking, it is a direct substitute for the carbon fibres found in traditional composites, but Bcomp's approach differs slightly in its construction. As a raw fibre, flax cannot match the strength of carbon (although it is usefully lighter). Instead, Bcomp combines sheets of its woven ampliTex fabric on the a-side, with a three-dimensional mesh structure made from flax fibres that have been twisted together to form a thick yarn. The elements that make up these grids are known as powerRibs and they give the part its fundamental stiffness and b-side geometry. When processed in this way the weight and ▶

RIGHT McLaren changed the face of Formula 1 forever when it harnessed its aerospace contacts to manufacture the MP4/1, the sport's first carbon fibre monocoque chassis

BELOW Started as a garage project in 2011, Bcomp has grown to become the world leader in natural fibre composites

BOTTOM The vibration-damping qualities of flax fibres (right) over their carbon counterpart (left) could offer an appreciable benefit for driver comfort, reducing fatigue over long distances

stiffness of the finished composite parts are said to be equivalent to monolithic carbon fibre up to a thickness of around 1,000 gsm.

Despite this rather different approach, Bcomp says that design engineers used to working with traditional composites should have no issues adapting to the new material technology. The company has comprehensive engineering support in-house and offers the reverse engineering of parts from existing designs if required.

"Our material has the same thermal expansion as carbon fibre, so it's possible to produce a Bcomp part in exactly the same mould and compare it to the carbon fibre equivalent," notes Wacht. "We also supply all the data that design engineers would need to carry out their calculations. It's not difficult to adapt."

Perhaps the biggest challenge is allowing for the additional thickness created by the powerRibs structure. These project 1.44 mm for the ribs themselves and 2.74 mm for the overlaps from the surface of the part, but Wacht points out that this is rarely an issue in body panels. Another factor to be aware of is that the heat tolerance – up to around 195 deg C – is somewhat lower than carbon fibre, so the Bcomp material is not likely to be suitable for parts such as brake ducts.

> *"A massive 75 per cent reduction in CO2 footprint compared to a traditional carbon fibre part"*

"There's a sweet spot for this technology," comments Wacht. "It compares well against the monolithic carbon fibre used in most categories. Formula 1 is a special case as the bodywork there is made using very lightweight sandwich layups that wouldn't be practical in most other forms of motorsport. You need carbon if you're going to really push a composite to its maximum like that, but there are a lot of other areas where it simply isn't required."

THE ROAD TO F1

Bcomp's material has now raced competitively in 16 different series, being validated successfully from GT4 to WEC, from F4 to Formula E, and now F1 as well as in Rally and Prototype racing. From the start of the 2020 season the material is used for some of the mandatory parts on the DTM cars, including the 'shoe box', an aerodynamic section that sits outboard of the rear diffuser. Elsewhere it's typically used for parts such as bumpers, fenders and rear quarter panels on GT cars, while engine covers and sidepods are likely applications on open-wheelers.

The applications for this technology aren't just limited to body panels. Prior to joining Bcomp, Wacht was team leader and head of composites on the Team proTRon project that created the world's first crash test-compliant natural fibre monocoque. He believes the Bcomp system could be used in structural roles like this too, although the resulting part would be somewhat heavier than its carbon fibre equivalent: "It's all a question of weight. Our solution compares favourably to ▶

the monolithic carbon fibre that you see on GTs and touring cars. Formula 1 normally uses a more exotic sandwich construction with extremely thin carbon plies, which is still the lightest option, but it has no road relevance and very poor cost efficiency."

The company's journey to Formula 1 began when it won the Most Innovative New Motorsport Product of the Year award at the RACE TECH World Motorsport Symposium in 2018. "Winning that award put us in touch with the FIA, which had a sustainability initiative for the new set of regulations," recalls Wacht. "We spoke to a number of the teams through that initiative, and McLaren was the one that really wanted to be the leader in this technology."

The next step was to look into various applications, both on and off the car. Soon it was decided to produce a seat as the first Formula 1 application of the technology.

"Formula 1 seats are a great example of an area where you need something stiff and light, but you don't really need the full capabilities of carbon fibre," comments Wacht. "There's now an 80 kg minimum weight limit for the driver and seat combination, which means a carbon fibre seat has to be deliberately over-engineered. McLaren's drivers weigh 68 kg and 72 kg, so a lot of the seat material is simply there to provide ballast. In that instance, our technology is well within its capabilities and we can take out a massive amount of the CO2."

SUSTAINABILITY

The principal sustainability benefit of flax comes from the processing of the fibres themselves. Carbon fibre is produced in three phases: oxidation, carbonisation and graphitisation. The third stage can involve temperatures in excess of 3,000 deg C, which means that the energy consumption of a carbon composite part is largely linked to the processing of the fibre.

Beyond that point, the process used by Bcomp is virtually the same as traditional carbon fibre production. The dry fibres for the ampliTex fabric are woven into a sheet and then impregnated with resin ▶

BELOW Using natural fibre composites in some components, such as front wing endplates and the floor, could reduce carbon fibre debris and therefore the risk of punctures

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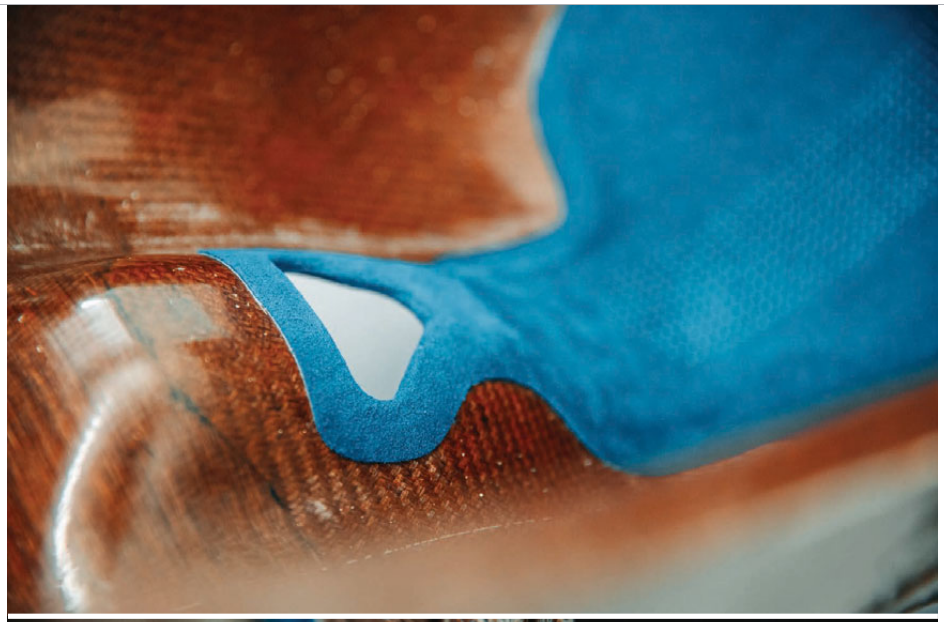


using the same process that's employed in carbon fibre production. However, there are a number of detail differences in the lay-up. Most noticeably, there are the powerRibs, but the concept also uses a second layer of ampliTex fabric with an increased resin content. This three-layer construction is then placed inside a vacuum bag in a mould and baked in an autoclave.

Only under pressure, the dry powerRibs suck the resin from the resin-rich middle layer to impregnate themselves, making them a highly cost-efficient vacuum distributor, too. Unlike conventional carbon fibre processes, which require a sacrificial breather layer to maintain air flow through the part when the vacuum is applied, the three-dimensional powerRibs provide this functionality on their own. This reduces the number of consumable parts involved in the production process.

In reality, the CO2 savings are likely to be in excess of 75 per cent, Wacht points out, because the current figure doesn't account for the lack of a breather layer. An additional area where significant sustainability advantages could be possible is composite tooling. The finished part might be 0.4 mm

LEFT Bcomp's ampliTex and powerRibs solutions reduce raw material cost by up to 30% compared to traditional carbon fibre

in thickness, whereas the tool might be 5.5 mm, so in a category like Formula 1 – where parts are often made in tiny numbers – the tooling accounts for a significant proportion of the cost and the environmental impact. There is no need to squeeze every last gram out of the tooling, so this is an area where natural fibres could be used, even for weight-critical applications that might require traditional carbon fibre for the finished part.

The final aspect to consider is recycling. "At the end of their life, most carbon fibre parts are ground up and put into landfill," notes Wacht. "There are a number of emerging approaches to recycling, but most involve considerable energy input and result in a material with much lower performance than the original composite. Our material completely outperforms recycled carbon fibre. Our fibres can be incinerated for heat without residual waste in the standard waste management system."

OTHER BENEFITS

Aside from the material's environmental credentials and its attractive stiffness-to-weight ratio, Bcomp says there are other potential benefits to using a flax fibre composite. For instance, the vibration damping capability is some three times better than that of carbon fibre, with the combination ampliTex and powerRibs even five times better. The effect is so significant that it could have an appreciable benefit for driver comfort, reducing fatigue over long race distances. It's also an excellent electrical insulator, which means that parts such as battery housings could be made from natural fibre materials without the need for additional insulation.

> *"When used in their 'sweet spot', flax composites have the potential to offer numerous practical benefits"*

Perhaps the greatest of these secondary benefits, when it comes to motorsport, is safety. Carbon fibre tends to fracture in an impact and it produces sharp splinters that can directly injure drivers or puncture tyres. In contrast, the Bcomp material is ductile and the powerRibs construction tends to keep debris attached to the main structure, which helps to dissipate energy.

"That's particularly important in GT racing with gentleman drivers," notes Wacht. "Professional racers can usually control the car with a puncture, but a high-speed blowout poses a real risk to Am drivers. Also, if you're on a long circuit like the Nürburgring, you don't have marshal posts every few metres to clear up the debris."

In the lead up to the 2019 season, the SRO announced that all newly-homologated GT4 cars would need to use natural fibres such as flax or hemp for their aerodynamic devices. The Porsche 718 Cayman GT4 Clubsport MR, for instance, uses flax for its doors, splitter, rear wing and diffuser.

Finally, there's the question of cost. Bcomp says that its approach reduces raw material costs by up to 30 per cent, depending on the benchmark carbon layup. That's a significant benefit in the cost-conscious world of GT cars and the lower formulas, but even in Formula 1 it could help teams to focus their resources on the areas that need it most when next year's cost cap is introduced.

As always, it will be a question of matching the right materials to their intended applications. When used in their 'sweet spot', Wacht believes that flax composites have the potential to offer numerous practical benefits to motorsport thanks to the powerRibs. But perhaps the biggest benefits are how those could transfer to the wider world, he points out: "When you look at it, motor racing is the only sport that can actively help to tackle climate change.

"Sustainability in motorsport has always been quite powertrain-focused, but that's only a small part of the car. With materials development – particularly when it comes to a comparatively affordable material like this – we have something that's extremely relevant to the wider world. The same technologies our partners race in motorsports will soon enable significant sustainability benefits in areas like large-scale automotive, marine and aerospace, too" RT

BELOW Bcomp's material is now raced in 16 different categories. They include some mandatory parts in the DTM, like the aerodynamic section outboard of the rear diffuser

Audi AG

THE KEY TO UNLOCKING FUEL CELLS?

Carlo Locci, global application specialist for hydrogen fuel cells at Siemens, tells **Chris Pickering** why motorsport could be the ideal testbed for this new technology

WE live in uncertain times. Whether it's climate change, Brexit or the coronavirus, 2020 never seems to be far away from another calamity. And yet there's possibly a flipside to all this disruption. While it must be tempting for policymakers to play it safe, it's also a great time to press ahead with new ideas.

In Germany, for instance, a post-COVID stimulus package has been announced that includes €50 billion allocated to future technologies. More precisely, €10 billion of that is specifically aimed at positioning Europe's biggest economy as a leader in hydrogen technology. This comes 12 months after China announced its own dramatic increase in subsidies for fuel cell development. The last time the country did something similar, it surged ahead in battery production, sweeping the global car industry along with it.

What – you might ask – does this have to do with motorsport? Well, in short, it means that hydrogen is back on the agenda. And where new technology is being developed, there's a natural desire to showcase its abilities.

"Extreme environments usually make for good test cases. Let's remember that jet engines were first used for extreme military applications, and were then transferred to civilian passenger aircraft," comments Carlo Locci, global application specialist for hydrogen fuel cells at Siemens. "Similarly, you can trace the motorsport influence in everything from dual clutch gearboxes to turbochargers on road cars. It allows us to push the boundaries, even when the application itself is quite different. The same applies to fuel cells, where the extreme conditions of racing could be a good testbed."

Locci's area of responsibility covers the use of Siemens' multiphysics simulation software for powertrain and fuel cell development, so it gives him an interesting perspective on the technology. "Motorsport customers are always very interesting to work with," he comments. "They're extremely demanding and really help us to push forwards the capabilities of modelling software."

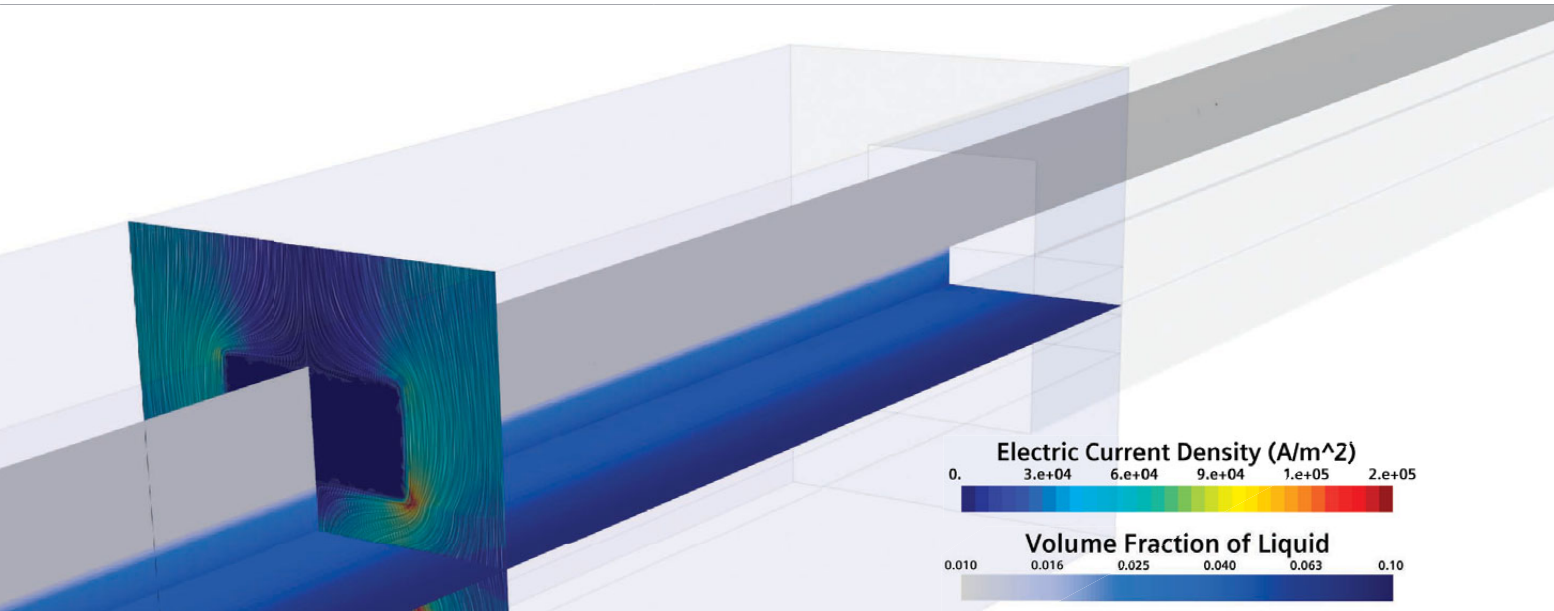
At present, fuel cell cars are pretty marginal for motorsport use. The ground-breaking efforts of organisations like GreenGT and Delft University have shown that a fuel cell-powered racing car is possible, but we've not quite reached the stage where one could reliably lap a track like Le Mans at GTE pace or above. That's a prerequisite if these cars are to safely mix it with the forthcoming LMDh and Hypercar machines.

MODELLING CHALLENGES

Refining the power output and energy density of fuel cells is exactly the sort of challenge that fuel cell manufacturers are looking at, but it's by no means a simple task. The fundamental principle behind a fuel cell is deceptively simple: it reacts hydrogen and oxygen to liberate electrons, which are forced to flow around a circuit, creating an electric current. The reality, however, is that high-power fuel cells are complex pieces of engineering that can be difficult – and computationally expensive – to model, comments Locci.

ABOVE Electric current density distribution and volume fraction distribution in a single cell configuration. In this picture, we can observe the electric current distribution in a plane perpendicular to the flow direction. Also, the volume fraction of liquid at the cathode side is shown. Liquid water is mainly produced at the interface and then escapes from the outlet

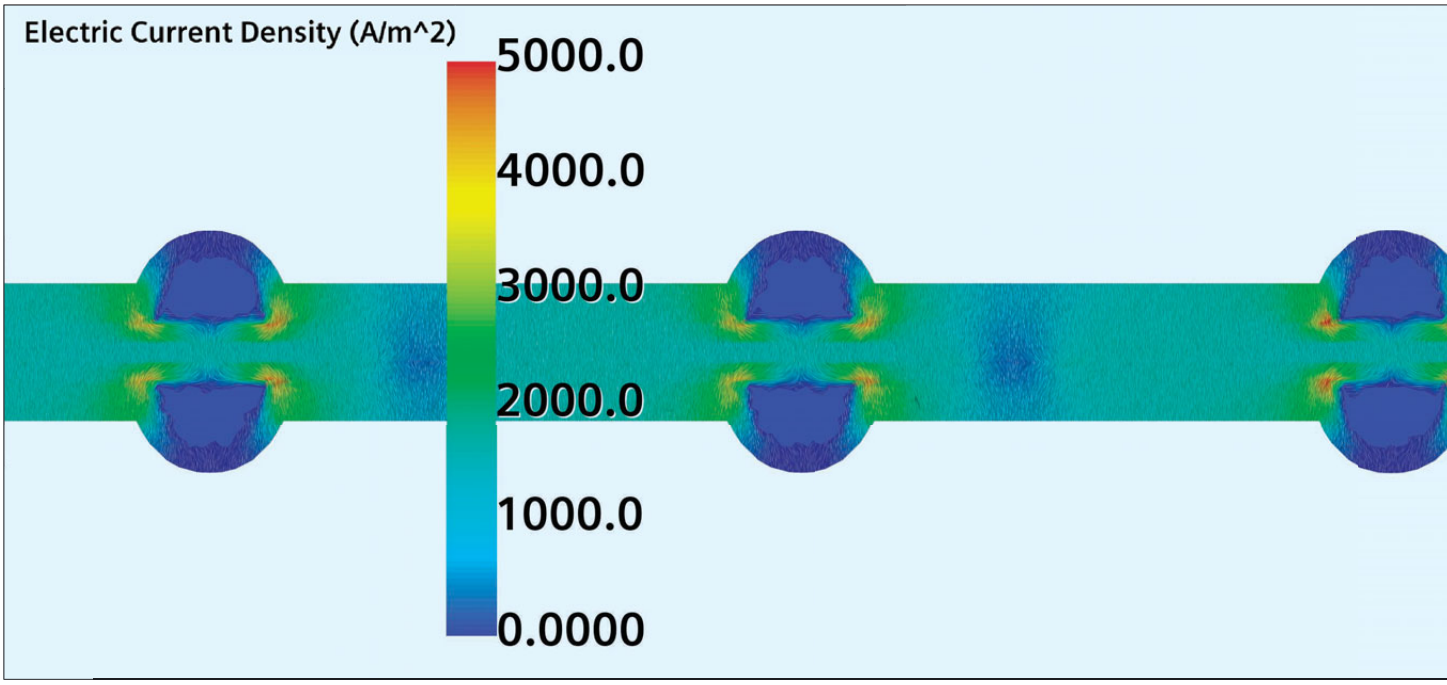
RIGHT Refuelling stops could provide a strategic element missing from battery-electric series. Total pioneered the world's first mobile hydrogen refuelling station for the ACO's Mission H24 project



Despite its challenges, computer simulation could be the key to unlocking the sort of compact lightweight fuel cells that would be necessary for use in motorsport. There are a number of aspects that fuel cell developers use this software to analyse, Locci explains: "First of all, you have the flow of hydrogen and oxygen through the fuel cell. Next, there's the water management. At the cathode side of a fuel cell you basically have a chemical reaction that forms gaseous water. This can lead to a degree of condensation, which can be a problem if it prevents the reactants from reaching the membrane – a situation that we call flooding. However, the opposite can also apply. If you don't have sufficient water content, then the membrane will dry out."

Another critical factor is the temperature distribution, he explains: "Inside the fuel cell, you have all sorts of gradients: gas gradients, electric current density gradients, velocity gradients. When you ▶

GreenGT/Charles Guenant



have a pronounced temperature gradient in one area, that might jeopardise the life of the fuel cell; ideally, you want the temperature distribution to be as homogenous as possible."

Finally, there's the ageing of the fuel cell: "Generally, long-term ageing would not be as critical for motorsport, but it's also linked to the reliability. That comes back to temperature distribution, as well as the electric current distribution. You have a series of parasitic reactions that reduce the thickness of the membrane over time. We have models that can predict that effect. Plus, you have what's known as compression ageing. That's a result of the thickness of the membrane continuously changing, creating a fatigue condition."

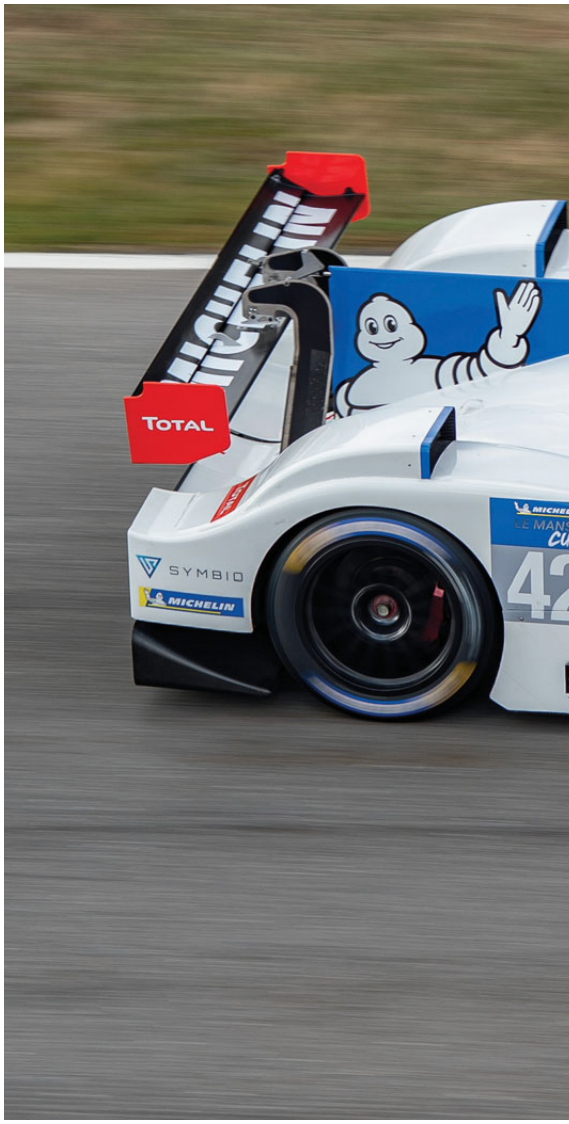
Understanding these issues is one thing, but modelling them is another challenge altogether. Much of the complexity inherent with fuel cell models comes down to the multi-phase physics that's required. Like all forms of computational fluid dynamics (CFD), these use the Navier-Stokes equations to describe fluid flow, but the properties of the fluids can change dramatically according to their phase. For instance, viscosity and thermal conductivity will behave in different ways for a liquid or a gas.

"The problem arises when the gas phase and the liquid phase interact with each other," explains Locci. "Generally, multi-phase CFD simulations use a volume of fluid (VoF) approach, where liquid and gas continuous phases interact with each other, which means you solve a set of transport equations for both the liquid and the gas, to keep track of what's known as the free surface.

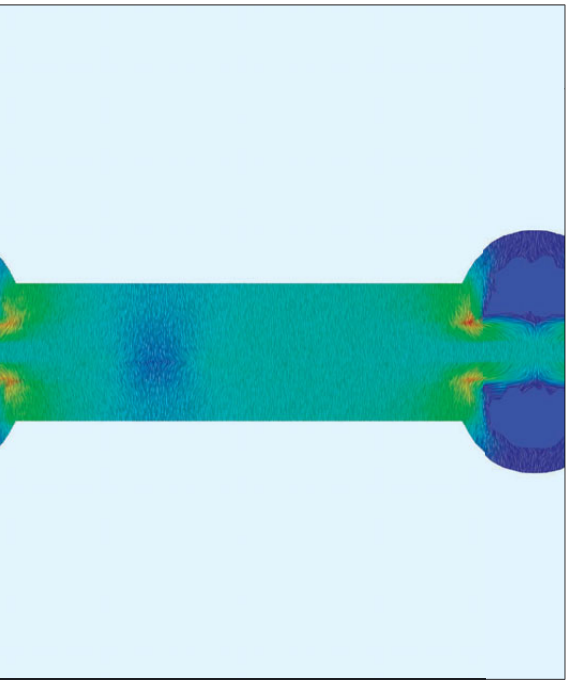
"In reality, the situation in a fuel cell is even more

ABOVE Electric current distribution layers in a fuel cell layer. In this image, the electric current distribution is shown on a plane perpendicular to the reactants' flow direction. Naturally, the electric current distribution increases as the voltage decreases. The red spots occur at the triple boundary interface, in which the bipolar plate, the gas diffusion layer and the channel meet

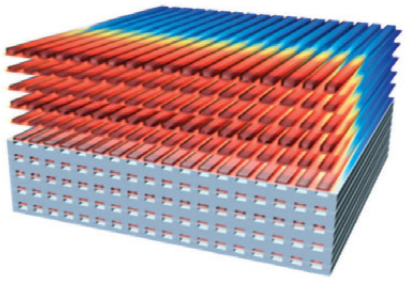
RIGHT GreenGT's LMPH2G prototype is the ACO's poster boy for hydrogen motorsport



> *"The physics inside a fuel cell present just about the most challenging conditions for CFD"*



complicated, because this interaction between the two phases occurs mainly in the gas diffusion layer [a layer that allows the gas to pass from the flow channels to the catalyst material, as well as providing a conduit for the flow of current]. This is a porous environment where a traditional VoF approach would be very computationally demanding. Instead, we use a simplified approach, which mimics the behaviour of the free surface rather than directly calculating it. We do that by modifying the transport equations to account for the presence of the free surface."



ABOVE The distribution of temperature in a fuel cell stack. Such information is fundamental to observe the thermal gradients that strongly affect the life and reliability of a fuel cell

The main substances that need to be modelled in a fuel cell are gaseous hydrogen (which is sometimes injected with water vapour) at the anode, plus air (principally nitrogen and oxygen) and liquid water at the cathode side. This means that there is a complex three-dimensional distribution of five main substances in three different physical states throughout the fuel cell. On top of that, you have the bipolar plates, which are solid and can be made from graphite, metal, polymers or composites.

"I would say that the physics inside a fuel cell presents just about the most ▶

GreenGT/Charles Guenant

> *"Fuel cells are very promising for long-distance applications where endurance is critical"*

challenging conditions for CFD," comments Locci. "That's firstly because you have multi-physics. You need to work with several different sets of equations and you need to satisfy the criteria for the stability of all those equations or you can end up with a conflict between them.

"Secondly, you're solving for environments that are extremely heterogeneous; that includes conventional gas flow within the channels, but also solids [the bipolar plates and membranes] and porous environments. It's also extremely complex from a meshing point of view, because you need to think about balancing the detail of the geometry against the processing time."

As with any CFD simulation, there are approximations that can be used to simplify the model and reduce computational time, but they risk losing important detail. "With complexity comes computational cost. You can use a 1D code to get very important information on things like the dynamic behaviour of the fuel cell and its control. That would be very costly to achieve in 3D, but you have to understand the simplifications that you're applying and their limitations," notes Locci.

LEFT Locci is opening up new frontiers

RACE TO DEVELOP

The sheer complexity of fuel cells, allied to the fact that the technology has only just started attracting mainstream interest, means that there's still plenty of scope for development. "There are many, many configurations of the bipolar plates, for instance," Locci observes. "That covers lots of different materials, some with wavy channels, some with square channels… Motorsport would provide a great R&D ▶

BELOW Fuel cell vehicles could ultimately be well suited to endurance events like rally raids

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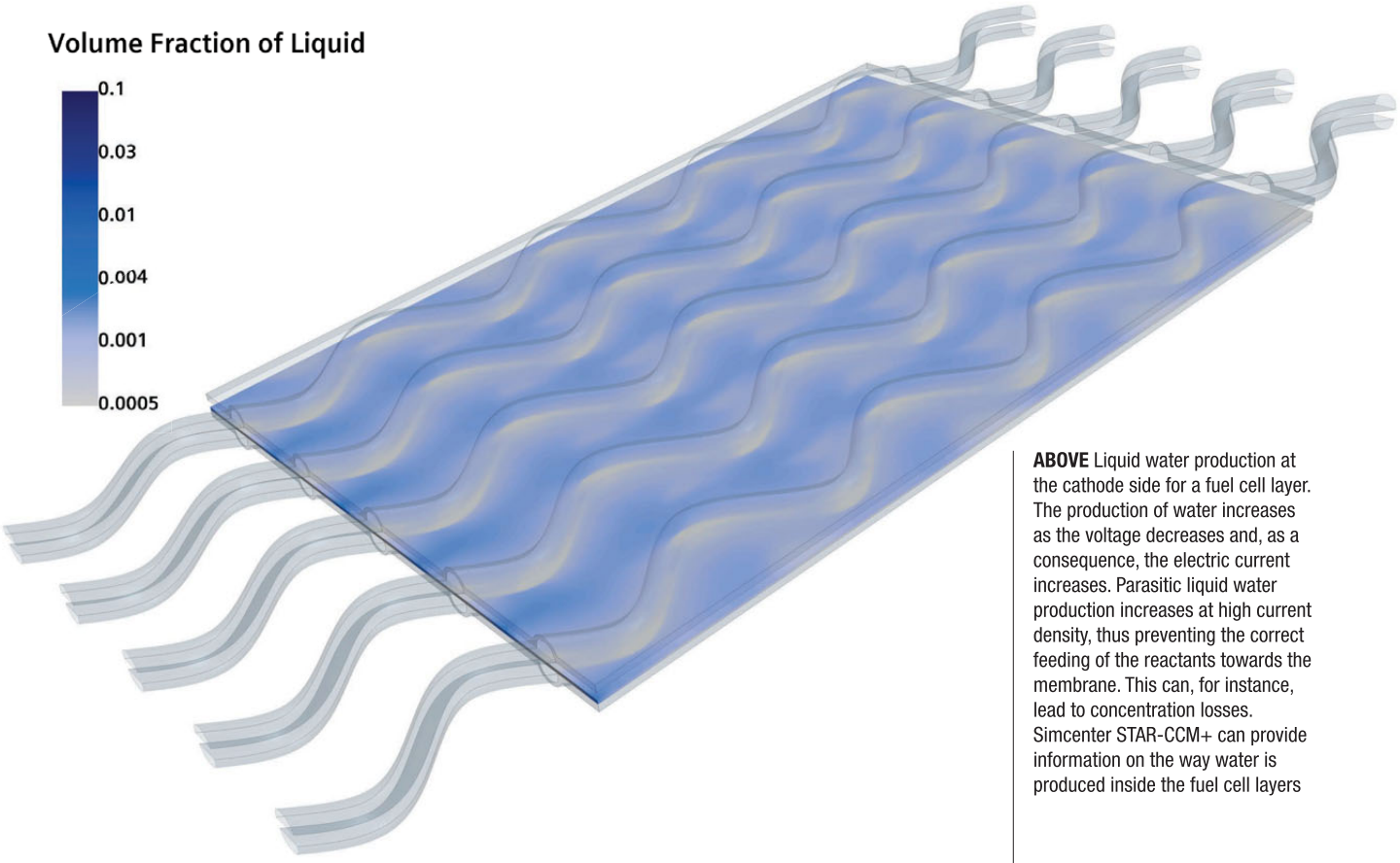


ABOVE Liquid water production at the cathode side for a fuel cell layer. The production of water increases as the voltage decreases and, as a consequence, the electric current increases. Parasitic liquid water production increases at high current density, thus preventing the correct feeding of the reactants towards the membrane. This can, for instance, lead to concentration losses. Simcenter STAR-CCM+ can provide information on the way water is produced inside the fuel cell layers

> *"Motorsport would provide a great R&D environment to try these new ideas"*

environment to try these new ideas."

One common concern is safety. It's often pointed out that the total mass of hydrogen carried onboard a fuel cell car remains quite small, and it arguably poses less risk on the electrical side than a battery-powered vehicle, as the voltage is produced on-demand. Nonetheless, the idea of carrying tanks of pressurised hydrogen around a racetrack in what is potentially a contact sport does bring its own challenges.

"You do need to be very careful with hydrogen, because it can explode, but the same applies to gasoline to a certain extent," notes Locci. "It's something that the teams and the race organisers would need to adjust to, but it's not an insurmountable challenge."

Refuelling is also a consideration. It certainly wouldn't be easy, with high pressures involved in the onboard tank and the refuelling, as well as the off-vehicle storage, but it could add something to green racing that's absent from series with battery electric vehicles like Formula E. "When we used to have refuelling in F1 it was part of the spectacle; it's doubtful that you could do that as quickly using hydrogen, but it could still be a feature of the competition," comments Locci.

This, of course, comes back to what type of competition you wish to enter. For short sprints like rallycross events or hillclimbs,

BELOW LEFT Simulation is one of the keys to moving fuel cells forward

it's already easier to use a battery than a fuel cell, and that situation is unlikely to change as the two technologies develop. Once you start talking about endurance racing, however, it's hard to imagine that a battery electric vehicle will ever fit the bill – the recharging times are simply too long.

FUEL CELL vs BATTERY ELECTRIC

This is a situation that's expected to be mirrored in mainstream applications, Locci points out: "The workflow to get a fuel cell vehicle going is much more complex than a battery electric car, because you have to capture the hydrogen – perhaps with an electrolyser powered by a wind turbine – then you need to store it, to fill the car and to release the energy in a fuel cell. All four of those stages are complicated.

"With a battery electric vehicle you basically just get your wind turbine and plug it straight in, so I think that's the way the market will go for typical passenger cars. But fuel cells are very promising for long-distance applications where endurance is critical and I think that could be reflected in motorsport. I'd love to see fuel cell vehicles in something like the Le Mans 24 Hours or a rally raid competition, to fully highlight these aspects."

There is, of course, already some movement in this direction. This month's running of Le Mans is likely to provide an update on the Mission H24 project, which was set up to create the framework for hydrogen fuel cell vehicles to join the competition from 2024.

There have also been hints from a number of major OEMs that hydrogen racing is on their radar. Two years ago BMW Motorsport boss Jens Marquardt commented: "[Hydrogen] is something we have seen from a study point of view that is feasible. It would be a technology to consider for a race application in endurance racing and it is something we could look at in the future from a prototype point of view."

By far the biggest factor in making this a reality will be the development work that goes into the fuel cells themselves. That's where the simulation comes into play. As for the motivation to go down the hydrogen route, and the funding to pursue it, that's in the realm of the CEOs and the politicians. But recent events suggest that they're going to be taking a keen interest in hydrogen.

BELOW Delft University has shown that a fuel cell-powered racing car is possible, but they can't yet lap longer circuits at respectable GTE pace

DATE WITH DESTINY

This year's endurance classic poses unique problems for the suppliers. **Alan Stoddart** discovers that the resourcefulness that can avert disaster, in the middle of the night, is also helpful in salvaging a pandemic-ravaged year

FOR motorsport, as with everything else, 2020 has been a difficult year. But unlike other sectors, racing has been making a strong comeback. Delayed seasons have resumed, postponed races have been rescheduled, and logistic leaps have been made to facilitate a season in some form, however disrupted.

Getting races to go ahead is only half the battle, however; teams, engineers and drivers are still going to have to deal with the consequences. At Le Mans, the first time the race has been run in September since 1968, the date change means cooler temperatures, more hours of darkness, and the likelihood of more changeable weather.

FAST PACE

Some in the industry have already guessed at the impact. Ben Crawley, Goodyear's Motorsport Director, has suggested that the cooler temperatures could mean that this is the quickest ever running of the race. Speaking on the official FIA WEC podcast, Crawley explained: "In September, we may see some cooler temperatures… and what we could see is one of the quickest Le Mans races in recent history.

"Typically, with cooler temperatures, there is a focus on some of the softer specification tyres. So, with cooler conditions there is more potential for the tyres to perform to the maximum with shorter and fewer pit stops. By using softer tyres, there is an expectation of faster speeds and so it could be a very fast Le Mans!"

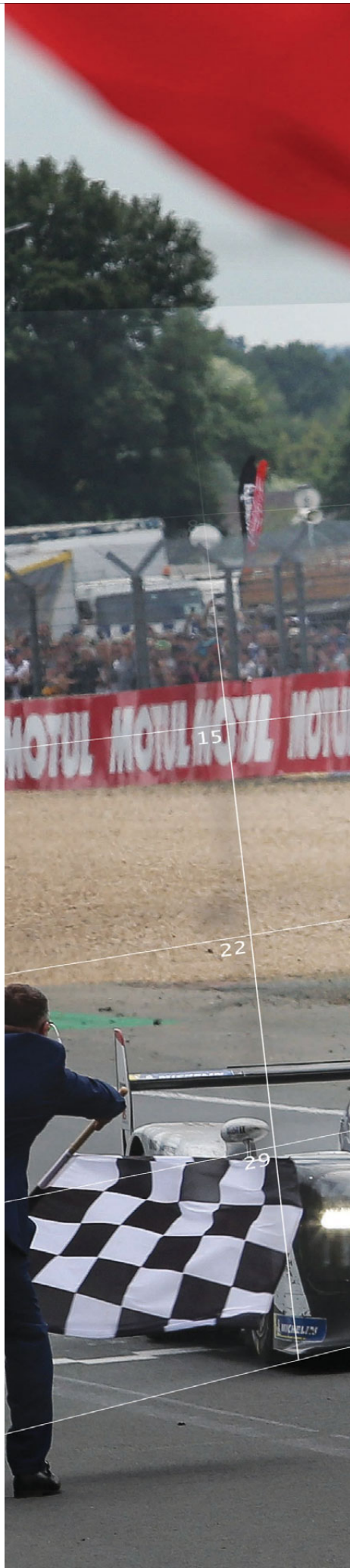
Goodyear's endurance programme manager, Mike McGregor, concurs. "The cars this year are going to be more efficient in terms of downforce, drag and engine performance," he says.

"And obviously, on top of that there is also what we are bringing in terms of this year's upgraded tyres. We have been preparing for this over the winter and as we have already seen across the ELMS races and WEC races, there is a significant performance improvement compared to previous years."

In fact, this season we have already seen this performance difference, only in reverse. The Spa-Francorchamps round of the WEC is normally held in May, but running it in the heat of August showed the kind of swing in performance that can be expected from a difference in temperature. In terms of tyres though, the temperature change should be no problem. After all, in every season, the specifications of tyres used in the WEC need to be able to work across a wide range of temperatures, from more than 40 degrees at Bahrain, right down to the low single digits that have been seen before snow showers in April at Silverstone. So while cooler temperatures might mean more time spent at peak performance, the tyres have to be able to cope with it all anyway.

Arguably more important than the temperature, is the track itself, with Goodyear rescanning the surface of the asphalt every year to understand it in minute detail, as this knowledge will help the tyre manufacturer deal with whatever conditions arise.

"It could be a big problem," McGregor ▶



ABOVE Victory in the Le Mans 24 Hours is always a feat to cherish. With no fans, yet plenty of COVID protocols in place, the 2020 race will be remembered whoever takes the chequered flag

Photos: Goodyear

notes. "There are huge differences in asphalt across all the different tracks now. Some of the tracks have what we call 'F1-style' surfaces, which try to give certain tyres an easier time in terms of tyre degradation. They are much more micro-rough and have much more of a closed surface, so it is a very different way of the compound interacting with the surface, and how the compound itself meshes with the Tarmac.

"So if you look at old-school circuits like Spa still is, and like Shanghai, they have a macro-rough surface, and there is a lot more interaction between the compound and the track itself, whereas at the resurfaced Silverstone for example, interaction between the tyre and the track is very different. The surfaces are also much darker, so they take in more temperature from sunlight and you tend to see higher track temperatures there."

For Le Mans, Goodyear's support engineers will work closely with the teams. The aim is to ensure the tyres can be managed so that they not only last for the targeted four stints, but the performance will be consistent from the first lap on full fuel load, to the last when they are running on empty.

Also aiding Goodyear in this task is the wealth of historical data available to it, from various WEC races to the 24 Hours Moto that used to run in September, the tyre company is doing whatever it can to understand the conditions it will face for this year's unusual running of the 24 Hours of Le Mans.

The change in date is one thing, but there are other, more mundane

> *"We make sure that people work in bubbles"*

headaches that Goodyear will have to overcome to make sure that everything goes smoothly. With the risk of COVID-19 ever-present, Goodyear, like everyone else in the WEC paddock, is having to establish and adhere to new protocols to make sure that the teams still get the service they have come to rely on.

"It has been a huge change," McGregor confirms. "We have had to adopt all the protocols for all the different countries which we travel through and they aren't always aligned. There we have had to put hand sanitising stations all over our

ABOVE LEFT This will be Goodyear's first Le Mans since its return to top-level endurance racing

LEFT The wet conditions at Spa's WEC round offered Goodyear the chance to collect valuable data on its wet tyres for LMP2 runners ahead of the 24 Hours

RIGHT The pageantry is part of the Le Mans spectacle we have become used to, but the usually packed grandstands will be empty in the build up to this year's event

servicing area, enforce social distancing at all times, and even work out how our team is interacting with the guys in the garage, making sure that people work in bubbles so even if there was a problem we could manage it.

"Even with people travelling to the track we have had to separate it into specific groups and say, 'OK you guys can have dinner together, and you are able to work in these garages, but you can't mix with these people'. It's all so we can manage it in the right way."

What's more, these protocols and additional considerations come when time is a most precious resource. After all, four months of the year have been lost. While that time compression affects the racing, it also affects all the testing and development work Goodyear is able to do, particularly disruptive given the tyre maker's LMP2 supply contract that is in effect from next season. Goodyear has to develop the tyres, and spend enough time on track to make sure they work with all the different cars in the LMP2 class.

"We had a full development programme of circuits booked to allow all the development to happen, but we have had to cancel that, and start our test programmes again," says McGregor.

Fortunately though, the same resourcefulness that is helpful in the middle of the night in an endurance race when there is an unexpected problem, is also helpful in salvaging a pandemic-ravaged year.

Or, as McGregor puts it: "The plan changes every day, but we are able to react, we just have to be able to move with it."

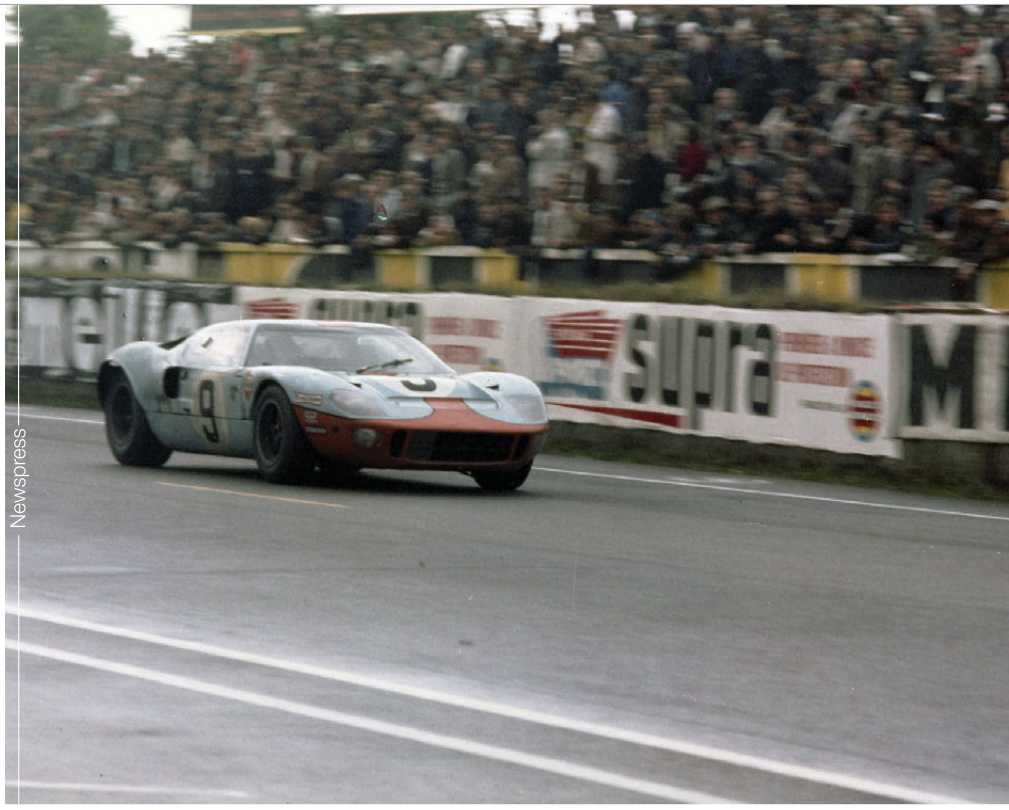
QUARANTINE HEADACHE

Another company dealing with the disruption of the global pandemic ahead of Le Mans is LMP1 and LMP2 engine supplier, Gibson Technology. The issues it is facing are not complex engineering challenges caused by atmospheric conditions, they are simply logistic and regulatory hurdles.

"The difficulties have been fairly complex," explains operations director John Manchester. "For instance, we have had staff that were in Spa for two weeks [for the ELMS and WEC rounds], and during that time the British government put Belgium on the quarantine list, so all those guys coming back would have to quarantine for the 14-day period, which wouldn't have given them time to get out for the next event.

"So we had to look into the logistics of how we could manage that. We therefore ▶

WEC/Adrenal Media



contacted the UK motorsport authority, who were extremely helpful. They provided the necessary documentation to grant exemption approval to be able to avoid the full 14-day quarantine period, providing their test results, which have to be taken upon their return to the UK, are negative… It's the same for all international motorsport and sports people because if we didn't have those kinds of controlled exemptions, motorsport and other sporting events couldn't happen."

Manchester explains that as well as getting

to events, there are also new protocols and considerations for the team when they are there. At Gibson's truck, for example, whereas teams would usually be able to come inside and discuss matters with Gibson's engineers, this year there will be an awning outside the truck and a bell; if someone from a team needs assistance, an engineer will come down to meet them. It is a small inconvenience, but will help protect everyone, and ensure racing can continue at a difficult time. At worst, many of the changes boil down to "a fair amount of paperwork and logistical planning".

This is a less drastic solution than that which has had to be employed at IMSA events. Due to the skyrocketing number of cases in the USA, there were several races where Gibson didn't feel comfortable sending engineers out. In these instances, the Repton-based supplier sent out spare parts to one of its customer teams, which would be able to share them with the grid when necessary, and all of the diagnosis and management of the engines was carried out remotely, with Gibson's engineers analysing the telemetry of the cars from a continent away, and feeding back guidance to the teams over the phone and via email.

One of the factors that made this possible ▶

ABOVE The race was last run in September back in 1968, when the Gulf GT40 of Pedro Rodriguez and Lucien Bianchi triumphed. It was an event that changed history: Willy Mairesse suffered appalling injuries when he crashed, having failed to shut his door properly at the start (inset). Following Jacky Ickx's protest the following year, the traditional sprint across the track to the cars was abandoned

LEFT The teams' familiarity with Gibson's GK428 engine will help overcome the challenges of this year's race

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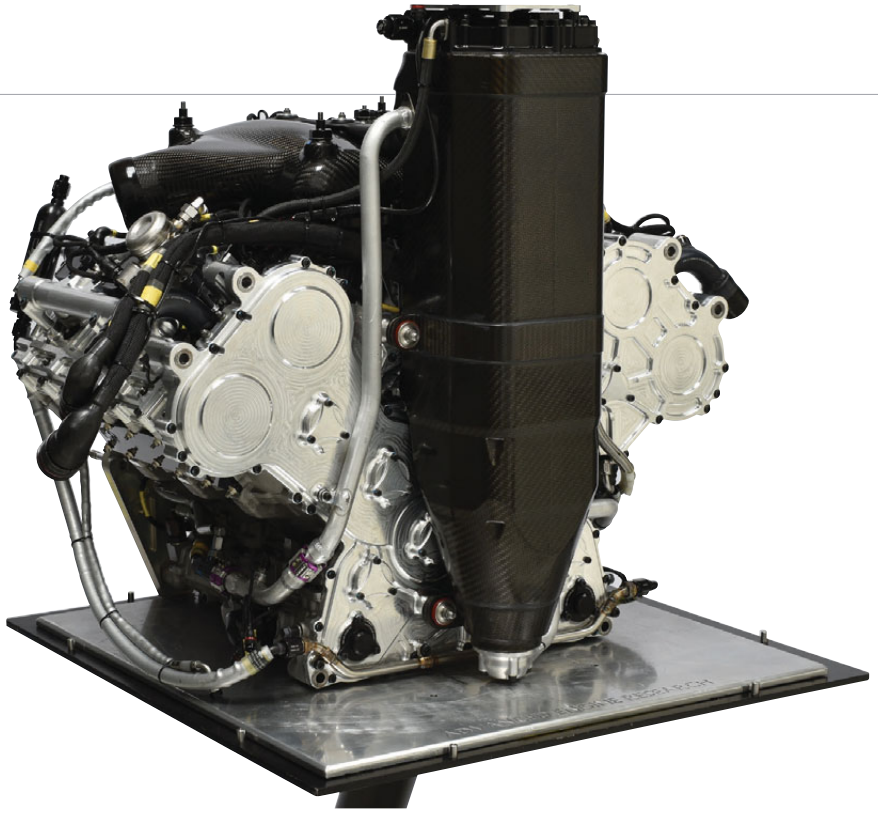


was the familiarity of the teams with Gibson's GK428 engine, as well as the powerplant's established reliability. These factors will also aid the teams who are running the engines in September.

"From our point of view the September date isn't going to have a big impact," says Manchester. "The cooler temperatures might have an effect on lap times but we aren't going to have to really do anything different on the engine side.

"Over the years we have gathered a lot of data with this engine, which has been running since 2016, so we have got a good understanding on the temperatures.

"But like everything else, there is an optimum. If the engine is run too hot or too cold it can cause problems, so it is really just about managing the situation and keeping it within the optimum temperature range. There might be more blanking, to run different coolant and oil temperatures, but other than that I can't see it really being too much of a problem at all."

PROVEN RELIABILITY

Equally confident is engine-maker AER, which is confident in its engines and their ability to perform regardless of the conditions. "The engines are very reliable," says managing director Mike Lancaster, "and the thing is that you do get a very wide range of temperatures anyway with the night running, especially if there is rain, so we already have to account for that.

"But on the engine side, they are able to cope with a great deal of variation, they are used to running cooler to an extent, they are used to running over heated intermittently – there might be a car running with limited airflow for example – so they have to be very robust, so a September race date shouldn't make much of a difference."

In fact, the company is confident and it hasn't had to conduct additional temperature testing of the engines beyond the pre-Le Mans testing that is part of each engine's post-build procedure. The combination of cooler and denser air at a typically very low-drag circuit might mean that the teams have done all the work they can: the engines are sitting pretty ready to go. There aren't any calibration tweaks that should be necessary for slightly cooler running in September.

"There will be no reduction in performance to run the 24 hours," continues Lancaster. "The engine ▶

ABOVE & RIGHT
Preparation of the upgraded P60C engine for Ginetta (right) has actually been the least of AER's problems in a COVID-disrupted campaign

> *"The engines should go to 5,500 km at full power"*

ABOVE RIGHT On this occasion, all fans of endurance racing will be at the mercy of the broadcasting studios

BELOW A new, greener fuel will be introduced next season by Total

programme is designed to ensure there is minimal calibration required, and there are no changes that have to be made for the sake of longevity, so the engines should go to 5,500 km at full power, it is what they were designed to do."

As with other suppliers, the bigger problem has been the disruption caused by COVID, and the restrictions that have been put in place to deal with it, and Lancaster is pleased with the stringency of at least the European series. At WEC events there has been very strict social distancing, very strict protocols for dealing with the virus and preventing its transmission, and constant testing to ensure that even if someone has contracted the Coronavirus, then it will hopefully at least be contained.

He explains that while AER has been able to get special dispensation to allow a restricted crew to travel in and out of America to support IMSA races, at those tracks there have been less restrictions, at least initially, although that could well change as the situation evolves.

There is another further change that will have an impact, says Lancaster: "There will be no spectators there, so that will be very strange."

METICULOUS PLANNING

Other suppliers are dealing with logistical challenges in different ways however, with the shortened race schedule causing headaches for official fuel partner Total. Normally, Total would fill the enormous fuel tanks buried beneath the pit lane about a week before the race, and then on the Friday, when there is no running, refill them in preparation for the race. This year however, the schedule is compressed, so the mid-week refuelling will have to be completed at around 2am on Saturday morning. This means there is far less time for uncertainty or upset. As such, everything is having to be ▶

Aston Martin

minutely planned, right down to things like identifying the best place to park lorries in advance so there isn't a single precious minute wasted on the night.

In other ways the September timing of the race will actually be beneficial. One of Total's jobs is to ensure absolute consistency of the fuel, both throughout the race week and throughout the grid. After all, it would be unfair for one team to get an advantage simply because of how or when they fill up. To control this, when Total fills the tanks under the pitlane, it takes a control sample, and then tests throughout race week. The September running, and its cooler temperatures, with less dramatic swings between day and night, will make this whole process easier and ensure there won't be any evolution during the week.

In reality, there won't be anything that is hugely different in terms of the fuel itself. Romain Aubry, Total's motorsports technical manager, explains that as with other suppliers, the fuel has been designed from the outset to cope with a variety of temperatures.

"The fuel condition and the fuel behaviour will be the same whether it is 0 degrees or 40 degrees," he says. "We want to be sure that in any part of the world, whatever the weather will be, we can be certain that the mechanics running the cars can rely on the fuel and give the engine their entire focus. So, in this regard, the few degrees of difference in temperature from June to September won't have an impact on performance."

> *"A different blend of fuel, with a new, greener focus"*

BIGGER CHALLENGE

A bigger challenge for Total will be dealing with excess fuel that hasn't been used up because of the race cancellations. All the races were cancelled from March to June, so the fuel that was already blended has just had to be siloed. What's more, it can't even be used next year as Total is introducing a different blend of fuel, with a new, greener focus.

Total's carbon neutral announcement was big news in February, but while it was the first promise of carbon neutrality, it was far from the firm's first move towards greener energy. One of the most exciting developments for those in the motorsport world is Mission H24, the plan to bring hydrogen race cars to Le Mans by 2024.

This project is making good headway. There have been strong technical advancements – such as massively increasing the rate of refuelling, down from eight to four minutes to pack 12 kg of hydrogen into the car's tanks – but there are also more logistical decisions, such as identifying the sort of infrastructure that would be needed to allow eight or 10 race cars to join the grid in 2024, and the kind of challenges that would have to be overcome. "Mission H24 is going in the right direction," says Aubry. "What I have seen from the car manufacturers with their fuel cells gives me confidence that 2024 is achievable – and Total will be ready to supply H2 in 2024 to all players in this new category."

Jakob Ebrey/JEP

ABOVE LEFT The entire Total group will be carbon-neutral by 2050

LEFT The pace of development for Mission H24 has been frantic, with big advances

LEFT The date change could throw up cooler temperatures, more hours of darkness, and the likelihood of more changeable weather

Toyota Gazoo Racing

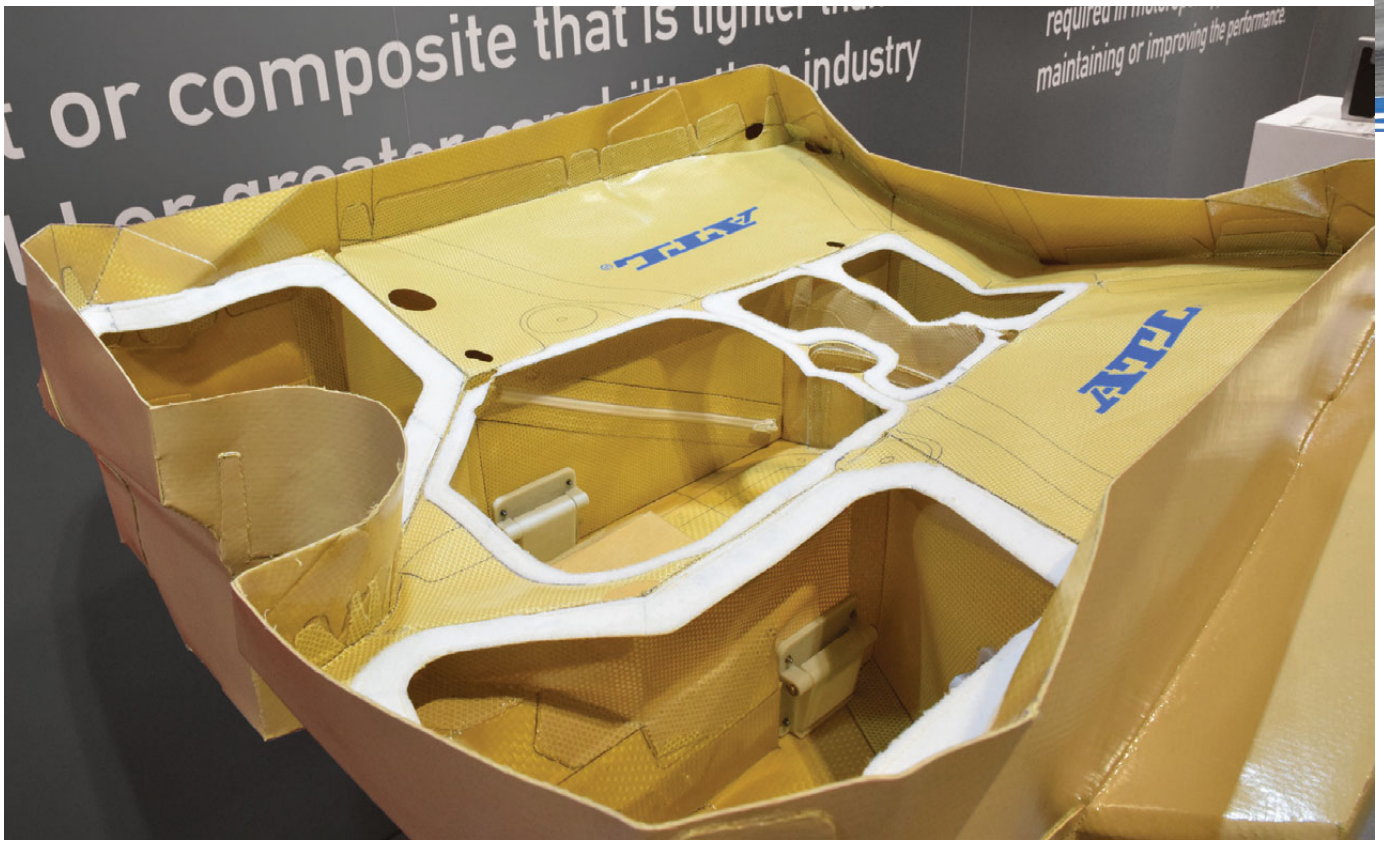
MATERIAL HELP

ATL might fly below the radar for most people, but without its products, motorsport would find it difficult to exist, as **William Kimberley** finds out from Giles Dawson, ATL UK's managing director

IN the next few years, Formula 1 will take big strides towards sustainability when 20% biomass will be added to the fuel as an intermediate step towards the goal of achieving sustainable fuel from 2023.

The fuel currently used in an F1 car is a minimum of 87 octane, keeping in line with the requirement that the petrol used must be similar to what would be put into a road car at the pump. The fuel suppliers are formulating different concoctions to achieve the targets, but an important part of the solution is the fuel cell system along with the internal collectors, surge tanks, catch tanks, fuel filters and fuel rails.

Aero Tec Laboratories UK (ATL) has long been at the forefront of designing, developing and



BELOW ATL has scooped awards for its lightweight F1 baffle material, seen here in a cutaway section of a Caterham F1 cell

Mercedes-AMG F1

building racing car fuel plumbing, adapting to meet the requirements set by the various sanctioning bodies. As such, it has been working hard to develop a system that is robust enough to meet the new fuels.

RISE TO F1

Founded in 1970 as a design and testing facility for 'flexible composite' materials, the firm quickly broadened its scope to include the actual fabrication of end products from its own outstanding fibre/elastomer composites. This led to the development of its remarkable bladder-type cells, which deform under high-energy impacts. Its fuel cells, motorsport refuelling equipment and accessories can be found in a variety of exciting projects, including the entire Formula 1 field for over 30 years.

"We were currently at the 5.75% minimum bio content and we are hoping that everyone is going to follow the F1 model in terms of continuing with the internal combustion engine (ICE)," says Giles Dawson, ATL UK's managing director. "I do think they are on the right path in terms of the 10% increase in something that is environmentally friendly year on year.

"Everyone thought that the third-generation e-fuels were the answer. There was the push for E85 – 85% ethanol fuel and 15% gasoline – but when was the last time a car ran around a circuit with E85 that was not in private hands? Five years ago?"

Dawson says that lessons have been learnt in supplying a number of teams in the World Endurance Championship (WEC) over the years. "The experience we gained in WEC as far as material is concerned is now being applied to Formula 1. However, the boundaries are being further pushed in terms of compatibility and understanding.

"For us at ATL it's making sure that we've got the right materials to sustain that. It has also been very helpful in terms of our diversification into military and aviation as it's driving us towards materials that are far more durable and wider ranging in compatibility anyway, which then apply to those other markets. It's the right direction for us.

"We've also looked at battery tech and have investigated what we could do there, but it's so limited that we changed our focus. Hopefully, everyone will follow the F1 path."

However, Dawson has his doubts about hydrogen as an energy source for cars. "Currently there is no green way of producing it," he says. "At the moment, 95% of what is being produced is coming out of fossil fuels and this electrolysis of water is so cost inefficient that I can't see how it can be used until they crack that. Once they do, then it only helps solve the problem of producing clean synthetic fuels so perhaps hydrogen will never be the long-term answer. OEMs are all ticking boxes by investing heavily in this R&D, but there's still a very long way to go.

"The hybrid cars that we are driving today are actually the answer," he says, "although lightweight vehicles that do not need a huge infrastructure to charge are definitely an answer for inner cities." He expands upon that from a motorsport point of view by saying electric karting could be an entry level for kids who might otherwise disregard motorsport as being too expensive.

ABOVE ATL supplies the entire Formula 1 field

> *"The flexibility means they can be fitted through a smaller aperture, which is a welcome benefit to designers"*

SHIFT IN BUSINESS PRACTICES

ATL has seen a shift in the way it conducts business by going into what it terms volume production, supplying fuel cells to GT3 and GT4 ▶

LEFT ATL's final assembly department has grown busier. As production capabilities have expanded, the workforce has grown from 35 people in 2012 to more than 100 today

manufacturers and teams. "With what has gone on in the last four or five months since the COVID-19 outbreak, we are currently producing tanks for Porsche because we know they are going to build these cars at some stage so it's allowing us to keep doors open and work at 90% capacity," says Dawson. "It's smoothed all the peaks and troughs out."

REVOLUTIONARY FABRICS

One of the GT3 projects ATL has been working on is the new Scuderia Cameron Glickenhaus 004C GT3 car. Manufactured from the ATL-797 material, this is an FIA FT3.5-approved fuel cell which includes ATL's foam baffling, custom plates, internal assembly, wiring and plumbing. Based on the same weave construction as ATL's FT5 material, these revolutionary FT3.5 rubberised fabrics are also manufactured from Kevlar fibres and an ATL proprietary synthetic elastomer coating. As fewer strands of Kevlar are required to achieve this specification, the result is an incredibly lightweight and highly flexible fuel bladder. The resulting flexibility means that they can be fitted ▶

BELOW DTM fuel cells are manufactured from FT3.5 material

Audi AG

through a smaller aperture, which is a welcome benefit to most car designers.

While no FIA-regulated category mandates the use of an FT3.5-approved flexible fuel bladder, they are very popular thanks to their properties and can be used to upgrade from an existing FT3 bladder. ATL's FT3.5 fabrics are widely used by Le Mans Prototypes, Grand Tourer customers and older specification World Rally Cars. The mandatory fuel cell for use in the DTM (Deutsche Tourenwagen Masters), designed and manufactured by ATL, is also manufactured from FT3.5 material.

"The new GTE/3 cars such as the Ferraris and Aston Martins have been fantastic for us," says Dawson. "I never thought getting an order for 20 parts would be a good thing. I guess the engineer in me hates it, but from a business perspective it has made us sustainable. We have seen growth from 35 people when I took ATL over in 2012 to more than 100 people today, peaking at 150 staff last year because of this volume production.

CHANGING CYCLES

"The cycle's also changed and where we used to have a three-year cycle with two really busy years and one quiet one, it has now become a five-year one, which has come out of sequence and so has smoothed the workflow. Another example is that we've done over 500 fuel tanks for the Ferrari 488 Challenge cars.

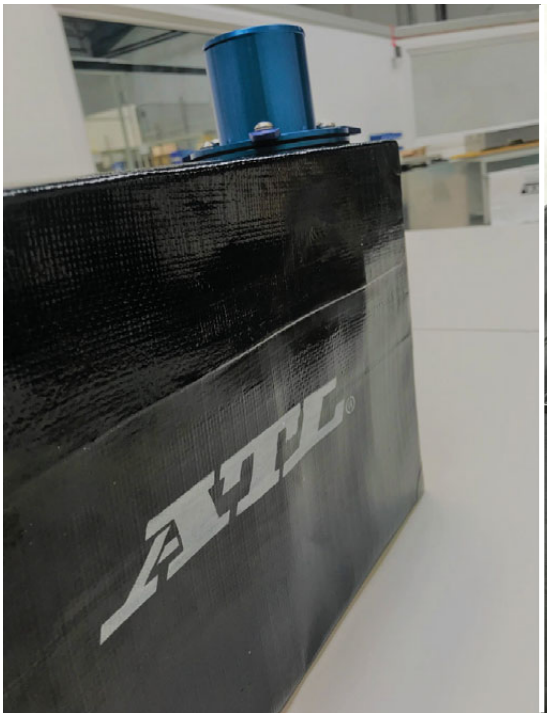
"However, things are evolving. Originally you could buy a GT3 car for around £150,000 but now you can't buy one for less than £350,000. We are therefore seeing GT4s coming through now. It's what happened with the original GT1s, which became too expensive and died, so everyone went GT3.

ABOVE Electric karting could be the entry-level formula of the future

"If you look at grid sizes around the world, I think we are starting to see that lifecycle happen again with GT3 and GT4. I'm sure that GT4 will become super-expensive somehow, then there will be a class of car that replaces that.

"There's also the guy who is track-daying his Porsche Cayman GT4, which may be banned from the public highways but not going anywhere near a race, and we can only see that market growing with the current government approach. Go to Silverstone, Snetterton, ▶

> *"The engineer in me hates it, but from a business perspective it has made us sustainable"*



LEFT ATL offers many different bladder materials to suit customer needs. Its 797-B material is used primarily in LMP2, GTE and GT3

Donington or Brands Hatch any day of the week and there are always a number of these types of cars out on the track with owners and guests enjoying themselves. I see more and more of those high-net-worth individuals having their toys that ultimately will have our products in. Ten years ago if you went to a circuit during the week, unless it was a general test, the circuits were empty."

Another string to ATL's bow is the World Rally Championship, for which it is the sole supplier. It has also supplied fuel cells for cars that have competed in the Dakar 2020 and other rally raids.

"All these series are making things sustainable for us," says Dawson. "Previously we needed a highly skilled workforce to produce what was required whereas now, because of the volume and not being a bespoke item, the bar doesn't have to be set so high. It has fundamentally changed the face of the business."

TECHNOLOGY TRANSFER

There is a huge crossover in materials knowledge between motorsport and the aviation and military industries, with all sides benefiting. "For example, the materials and technologies we have developed for

> *"Everyone thought that the third-generation e-fuels were the answer"*

WEC

Lockheed Martin Corporation

ABOVE ATL's materials have to withstand life in the fifth-generation F-35 Lightning. The crossover from its work in defence and motorsport benefits both sectors

the McLaren Senna GTR are now being fed back into the military and aviation industries," says Dawson. "They want a 15-year storage life – a missile that's put into the belly of a ship and may sit there for 15 years before it's refurbished, pressure checked and refilled. A big focus on our R&D is therefore making sure our materials and all our processes are strong enough to ensure that our products will last that long."

Dawson explains that the materials have to withstand things like temperature shock and perhaps extreme locations such as in the wings of a Lockheed-Martin F-35 fighter that can experience temperature change from -40 deg C to +35 deg C in in two minutes over a big thermal mass.

PHENOMENAL RESEARCH

"The research that we've had to put into the materials to develop things that will serve that market is phenomenal, but along with that comes a more durable, lightweight material that is also safer," he points out. "It has been an enlightening experience with our customers and we want to put that knowledge into our motorsport products. We also want it to be what drives F1 research, and ultimately it's what everyone wants which is spreading the costs and coming up with one product that will do a lot more.

"These technologies are converging and we are all going down the same path. In 20 years' time I wouldn't be surprised if current jet fuels aren't around and we are all running on whatever synthetic fuel or derivative that actually works and we've also managed to crack how to extract hydrogen that is clean and doesn't burn more fossils than a thousand cars driving around."

The historic market is picking up for ATL, although it has been out of it for a while. "We lost our agility working for the big clients, but over the last few months we have seen historic racing customers return and we still have all the tooling back to 1990," Dawson notes.

"With the Masters Endurance Legends Historic Series, we are suddenly digging out tooling for cars like the MG-Lola, which was designed for the LMP675 regs, and things like that. We also do 5-10 tanks a year for Ferrari and its historic collection. Modern historic stuff includes cars that I was working on 12 years ago when I joined the company. The historic market is becoming ever more important to us and is an area we will be focusing on." RT

LEFT The lessons learned in the World Endurance Championship have been applied to F1

ROBORACE
THE FUTURE OF MOTORSPORT?

Roborace, the world's first racing series for humans and artificial intelligence, is pioneering new frontiers in the development of autonomous software. It is also dividing opinion, as **Niki Dupont** from the National Motorsport Academy discovers

MOTORSPORT is a paradox. By its very nature, it pushes the boundaries of engineering yet is steeped in tradition.

Ask any true motorsport enthusiast about their most memorable moments of the sport and people will be waxing lyrical about the late great Stirling Moss at Goodwood, the days when F1 wasn't subject to so many sanctions and when racing was more about the will to succeed, not the money and sponsorship.

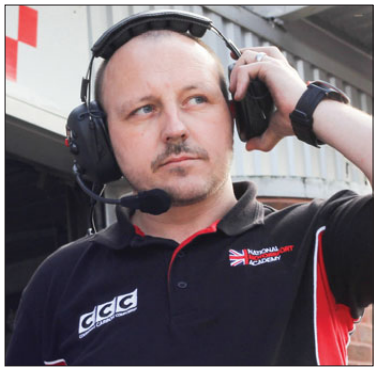
But there are some new kids in town who some believe are hell-bent on 'destroying' all that motorsport holds dear by removing the ego, the personality, the life from the sport. Whether you're a motorsport purist or like us, keen to see any level of innovation in the racing world, you're bound to have an opinion on this apparently very contentious subject: Roborace.

The autonomous, driverless, electric racing series was first unveiled during the 2016-17 Formula E Championship. In 2019 Season Alpha of the championship commenced and the first race between two totally autonomous cars took place. Team Arrival, already a specialist in autonomous vehicles, and the Technical University of Munich were the first two outfits to take an identical car and compete to win using 'only' algorithms and artificial intelligence. Updates on progress for the series have been limited but the super-slick marketing materials from Roborace HQ keep promising serious speeds and multiple sexy-looking DevBot 2.0s which can be driven by a human or 'robotic' driver.

As with all industries, motorsport is now

heavily reliant on technology, with software and sensors as much a part of a team's priorities as tyres and aero. Roborace takes that one step further and this is surely the motorsport engineer's dream? No driver ego to consider, no human error on track, just mechanical and software engineering at its most advanced level.

You only need to look at the comments on Roborace's You Tube Channel and social media to see the excitement that this series is creating. Yet opinion is still split. Is Roborace sounding the death knell of motorsport as we know it, or is it the beginning of the future? We asked our tutors at the National Motorsport Academy to weigh into the argument, with some surprising insights.



Kieran Reeves
NMA DIRECTOR OF MOTORSPORT
Studying towards a PhD in Mechanical Engineering, focusing on energy management of hybrid race vehicles. Former chief engineer and consultant.

"I'VE kept one eye looking over at Roborace as it started to develop from the 2016/17 season as the concept is the next step from my own PhD research. I have developed many algorithms that optimise trajectory and racing lines to improve lap times. These are also based on vehicle performance, energy management strategies for Hybrid Electric systems and to some extent contain an Artificial Intelligent controller as a 'Driver'. These all reside within a MATLAB/Simulink model and I can run genetic optimisation and/or particle swarm optimisation algorithms in a fully validated simulation environment to find the perfect race time. So, after that overview I return to my first comment that Roborace naturally is the next step. It uses AI systems in a real-world environment ▶

LEFT The DevBot 2.0 used for Roborace's Season Alpha runs on the Nvidia DRIVE platform when in autonomous mode. It can be driven by a human or AI driver, enabling the exploration of the relationship between man and machine for assisted and autonomous technologies

rather than just a virtual simulation.

"This is what excites me. As the speed has increased in the Robot vehicle and the first two-car race occurred, it is now starting to get very interesting on how individual teams will build their AI systems. From a pure engineer's view, I am looking forward to the day where we see a 20-car grid and all cars have to adapt and utilise split-second decision making.

"What makes a race exciting? The drivers who push the boundaries and make the perfect last-minute decisions that ultimately conclude with a clean but daring overtake. Developing the AI to a place where it will behave like a human is the challenge. In theory, with all other controllable parameters the same – car, set-up, tyres etc – then as proposed the only differentiator is the AI system. As with my PhD theories, it's inevitable with time that all teams would end up with something similar with regards the AI algorithms, therefore a perfect line and race time is going to be relatively straightforward to optimise and for the AI to learn. It is when 19 other cars are wanting that Tarmac space that this race series will get really interesting for the engineers.

"Whether this will spawn boring races or extremely exciting races is yet to be seen but I will continue to watch with an eager eye at how this series develops. It is an excellent proving ground for the software engineers and of course will ultimately help to inform the automotive industry with regards to autonomous driving too. Exciting times ahead!"

ABOVE What happens when two sets of AI cherish the same patch of Tarmac?

RIGHT When Roborace first started, an autonomous driven DevBot was 15 or 20 seconds per lap slower than a human. Now that deficit is closer to 3% –the level of a Bronze driver at Le Mans

Tim Mullis
NMA TUTOR SPECIALISING IN DATA ACQUISITION, STRATEGY & SIMULATION
Tim is currently a Data & Strategy Engineer working in the European Le Mans Series as well as a tutor at the NMA

"ROBORACE is great for engineers! Come on, how could it be any better? It's seriously high-tech vehicles with sensors feeding information to an AI. Real cutting-edge stuff with problems to solve. It's an engineer's dream come true!"

"For the engineers working with Roborace out there, please give us more details! Where are you are up to? What does your current system actually do? What doesn't it do at the moment? Are the cars actually 'thinking'? Give us answers and you would gain a great many engineering fans. Perhaps a different fanbase to typical motorsport, but we're with you! We want to know more about how this all works and what the impact will be on the wider world of motorsport, so please start sharing more of the technical innovations going on.

"As for 'traditional' motorsport, perhaps it's not so great. Take away the driver and the vital source of excitement is lost. Where's the adrenaline coming from? Surely the exhilaration of motorsport comes from watching a human being on or in a man-made vehicle going as fast as it will go? There's no fear, no thrill in an autonomous racing series. The passion to race comes from one of the most primal instincts – the thrill of the chase – so when you remove the human element, what have you got?

"Also, in many forms of motorsport, the driver brings in the money. The sponsorship is tied to the ego, the personality. People follow people. They get behind their favourite and spend huge amounts of money on fandom: merchandise, tickets etc. Without that personality, how much money would be available to continue development?

> *"An engineer's dream come true!"*

"However, times change and although I can't find a source for this, I once heard a story that text messaging was developed by engineers to be used only by engineers to communicate and that it was felt it would be far too 'geeky' for the general public and look how that turned out! Take away the technology from motorsport and you also take away ▶

the argument that motorsport helps push development that eventually finds its way into our everyday lives.

"Environmental factors can't be ignored – perhaps driverless is just the first rung on the ladder to only 'virtual' racing without the need to travel or use resources? Let's face it, the current COVID-19 situation has seen the popularity and professional standing of eSports skyrocket.

"Perhaps it is still motorsport, we just need to get used to it as times change. Let's not forget the first race was won with an average speed of 15 mph and in 1895 that was cutting edge and exciting!"

> *"There is always an element of 'fear of something new'"*

Wayne Gater
DEPUTY DIRECTOR OF MOTORSPORT & BIG KID
Specialist in Aerodynamics and Electrical Engineering

"ROBORACE has been an interesting innovation in motorsport for me and I think it will continue to be of interest to those of the Electronic generation. Having grown up with radio-controlled cars, I was effectively a spectator even when I had the controls, so to see these cars career around a track 'unmanned' doesn't pose a problem for me. If anything, it almost feels somewhat nostalgic, not to take away from the massive advances in tech!

"I haven't seen the latest in developments so I'm not sure what they are proposing now, be it pre-programmed or whether there will be any real time remote driver involvement, but I recently attended a conference where there was a balanced amount of praise and reservation for the autonomous racing form.

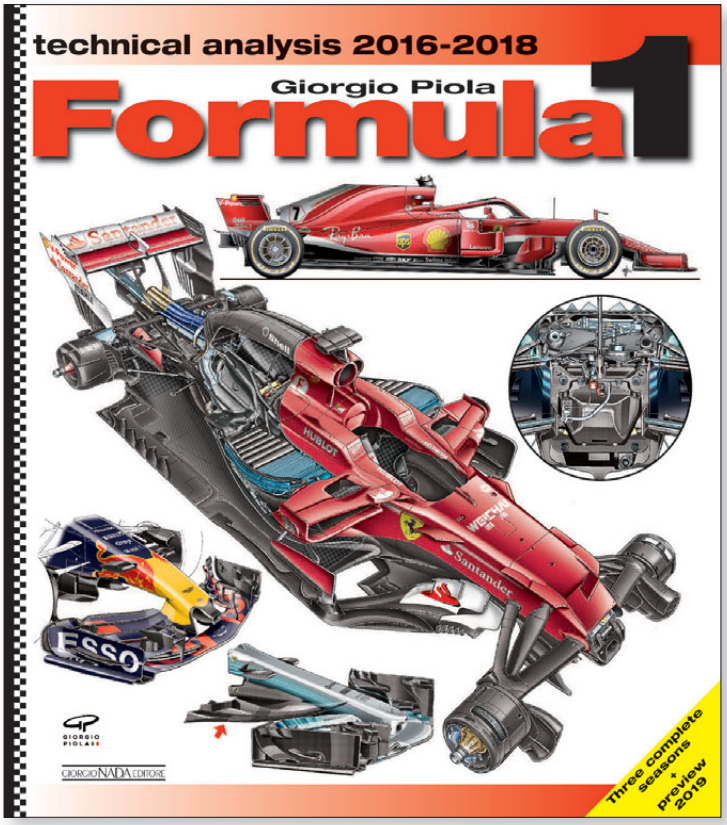
"It's interesting to think how two computers will perform in terms of going for the gap. Does one decide on its line and the other compromises? Which one gives? Is this a decision that the sensors make depending on how they're set up? Or do they both go for the line? If they do, does one know it can't hold its line if it runs a tyre onto the kerb or the grass even? Depending on the crashfest ▶

LEFT Roborace's Robocar became the first ever fully driverless race car to successfully complete the iconic Hillclimb at the Goodwood Festival of Speed in 2018

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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potential, this may make for a winning formula for attracting spectators! I know that when I was racing my RC10B2 (the R/C boys will know what that is), all gaps/opportunities were taken. Whether the car ended up on its roof or in the wall of the hall we were racing in, scale that up and you have the recipe for some interesting watching!

"Although a corner on my R/C car only cost me a week's pocket money, so there's another factor that may dictate how this race series would play out. As Tim said, it's the human element that provides the cash to compete. The tickets, the merch, the sponsorship. Without that, will money dry up before the series has even had a chance?

"It's incredibly interesting from an engineer's point of view though and I think it will certainly be a gateway for programmers to get into motorsport. That will in turn have a knock-on effect on motorsport as we currently know it, as all the best tech eventually filters down.

"All vehicles will be autonomous at some stage so I think this should also act as a reminder to appreciate the driver! I hate driver aids and all the nanny systems are always switched off on my car (where legal obvs). There's a purity to having to control your own throttle, steering and braking. This is something that wouldn't impact Roborace, but if the tech started coming into other race series, it may start to make the drivers feel like passengers. However, minds can be changed and there is always an element of 'fear of something new'. I'm an optimist, I think it will be a good addition to motorsport generally."

Roger Grimshaw

SPECIALIST IN MATHS FOR ENGINEERING & FUNDAMENTALS OF MOTORSPORT TECHNOLOGY

Grumpy Old Man and ex-race car driver

"AS far as I am concerned, Roborace is Satan's doing. I have nothing more to say."

[Editor's note: Roger was a reasonably successful amateur race driver at one time, so this stance is unsurprising.]

THE VERDICT

All in all, the verdict is favourable. But what would you expect from a bunch of academically-driven motorsport nuts? That's also why we chose them! All of our tutors, Roger included, are involved in the

RIGHT The Roborace Robocar recorded 175.49 mph at RAF Elvington, Yorkshire, to become the World's Fastest Autonomous Car

BELOW The AI Robocar has pushed the technical boundaries, attracting a new generation of fans – and critics!

> *"Roborace is Satan's doing!"*

grassroots of motorsport innovation and help our students to expand their learning far beyond what is already possible. We have details of some final year projects which explore applications of simulations far beyond what is commonplace in the industry, which we'll soon be sharing.

The field of engineering is in a constant state of flux and progression. It's the true nature of the beast. Without innovation, without improving on existing and developing new concepts, what's it all for? Let's be honest, it's still the human brain powering the cars, just not in the form of driving. If you want an example of engineering excellence, you don't get much more convincing than this.

According to Lucas di Grassi, Roborace CEO and ex-Formula E World Champion, Roborace poses no threat to real-world drivers, just as sim racing poses no threat to motorsport engineering.

"We don't anticipate that autonomous racing will ever replace human racing," he insists. "Even if Deep Blue beat Gary Kasparov at chess in 1997, people still want to know who plays better chess – me or you – so it's not going to replace motorsport as we know it, but will add something different that people can enjoy for its own merits.

"Humans will always compete! We are just evolving the technology." RT

SIR FRANK WAS THE 'LAST OF THE MOHICANS'

Sergio Rinland laments the end of an era with the sale of Williams – and debunks a myth that clouds the 'customer car' debate

WHEN investment firm Dorilton Capital bought Williams Racing, formerly known as the glorious Williams Grand Prix Engineering, it marked the end of an epoch – the era of Formula 1 teams owned by risk takers and ambitious racers. It also demonstrated how perilous the current F1 business model is.

Sir Frank Williams was the 'Last of the Mohicans', as James Fenimore Cooper calls the hero Uncas in his 1826 novel. He resisted to the end. But Formula 1 is not what it was in his youth, nor can he take the risks he used to.

It is ironic that just when the powers-that-be realized they were killing these motor racing giants, finally changing the utterly unfair financial distribution among the teams with the new Concorde Agreement, Williams ran out of breath. Had the decision been taken earlier, Williams could still be a family-owned team today.

Under the new Concorde Agreement a mid-grid team could be financially sustainable, needing a reasonable amount of money only to top up the income from Formula 1 itself. We can only hope that scenario comes true.

BELOW Rinland is well-placed to know the secrets of Williams's rise to glory: he had a hand in the design of cars like the FW11

Williams Racing

To analyse how Williams and many other teams were formed in the '60s and '70s, we need to stray into territory that is a bit taboo at the moment. These were outfits which started in F3 and F2 and one day the owner, as Frank did, put all their passion and resources into the F1 chimera, mortgaging their houses and fighting for success.

They would buy the previous season's car from one of the top teams, race it for a year or two, then venture into building their own cars. Rob Walker Racing would buy a Lotus, Frank Williams a Brabham, Ken Tyrrell a March and then Matra; it worked for them, but many others fell by the wayside.

Williams and Tyrrell determined that the only way to beat those established teams was to build their own cars, so they did and achieved huge success. Today, what was once the Tyrrell Racing Organization has metamorphosed into the Mercedes-AMG Formula 1 Team.

By the 1980s, so many teams were building their own cars that it entered the rules and Concorde Agreement: now every team, to participate in F1, *had* to build its own car. So, when people talk about this situation being 'the DNA of F1', it is not entirely true. For the first 30 years of the 70-year-old discipline, that was not the case, so how do we now define that 'DNA'?

> *"They put in all their passion, mortgaging their houses and fighting for success"*

I like tradition. Who doesn't? But we need to be pragmatic. If we want new teams to come to Formula 1, it needs a lowish cost entry-level, where people can somehow repeat history and a new Williams be created – over a few years, not from one day to the next – by 'investing' a fortune just to get a foot in the door.

Out of all those teams that came into existence in the 1970s, Williams was by far the most successful. Its achievements were thanks to the 'never give up' attitude of Sir Frank and due to the engineering genius of Patrick Head: it made for a lethal combination.

Could it happen again? It would be nice. We need new blood in F1, we need racers that put their livelihood on the line, as Nassim Taleb put it, to have 'skin in the game'. Just like Frank Williams did.

Williams as a company and a team will carry on, but it will not be the same. Williams fought for his independence like no other. This certainly cost him. Sometimes it worked and sometimes it didn't, but Frank was always his own man: no one would dictate which driver he took or how to run his team. That attitude cost him the Honda engines in 1987 and the BMW engines in 2005, but won the admiration of his peers. He never had to sell his soul, until now… RT

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