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# F1 WARS
## The sequel
### How the 2022 cars draw new battle lines for rivals

COVER STORY PAGE 24

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# IS THERE *REALLY* NO SUCH THING AS BAD PUBLICITY?

**I WAS** accosted the morning after the World Championship decider. And, as became a familiar refrain in the days that followed, Formula 1 was to blame.

Barely was I out of the door before a neighbour was jabbing his finger in my chest, accusingly. "I will *never* watch an F1 race ever again," he swore. Just around the corner lurked a Mercedes fan. He had bet £50 on Hamilton to win. It wasn't only Lewis who was feeling sore that morning, I reflected.

The controversy ignited the most unlikely debates, between people you wouldn't normally imagine were F1 fans. Not that we want the so-called 'fans' who resorted to death threats against Nicholas Latifi on social media. Glorious though the season was, did it suggest that the sport is in danger, as some fear, of disappearing down the 'Reality TV' route with its impromptu decision-making?

You can read some explosive expert opinion on that title finale in Sergio Rinland's Last Lap column. Be warned, some of it might upset you!

For what it's worth, I was with Mercedes all the way with its tantrums. Then again, I come from a long line of bad losers and would with a clear conscience protest the result of the Christmas game of cards – even if I had dominated the previous seven annual festive contests...

I've noticed, however, that such emotion, even though fuelled by a burning sense of injustice, doesn't always make for the most dignified behaviour. Which is why I was impressed that Lewis Hamilton could dig so deep within himself, one final time in an exhausting season, to congratulate Max Verstappen after the race. That was classy on a day when such decorum, understandably perhaps, was in short supply.

I'm not sure many people ever make it to the F1 pit lane in the first place without harbouring an aggressive, competitive streak within them. As you can read in our lead news story, the governing body is even banking on exactly that motivation to work in its favour. It hopes to leverage the fierce competition between teams as the catalyst for the development of sustainable fuels that can help win a race of rather more import: to save the planet from its climate crisis.

Mark Skewis
**CONSULTANT EDITOR**

# F1 could become trailblazer for sustainable fuels

Rivalry reached boiling point in the title showdown. Now it could be harnessed to drive F1's sustainability agenda. By **Mark Skewis**

**LEADING** experts have welcomed Formula 1's plan to leverage the intense competition between its teams in a bid to drive the development of sustainable fuels.

"We believe Formula 1 can set an example of how a sustainable fuel can be created and used, and that's a big thing we're working on now," revealed Ross Brawn, F1's managing director for motorsports, at a recent event.

"We all know this massive environmental challenge we're all facing," said Brawn, "but I know from my experience of Formula 1 that if you set the 10 teams a challenge and make it a competitive challenge… So what we're discussing is sustainable fuels."

Rising to meet the environmental challenge was, he said, the next stage for Formula 1. That push towards sustainability had, Brawn suggested, been a major factor in attracting the recent interest of the Volkswagen Group, which has attended meetings about the next generation of Formula 1 powertrains.

"Electrification has its place, we believe sustainable fuels have their place," stressed Brawn, the guest speaker at the RACER / EPARTRADE Online Race Industry Week. "There's a billion vehicles, getting onto two billion vehicles, on the road at the present time and you can't get rid of them so unless you find something which can be applied to the vehicles you're not going to have the impact that you want.

## Fuel you could put in a road car

"So in 2026 at the latest – and maybe even earlier – you will have to race with a sustainable fuel, in other words a net carbon zero fuel. So the way that fuel is made, is produced, has to be net carbon zero. And this will be a plug-in fuel that you would be able to put into a road car, so it's another weapon in the fight against the environmental challenge."

Both the World Rally Championship and the Le Mans 24 Hours are switching to sustainable fuels for the 2022 season, with spec fuels developed by

**ABOVE** Coryton Advanced Fuels is one of the companies leading the development of sustainable fuels for motorsport

P1 Racing Fuels and TotalEnergies respectively. In Formula 1, however, many of the top teams enjoy strong technical partnerships with fuel suppliers. So how realistic is it that sustainable fuel could one day become a technical battlefield driving forward game-changing research and development?

> *"We believe that Formula 1 could be instrumental in driving demand for sustainable fuel"*

"Under current performance criteria a fully sustainable Formula 1 fuel is not currently available. It's something many people are working towards at the moment," explained David Richardson, director at Coryton Advanced Fuels. "For everyday road use we have sustainable fuel ready to go now but, for obvious reasons, F1 requires very specialist fuel.

"We believe that Formula 1 could be instrumental in driving demand for sustainable fuel. The current spending cap and restrictions on dyno time would need to be raised, or there would need to be a specific allowance for sustainable fuels to enable that building of knowledge and expertise. If that happens then there will be a rush of people investing time and money to develop the fuels needed and it would really drive innovation."

Steve Sapsford, managing director of SCE, added:

Pirelli

**ABOVE** F1 wants to harness the teams' competitive spirit, so evident in last year's title finale, to progress the development of sustainable fuel

"F1 leading the way would be a brilliant thing as it would help drive more general market awareness about these fuels, how well they work and the impact they could have here and now in reducing greenhouse gas emissions. It's always a case of supply and demand. They could be the trailblazers for sustainable fuels." RT

**A BEGINNER'S GUIDE TO SUSTAINABLE FUEL**
See page 8



**ABOVE** The switch to sustainable fuel has attracted manufacturers like Porsche to consider F1

# A beginner's guide to sustainable fuel


**LEFT** The momentum for sustainable fuel is growing

**WHATEVER** discipline of motorsport you love, from Formula 1 to rallying, or from endurance racing to touring cars, sustainable fuels are going to have a big impact in the near future.

But the march towards carbon neutrality is littered with so much different terminology that it can often cause confusion. So RACE TECH asked two experts in the field to simplify matters.

David Richardson, director at Coryton Advanced Fuels, said: "Trying to put it as simply as possible, sustainable fuel is made with carbon previously captured from the atmosphere. That same carbon is then released from the tailpipe of the vehicle as the fuel is burnt.

"So, it becomes a big circle – the carbon is captured or absorbed from the atmosphere during the production process, then once it is turned into fuel and burnt, that same carbon is then released back into the atmosphere. It's then captured again to be turned into more fuel, to repeat the cycle.

"Fossil fuel, on the other hand, has held its carbon safe for millions of years, which is then released into the atmosphere when it's burnt. It's additional $CO_2$, which the planet struggles to deal with."

Steve Sapsford, managing director of SCE, added: "There are several different types of sustainable fuel. They can be biofuels, made with agri-waste and waste plants or crops which wouldn't be used for consumption, or they can be synthetic fuels, created in a chemical process.

"There doesn't have to be just one 'right' solution – there can be lots of complementary ones. Electric vehicles and various types of sustainable fuel could all be part of the answer to tackling climate change.

"Sustainable fuels have been sidelined somewhat because of the government's way of measuring environmental impact. Sustainable fuels do create tailpipe emissions – but it is the same $CO_2$ which has been captured during the production process. The government's own figures show switching to sustainable fuel could reduce carbon emissions by more than 80 per cent*.

## Climate emergency

"Given this could be done much more rapidly than the transition to all electric, we believe this is something we should be looking at very seriously to help tackle the climate emergency and whilst the infrastructure for electrification is put in place."

Drop-in fuels are often billed as the 'holy grail' of the technology, but in reality how drop-in are they? After all, the sustainable fuel developed by Prodrive and Coryton for this month's Dakar Rally involved a lot of iterative blends.

"Drop-in sustainable fuels are ready now for everyday road cars which would typically run on regular pump gasoline," said Richardson. "In fact, we recently provided a 100% renewable Coryton Sustain 95 RON fuel for Bentley when it launched its Hybrid Flying Spur in Iceland. But, of course, there will always be vehicles which require a more complex specification. That's true whether we're talking about sustainable or standard fuel.

"We've been working with Prodrive to provide sustainable fuel for its team in the Dakar. For that, the application demanded specific performance criteria to be met, so by balancing performance with multiple sustainable technologies we created a bespoke fuel.

"But that fuel may not be suitable for other situations – for example, high-revving motorcycles would need a different chemistry due to the operating conditions and F1 would need a different specification again. So, drop-in fuels very much exist, but it will depend on what you want the fuel for." RT


**RIGHT** A new generation of advanced sustainable fuels has been developed for the Bahrain Raid Xtreme (BRX) team's rally raid programme

* The Renewable Fuel Statistics 2019 Report from the Department of Transport found an 83 per cent saving against fossil fuels.

# Changing of the guard as Brawn and Symonds follow Todt to the exit

**FORMULA 1** gears up to enter a new era this season, but two of the respected figures who played vital roles in its transformation are expected to depart.

It is anticipated that Ross Brawn, Managing Director of Motorsports, and F1 Chief Technical Officer Pat Symonds will both leave their roles later this year.

Set against the backdrop of the controversial 2021 F1 season finale and a feeling that F1 is moving more towards a 'Reality TV' culture, news of their exit has prompted some unease. That concern was not eased by former Ferrari chief Jean Todt's departure from the role of FIA President after serving three terms of office.

Following his departure from Mercedes at the end of 2013, Brawn enjoyed a period of relaxation away from the sport before returning to his current job in 2017, shortly after the takeover by Liberty Media. He has been a pivotal figure, a trusted link between old and new, as an overhaul of sporting and technical regulations took place.

The latter have involved a complete change of philosophy, with Liberty and the FIA employing a team of poachers-turned-gamekeepers in their bid to anticipate teams' efforts to workaround a new breed of cars designed to promote batter overtaking.

Symonds is a former colleague of Brawn's during a period of success at Benetton. He has headed a technical department that not only delivered the 2022 car, but was influential in helping police the aero rules during a fractious battle between Red Bull and Mercedes last season.

These 'old heads' have been a reassuring presence for the teams during a period of upheaval for the whole industry, as well as for F1. The march towards electrification, rise of Formula E and withdrawal of the Honda factory effort from F1 have all caused jitters as the sport contemplated a major powertrain upheaval for 2026. However, F1 has pledged to continue with the Internal Combustion Engine, but with increasing levels of electrification and the championing of sustainable fuels. Brawn and Symonds have both been key figures during this process. RT

**BELOW** Brawn (right) and Symonds are both expected to depart this season

# New FIA President faces baptism of fire

**NEW** FIA President Mohammed Ben Sulayem had to hit the ground running as he took charge of a governing body thrown into crisis by the dramatic end to the F1 season.

Former rally driver Ben Sulayem was elected President of the Fédération Internationale de l'Automobile (FIA) after receiving 61.62% of the votes from FIA Member Clubs to Britain's Graham Stoker's 36.62%. He succeeded Frenchman Jean Todt, who was President since 2009 and served the maximum three terms possible.

Ben Sulayem, 60, from United Arab Emirates, President of the Emirates Motorsports Organisation (EMSO) since 2005, was FIA World Motor Sport Council Vice President for Middle East. He was 14-time FIA Middle East Rally Champion, winning 61 international events from 1983 to 2002. He campaigned under the banner "FIA for Members", committing to double motor sport participation worldwide, strengthen diversity and inclusion and be a leading opinion-former on sustainable mobility.

Elected for a four-year term, the new FIA President said former Formula 1 supremo Bernie Ecclestone is not involved behind the scenes, despite wife Fabiana taking a senior position in his team.


**ABOVE** Mohammed Ben Sulayem succeeds Jean Todt

In a separate move, the FIA has announced that it has become Carbon Neutral and certified ISO 14001:2015, in accordance with its commitment to manage and reduce the environmental impact of its activities.

In order to comply with the Paris Agreement, the FIA put in place a carbon reduction plan aiming at reducing emissions of its own operation by 20% in 2025 and 50% in 2030. At the same time, the carbon footprint of 2020 was fully compensated for by investing in offsetting projects. The investment involves forest conservation and restoration as well as avoidance projects that allow renewable energy generation. RT

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FIA/Formula E

# Formula E cost cap to safeguard Gen3 era

**ABOVE** The financial framework for Formula E has been 18 months in the making

**A FORMULA E** cost cap will come into force in October to safeguard the championship's transition to the Gen3 era.

Rising costs provoked criticism as Audi, BMW and Mercedes quit the series. But the new financial regulations create a regulatory framework designed to underpin the long-term financial sustainability of the ABB FIA Formula E World Championship.

The spending level for teams for Seasons 9 and 10 will be set at €13 million per season. From Season 11 onwards, that will increase to €15 million per season inclusive of driver costs and other costs associated with the second phase of the Gen3 car.

A separate set of financial regulations will govern manufacturer investment in research and development related to powertrain development. They will operate within a spending level of €25 million over two consecutive seasons starting from Season 9. This includes costs for R&D, manufacturing activities and ongoing mandatory services to support Formula E teams. It is estimated that the biggest spenders are currently operating on a €40 budget.

Jamie Reigle, CEO, Formula E, said: "The financial regulations are designed to complement our ambitious technical roadmap and enable manufacturers in Formula E to showcase the potential for electric vehicles in the most demanding racing conditions: the ABB FIA Formula E World Championship. The shift to electric vehicles is accelerating; Gen3 will set the standard for performance and efficiency. There is no turning back."

Frédéric Bertrand, Formula E & Innovative Sport Activities Department Director, FIA, said the measures, "will grant all stakeholders a clear vision of where the Championship is headed, enabling them to plan for the future with confidence."

The regulations will be enforced via the FIA's Cost Cap Administration, which will monitor compliance, investigate instances of suspected non-compliance and update regulatory documentation. RT

# Nissan unveils FE-inspired concept car

**NISSAN'S** participation in Formula E has inspired a new Nissan Ariya Single Seater Concept: a high-performance exploration, development and demonstration project of how the all-electric Nissan Ariya road car powertrain could be used in a bespoke single-seater racing car chassis.

The concept was presented at the Nissan Futures event by Alfonso Albaisa, Nissan senior vice president for global design, and Juan Manuel Hoyos, global marketing divisional general manager for brand and engagement.

"At Nissan, we dare to do what others don't," said Hoyos. "With this concept we want to showcase the high-performance potential of the Ariya's powertrain in a motorsports-inspired package that not only hints at the design and styling of the road car that inspired it, but that also demonstrates a new and efficient EV performance language. Acting as a testbed for future technological evolution, this project can help bring excitement from the road to the racetrack, and also demonstrate Nissan's expertise in transferring knowledge and technology from the racetrack to the road."


**ABOVE** Nissan's Ariya Single Seater Concept

"Nissan competes in Formula E not only to race on track, but also to support the development of compelling electric vehicles for customers," said Tommaso Volpe, Nissan global motorsports director. "The Nissan Ariya Single Seater Concept explores the combination of the all-electric powertrain, dual motors and revolutionary all-wheel drive system of the Ariya with a pure single-seat racing chassis – a powerful demonstration of just how thrilling electric vehicles could be." RT

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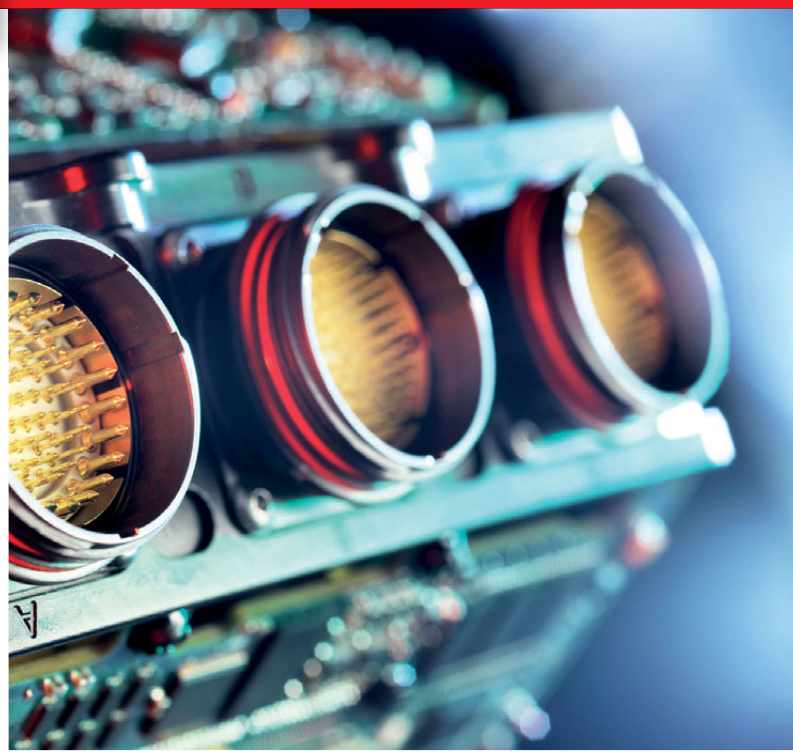
# McLaren Applied and Control target Gen3 with global collaboration agreement



**McLAREN** Applied has announced a new global collaboration agreement with Control – Race Winning Telemetry, the motorsport cellular telemetry solution provider, to integrate Control's modems with its world-leading motorsport Electronic Control Units (ECU).

Initially targeting outfits in the likes of Formula E, the new McLaren Applied VCU-500, complete with Control's TLM-P1 modems, will allow teams to use cellular connectivity to gather telemetry data from their vehicles without the need for complex and expensive trackside infrastructure. The first application will be to support a Formula E team with Gen3 car testing throughout 2022.

The Control - Race Winning Telemetry device will transmit data from the McLaren Applied ECU via cellular mobile networks and through its secure private networks to ATLAS data viewer. As well as providing a primary telemetry option for series and teams, Control's TLM-P1 also provides users with a solution for occasions where a full series-provided telemetry infrastructure is not possible or available.

The TLM-P1 features three separate simultaneous LTE cellular connections ensuring the delivery of live data from the vehicle to the garage, using the best network available at any given point on the track.

Commenting on the new agreement, Matthias Dank, Director of Motorsport at McLaren Applied, said, "This is a great partnership for both sides. In bringing together two proven innovators we've created a compelling new offering for the motorsport industry."

Technical Director and Founder of Control - Race Winning Telemetry, Nathan Sanders, added, "This is an important next step in our development. The two companies share a common desire to innovate and provide the motorsport industry with cutting edge technical solutions. This is going to be good for both companies and the development of our sport."

It is envisaged that by the end of Q1 2022 all McLaren Applied ECUs will support Control telemetry solutions.

**ABOVE** McLaren Applied ECUs will soon support Control telemetry solutions

# AI boost for McLaren

**McLAREN** Racing has announced a new partnership with AI Cloud platform leader DataRobot.

DataRobot delivers a unified platform for organisations across industries to unlock the full potential of AI and deliver clear impact for their business goals, powering over a trillion predictions for leading companies around the world.

As part of this relationship, DataRobot's AI Cloud technology platform will be integrated into the McLaren Racing infrastructure, delivering AI-powered predictions and insights to maximise performance and optimise simulations.

Zak Brown, CEO, McLaren Racing, said: "DataRobot is a leader in its field, bringing its innovative technology and platform to top businesses around the globe. McLaren Racing continues to lead in innovation and technology, and partnerships with the likes of DataRobot allow us to progress, improve and support our team in our ongoing push for optimum performance."

Dan Wright, CEO, DataRobot, said: "DataRobot is excited to unlock the next generation of racing with McLaren Racing, leveraging AI to transform millions of pieces of data into insights that optimise team strategy, operations and performance. This innovative partnership brings together the most advanced platforms in racing and AI, where every millisecond is key."

McLaren F1

**LEFT** The deal included branding on the McLaren MCL35M

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**ABOVE** A STARD Ford Fiesta ERX on an AVL HiL Dyno

# AVL RACING and STARD enter tech partnership

**MOTORSPORT** experts AVL RACING and STARD have announced a technical partnership. Their cooperation will focus on the areas of simulation, development and testing of motorsport EV high-performance powertrain solutions and vehicles.

AVL RACING is currently involved with customers in 17 race series around the world, ranging from F1 and NASCAR to MotoGP. STARD (part of Stohl Group GmbH), meanwhile, has been a key player in the electrification of rallycross.

The companies have established a multi-year action plan to develop and build several tailor-made EV powertrain-specific software tools, testing solutions and dyno facility features together. All these areas will also incorporate rallycross and rally-oriented solutions, such as a specific driving simulator cockpit for the state-of-the-art AVL Driving Simulator in Graz, to just name one example.

"We cannot think of any entity to be a more capable or better suited partner than AVL RACING to cooperate with on further improving our pioneering EV motorsport solutions and engineering," said Manfred Stohl, Stohl Group GmbH President. "With the ERX (Electric Racing "X") battery and electric powertrain system, which was developed and produced entirely in-house by STARD, the world's first and most powerful turnkey package available on the market, we have set worldwide standards in user-friendliness, safety, performance and affordability."

Michael Peinsitt, Skill Team Leader Racing at AVL, added: "Since STARD is without doubt one of the true pioneers in the EV racing sector, they possess vast and unique know-how and experience in this area. Marrying these assets with our sophisticated simulation tools and engineering services will enable us to create winning solutions and products for our customers. This powerful cooperation is a perfect setting, in which to further push the boundaries, which is exactly what the DNA of both companies is all about."

After a close project-related cooperation over many years, both companies will expand their partnership in several areas, from entire EV vehicle and powertrain simulation and development of new simulation tools for EV powertrain components, to entire HiL (Hardware in the Loop) Dyno testing. RT

# RML's first road car nears completion

**AFTER** nearly 40 years building and preparing road and race cars wearing other OEMs' names, RML is close to completing Short Wheelbase 'Car Zero', the first model to carry the company's own name and logo, and the precursor to a limited series-production run.

Installation of the Short Wheelbase's 5.5-litre V12 engine marks the start of the final stage of build before Car Zero embarks on an intensive durability programme. RML has started preparation of the first two customer cars, each of which will take six months to build.

RML's expertise with vehicle dynamics – both for road and track cars – has been applied to fine-tuning the car's suspension. The development team has adapted key elements to suit the car's lighter weight and GT credentials, while making it more controlled, refined and capable overall. This has included working with damper specialist Öhlins to develop bespoke units for the model. For Car Zero, the units remain two-way adjustable, giving the chassis team more scope to revise settings when real-world testing commences.

The V12 soundtrack further endorses those GT credentials. "The target was to emulate the exhaust note of a classic V12 road-racer," said Adnam Rahman, the Short Wheelbase's powertrain design engineer. "We started by making recordings of the donor car's Ferrari V12 from inside and outside the car at various speeds and loads, from idle to full-throttle acceleration. The engine was also put on a dynamometer, and data from both tests was built into a computer-simulated model that could be adapted to suit the new noise requirements of the Short Wheelbase. We also had to achieve all this while still meeting current noise regulations, and without impacting on the car's 485 bhp performance."

Safety within the carbon-composite construction was also a priority. RML's own roof-crush test produced just 15 per cent of the permissible displacement after a 23.9 kN load was reached in a roll-over simulation. RT

**ABOVE** The car's pre-production prototype


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# Fifteen Eleven restores title-winning Williams


**FIFTEEN** Eleven Design, the classic arm of the World Rally Championship team Mellors Elliot Motorsport, completed a punishing eight-week restoration of the 1980 title-winning Williams FW07/04 in time for the tributes to Sir Frank Williams at the Saudi Arabian GP.

The project involved the car being dismantled and shipped from its Saudi Arabian home. Then, from its premises in Bakewell, Derbyshire, the firm was responsible for a ground-up re-build of the iconic car, which Alan Jones had used to win his 1980 World Championship.

The machine was then returned to Jeddah where it was the first Formula 1 car to sample the all-new race circuit used as the penultimate round of the 2021 F1 World Championship. It was driven by a host of F1 legends such as David Coulthard, Emerson Fittipaldi and Damon Hill and featured in a Sky Sports documentary.

The painstaking process included 3D scans and modelling to ensure a faithful re-creation of unavailable parts. A total strip-down and rebuild of all components was undertaken, from the wiring loom to the iconic green leather steering wheel often associated with the FW07/04. A brand new 3-litre V8 Cosworth DFV engine was commissioned and built by Geoff Richardson Racing Engines, coupled with a full transmission overhaul by specialists Mark Bailey Racing.

Over 1,000 hours were spent bringing the legendary car back to life.

"The Williams FW07/04 project has undoubtedly been one of the biggest tasks Fifteen Eleven Design has undertaken and we certainly faced many challenges along the way, but it's been simply magical to be able to return this iconic machine to its former glory," said Managing Director Chris Mellors of the high-profile project.

"Whilst we had an idea of the amount of work required, when we arrived at Saudi to analyse the state of the car it was pretty clear it would be a big ask to get it ready for the Formula 1 race at the start of December. But when you oversee something like this, you know you simply cannot cut corners in any way; you just make it happen.

"We ensured we had a superb team around us and were equipped with all the experts we could find from both the '70s and '80s and immersed ourselves in that world for two months solid. Of course, there were modern elements that came into play such as 3D modelling, but that further reinforced the desire to ensure it took to the Saudi track in as original condition as possible."

Mellors admitted that seeing F1 legends take to the track after all of his team's hard work was a "lump in the throat" occasion for many. "Seeing Alan Jones at the circuit and having the opportunity for him to be reunited with his winning Williams was a fantastic moment," he said.

**SIR FRANK WILLIAMS**
See page 56



**ABOVE & BELOW**
The race was on to restore FW07/04 in time for the poignant occasion

# Gen3 launches new Supercars era

**THE** new era of the Repco Supercars Championship has arrived, with the two Gen3 prototypes unveiled in Bathurst.

The covers came off the Ford Mustang GT and General Motors Chevrolet Camaro ZL1 on the Friday morning of the Repco Bathurst 1000. The Gen3 cars will make their racing debut in the 2023 Repco Supercars Championship.

The prototype Mustang and Camaro bare a closer visual connection between race and road vehicles than the current model race cars. Gen3 cars will share the same key dimensions as the road cars they are based on.

The Bathurst unveiling brings the project full circle, with the Gen3 ruleset revealed at the 2020 Great Race.

The last 12 months have been headlined by a painstaking effort by Supercars and the two homologation teams to bring the cars to life. Dick Johnson Racing has been charged with the development of the Mustang, and Triple Eight Race Engineering the Camaro.

"These are incredible-looking race cars and it's an historic occasion to be unveiling them at the foot of Mount Panorama, our spiritual home of racing," said Supercars CEO Sean Seamer. "The motorsport and motoring worlds have been watching this announcement very closely as it is a massive opportunity for our sport to step up on several levels and attract a wider audience.

"Both the Mustang and Camaro give a nod to the Supercar of the past, with as much attention given to the design and appearance of the cars as the new technologies.

"With the work of the Gen3 Steering Committee, our manufacturers and the homologation teams, we truly believe these cars will create close racing with a more level playing field.

"The Ford Mustang and GM Camaro are the first chapter of our new era that will be cost-effective for our major stakeholders and teams but retain the very core of our success – terrific and exciting Supercar racing, which is what our fans have been asking us for." RT


**ABOVE** The Gen3 cars hit the track at the championship's spiritual home

# M-Sport reveals Fiat Panda 4x4

**ABOVE** The Panda 4x4 will be eligible for national rallies

**M-SPORT** has completed a bespoke vehicle build – with a twist. The brief was to make a Panda fit for rallying.

The Panda by M-Sport started life as a standard road-going Fiat Panda. The engineering team took the underpinnings of a Fiesta R5 Mk1 as their starting point, the most successful customer competition car ever produced by M-Sport. The original shell of the Fiat Panda was carefully widened by 360 mm to allow it to fit the Fiesta chassis.

In order not to overstretch the original shape of the Panda, aggressively-styled wheel arches were sculpted and fitted, with the added effect of giving the car that subtle Group B-esque look.

The car is powered by a 1.6-litre Ford EcoBoost engine, producing just under 300 bhp and 450 Nm torque through a five-speed sequential Sadev transmission, mated to bespoke front and rear differential units.

The interior features a dashboard inspired by the same basic one found in early Fiat Panda models, with added six-point harnesses and an FIA homologated roll-cage.

Matthew Wilson, M-Sport Director, said: "It has been very special watching the Panda by M-Sport come to life and I am blown away by what we have been able to achieve. I was very fortunate to complete the car's shakedown and put it through its paces; not only is it amazing to look at, it drives very well too.

"The Panda by M-Sport is one of the first of a new era of bespoke, low-volume projects being carried out at Dovenby Hall. It has provided M-Sport the perfect springboard to launch M-Sport Special Vehicles, highlighting that we are geared up and ready to accept new clients with unique commissions of their own." RT

# Formula E looks ahead to "world's most efficient racing car"

Photos: FIA/Formula E

**THE** ABB FIA Formula E World Championship has published its Season 7 (2020/2021) Sustainability Report. It details a series of notable 'firsts' in sustainability achieved and implemented during the year, plus looks ahead to its forthcoming Gen3 becoming "the world's most efficient racing car".

When it enters competition in Season 9, the Gen3 will, it says, set the benchmark for sustainable, high-performance racing cars, with 40% of the energy in a race coming from regeneration. The car will be certified net-zero carbon.

It is a machine of which Jamie Reigle, Formula E CEO, said: "In designing the Gen3 car, we set out to demonstrate that high performance, efficiency and sustainability can co-exist without compromise. Together with the FIA, we have built the world's most efficient and sustainable high-performance race car.

"The Gen3 is our fastest, lightest, most powerful and efficient racing car yet. It is a creature designed for its habitat: racing on city streets in wheel-to-wheel combat."

Among the landmarks referenced in the new report was the introduction of a pioneering programme to ensure damaged chassis parts collected since Season 1 are given a second life. All carbon fibre broken parts will be recycled by an innovative process from the aviation and aerospace industry into new fibres reusable for other applications.

Formula E achieved ISO 20121 re-certification last August and remains the only motorsport series to achieve ISO 20121 since original certification in 2016.

Formula E also became the first sport in the world to join the Science Based Targets initiative (SBTi) and the Business Ambition Pledge for 1.5°C commitment. Formula E will further reduce its emissions by 45% by 2030.

The series was awarded the top three-star rating in the FIA Environmental Accreditation Programme for a third successive time, the first championship to achieve the standard.

Starting in Season 7, tyre allocation was reduced by 25% for a single race competition and up to 50% at double-header competitions. Compared to the Season 5 calendar, this results in saving up to 720 tyres and a 29% reduction in emissions.

The Heineken Greener Bar was also launched last year, delivering the first sustainable bar concept aimed at reducing waste, water, emissions, and energy usage at events.

"Our world faces ongoing environmental, social and economic challenges and Formula E is committed to ensure everything we do leaves positive, tangible legacies," commented Reigle.

"As we look ahead to Season 8 and the full return of fans to all Formula E events, I am excited at the prospect of once again using our unique global platform to champion the fight against climate change. We hope to inspire individuals and communities around the world to believe that adopting a sustainable lifestyle does not require compromise." RT

**ABOVE** The third-generation car is designed to Life Cycle Thinking with a clear path towards second life and end of life for all tyres, broken parts and battery cells


**BELOW** Formula E was one of the most active elite sports to participate in the COP26 global climate conference

# TIME FOR FORMULA 1 TO *WAKE* UP


A change of philosophy dictates the aerodynamics as F1 seeks better racing this season, but will the teams still have enough freedom to innovate? **Craig Scarborough** runs the rule over the 2022 car

**FORMULA** 1 thrives on controversy. So as soon as the flurry of protests and appeals surrounding the 2021 season finale had abated, team insiders could focus on their next target: criticism of the 2022 regulations.

F1's central problems have gone unchecked for many years: it's become too expensive, with huge teams of aerodynamicists and designers looking at every aspect of the car to find performance. This led to a key problem, which is the cars not being able to overtake.

It's an issue caused by ever-more complex aero, plus a widening disparity between rich outfits and the poor ones, who can't compete with their development rate.

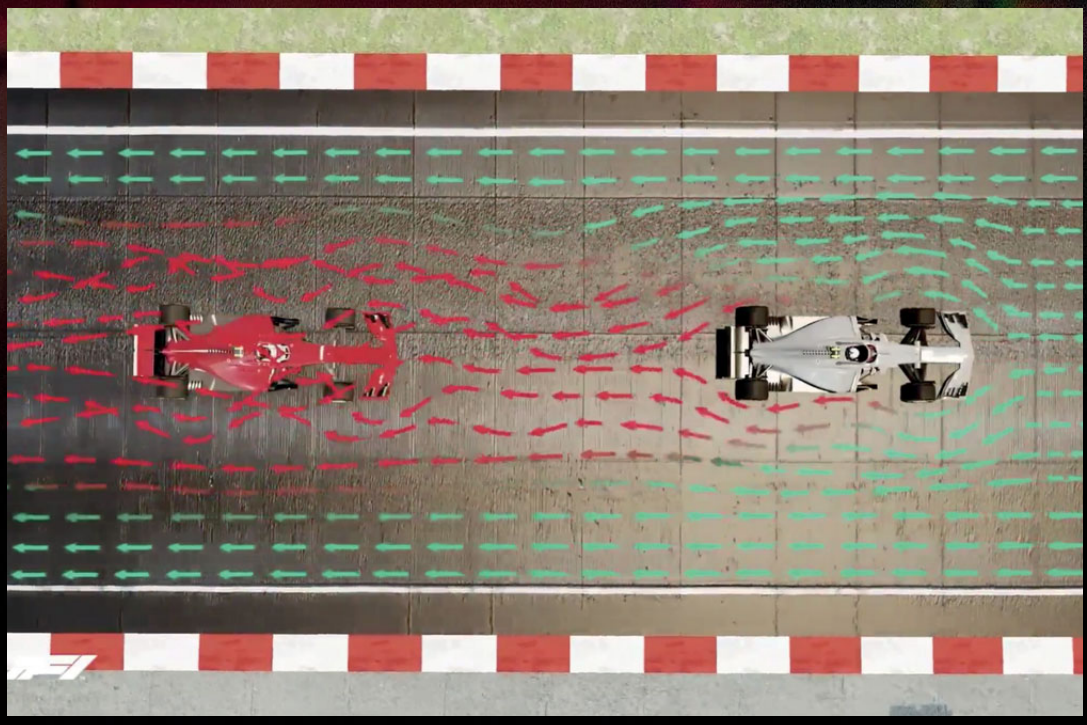
This dilemma couldn't be solved simply with the introduction of a new-look aero package. The teams are well-versed in circumnavigating new rules through the inventiveness of their aero departments.

Instead, what was needed in addition to the new shape aero was a fresh approach to the enforcement of the rules, limiting teams' ability to go off down unexpected rabbit holes and focusing ever more on the minutiae. With the 2022 rules teams have finally been reined in and given areas to focus upon that are in keeping with the aim of the rules. But, unsurprisingly, the new boundaries enforced by F1 have provoked criticism.

## 20 extra pages

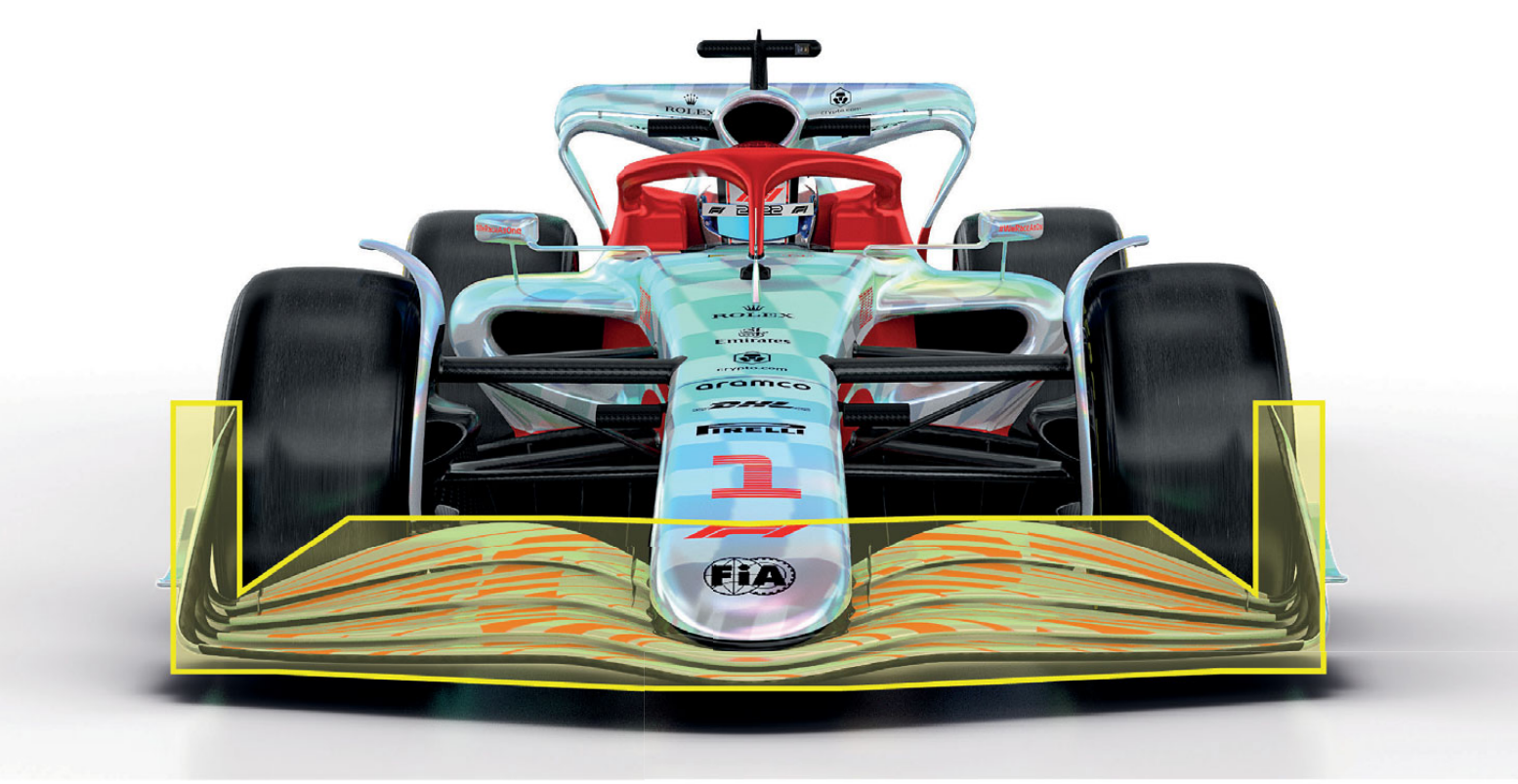
The bulk of the new regulations are aimed at aerodynamics. 2022's upheaval stretches the old 26-page rulebook, with over 20 extra pages describing the allowable bodywork. The reason for this is no secret: F1 drivers have increasingly been unable to follow closely in the wake of another car, making overtaking near impossible without the artificial DRS (Drag Reduction System).

What's more, teams have huge aero departments. Every wetted surface, whether visible or hidden to the onlooker, is highly developed. So, a huge amount of the millions spent on R&D is dedicated to tiny gains in invisible areas. Is it necessary, ▶



**LEFT** An unprecedented use of simulation by the FIA underpins this attempt to manage the cars' harmful wake

Photos courtesy of F1




for example, to have a brake duct or front flap tuned to each race circuit?

Under the recent restructure of F1, managing director of motorsports Ross Brawn has set up an F1 technical group, a small team – far smaller than the real teams' design groups – to look at the future regulations. Headed by Jason Somerville and Craig Wilson, they have been tasked to resolve the current problems of cars' ability to race closely and the expenditure funnelled into their design.

In regard to the difficulty of overtaking, F1's technical group has looked into the reasons in two areas: the wake of the leading car and sensitivity of the following car.

## F1's magic mushroom

As a result, the rules seek to change the wake behind the lead car, keeping it narrower and thrown high up behind the car, in what's been termed the 'mushroom'. The primary downforce surfaces have been altered not just to work in the turbulence, but also to maintain the car's aero balance whilst doing so. Unlike most of F1's previous rule changes, this has been proven with aerodynamic simulation, by the technical department with the support of the teams themselves.

However, this is where the real issues start. The rules are created with a motive in mind – in this case, better ability to follow another car – but the teams' motivation is wholly unrelated to that. They simply want more performance, without worrying about any disruption for the car behind!

This is where the new rules start to benefit from a 'poacher-turned-gamekeeper' approach: the tech team have anticipated what the race squads will attempt to do, and tried to prevent the rule changes

**ABOVE** The wings now sit within a reference volume

being watered down.

The result is a tight limit on specific regions of the car's aero surfaces, both with specific geometry and precise wording of the rules. For example, the new brake ducts – an area successfully exploited in the past – now have a tightly defined geometry, that the teams have little influence on.

The floor and the wings, meanwhile, now sit within a reference volume, effectively a box that tightly constrains where the bodywork within can lie. Moreover, within the reference volume there is then a reference surface, which is the actual bodywork, with further limits on geometry.

An immediate criticism of this approach is that the aerodynamicists and designers have little scope to create the bodywork they'd like, making it a pseudo 'spec' aero formula. Already the likes of Adrian Newey have commented that the tight restrictions limit freedom, and work against what the aerodynamicists would like to do with the surfaces. There's a danger that the restrictive nature of the bodywork geometry could create an unavoidable aero problem in some areas.

This certainly is a valid point of view. Indeed, the teams can't create huge diffusers or complex front wings and endplates. Yet that is exactly the point: they want to gain performance in these areas, but to the detriment of the carefully considered mushroom. F1's approach has been to take the attitude: keep your hands off this stuff, but go play with other areas. So, we now have a rule book of tight restrictions where it matters, but leaving a sandpit for the teams to play with in other areas. ▶

**BELOW** Wheel covers return, this time at the behest of the gamekeepers rather than the poachers

> *"F1's approach has been: keep your hands off this stuff, but go play with other areas"*

Allied to that, those areas of obsessive detail development have been limited. The intent is that money spent on aero will be on those areas that aid performance without harming overtaking, but also on those areas that are visible.

As the new larger underfloor tunnels are key to the changes, feeding the floor with airflow will be the teams' new top priority. Upstream this means the shape of the nose and front wing are vital. The reference volume for both is quite large. The four-element front wing has a range of ride heights possible across its span, while its intersection with the nose can be with pylons as it is now, or merged into a '90s-style nose tip, again at different heights.

> *"Teams won't have the resources to redesign their whole philosophy or even adopt a specific design from a rival"*

Teams will be able to play with high or low noses, with the front wing interacting to play with the airflow towards the underfloor's inlet. For 2022 there's going to be a range of solutions, each with a different emphasis on front wing loading or feeding the floor.

Likewise, the sidepods. On the concepts shown so far, there's been a consistent style with slanted inlet and conservative shaping around the coolers within and the coke bottle shape at the rear. Given the extreme shapes of the sidepods in 2021, this design isn't likely to be followed.


**ABOVE** The four-element front wing can intersect with the nose with pylons or merge into a '90s-style nose tip

**BELOW** Teams completed their first group test of the Pirelli tyres and 18" OZ wheels in Abu Dhabi

For the sidepods there are three reference volumes covering the front, mid and rear. There is the obstacle of the floor and the side impact protection structures beside the cockpit, then an added twist: since 2009 no openings in the body of the sidepods have been allowed, but a cooling outlet section has been included in the new rules. A generous louvered section is now permitted in the rear of the sidepods. Given the potential for directing airflow over the diffuser trailing edge and the lower beam wing, the sidepods will continue to be a development playground for the teams.

## Sidepod strategy

It's possible the high inlet and deep undercut of the current cars could be carried over, or something quite different. This louvered panel could be used simply as a means of tuning the cooling package, or more aggressively to replace the current coke bottle exit, creating a tiny truncated sidepod. They will certainly all look very different.

In my opinion at least, we will once again see a range ▶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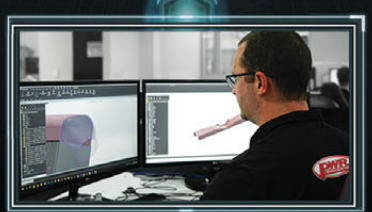
CFD Simulation



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of F1 cars that are obviously different, where the more seasoned observer can clearly see the direction in which the teams are focusing their development.

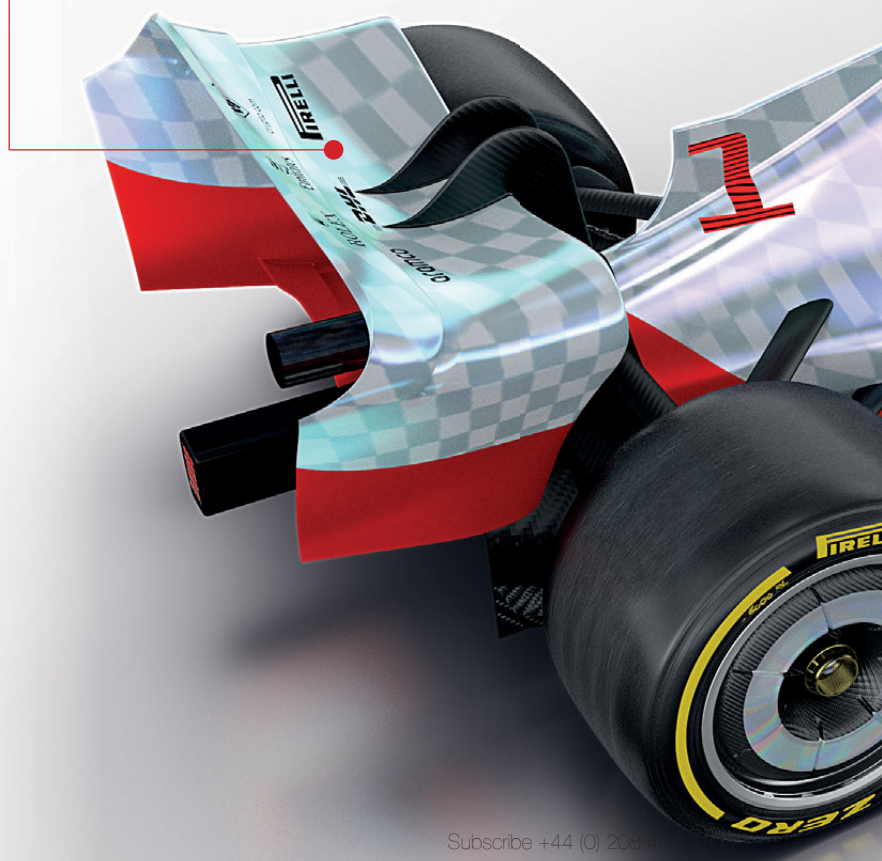
Another fear would be the ongoing convergence of design between the teams, ending up with a generic design sported on all the cars. Two things will prevent this happening too quickly: firstly, the rule set is only in place until 2026, when new rules for car and power unit come into force; secondly, the overriding budget cap and aero testing restrictions will slow the rapid convergence of designs too. Teams won't have the resources to redesign their whole philosophy or even adopt a specific design from a competitor. It should be easier to develop your chosen philosophy for the four-year life of these rules.

## 18-inch wheels

Much of the talk about the 2022 rules has been focused, quite rightly, on the aero, but there is lots more to the new tech regs. Wheels and tyres are an obvious change, with the teams having completed their first group test of the Pirelli tyres and 18" OZ wheels.

F1 has been clear that the switch to the larger wheel was for the perception aspect, seeking a more modern-looking wheel size, compared the 13" rims run for decades. But the larger wheel does not make for a low aspect ratio tyre; the tyres are larger in diameter (670 mm to 720 mm), so there is still a

**REAR WING** The rear wing creates a rotational airflow that collects the rear wheel wake and rolls it into the flow exiting the diffuser, forming an invisible 'mushroom'-shaped wake



considerable sidewall to deflect and be controlled, wrapped in a new generation of Pirelli tyres intended to be less thermally sensitive than those raced in recent seasons. Plus, there is the return of wheel covers, this time around spinning with the wheel and not staying oddly static as they were back in 2009.

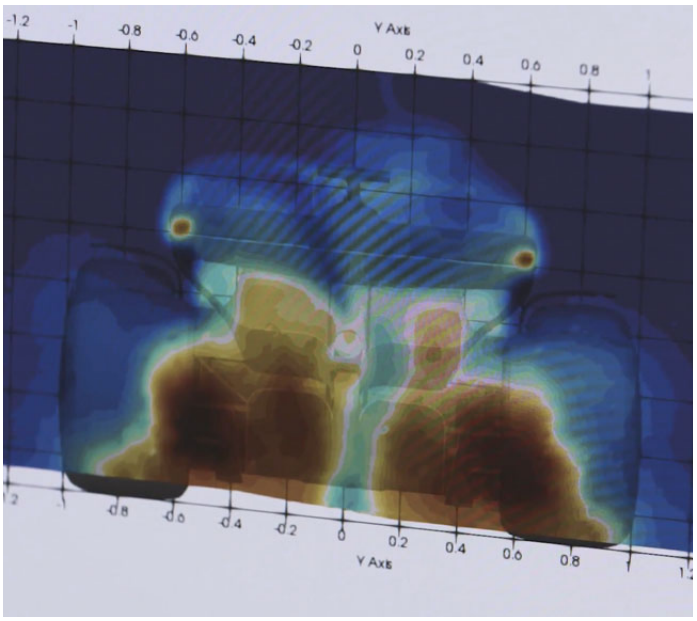
This entire tyre, wheel and cover assembly is a spec part, supplied to all teams. Along with the inner brake ducts, the entire area is free from team development. There will not be the excessive blowing through the wheel to create aerodynamic outwash. Nor the fins and duct blanking to alter the heat transfer from brake to tyre.

## Blanket ban

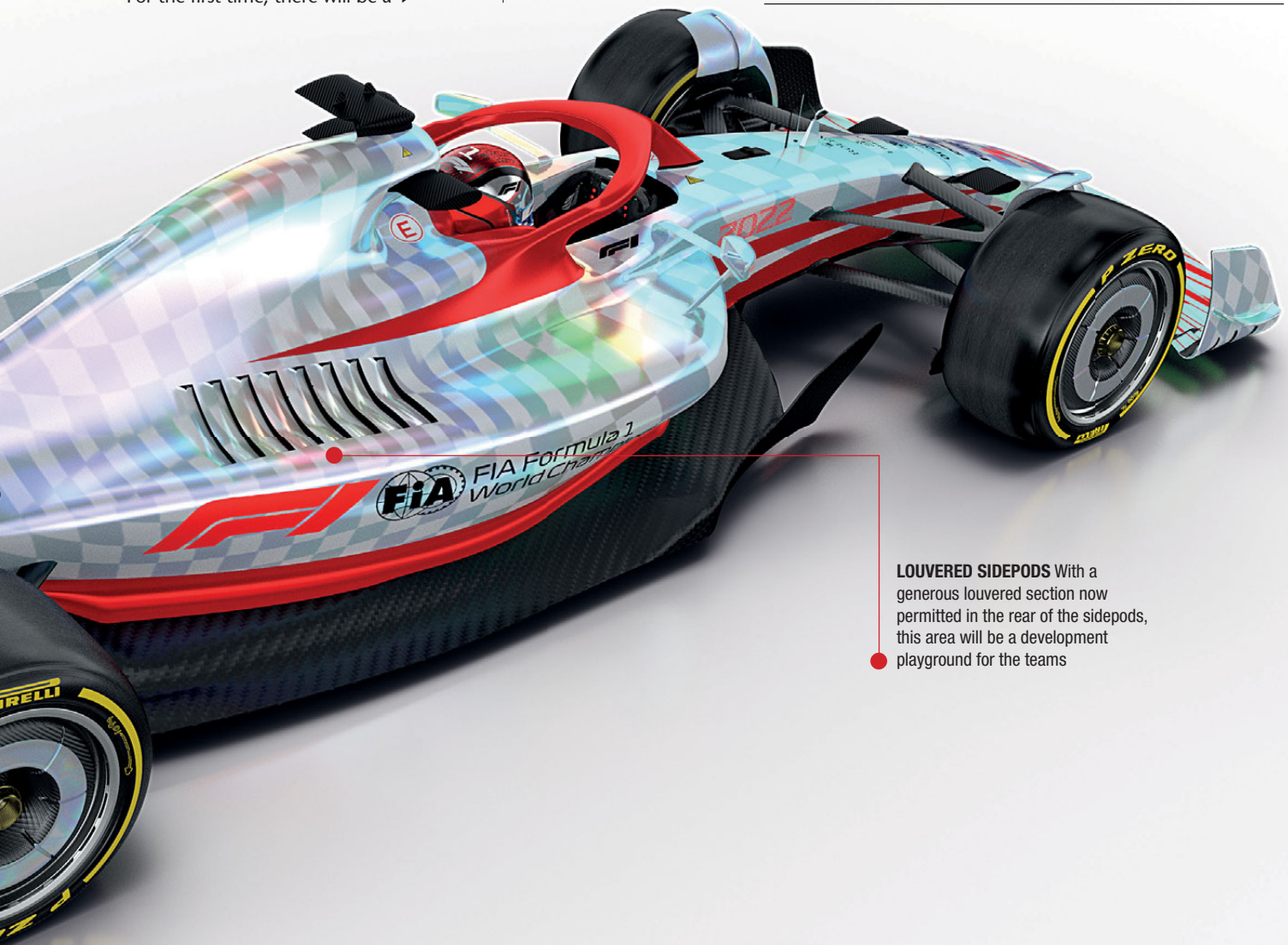
Over the coming years there will also be a restriction leading onto a ban on tyre warmers. Each year the storage temperature will be reduced on the blankets until they are made redundant. For the first time, there will be a ▶

**LEFT** Much of the wheel-to-wheel combat has been achieved only through the artificial use of DRS

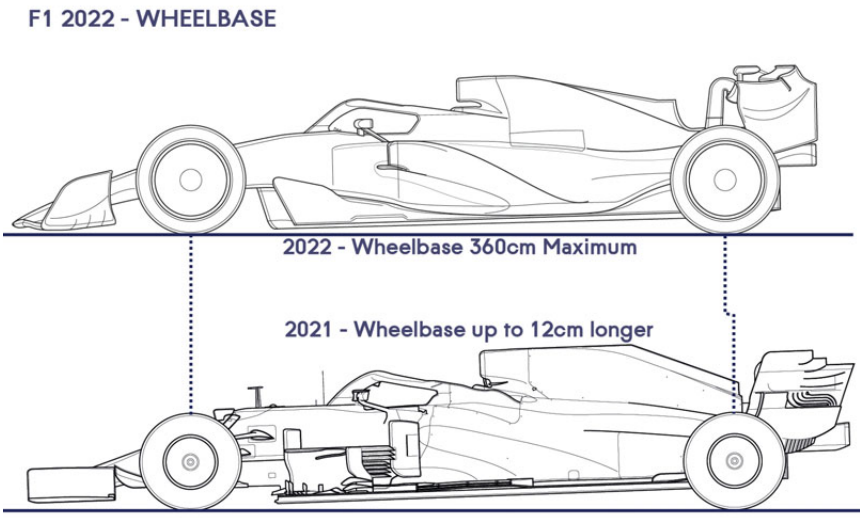
**RIGHT** Computational Fluid Dynamics played a pivotal role in researching wake behaviour




> *"Is it necessary to have a brake duct or front flap tuned to each race circuit?"*




**LOUVERED SIDEPODS** With a generous louvered section now permitted in the rear of the sidepods, this area will be a development playground for the teams




Craig Scarborough

homologated TPMS installation on every wheel, to ensure teams are running the tyres at Pirelli's recommended temperatures and pressures, to avert any failures like we saw in Baku in 2021. Again, all of these new rules seek to bar teams from tiny areas of development that have become so important, but also driven up costs.

One adverse effect of the larger wheels/tyres and other changes is weight: the already-heavy F1 car (inc 80 kg driver allowance) at 752 kg will balloon to 790 kg. This sounds a lot, especially to those who remember the c500 kg (less driver) minimum weight F1 cars of the late 20th century. In contrast, a modern F4 car weighs 570 kg, so the added weight is just a part of the evolution of safer, more cost-effective racecars.

To those still hurt by the 710 kg bare weight, the new rules for 2026 will specifically seek to make the cars lighter. They will be smaller too. A step towards this has already been taken with a first ever cap on wheelbase in the 2022 rules. Again, those recalling far shorter cars, even just 10 years ago, will find a 3.6m wheelbase cap excessive. But some of the 2021 cars were up to 10 centimetres longer!

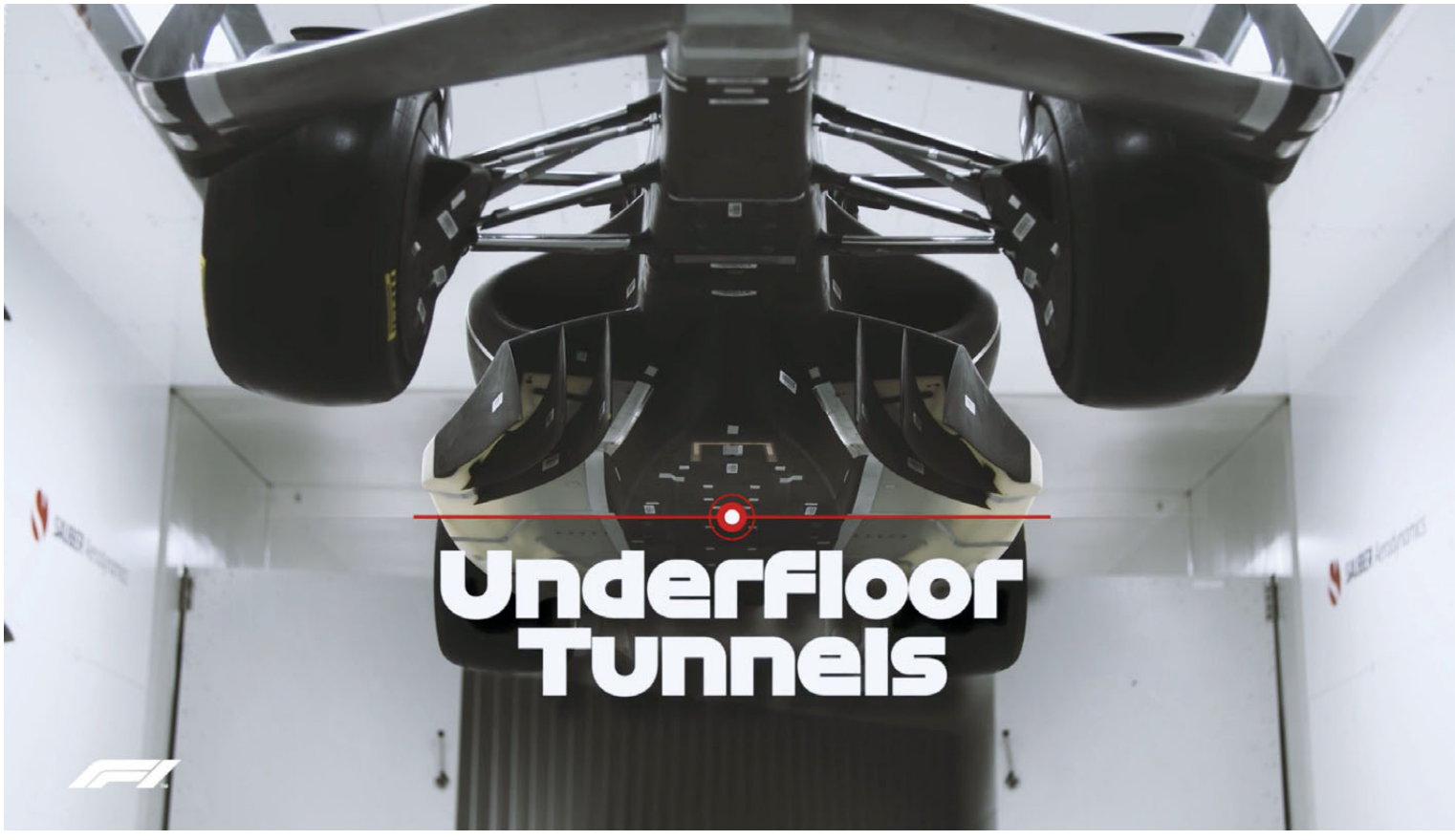
## Clampdown on inerters

Bearing this weight and controlling the tyres and the aero platform is the suspension. After years of being unable to determine quite how some of the complex hydraulic lining and gas springing was working, the FIA has moved to simplify the inboard set up of the suspension. Now banned are the remote-mounted heave springs, with their hydraulic connections and also the use of inerters.

Additionally, there is a wording to deter extreme hysteresis in the set up, to prevent the collapsing rear height achieved across the grid in recent years in order to stall the

**ABOVE** For the first time there will be a cap on wheelbase length

**BELOW** With the underfloor tunnels key to the changes, feeding the floor with airflow will be the teams' new top priority




**ABOVE** The tech team have tried to address the disruptive wake faced by the following car

aero and gain top speed on the straights. The need to employ this technique might be negated anyway by the setup required to get the best from the tunnelled underfloor. It's thought that extremely low ride heights will work better than the high rake settings raced in 2021. This gives the simplified suspension a tougher job in finely controlled, very small ride heights.

In many respects, the change to the new wheel/tyre package, combined with the aero changes and restrictions on suspension design, is probably the biggest challenge for the new car design.

> *"The new rules benefit from a 'poacher-turned-gamekeeper' approach"*

Much of the rest of the regulation changes have far less impact. The power units operate under the same rules. There will be a new homologation of the PU at the start of 2022, with just one update permitted in 2022 before they are fixed until the new 2026 specification is introduced.

Gearboxes, meanwhile, get a light pass on the regulations, with minimum weight limited and some dimensional restrictions. The gear cluster has a minimum length (170 mm) and the position of the differential and cluster relative to the rear axle line is tightly confined.

Sensibly, the life of the gearbox has switched from six consecutive races to a pool of gearboxes for the season, the numbers matching those of the power unit components. Even the fuel system gains a spec pump/collector set up to limit any trickery with fuel flow to the power unit.

However, there is one last subject likely to be missed by most of the F1 fanbase: safety. It's never a subject that grabs much attention until the systems/structures are tested in a crash. Indeed, the 2018 introduction of the Halo was seen as a huge negative for the sport by many, until a series of crashes proved its worth. Now it's rarely mentioned. The new rules cover a number of key areas that have been overdue an overhaul, many introduced in the light of the fiery 2020 Grosjean crash in Bahrain.

The lessons learnt in that accident were soon apparent: even in the 2021 cars, the pedal design was altered to prevent a driver's boot being caught in them. The rear end breaking off in the crash was part of the mechanism that led to what was already a big impact becoming a major conflagration. Accordingly, the new rules detail the failure stress of the engine mountings, to prevent parts of the survival cell being ripped off with the engine, plus the fuel filler hatch being mounted to the inner fuel bladder and thus not being ripped off with parts of the survival cell, exposing the fuel within.

One last addition concerns F1 catching up with junior formulae safety with the front anti-intrusion panel. Lessons learnt from Billy Monger's debilitating F4 crash sought to prevent any breach of the survival cell through the front bulkhead. Already anti-intrusion panels flank the footwell area; now a plate over the front bulkhead protects the driver's feet in a similar way.

## The legislative net tightens

Looking at the rules in totality, there is reason for some designers and even fans to be upset at certain restrictions or features. But for the first time a well-researched set of rules has been presented to the teams. What's more, the rules will be followed up year on year, reacting to the teams' work-arounds and leading up to another major rule set being introduced in 2026.

On the technical side, F1 appears to have made steps towards a path of reasoned regulations with clear aims, diligently tested and applied. In a world where budgets are tightening and the fanbase is growing, in my opinion this bodes well for the sport's future direction.

# "He said, 'I've found a disused tunnel that's 2.7 kilometres long. What do you think?' We all laughed at him!"

**Chris Pickering** discovers how a dream of turning a Victorian railway tunnel into the world's largest indoor aerodynamic test facility became a reality

**ABOVE** The tunnel offers the idyll of repeatability and reality, where normally engineers throw away one to have the other. That could translate into efficiency improvements for endurance racing. This is Mazda's DPi RT24-P

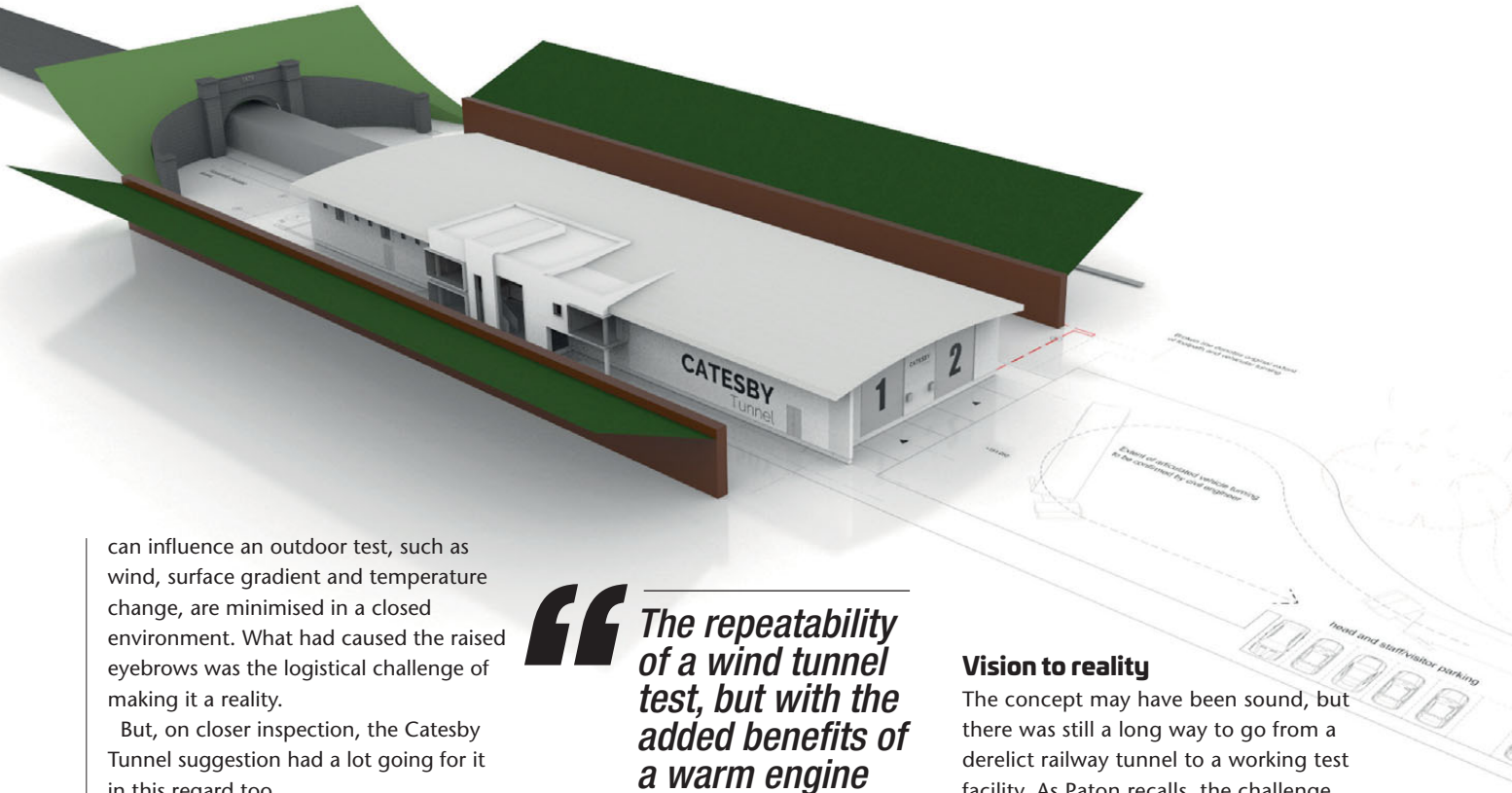
**WE** all come up with grand schemes occasionally. The sort of thing that you might mull over while having a quiet cup of coffee or perhaps bounce off some colleagues in a meeting.

For most people, these pipedreams remain nothing more than that. But for Rob Lewis and his colleagues at TotalSim, the idea of taking a Victorian railway tunnel and turning it into the world's largest indoor aerodynamic test facility has just become a reality.

First discussed at a shareholder meeting for TotalSim in 2007, the project weathered a major global recession, Brexit and the COVID pandemic to arrive at its official opening in December 2021. It's also led to the foundation of a separate entity, Aero Research Partners, which includes TotalSim and an automotive OEM.

"We'd bounced around this idea of using a tunnel to carry out aerodynamic testing in the past. It's the ultimate way of testing a real car in strictly-controlled, repeatable conditions," comments Jon Paton, group leader for Catesby Projects. "And then one day Rob [Lewis] came into a meeting and said, 'I've found a disused tunnel in Northamptonshire that's 2.7 kilometres long. What do you think?' We all laughed at him."

Coming from an aerodynamic research background, they all agreed that the idea of testing in a tunnel made a lot of sense from a theoretical perspective. All the external factors that ▶




can influence an outdoor test, such as wind, surface gradient and temperature change, are minimised in a closed environment. What had caused the raised eyebrows was the logistical challenge of making it a reality.

But, on closer inspection, the Catesby Tunnel suggestion had a lot going for it in this regard too.

As part of his research, Lewis had drawn up a list of disused tunnels in the UK. Most were crossed off early on – they were generally either too short, too small or beyond economical repair. That left just one serious contender, which also happened to be local to TotalSim's Brackley HQ and just 25 minutes down the road from Silverstone. Suddenly, the proposal seemed a whole lot more sensible.

Catesby isn't the first facility of this kind. That's believed to be another ex-railway tunnel owned by Chip Ganassi Racing in Laurel Hill, Pennsylvania. But the idea had already been floating around in motorsport circles for at least a decade before the North American tunnel began operating. The vision behind Catesby was to offer a facility that would be commercially available to all, not to mention longer, flatter and larger in cross-sectional area than its transatlantic counterpart.

> *"The repeatability of a wind tunnel test, but with the added benefits of a warm engine and real tyres"*

"We were already talking about doing something like this before we became aware of Laurel Hill," comments Rob Lewis, director of Catesby Tunnel. "If you take away the other variables in the test, you're inevitably going to get a better result. So, from an engineering perspective, it's just common sense, really. But we did actually test at Laurel Hill with Aston Martin Racing, and seeing how repeatable the data was from the tunnel certainly gave us confidence in that idea."

**LEFT** An engineering marvel of the Victorian age will now be playing its part in developing cutting-edge technology for the transport industry for generations to come

## Vision to reality

The concept may have been sound, but there was still a long way to go from a derelict railway tunnel to a working test facility. As Paton recalls, the challenge comes from the sheer scale of the project: "There's nothing complicated about it if you look at a small section of the tunnel in isolation, but the problem comes when you multiply that out over a length of 2,740 metres [1.7 miles]. Even simple things like setting up the lighting become deceptively complicated when you have to take into account the voltage drop along the tunnel and ensure that you don't get any strobing effects as the car drives down."

There are more fundamental issues too, like measuring the speed of the car. To get a fully accurate speed measurement, it has to be independent of body movements and small changes in course; it also can't use conventional GPS as there's no signal from the satellites.

For the time being, the measurement side is left to the customers, with the tunnel pitched as a controlled environment where they can collect their own data. Not only is it free from wind and rain, but it's very smooth and very flat, with an elevation change of less than ±3 mm over its entire 2.7-kilometre length.

Both ends are sealed and the tunnel itself is covered in earth, meaning that there's an average temperature fluctuation of just 3 deg C over the course of a year (and closer to 1 or 2 deg C over 24 hours). This also ensures that the tunnel is a very secure facility, well away from prying eyes,


Mark Lewis Photography

**LEFT** The vision behind Catesby was to offer a facility that would be commercially available to all

**RIGHT** The Royal Automobile Club awarded the Simms Medal to Dr Rob Lewis OBE for the development of the Catesby Tunnel Test Facility and the associated Innovation Centre. The award recognises both innovation and the spirit of adventure

not to mention ears – there are no plans at present to enforce any sort of noise limit.

Customers are free to bring their cars and essentially carry out any form of testing that passes Catesby's risk assessment. Downforce and drag measurement is likely to be top of the list, but there's a multitude of other things that can be assessed in this controlled environment. For road cars, this could extend as far as EMP testing, NVH studies and dirt deposition. For motorsport, it's thought that cooling performance could be a major focus.

The aim is to provide a facility that combines the repeatability of a wind tunnel test, but with the added benefits of ▶

**BELOW** Gradually, the dream moved ever-closer to reality. The project was a huge undertaking


a warm engine, real tyres and other aspects that can be hard to simulate in the lab.

At the time of our interview, there was a 70 mph speed limit in place to ensure safety, but by the time you read this, crash barrel chicanes should have been installed at both ends, allowing much higher speeds.

Once those are in place, the speeds will be determined by the risk assessment for each test, taking into account the design of the vehicle and the background of the driver. "If we have an amateur driver in an historic racing car, the situation is somewhat different to a professional driver in a modern LMP1 car with a carbon tub," notes Paton.

## Future plans

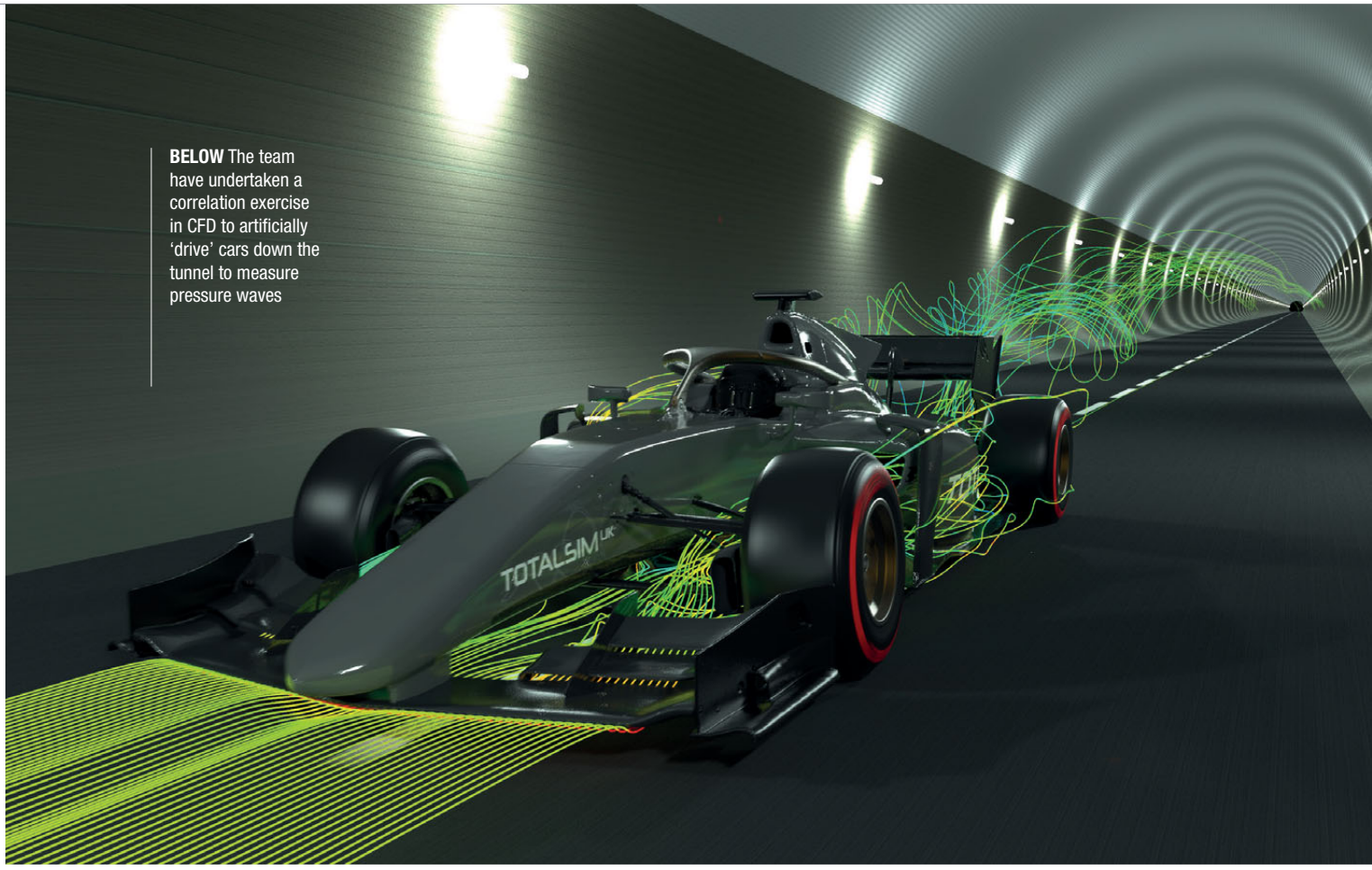
Catesby is now open for testing, but the team behind it has plans for a number of further developments. Top of the list is an ultra-wideband indoor positioning system that will allow accurate measurement of speed and location within the tunnel. This is another feature that is complex to engineer. Instead of the four satellites needed for a conventional outdoor GPS system, Catesby will require literally hundreds of beacons to maintain coverage down the full length of the tunnel.

The next phase of the plan is the addition of force plates in the road surface. These would give the engineers in the control room an instant measurement of the vehicle's load on the ground (and hence its downforce). Without the need to download data from the car (or cars) after each run, Paton believes it could significantly boost productivity. What's more, it could lower the barrier of entry even further for club racers who don't have a means of ▶

**ABOVE & BELOW** The iconic ground effect Lotus 79, Cosworth DFV reverberating through the tunnel. Quite an opening


Photos: Jonathan Symonds

> *"External factors that can influence an outdoor test, such as wind, surface gradient and temperature change, are minimised in a closed environment"*




**BELOW** The team have undertaken a correlation exercise in CFD to artificially 'drive' cars down the tunnel to measure pressure waves

accurately measuring the force on the car.

Installing the force plates will be part of the challenge, but there's also the physics of underbody downforce to consider, he points out: "With racecars in particular, there's obviously quite a bit of suction underneath the car. So being able to account for that, as a vehicle drives over the plate is actually quite a challenge. It's not the same as jumping on a set of bathroom scales, because of that low pressure area on top of the force plate, so we need a way of measuring and correcting that or taring it off. So that's part of the process that we're going through at the moment with a pilot study to see how we might remove the effects of that pressure. Hopefully, we can have the plates installed sometime in 2022."

One of the things that sets Catesby apart from other forms of testing is the presence of its walls (constructed from an estimated 30 million Victorian bricks). The working cross section of 40 square metres comfortably exceeds that of most wind tunnels, and the team says they can supply the appropriate correction factors to account for the aerodynamic blockage. This means that the tunnel is expected to be used to test vehicles up to the size of small trucks.

> *"Force plates in the road surface would give an instant measurement of the vehicle's load on the ground and hence its downforce"*

In fact, Paton and his colleagues say they can use the walls to their advantage. "We can measure pressure on the walls of the tunnel. And by measuring the pressure before, during and after the point the car passes the sensor, and how quickly it decays, we think we can do a pretty good job of measuring drag," he comments. "We've been doing quite a big correlation exercise in CFD to artificially 'drive' some vehicles down the tunnel and measure those pressure waves. And then we hope to carry out some physical testing later in the year to close the loop on that measurement."

## Launch

Catesby Tunnel was officially opened in December by Cosworth co-founder Mike Costin and pioneering Formula 1 aerodynamicist Peter Wright. To celebrate the occasion, one of Wright's most famous designs, the Lotus 79 ground effect car, was demonstrated at Catesby, sending the echoes of its Cosworth DFV engine ricocheting down the tunnel.

Customer testing in the facility actually began in October, but since then a second layer of Tarmac has been added to make the surface even smoother. Further work has also been carried out to seal both ends of the tunnel.

Originally, the team expected the majority of the enquiries to come from mainstream automotive industry, but Lewis says they've been surprised by how much interest has come from motorsport.

"We've had enquiries ranging from national-level touring car outfits up to World Endurance Championship teams," he notes. "We expect people to use the tunnel in different ways, depending on what they're racing. If you're in a single-make championship, it's the perfect place to do your aero mapping and really get to understand the performance of the car over its full range of wing settings,


ride heights and so on. Another area where we think the repeatability of the facility could be particularly useful is for chasing marginal gains, such as efficiency improvements for long-distance endurance racing."

These opportunities could be particularly relevant in view of the budget constraints that are now being found in a lot of areas of motorsport. The investment that's gone into creating such a large, highly-controlled facility means that hiring Catesby for the day will set you back more than a windswept airfield. On the other hand, it's said to be an order of magnitude cheaper than a fully-equipped full-scale wind tunnel.

"If you can do something outdoors on a track or an airfield to the required levels of accuracy and repeatability, then that's probably the best option, but you can go much further with the environment we have at Catesby," Lewis notes. "It's almost a hybrid approach of wind tunnel and track testing, where we've got the repeatability of a lab test, but with a real car on a real road."

Aside from hiring the facility itself there's very little upfront investment required, he points out: "It's not unusual for teams to spend £150,000 on a scale model for the wind tunnel before they even get to start testing. There's also quite a lot of work involved in building a CFD model. Here, as long as you've got your own datalogging equipment, you can just turn up and test with the real car."

Now, after nearly 15 years of planning, investment and development, teams have the opportunity to do just that. It's a spectacular achievement for what started off as a discussion in a small business specialising in CFD consultancy. And proof of what can be accomplished when you see something through.

**ABOVE** Catesby Tunnel was officially opened by pioneering F1 aerodynamicist Peter Wright (left) and Cosworth co-founder Mike Costin

**BELOW** The walls were constructed from an estimated 30 million Victorian bricks

# WRC HOLDS ITS BREATH

The World Rally Championship enters its new hybrid era with a mix of excitement and trepidation! **Hal Ridge** reports

**MUCH** has been made of the outgoing World Rally Car regulations at the pinnacle of global rallying. First introduced in 2017, the generation of cars that saw competitive top-flight action for the final time at Rally Monza last November were widely regarded as the best ever.

The aggressive aesthetics and increased performance of the '2017' cars took the sport to a level not seen since the heady days of the monstrous machines of the Group B era.

When Group B was banned, in 1986, Group A followed, and while it brought benefits and advantages, things were different.

As (COVID-permitting) the World Rally Championship heads to the Monte Carlo Rally for the start of the 2022 campaign, and a brand-new era, things will indeed again be different. But those who believed that the cars would be less impressive, might need to think again. While the change in regulations has been adopted to facilitate the introduction of hybrid technology, the latest cars to grace the WRC's stages have the potential to be some of the most impressive of all-time.

Given that the new machines are based on tubular spaceframe chassis,


M-Sport

**BELOW** Ford's new Rally1 Puma testing. During a special stage hybrid power will be deployed through the use of three personalised 'maps'

they arguably share more architectural similarities with their Group B forefathers than even the '2017' machines did. But the 2022 cars will be significantly safer as part of the FIA's drive to increase crew safety, alongside boosting the discipline's more sustainable credentials.

Heading into the first rally, outgoing champion Sebastien Ogier admits the start of the hybrid era brings, "Huge question marks for everybody and more uncertainty than ever." There is one constant, however: all three manufacturers – Hyundai, Toyota and M-Sport/Ford – will retain the 380 horsepower, 420 Nm torque, 1.6-litre turbocharged internal combustion engines (complete with 36 mm restrictor) run in the '2017' cars. The new plug-in hybrid system, developed by Compact Dynamics, is a spec item.

The German firm boasts experience from projects in Formula 1, the World Endurance Championship and Formula E. Its high-performance P3-topology hybrid system incorporates a motor-generator unit (MGU) operating at 12,000 rpm, inverter control unit and 3.9 kWh capacity battery, operating at up to 750 volts.

The battery package has been developed by Austrian outfit Kreisel, the same firm that will provide the electric powertrain kits to all cars competing in the World Rallycross Championship from this year.

In the new WRC 'Rally1' machines, the engine remains in the conventional engine compartment, now mated to a five-speed sequential transmission with manually-operated gearchange and spool centre differential for 2022, rather than hydraulic paddle shift gearchange system and active centre diff used until last year. The hybrid system meanwhile is connected to the propshaft further down the chassis, delivering 100 kW (134 horsepower) and 180 Nm torque during acceleration ▶

to increase the peak vehicle performance to the equivalent of 500 horsepower, and 500 Nm torque.

Rules for minimum weight have been increased to 1,260 kg from 1,190 kg in the previous iteration of cars, mostly to accommodate the 84 kg of the hybrid system.

The hybrid system will regenerate energy during braking and coasting but can utilise a plug-in option at services during the rally if required.

## Deployment strategy

One of the key discussion topics ahead of the new era getting underway has been the deployment strategies of the electrical energy. To the evident frustration of some of the WRC engineers, this is something that has seemingly taken some time to clarify within the new rules.

Rally1 cars can run in full electric mode for a range of 20 km, with the output restricted to 50 percent to extend battery life. Competitors will be able to use full electric mode in 'road section mode' for road sections, but it's likely that the system will only be used for dedicated passages marked in the route, around the service park and in built-up areas. The road section mode cannot be used in stages, and if the car goes out of 'stage mode' in a stage, the hybrid system must be disabled.

> *"One hard-coded hybrid boost map can be used as part of the launch process, releasing 1,000 kilojoules of energy in the first acceleration"*

Cars retain a form of stage mode for switching on the ICE anti-lag system (ALS) and the launch strategy.

As part of the launch process, one hard-coded hybrid boost map can be used, whereby the hybrid system can release 1,000 kilojoules of energy in the first acceleration, on top of the ICE output. Even if the 1,000 kJ have not been fully used, a release of the throttle or a press of the brake pedal by the driver will terminate that boost period of the launch phase.

Following the start, the car will switch into a 'stage hybrid boost' mode. Within the special stages, one of three homologated custom maps can be used, but the crew cannot change between maps during a stage. A maximum battery SOC (state of charge) will


**BELOW** Hybrid deployment remains a talking point as the latest cars, such as Toyota's GR Yaris, venture into uncharted territory

be defined for each test by the FIA, and once in the stage, after each 'valid regen', one 'hybrid boost' can be used as soon as the driver presses the throttle.

That boost period will terminate as soon as the pre-defined maximum amount of energy has been released, or the regen energy counter threshold has been reached. The system features a 'disable' mode, that can be switched to, but a re-latch time of one minute (60 seconds) is in place before being able to return to the hybrid mode.

The maximum amount of energy that can be used will be dependent on stage length and the road surface of the specific rally. These will be defined by the FIA and communicated to teams in advance of each event.

During this first year of the new homologation cycle, maps must be hard-coded. A new map can only be homologated together with a new ECU software, although one 'joker' to change the hard-coded mapping will be permitted in the first year.

As with the hybrid boost, three maps are also permitted for the 'regen' phase. These can't be changed during the stage. The minimum accumulated energy recovery permitted will again be defined pre-event, but the regen energy counter will only be active when the front braking pressure is in excess of five bar, and the throttle angle is lower than 30%.

When the battery is at maximum SOC, regen won't be permitted. If the SOC is below 80%, it is compulsory to automatically activate one hybrid boost. At the conclusion of that phase, defined above, if the SOC is still above 80%, the driver will need to release the throttle or press the brake to use an additional hybrid boost.

The 'regen energy counter' resets after each hybrid boost initiation. Naturally, the hybrid unit can assist with 'engine' braking while primarily recovering electrical energy to recharge the battery.

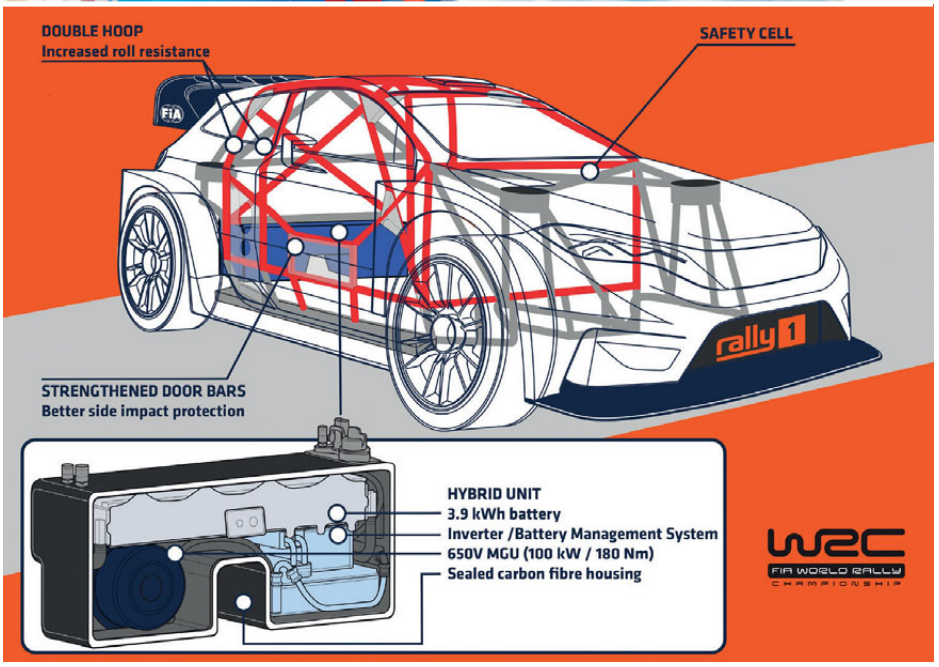
## Biggest names

The system might be all-new to the WRC, but for its creators, it's been a case of taking what it knows from experience working with some of the biggest names in motorsport – including Audi, Williams and Honda – and applying existing technologies to its first effort as a single supplier to a new discipline.

"Apart from Formula 1, the WRC is the highest profile series for the FIA. Therefore, we are very proud at being nominated as single supplier for the WRC-hybrid system – especially due to the fact that other very big-name companies also applied for the tender," says Compact Dynamics managing director Oliver Blamberger.

"Each development of a new electric powertrain or a new hybrid system will lead to challenges; this is quite normal," he says. "As a safety-feature we added a safety-clutch into our hybrid system, which enables the rally car to operate in the event of the hybrid system failing. The biggest challenge in this context was to qualify and to redesign the hybrid-system for the upcoming race season without a mule-car in place. We had a very tough timeline during the design process."

Compact Dynamics has been consulted over ▶




**TOP** The switch to a 100 per cent sustainable fuel, with P1 Racing Fuels, is an important step for the series

**ABOVE** The early signs are that these could be the safest cars in the history of the sport


Compact Dynamics

hybrid deployment strategy by the governing body – "because we have a strong knowledge about the boundaries of our system," says Blamberger – but major tasks in that area like simulation work have been defined by the FIA and approved by the OEMs.

The new WRC era hasn't been without its critics, including those who have suggested that the current limitations on the deployment of the hybrid power are tantamount to mere lip service to appease the manufacturers' marketing messages. To a degree that is justified, but only in that several manufacturers have been on record to say that without a change in technology, the WRC would be an unsustainable for investment.

As such, the WRC's new hybrid era could well be saving the highest level of the discipline. In time, once the inevitable new-project floors are resolved and the concept is proven, it's possible that the hybrid potential will be let off the leash.

## Fossil-free fuel

The switch to a sustainable fuel further boosts the greener credentials of the WRC's new era. In line with emission reduction targets laid out by the Paris Agreement, Rally1 cars will run on hydrocarbon-based fossil-free fuel from this season, a step on the road to an ambitious 2030 net-zero target for the series.

The fuel is supplied by P1 Racing Fuels under a three-year agreement. It is a blend of synthetic (created using hydrogen and carbon) and bio-fuel (produced from biological waste) components, billed as being the first of its kind to be used in an FIA World Championship.

Better still, it's a drop-in alternative to previous fuels used in the series. "Our proprietary formulation is the product of four years of research and innovation, representing a first in the world of racing technology, but also, an important step towards carbon neutral engines as part of the future of sustainable mobility," says P1 CEO Martin Popilka.

"Providing an innovative, sustainable and cost-efficient fuel available at scale is not only exciting for the world of motorsport, but the world of motoring, a promising sign that the future of carbon-neutral production automobiles is now a step closer to reality."

**ABOVE & BELOW**
Compact Dynamics, a subsidiary of Schaeffler, has developed the hybrid system, drawing on its top-flight experience in other categories

## Strides forward in safety

Just as important to the crews climbing aboard the new Rally1 machines is the fact that safety measures ▶

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have taken another step forward too. Since the Group B era ended in 1986, Group A and then WRC regulations have mandated the use of production-based pressed steel bodyshells. Now, FIA-regulated tubular steel spaceframes are back, with provision in the rules for manufacturers to scale production models up or down, allowing a larger variety of potential cars to be used, effectively as prototypes.

FIA homologation crash testing confirmed improved safety, with side-impact protection taking a substantial step forward from the previous generation of cars. Studies using a 255 mm pole to simulate impact with a tree showed 51 per cent reduction for the intrusion into the passenger compartment in the door area.

An additional lateral roll bar, in front of the main roll bar (hoop) in the area of the car's B-pillar, meant that intrusion of the pole was reduced by 38 per cent during the tests, while the roof section is said to be able to absorb energy up to 115 per cent better than the previous steel bodyshells. A frontal impact with a rigid obstruction has resulted in 70 per cent less intrusion to the bulkhead area during the analysis.

Those tests were undertaken in controlled environments, but high-profile accidents have since borne out their findings. Toyota's Elfyn Evans and Hyundai's Thierry Neuville, who crashed in the French Alps while testing for the Monte Carlo Rally, have given the concept validity in a real-world environment.

While Evans' accident in the GR Yaris is known to have required the car to return to the team's workshops to be repaired, details have been kept largely under wraps. But images circulated on social media of Neuville and co-driver Martijn Wydaeghe's Hyundai i20 N in a river at the bottom of a ravine following their accident.


Red Bull/WRC


WRC.com

**LEFT** The new Hyundai i20 N WRC has already demonstrated the worth of the spaceframe structure

Having gone off the road, the car fell down a cliff, landing on its roof some 30 metres below. Both crew were able to climb out of the car and taken to hospital but released the same day. The car was believed to be destroyed. However, it's understood that the hybrid system – located behind the driver and co-driver's seats and housed within a carbon fibre casing designed to withstand 70G – remained undamaged.


Red Bull/WRC

**LEFT** Cars will run in electric mode on road sections between stages

**RIGHT** Deployment of the hybrid system at the start of a stage is one of three modes available to drivers

## Aggressive looks

Part of the new-for-2022 rules mean that, just like Formula 1's new regulations, bodywork on the Rally1 machines has been simplified. Gone are many of the small aerodynamic aids that increasingly appeared on the previous iteration of cars throughout the homologation cycle, since the 2017 introduction.

The much-revered aggressive look is still very present though, with wide arches, large rear wings and significant air intakes in the rear quarter of each car to aid with cooling of the hybrid system. Another feature that stands out, giving a hint as to the purposeful nature of the new machines – especially evident on M-Sport's Ford Puma but existing on all of the new cars – are the fans, venting of hot air from the hybrid cooling radiators at the rear of the car, in the bumper area. Viewed from the rear, it's possible to see the fans, not dissimilar to those in a rallycross Supercar.

It's a nice, albeit unintentional, nod by the new Rally1 machines to the infamous Brabham BT46 'fan car' that won the only F1 race it ever started, and the modern road-going Supercar, the T.50, created by the same designer, Gordon Murray. While the Rally1 cars have a very different kind of life ahead of them, they share common values with both the BT46 and T.50. If the new rally monsters can share allure and performance in line with those automotive cousins, the next few years of the WRC could be a pretty special period.

# WHEN THE WALLS CLOSE IN...

F1's relentless quest for performance has pushed the envelope in every area. **Chris Pickering** investigates an ingenious example of how additive manufacturing advances energy and fluid management for the Alpine F1 Team

**ADDITIVE** manufacturing (AM) is now a fairly well-established branch of engineering – particularly in the fast-moving world of motorsport, where timescales are short and batch sizes are generally small. But while the concept of AM has been with us for several decades now, new materials and techniques continue to be developed at an impressive pace.

Consequently, the list of applications is growing rapidly too. What began as a technology for the rapid prototyping of non-functional parts has long since expanded to include components that you'd find on the actual car (more than 100 of them at the last count, according to one team).

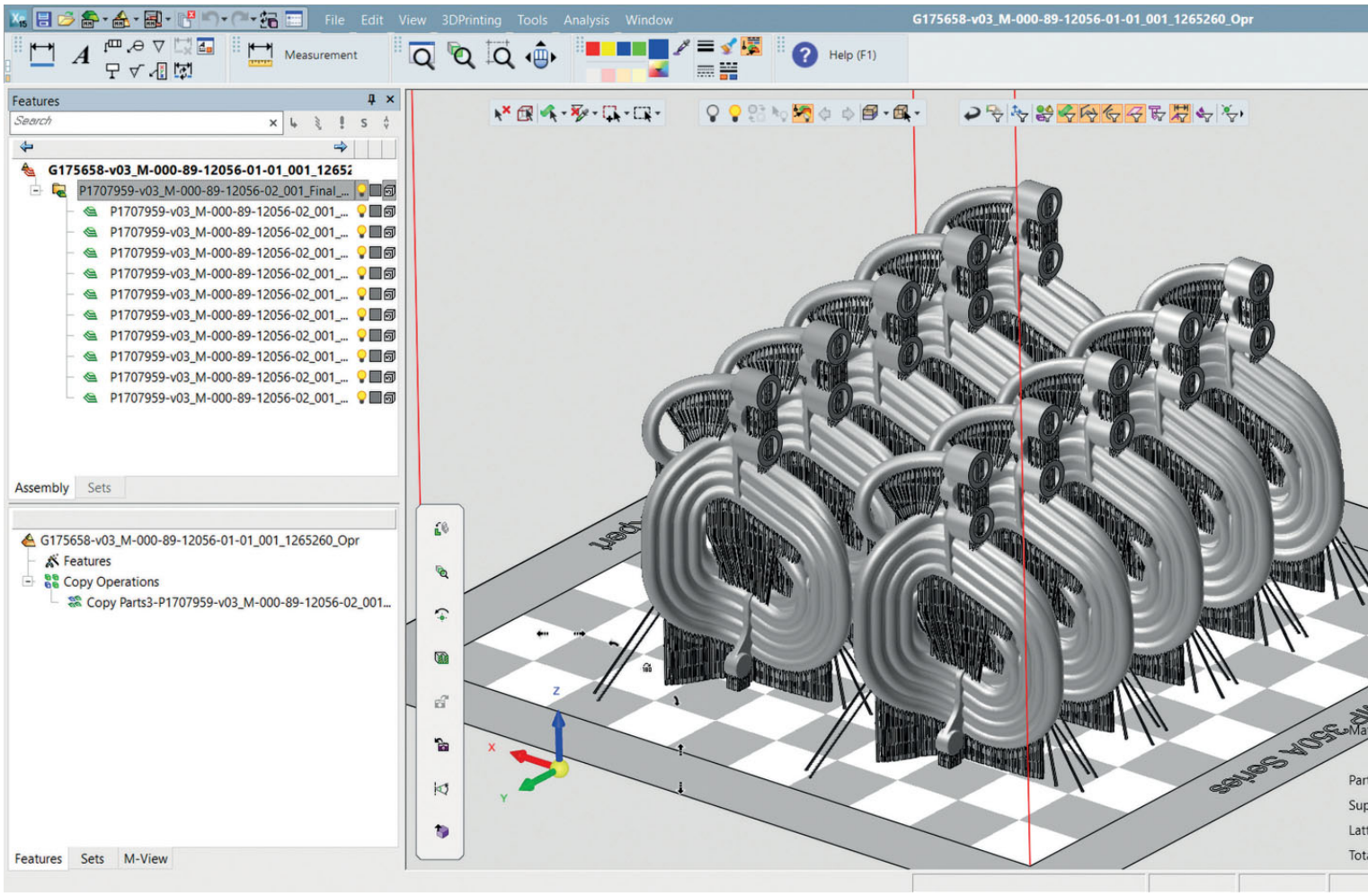
One of the most ingenious examples of this is the hydraulic accumulator created by the Alpine F1 Team with the support of additive manufacturing specialist 3D Systems. This acts as a reservoir for the fluid inerter that's used to control heave in the rear suspension. As the suspension moves, fluid is pushed in and out of the coil-shaped accumulator, but its physical inertia helps to store and release energy, smoothing out fluctuations in load, and thus giving a more consistent force on the tyre contact patch. It's similar in concept to the tuned mass dampers that were first seen in the mid-2000s.

"Essentially, it's a fluid reservoir, energy storage, and energy distribution component," comments Kevin Baughey, segment leader for transportation and motorsports at 3D Systems. "They don't use a big tank, because that doesn't give the required fluid dynamics and energy management function that they want; the cross-sectional area needs to be kept pretty consistent. So that lends itself to a long tube, which then has to be coiled up if you want to package it tightly in the vehicle."

## Multiple walls combined

In theory, it would be possible to take a length of conventional tubing and bend it into shape, but the Alpine F1 Team's engineers needed very precise control of the cross-sectional area. They also noted that additive manufacturing would allow them to define the geometry of the part from a clean sheet – not just optimising the packaging, but also minimising the thickness (and hence mass) of the tubes and combining multiple walls into one. ▶

**ABOVE** 3D Systems' direct metal printing (DMP) technology was harnessed to produce the complex hydraulic accumulator with a minimized footprint




"Using individual tubes would basically have meant stacking multiple sections of tube against each other, which would give you two walls between each pair of tubes," notes Baughey. "Instead, additive manufacturing allowed them to save a lot of space and a lot of mass."

The walls really are incredibly thin – just 0.5 mm in thickness. Like the rest of the part, they were laid down in laser-sintered titanium using 3D Systems' DMP Flex 350 direct metal printer. This uses a vacuum chamber with very low oxygen level (less than 25 ppm) in an inert atmosphere to ensure high chemical purity as the material is deposited.

## Packaging challenge

"The main priority was to find something that delivered the required structural performance with low weight," recalls Baughey. "They had a target length and cross-section for the accumulator based on the physics of how the fluid behaves. The challenge was really to consolidate the packaging space as much as possible, and get the walls as thin as possible to reduce weight, while producing something that would still be capable of withstanding the hydraulic forces inside."

> *"Using artificial intelligence techniques to solve complex manufacturing problems, including support structures"*

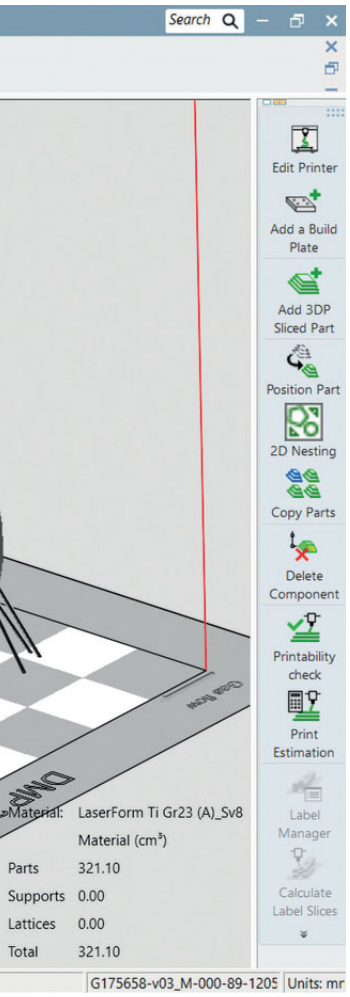
But creating the walls of the accumulator was just part of the problem. A temporary structure had to be put in place to support the material that would form the walls as it was laid down. Not only would this need to be removed after the walls were in place, but the part would have to be flushed clean to avoid contamination.

"Beyond the necessary accuracy of the part itself, we had very strict fluid cleanliness requirements for the inverter coil," says Pat Warner, Advanced Digital Manufacturing Manager, Alpine F1 Team. "3D Systems' proprietary cleaning process has a proven track record in high performance applications for delivering particle-free components, even on challenging internal channels."

## Particle-free

"Our Application Innovation Group (AIG) engineers worked with the Alpine F1 Team to develop a process to be able to effectively clean out the very complex structures inside and verify that there are no particles or debris left in there," comments Baughey.

The surface finish was also critical in this particular application, ensuring a smooth and consistent texture across the




**LEFT** The support structure that enabled the manufacturing process was designed using the 3DXpert software package

**BELOW** Optimising the inerter was vital with suspension development playing such a key role in last year's series

part. "Our metal printers are particularly well known for being able to maintain a quality surface finish, thanks to the way that we handle the environment inside the chamber," he notes.

The team selected 3D Systems' LaserForm Ti Gr23 (A) material for the design, based on its high strength and the ability to accurately produce thin wall sections. This is just one of a number of different materials that tend to be selected for fluid systems, Baughey explains: "As with anything, it depends on the application. Titanium is very good at managing the forces; Scalmalloy or 6061 aluminium would be very good for packaging in an application that wasn't as critical on weight savings; and then the LaserForm nickel would be good if you were looking for very high temperature fluid systems, where you really need to manage the temperature."

The support structure that enabled the manufacturing process was designed using the 3DXpert software package. Now available from Belgian-US company Oqton – recently acquired by 3D Systems – this uses artificial intelligence techniques to solve complex manufacturing problems, including latticing and support structures within the part designs.

At first glance, the basic design of the part seems relatively straightforward, but it's the detail control of the manufacturing process and the additional design steps to make this possible that introduce the complexity. Recent years have seen the precision of additive manufacturing processes improve significantly, enabling the use of thinner walls and more complex geometries, Baughey explains.

## High precision

"A lot of it comes down to the control of the process actually at the tip where the machine meets the part. We tend to split that into application areas, with a different approach, depending on whether it's a structural part or a fluid management part," he comments.

"With metal structural parts, you might need very fine detail for things like latticing to provide the lightweighting, but it's generally not as critical on the specific geometry of those features. In contrast, with energy and fluid management, where the part is often designed to manage pressure or heat, you need very high precision, as well as those fine details. They have to be in exactly the right spot to control the dynamics effectively. That's why we split out those two scenarios into separate application areas." ▶

Alpine F1 Team

This hydraulic accumulator is a classic example of a fluid transfer application, he points out. From a 3D printing perspective, it shares a lot of similarities with heat exchangers. These also feature thin walls, precise geometry requirements and the need to flush all debris out of a complex shape once the support structure has been removed.

Thermal management applications are something that Baughey is expecting to come across more often as motorsport moves towards greater electrification. Highly-optimised cooling systems for batteries, motors and inverters are driving new challenges in weight-reduction and packaging.

> *"Additive has become a critical element of the development and production process in motorsport"*

He also predicts that the manufacturing processes themselves will continue to evolve: "I'd say the fundamental science behind the various additive techniques is now pretty mature. We probably won't see too much change there, but there are four areas where I think we'll continue to see fairly rapid development.

## Efficiency improvements

"New materials are continuing to come through that suit different applications. Meanwhile, on the productivity side, there's a drive to get direct energy down to the material as fast and precisely as you can. I think there's still quite a lot of headroom to make that more efficient. Likewise, there's a lot of work being done on automation to bring what's currently seen as an advanced manufacturing solution into a true production system. And the fourth aspect is the software integration that goes into that, allowing the additive systems to talk to the mainstream production systems."

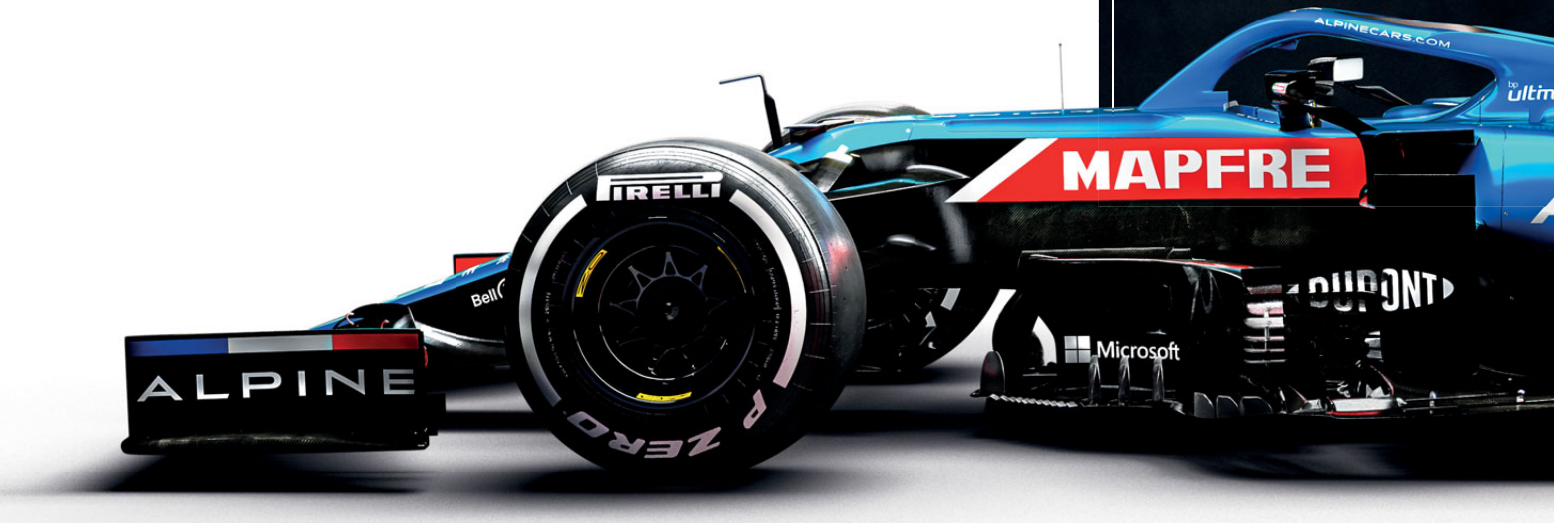
Of course, the sport faces commercial challenges as well as technological ones – notably with increasingly stringent cost caps being introduced in Formula 1. This too, will have an impact, he believes:

"Additive has become a critical element of the development and production process in motorsport, and especially in Formula 1," he acknowledges. "We've already started to see the cost caps having an impact in terms of where and how the teams are going to invest, and I think that's going to push both the materials development and the productivity.

"In general, motorsport teams aren't focusing on pure automation processes, because they deal with very specialised designs working in small quantities, but productivity is still important. It's a question of how fast they can get the design optimised, and whether they can get it right first time. They're focusing their resources on iterating the functional design of the part, and that time is wasted if it takes multiple attempts to get it to come out of the printer correctly."

In the end, it's all part of additive manufacturing's journey from a concept that was once confined to space models and wind tunnel parts, through to one that can also cover hundreds of functional components on the car itself. The technologies behind it may have come on in leaps and bounds in recent years, but it seems there's still plenty of scope for development. RT

Alpine F1 Team




**ABOVE & BELOW** Additive manufacturing offers a unique opportunity to overcome the challenges of fast-paced innovation by supplying highly complex parts with short lead times to meet the team's very short iteration cycles

# "A TRUE GIANT OF OUR SPORT"

Frank Williams was the last of a heroic breed of racers who risked all to take on the big boys in Formula 1. By **Tony Dodgins**

**THE** news that Sir Frank Williams had passed away marked the end of an era. But what an era!

Such was Frank's passion for racing that he spent every penny he had – and many more that he didn't have – chasing his dream. From hiding from the bank manager, to at one point operating the business from a telephone box, you couldn't have scripted many of his early escapades.

Patrick Head, his partner at Williams Grand Prix Engineering, admitted: "There were times when I found the challenges overpowering, but Frank was always so positive, always convinced that 'everything will work out, chap', that it was hard not to be swept along with his positive attitude."

That enthusiasm was infectious; the partnership with Head formidable. Together, they not only took on and beat the sport's elite, they redefined the benchmark required for success in Formula 1. With Patrick's technical ability and Frank's drive and quick wits, Williams won nine F1 Constructors' titles and Drivers' world championships with Alan Jones, Keke Rosberg, Nelson Piquet, Nigel Mansell, Alain Prost, Damon Hill and Jacques Villeneuve.

Little wonder, then, that F1 president and chief executive Stefano Domenicali was moved to describe Williams as "a true giant of our sport".

Domenicali added: "He overcame the most difficult of challenges in life and battled every day to win on and off the track. We have lost a much loved and respected member of the F1 family and he will be hugely missed."

## A passion born

Frank was born in South Shields in 1942. His father was an RAF Wellington pilot, who left when Frank was 11 months old. His mother was a schoolteacher and much of his early years were spent with his grandparents until, just before four, he was sent to a Catholic convent school at Blundellsands, near Liverpool. At seven, he was sent as a boarder to the Catholic Marist Brothers' School in Dumfries, Scotland.

It was there that he developed his passion for cars and racing. In the mid-fifties there was keen motor racing rivalry and Frank's school was split into a Scots faction supporting Ecurie Ecosse and their private Jaguars and the English who got behind the works Jaguar team.

The father of a school friend was a well-heeled motor trader based in Newcastle and the company would buy stock from auctions in Glasgow, taking a bevy of drivers with them. Frank would go along for the ride, just to spend time in the passenger seat of a Jaguar. And, soon,

XPB Images/Williams Racing


Pirelli

**ABOVE** The F1 community gathers to pay tribute to Frank Williams on the grid in Saudi Arabia

**LEFT** Frank Williams, seen here on the Brands Hatch pit wall in 1984, was a wheeler-dealer racer with infectious enthusiasm

> *"Frank was always so positive, always convinced that 'everything will work out, chap', that it was hard not to be swept along"*

in holidays, he was hitch-hiking all over the country to racing circuits. One of the first races he attended was the 1958 British GP at Silverstone, the scene of Williams Grand Prix Engineering's first victory some 21 years later! Ironically, it was the first season of a separate championship for constructors, although initially it was as a driver that Frank saw himself.

The only problem, he wasn't wealthy, and it was also an ambition to one day put that right. In 1960 he left school and took a management trainee course with Cripps Brothers, a Rootes Group car distributor. After learning to drive in his mother's Morris Minor, she helped buy his first car – an ex-Graham Hill Austin A35.

The club racing scene offered a number of classes for tuned road cars and Frank was soon in action. In his third race, at Mallory Park, he rolled the A35, scrambled out and sat on the bank watching the race, where he met a guy called Jonathan Williams, who'd also crashed. In the paddock, Jonathan introduced Frank to a well-spoken friend, who had come to help out. It was Piers Courage, of the Courage brewery dynasty.

Meanwhile, things weren't going too well at Cripps Bros. Although Frank was enjoying the technical side, the course also comprised studying basic English one day a week at the local tech, which, considering he had an A-level in the subject, got up Frank's nose. He decided not to bother, so Cripps fired him.

There followed a spell delivering crumpets around England and Wales and then a period as a trainee Campbell's soup salesman, which came with £10 a week and a Ford Anglia! But also, lots of bluff Yorkshire shopkeepers telling him where to stick his soup…

Frank was a racer at heart. His schooling had bred independence and an exposure to the well-heeled and their attitudes. Jonathan Williams and Piers Courage were sharing a London flat in Lower Sloane St with Sheridan Thynne, who would later work for Frank on sponsorship liaison. In October '63, aged 21, Frank moved in, renting their sofa.

He became Jonathan Williams' mechanic and from May to September they lived a gypsy existence around Europe following the Formula Junior (which ▶


XPB Images/Williams Racing

became F3) circuit. They lived in the pick-up used to transport the Lotus 22, stayed in a hotel one night a week to freshen up, and survived on start/prize money.

When they ran short of cash, Jonathan returned home to get hold of some more and Frank stayed in Europe. At the first ever race at Zolder he spannered for Picko Troberg, and sent the Swede out for first practice with one forward gear and four reverse. "I thought I could change ratios, but I couldn't…" Frank admitted.

But what he could do was speak languages. His education had seen him excel at French, German, Italian and Latin. He now put that to great use talking to continentals who wanted parts for their British-built race cars. Frank would happily sort them out and stick on a tenner as a handling charge. He was on his way as a wheeler-dealer racer.

The dealing soon took over, with Frank realising he wasn't going to make it as a driver, the highlight of his on-circuit exploits being a minor F3 international win at Knutsdorp, Sweden, in 1966. Asked what the biggest problem he faced as a driver was, he responded, "The corners!"

Williams set up Frank Williams (Racing Cars) Ltd and in the March 3, 1967 issue of *Autosport* could be found a full-page advert. Under a picture of Frank driving his Brabham, the text read: "Who is Frank Williams? He sells racing cars… and guarantees them. Telephone Harrow 0460/7854 (Middlesex).

What, exactly, was the guarantee?

"I guaranteed that they would get delivery and I wouldn't scarper with their money!" Frank smiled, many years later.

Based in Bath Rd, Slough, a Formula 2 Brabham was run for Piers Courage in 1968 before the combination moved up to the big time, F1, in '69. Using a Brabham BT26 with a Ford Cosworth DFV, Piers scored 16 points (9-6-4-3-2-1 to the top six in those days), with second places in Monaco and at Watkins Glen. It was the season that saw

Jackie Stewart win his first world championship.

Contrast that with, 50 years on, Frank's daughter Claire supporting the argument that being a 'constructor' was part of F1's DNA, during the vexed issue of Racing Point 'reverse-engineering' the championship-winning 2019 Mercedes W10.

Obviously, you could see the point. Why go to the expense of hiring hundreds (in some cases thousands) of staff if it's possible to copy another car to such an extent and still retain the financial benefits of being a constructor?

## A racer's DNA

But in the early days of F1 history, men like Frank and Ken Tyrrell existed by buying someone else's chassis, bolting in a Cosworth DFV and contending for the world championship. In fact, there's an argument that such a concept is arguably more in a racer's DNA than the unattainable cost requirements of Formula 1 when the money was driven exponentially skywards by major motor manufacturers.

Initially, the sport was populated by more niche manufacturers, like Ferrari and Alfa Romeo and, briefly in the fifties, by Mercedes. Indeed, by the end of the seventies, Enzo Ferrari viewed himself, Alfa and, by now Renault, as the *Grande Costruttori*, while Williams and their ilk were mere *Assemblatori*.

It was such a divide that led to the FISA/FOCA war of 1980, in which the major manufacturers, aligned with FISA, the sport's governing body, took on the British-based 'garagistes' – teams like Lotus, Brabham, McLaren, Tyrrell and Williams – over money, influence and governance.

Williams had become a true 'constructor' in 1971 when, disillusioned with running supplier cars, Frank undertook the build of a Politoys F1 car with £40,000 from the Italian model manufacturer.

Without any manufacturing capability at Bath Rd, Williams recruited Maurice Gomm, who had a sheet metal business in Old Woking and Len Bailey, a design engineer who had worked on the Ford GT40 project. The team moved into new premises in Bennett Rd, Reading.

Frank spent his every penny – and quite a few of soon-to-be-wife Ginny Sawyer-Hoare's – on racing as they set up home together in a Windsor cottage rented from Gordon Spice after Frank had been lodging with long-time friend Dave Brodie.

The marriage to Ginny, who was three months pregnant with Jonathan Piers Williams, took place three days after the '74 Austrian GP when Frank was 32. He, of course, had no money.

'The Brode' paid £8 for the ceremony, ▶

**LEFT** On-track and off, Frank Williams was a fighter. Despite his paralysis, he never wallowed in his troubles

**BELOW** Damon Hill drives Alan Jones' 1980 championship-winning Williams on the Jeddah Corniche Circuit in tribute to Frank Williams, a man he says he will be "forever indebted to"


XPB Images/Williams Racing

**LEFT** Carlos Reutemann driving the Patrick Head-designed FW07 which catapulted the struggling team to F1's summit – and kept it there

**RIGHT** Williams was not a man to harbour regrets. But one he did admit to, was the loss of Ayrton Senna (below) in 1994 at the wheel of a Williams racing car. The team had given the Brazilian his first F1 test drive (above) back in 1983 at Donington Park

## A wink, an award and a missed scoop

**Tony Dodgins** recalls an act of kindness from Frank Williams which set his career in motion

**IN** '79, as an 18-year-old, I entered the Sir William Lyons Award for aspiring young motoring journalists. I wrote to a number of F1 people and ended up being granted interviews by Frank Williams, Ken Tyrrell and Lotus boss Colin Chapman at the British GP, which I was attending as a fan. This was pre-dictaphones and I set off with my cumbersome radio/tape player and a few cassettes.

Lotus had dominated the previous year with Mario Andretti and its Type 79 and had signed Carlos Reutemann from Ferrari after Ronnie Peterson's death. They were having a bad time with their Lotus 80 and I remember Chapman gritting his teeth and trying to retain his sense of humour when I asked him why it didn't work? His face said, "Well, if I knew that…."

Ken Tyrrell was great, hugely encouraging, but it was Frank who provided me with the interview that won me the award and got me a foot in the journalism door. Maybe it was because he, like me, was born in South Shields, or simply that he was just a good fellow, but he'd responded personally and quickly to my request, arranging a time on Friday.

F1 paddock hospitality back then comprised either a small motorhome or, in the case of Williams, a small white caravan. I went in and was given a seat on a brown sofa for my interview with Frank. Moments after I arrived, so did Reutemann. Frank ushered him in, sat him down at the other end of the caravan and asked him to wait while he did my interview.

The season had been exciting, the Williams FW07 emerging as the class of the field. My first impression was of this live-wire guy with enthusiasm that you could almost reach out and touch. I'd approached these interviews with a mix of excitement and trepidation but Frank was tremendous, took my questions seriously and really made an effort.

My only concern at one stage was whether he'd said, 'You do ask pertinent questions,' or else, 'You do ask impertinent questions!' I couldn't quite hear because Carlos had coughed at the same time, no doubt getting a bit fed up waiting for the kid with the enormous tape recorder…

I was so focused on my questions and intoxicated by the moment that I didn't start thinking outside the box. What was Reutemann, the Lotus driver, doing calling in for coffee with Frank in the middle of July? I just figured that these F1 folk were a sociable old bunch! My first scoop had eluded me…

I remember Frank showing me out with his best wishes, a handshake and his infectious grin, as well as a wink. Which, on reflection, probably meant 'Keep your mouth shut about Carlos!' Twenty-four hours later, Frank had won his first GP and a short while afterwards, Reutemann was confirmed as a Williams driver for 1980! RT

Ginny bought her own ring for £30 and Frank excused himself from a pre-wedding lunch because he was tied up at work. He left Bennett Rd at 10 minutes to two, arrived at the church one minute before the ceremony, kissed the bride and was back at work by 2.30 pm. It was not until the following year that Frank first had a bank account, so that he had a cheque book to pay the £120/month rent on their house.

After eventually being evicted and following an interview with a country estate owner, they were selected as tenants of a beautiful but run-down old laundry house needing renovation outside Basingstoke. At around this time, non-payment of the telephone bill saw the Bennett Rd phone cut off… and Frank running his affairs from the local phone box outside Reading Speedway, the inspiration apparently, for Arthur Daley in an episode of *Minder*!

Sutton/Newspress

> *"Frank ran his affairs from the local phone box, the inspiration for Arthur Daley in an episode of Minder!"*

Frank credited racing enthusiast the late Ted Ward, who owned a machine tools business, as a tower of strength in those days, estimating that over a seven-year association he put up around £200,000 – about half as sponsorship and the other half as loan capital which he subsequently wrote off.

"He died in 1978 but I will never forget him," Frank said. "He gave us the chance to build a team that would win a world championship."

With his energy, charm and ready smile – which had swept Ginny Williams off her feet on first acquaintance – Frank made many friends, and no enemies. People wanted to help him.

## Seen as no threat

As an example, the major racing cost was engines. And, mid-seventies, Williams was blowing them up without knowing why. Finally, they discovered it was due to a kinked oil line restricting flow. So Ken Tyrrell allowed them down to his Ockham factory to study his system and copy it. It probably helped that, at that stage, nobody regarded Frank as a threat. He was universally known as 'Wan*** Williams'.

The US GP of 1975 with the rather ordinary Williams FW04 was an example of the sort of thing that would happen to him. In a race of attrition in Germany, Jacques Laffite had finished second, ensuring Frank's lucrative FOCA benefits for '76. But they still very much needed the money for starting the season's most lucrative race at Watkins Glen.

Williams Racing/LAT

In the other car, Lella Lombardi, the only female to score F1 championship points (albeit two laps behind in the tragic Spanish GP that year) broke a valve spring in practice, didn't notice, and carried on until the DFV dropped a valve and lunched itself at a cost of £9,000.

Then, just before the race, Laffite's wife Bernadette mixed up his Optrex eye drops with a bottle of visor cleaning fluid and almost blinded him. Laffite was rushed to hospital, missed the race, and was so slim that Lella couldn't fit into his car… ▶

It was during this period of constant financial struggle that Frank met Canadian oil millionaire Walter Wolf, who offered to pay off the team's £140,000 liabilities for a 60% interest. Frank turned it over and over in his mind before finally accepting.

"Why?" he reflected later. "Because it seemed an awful lot of money to have available at the time. I had never had more than £20,000 in my hand at any one time during seven seasons in F1."

Wolf had also bought Lord Hesketh's liquidated stock when the team closed its doors, taking the old 308Cs and Harvey Postlethwaite as chief engineer as part of the deal, just weeks after Frank had offered Patrick Head that position.

> *"He sent the car out with one forward gear and four reverse. 'I thought I could change ratios, but I couldn't…' Frank admitted"*

The cars were a disaster, with driver Jacky Ickx barely able to qualify at most races. For the following season, the disgruntled Wolf brought in Peter Warr to run the team and although he doubled Frank's salary, he would work from home, chasing sponsorship on commission.

Rubbing salt in his wounds, Postlethwaite designed a simple, effective car, the Wolf WR1, which Jody Scheckter took to victory first time out in the season-opening Argentine GP, with Frank not there to see it.

## Final straw

He was now effectively a high-powered flunky, sent somewhere first class to pick up Wolf's Mercedes, drive it to Geneva, pick up his Lamborghini, drive that to Paris, then fly first class somewhere else. Depression set in, a new experience for such a live-wire, disciplined worker who did his thinking as he pounded the running trails six-minute miling.

The final straw came when Wolf's wife phoned and asked Frank to advertise for and select a married couple to live in one of their many houses. It was time to move on…

And so began Williams Grand Prix Engineering, with Patrick Head joining him. Roger Penske was shutting his F1 operation at the end of '76 but wanted £20,000 per car, less engine/gearbox. That was too much but, with his severance money from Wolf, and cash from Ted Ward and Personal steering wheels, Frank bought March 761/7 for £14,000 plus two low mileage Cosworths from Italian Tyrrell private entrant Alessandro Pesenti-Rossi and a third from Bernie Ecclestone. He was approached by Peter Mackintosh who was promoting Belgian Patrick Neve, with support from the Belgian Belle-Vue brewery. Williams GPE moved into Unit 10, Station Rd Industrial Estate, Didcot on March 28, 1977.

It's worth remembering that Williams had now been a constant trier for eight years in F1 without any success. Courage's brace of second places in that debut '69 season, a year before he was killed at Zandvoort, to Frank's great distress, were still his finest hours. But that was all about to change.

While it's true that Frank had a car fully liveried and delivered to a Saudi company while touting for middle-eastern backing, the first contact came because the Saudi Arabian state airline's British advertising agency was Gordon Procter & Co and Frank had a friend working there.

Photos: XPB Images/Williams Racing

**BELOW** Keke Rosberg (bottom with Frank and Patrick Head) won the Drivers' World Championship in 1982. He fended off the inexorable rise of the turbo cars with a single victory with the Cosworth-engined FW08 at Dijon

Tony Harris appreciated that Saudia was a fast-expanding airline wanting to promote its name in the west. He thought motor racing would be ideal and introduced Frank to Mohammed Al Fawzan of Saudia. Williams took him to Silverstone to see Neve in Formula 2. A few days later it was agreed that WGPE would run Fly Saudia on Neve's rear wing for £30,000 sponsorship.

When the paint was stripped off for the new livery, it became apparent through the orange 'Beta Tools' identification beneath that Frank's March 761/7 had probably actually started its life as early as 1974! ▶

XPB Images/Williams Racing

Patrick Head's first Williams chassis for 1978, the neat FW06, put the team on the map even if Head had shied away from copying the Lotus '78 of 1977, which had been the car to beat in the hands of Mario Andretti. Head hadn't fully understood how ground-effect aerodynamics worked but, a year later, certainly had a handle on it.

## Blisteringly fast

Alan Jones had impressed both Frank and Patrick by winning the '77 Austrian GP for Shadow and, with an offer of £40,000, they got Jones's signature on a contract for 1978. He ran an amazing second at Long Beach before a front wing failure dropped him back, but he finished there in the US GP at Watkins Glen.

Patrick's ground-effect FW07 was super-quick on its debut at the '79 Spanish GP and Clay Regazzoni took it to second place in Monaco. When Head and Frank Dernie produced an underbody engine fairing to tidy up the rear aerodynamics, the car was blisteringly fast, stunning the opposition at Silverstone as Jones took pole. In the race though, the car broke, and it was left to Regga to give Frank his first F1 victory, those 21 years after he'd hitched to the '58 British GP. In their little white team caravan in the paddock, Frank and Ginny just sat taking in the moment as darkness fell and the paddock emptied around them.

The rest, as they say…

Frank had always believed that with the right funding, he was as capable as anyone of getting the job done. And now he was in a position to prove it.

Jones won the championship in 1980 but fell out with team-mate Carlos Reutemann in '81 when the Argentinian chose to ignore a 'Jones-Reut' board hung out at the Brazilian GP, and won the race. The title that year went to Brabham's Nelson Piquet after Reutemann failed to convert the series lead at the Las Vegas season

XPB Images/Williams Racing

> *"He didn't abandon his principles, even if it cost his team the best power unit in F1"*

finale after taking pole, when fifth would have been sufficient. Both drivers then retired, which opened the door for Keke Rosberg to take full advantage and win the '82 title against the rapidly-advancing turbo opposition with just a single victory at Dijon.

Williams entered F1's first turbo era with Honda in 1984. The FW09 was not the greatest chassis and the power delivery was a little on/off, but both team and engine supplier progressed rapidly. The team's first carbon car, FW10, allowed Rosberg to set F1's first 160 mph lap on the way to the '85 Silverstone pole, and new team-mate Nigel Mansell to win his first grand prix in the European GP at Brands Hatch.

By that stage, Rosberg had announced his departure to McLaren for '86, his final season in F1, and Williams had replaced him with twice world champion Nelson Piquet, who assumed he would be de facto number one driver.

In terms of access to the spare car, he was, but Mansell's pace and tenacity assured that on the track, he was the quicker driver. Before the season even started though, Frank Williams had suffered his catastrophic paralysing car accident as he drove too quickly on his return from a pre-season Paul Ricard test.

Mansell and Piquet took wins from each other and although one or other was expected to win the title in the Adelaide season-closer, Mansell's blown left-rear Goodyear robbed him with 18 laps to go. The team pitted Piquet on safety grounds and Alain Prost who, by good fortune had already changed tyres after an early race contact, stole the title.

## Purple patch

The watching Soichiro Honda was unimpressed and believed that Williams was lacking in management savvy by being unable to control its drivers. Frank though, was not about to abandon his principles of fair play even if, ultimately, it may have cost his team the best power unit in F1.

After Honda followed Ayrton Senna to McLaren in '88, Mansell was left to compete with a normally-aspirated Judd engine in '88 before moving to Ferrari for a couple of seasons. In 1991 though, he was back, just as Williams, with Rothmans support and ground-breaking active ride development, was about to hit a purple patch.

F1 in the nineties was dominated by Williams and McLaren, with intervention from Benetton and, latterly, Ferrari. It was Frank and Ron; Ron and Frank, both with lucrative tobacco backing. Mansell finally won the title in '92 with the dominant FW14B, with Alain Prost following up the year after.

After the dark days surrounding the death of Ayrton Senna in 1994, the team bounced back with Damon Hill, who won the championship in '96, followed by team-mate Jacques Villeneuve the following season.

Arguably, the back end of the nineties was the last time that a specialist racing constructor, rather than one with major motor manufacturer backing, could really hope to win world titles.

Williams Racing

**ABOVE** Glory days: The team was at its zenith when Nigel Mansell romped to the '92 title in the active ride FW14B, one of the most technically advanced cars in F1 history

**ABOVE LEFT** The last of the team's 16 Drivers' and Constructors' titles were won in 1997, despite Michael Schumacher's doomed bid to drive Jacques Villeneuve's Renault-powered FW19 off the track at Jerez

**LEFT** Alan Jones won the team's first Drivers' and Constructors' titles in 1980 with the FW07B. The tough-talking Aussie was the kind of racer Williams loved

## Changing landscape

Since the new millennium, Formula 1 has seen lengthy domination by, in-turn, Ferrari, Renault, Red Bull and Mercedes, with a specific set of the most unusual circumstances permitting the fairy story that was Brawn GP in 2009. With top team budgets approaching half a billion dollars, it is hardly surprising.

People suggest that Red Bull is an anomaly and proves it's still possible. But then, when Forbes has owner Dietrich Mateschitz's net worth at $26.9 bn, making him the world's 40th wealthiest person, how much of an anomaly is it?

The sale of Williams, midway through the 2020 season, was as sad as it was inevitable. The supreme irony was that it came just as F1 was imposing budget caps and seemed intent on levelling the playing field as much as possible between the haves and the have-nots.

One can only imagine the thoughts of Sir Frank as the ink dried on the contracts. It was almost 45 years since he sold out the first time to Walter Wolf for £140,000 – and regretted it. Second time around, the sum was rather more, almost a thousand times more, at £136.5m. It cleared debt, secured the futures of Frank's family and, importantly too, the futures of the Williams employees after seasons bringing up the F1 rear.

The sale, to an investment company, Dorilton Capital, underlined the transformation of the Formula 1 landscape. F1 will not see the like of Frank Williams again but, as Domenicali observed, "His incredible achievements and personality will be etched on our sport forever." RT

# KNOWLEDGE IS POWER


Pressure measurement specialist Druck has partnered with Elite Sensors for its latest innovation, the new P4400T combined temperature and pressure sensor. **Chris Pickering** investigates

**PICTURE** the scene. Two protagonists squaring up at the title-deciding finale of a world championship. The lights go out, the revs flare and then one of the cars splutters to a halt. The whole year's racing is ultimately decided by a single component failure somewhere deep within the engine bay.

This nightmare scenario is virtually unthinkable in the upper echelons of modern motorsport thanks to years of cumulative testing, rigorous quality control procedures and carefully designed redundancy in the systems themselves. But it highlights just how crucial every part of the car is in delivering a result.

"If you take Formula 1 as an example, there's an assumption that the teams are always clamouring for something new, but the reality is that they want something that's not going to break," comments Bob McDonald, chief technology officer at Elite Sensors.

Prior to joining the firm, which he co-founded in 2019, McDonald had spent more than 30 years at a leading motorsport technology company. He remembers a time when Formula 1 teams would turn up with five engines per car for a race weekend, knowing that they'd probably blow up at least one of them.

## Changing times

"In those days, the teams would design new parts during the week and ship them out to be used on the racecar at the weekend. Now, when a new product comes through from a supplier, it'll probably go through 5,000 km of dyno testing before it even reaches the track," he explains.

In this environment, it pays to have someone who understands the needs of the customers inside out. That's why pressure measurement specialist Druck has partnered with Elite for its new P4400T series combined temperature and pressure sensor.

"Druck has been around since 1972 and we've been supplying motorsport through engine manufacturers and third-party suppliers for around 20 years now, but it's largely been in the background," explains Mike Thomas, senior product manager for industrial pressure sensors at Druck. "We recognise that motorsport has a very specialised set of requirements – not just around the product, but also around the way that suppliers need to react to changes and provide support. That's why it's really important for us to have a technical partner who understands that side of the industry."

Druck designs, tests and manufactures its sensors in-house at its facility in Leicestershire. This includes a class-100 clean room where the raw silicon is processed into the sensor. Each pressure module is temperature cycled to enhance its long-term measurement

stability and all metalwork is welded to form a rugged housing. Upon completion of the electrical connections, the units are again thermally cycled to eliminate any possible defects in application.

The 4400T series is a development of Druck's existing 4400 series pressure sensor. As you'd expect, the key benefit comes from combining temperature and pressure within the same sensor.

## Best results

"By combining the two measurements you're reducing the amount of wiring that's required and simplifying the harness," explains Thomas. "The other advantage is that these are measurements that very often go together, so you get the best results if you take them at precisely the same point."

The key selling points of the 4400 are its compact dimensions and its robustness; it's 12.5 mm in diameter and operates reliably at up to 175 deg C. Druck's aim was to carry these qualities through to the new combined sensor.

Druck produced a series of design concepts around 12 months ago and the P4400T has relentlessly evolved since then, with input from Elite helping to shape the requirements. The module has now passed its final stages of development testing with highly-accelerated life testing (HALT). "Our test rig subjects the sensors to vibration at very high g levels, while also exposing them to very high, fluctuating, temperatures," notes Thomas.

The end result is a sensor that operates over the same -20 to +175 deg C temperature range and offers the same accuracy of ±0.25% FS BSL as the 4400. It weighs less than 25 grams (minus the cable) and is packaged in a module with the same 12.5 mm diameter.

Some sensors have to operate remotely via a sample tube to keep them at a safe operating temperature, but the 4400T is said to be capable of being mounted directly onto parts such as the crankcase, fuel rail or gearbox.

"Making a sensor that will survive in these harsh environments is quite a feat of engineering," comments McDonald. "What really sets these apart is their breadth of ability – not just withstanding the temperatures, but also the vibration levels, and doing so with high accuracy in a light, compact package."

Not only do the sensors have to pass Druck and Elite's own test programmes, but they also have to convince the teams' own quality assurance departments. It's not unusual for manufacturers in Formula 1 to CT scan sealed components so they can fully understand what's inside and any possible failure modes that might occur.

Even with these precautions, issues are not unknown, McDonald explains: "I remember the first time that Formula 1 visited Singapore. There's a metal bridge there that has its own magnetic field. Every time the cars went over the bridge, the Hall Effect sensors would see a blip. They were used on throttle position sensors, brake master cylinders and all sorts of things. The engineers were scrambling around trying to find a solution."

These days it's common to fit more than one sensor in highly critical applications, and the ECUs are also set up to infer some data from other sources if they detect an error. In NASCAR, for instance, the airbox pressure sensor is used to calculate throttle position if the module attached to the pedal linkage fails.

**ABOVE** The 4400T enables the measurement of temperature and pressure to be taken in the same location, resulting in more consistent data

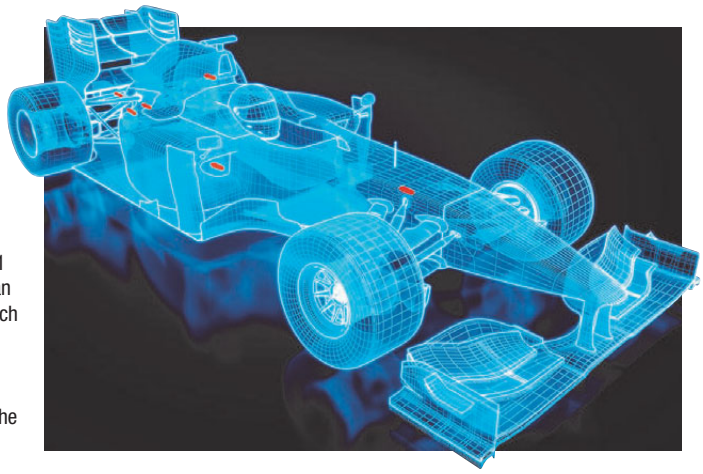
> *"Making a sensor that will survive in these harsh environments is quite a feat of engineering"*

## Focus on reliability

The pace of development can be very rapid on some areas of the car, particularly where Formula 1 and NASCAR are concerned, but when it comes to parts such as sensors, the focus remains on reliability.

"We've been looking at some more exotic concepts like thin-film sensors that we could put between wing surfaces, but even if we decided to go ahead with those, we'd probably be two years away from actually getting it on the car," notes McDonald. "For sensors, the focus is very much on evolution of existing concepts. As a general rule, it's all about refining something into a smaller, lighter package that works across a broader range of temperatures." ▶

> *"When a new product comes through from a supplier, it'll probably go through 5,000 km of dyno testing before it even reaches the track"*



**BELOW & RIGHT** F1 cars carry more than 200 sensors. Yet such is the progress that retirements due to sensor failures are virtually a thing of the past at this level

The Formula 1 cost cap has accelerated this trend, he points out: "If you've got a finite budget and there's a choice between developing a new front wing or delving into a technology demonstrator project that might be useful two years down the line, it's no surprise which one the teams would pick. The 2021 season was the teams' first real taste of that, and this balance between cost-control and innovation is going to get even harder."

As well as tightening costs caps, the upcoming changes to the technical regulations have also complicated things.

Ultimately, it's unlikely that the number of sensors on the car – around 200 in the case of a modern F1 machine – will be reduced. Similarly, reliability will remain every bit as crucial, which means the teams won't be willing to push the existing components beyond their intended service lives. Instead, the emphasis will be on suppliers to produce parts that are designed to last longer, predicts McDonald: "I think it'll come down to teams asking, 'Could we get a full season out of this part, rather than ▶

Pirelli

# Giorgio Piola

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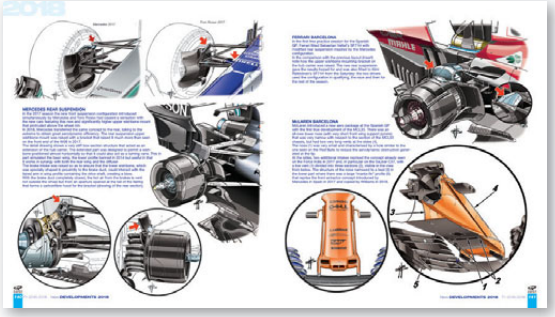

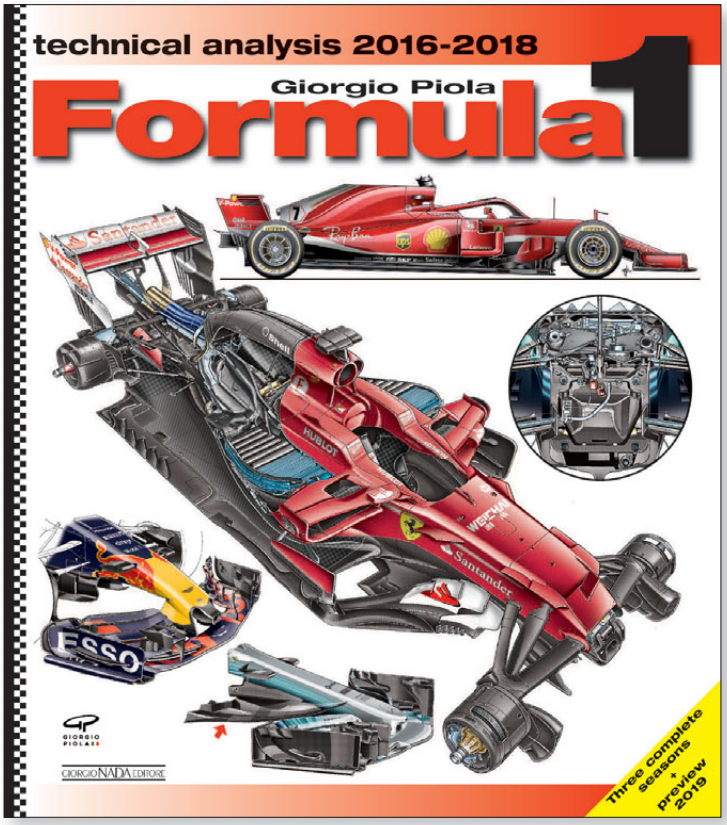


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**ABOVE** In Elite, Druck found a partner that understood both the requirements and reaction times demanded by F1 teams. Its existing product range includes this small, lightweight radiometric thermal camera (top), and CAN interface unit (above) which allows the connection of 16 Analogue or Pt1000 temperature sensor inputs

> *"We've been looking at some exotic concepts like thin-film sensors that we could put between wing surfaces"*

just six months, if we changed to a different design?'"

Longevity goes hand in hand with controlling the cost of the sensors themselves, but there's a limit to how far this can be squeezed, as Thomas explains: "We try to make everything as cost effective as it can be for its level of quality and performance, but there is a lot of work involved in manufacturing and testing these parts. We have inspection points to ensure that the parts are consistently reliable, between each unit and between each batch."

## Track and trace

Elite Sensors has a similar internal quality process, McDonald explains: "We can batch trace any of our products from a serial number, right back to the materials that went into it, who manufactured it, when it was manufactured, we can then view the test results. Most of our products are potted, then we do a thermal cycle of every sensor before we do a final test to ensure that there's nothing untoward going on inside."

It's this rigorous approach to manufacturing and testing, allied to an endless cycle of incremental development, that has seen motorsport sensors evolve into the highly-capable devices that we have today. That's why retirements due to sensor failures are virtually a thing of the past in series like Formula 1. As for the drivers, however, their chances of reaching the chequered flag remain largely up to them. RT


**LEFT** The breadth of its ability sets the 4400T apart from existing products

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Mercedes-AMG F1

# A SEASON TO REMEMBER

Yes, some dreadful decisions decided the destiny of last season's F1 crown. But, says **Sergio Rinland**, some of those bad calls were made by Mercedes

**2021** will go down in history as one of the most exciting seasons in Grand Prix history. That dramatic finale ended seven years of dominance which had threatened the survival of the sport we love.

Finally, Lewis Hamilton and Mercedes found a worthy opponent in Red Bull, Honda and hot-shoe Max Verstappen.

To suggest that the championship shootout was controversial is a gross understatement. We have not witnessed such drama for many decades. For it all to come down to the last lap of the final race of the season exceeded even the 1974 championship battle between Emerson Fittipaldi and Clay Regazzoni.

Was Mercedes' reaction to the way they were beaten justified? Not much, in my opinion. Those nail-biting last five laps were the culmination of a number of mistakes. Some of them were of Mercedes' own making.

First and foremost, the way the racing director handled the situation was, in my book, unacceptable. (And certainly not of the standard I was fortunate enough to enjoy when racing during the 'Charlie and Herbie show' with Charlie Whiting and Herbie Blash.)

**ABOVE** Lewis Hamilton leads. Then chaos…

If you are in a position of such high pressure and responsibility, the luxury of doubt is not available, and Michael Masi doubted his initial stance. Crucially, he changed his mind in the middle of the drama.

What was his mistake? Faced with the pressure of *not* finishing the race under the Safety Car regime, he tried to hurry a process which would normally take three laps, condensing them into just one.

In usual circumstances, the SC would come out to slow down the cars, and would maintain that position until the track was clear. Then it would allow the back-markers behind it to overtake and regain the lead lap until the leader was behind the SC. It would then allow one or two more laps to enable the back-markers to join the queue. Then the race would restart.

The situation in Abu Dhabi was that, by sheer chance, the SC came out in front of the leader, Lewis Hamilton. So the situation was tricky.

Allowing all the back-markers to recover the lap and have a line of all the cars in position would have taken more than two laps. Then the race would have finished under the SC – not a nice situation after such a high-tension season.

So instead, the race director allowed the five back-markers between the title protagonists to overtake and restarted the race with one lap to go. I would not have liked to have been in Michael Masi's shoes that day: it was a case of damned if you do; damned if you don't.

The other mistake that day was by Mercedes. Juan Manuel Fangio once famously stated, "Races end when the chequered flag drops". Such a basic ▶

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concept was ignored by the Mercedes team.

Once Nicholas Latifi crashed, Red Bull reacted by bringing Max in for a set of soft tyres; Mercedes did not. The mistake was to consider the race finished five laps before the end, rightly thinking that given the remaining laps there was no way to re-start the race. Wrong!

They underestimated Michael Masi's erratic behaviour. Hence, Mercedes did not follow Red Bull and left Hamilton out on worn hard rubber which was no match for Verstappen in the confusion of the last lap. Lewis was a sitting duck.

So, were Mercedes and Hamilton right in being so upset? No more than any of us. The race director made a mistake, which allowed Verstappen to beat Hamilton in a race that the Mercedes driver had in the bag after a dominant weekend. Yes, they all had the right to be upset and critical of Michael Masi, but leave it there. The circumstances and their own judgement call played against them. End of story. Come back next year and start the fight again. Learn the lesson and follow Fangio's statement.

If that had been me, yes of course I would have been incredibly hacked off. But if I had made the mistake of wrongly second-guessing the race director's decision, I would be doubly hacked off. Would I have protested? Probably not officially, but I would certainly have criticised the race director's behaviour.

At the end of the day, you can plan until you are blue in the face, but if an imponderable happens such as an accident, your reaction should be faster than your thinking! Mercedes made the wrong decision. Leading the race on old tyres, the instinctive reaction should have been to pit and think later.

Mercedes-AMG F1

**ABOVE** A rare moment in what was to be an acrimonious weekend

**BELOW** Formula 1's World Champion enjoys the moment

Red Bull

Just imagine for a minute you are a driver: you decide that in turn 3 you will brake in a certain spot; but, as you approach the braking zone, you doubt it for a fraction of a millisecond. What would happen? You slow down, someone overtakes you or you crash.

The word DOUBT should have no place in these people's dictionary.

The same goes for the decision-makers, be they the race director, team principal or race engineer.

## Worthy champion

Verstappen is a worthy champion. He fought a driver of the calibre of Lewis Hamilton and yes, he made some controversial manoeuvres during the season. Given his 'young gun' exuberance, these were probably not dissimilar to those of the young Hamilton when he won his first championship.

Hamilton is the veteran here, a talent in the top five or six of all-time, with the serenity behind a steering wheel which a driver has after so many years of winning races and championships.

Before you complain, that means up there with Nuvolari, Fangio, Clark and Senna: quite good company, I believe!

Who do I believe is a better driver? I still think that Hamilton is the best driver of his generation by far; Verstappen may achieve a similar level in the future, but for now, he is not at that level, hence his mistakes. Is he a worthy champion? Absolutely, he deserves the championship.

As I say, you simply can't plan for every eventuality. Formula 1 has these coincidences in its history: only two weeks after we lost the master of all fighters, Sir Frank Williams, it had to be a driver of his former team, bearing his name, who was the trigger for such a dramatic end to the season… RT

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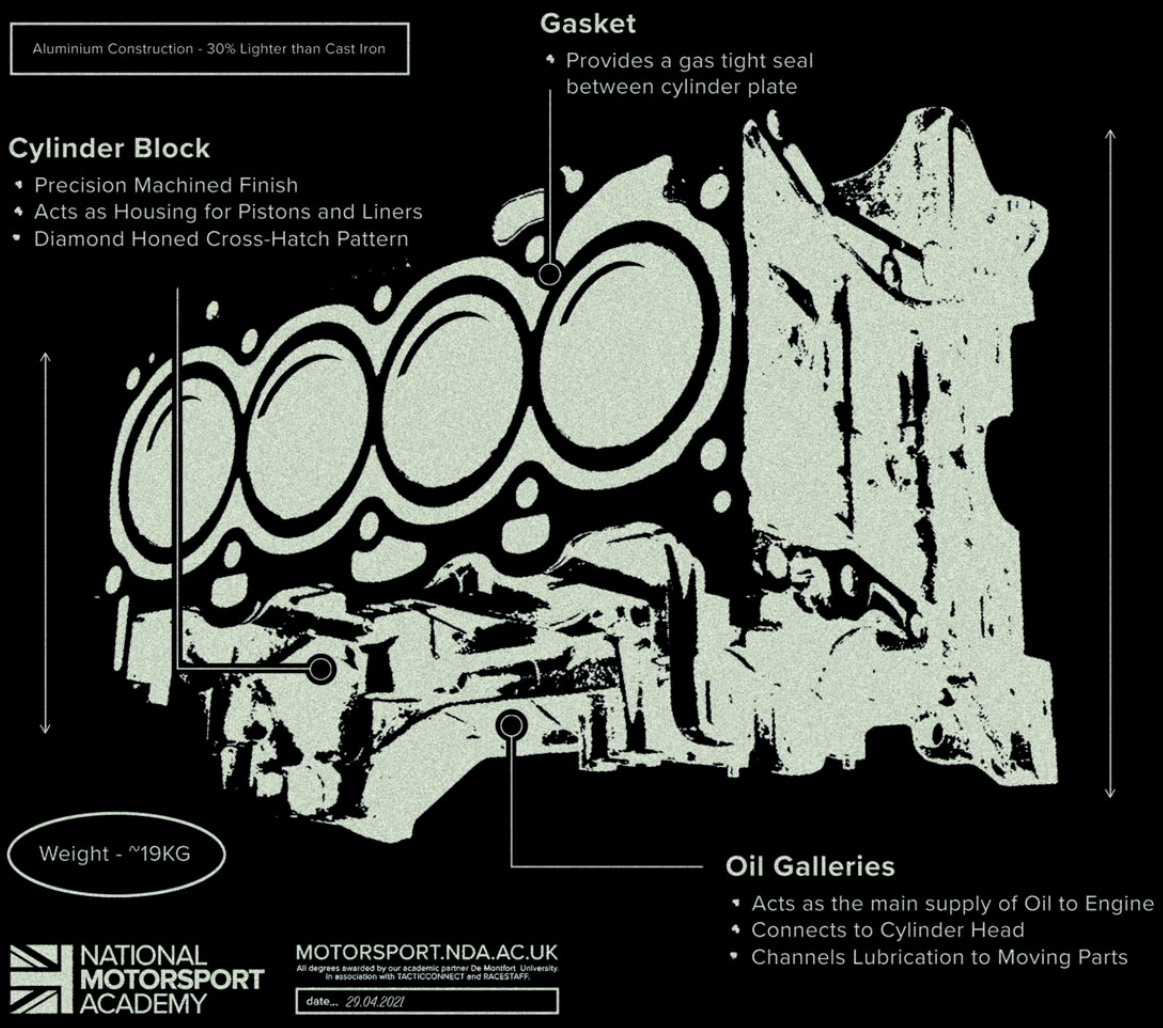


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