

Formula 1

Future Technology Series Season 3:

Technology & Formula 1™





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Foreword on the Future Series Season 3: Technology & Formula One™



Peter Brabeck-Letmathe
Chairman Emeritus of Nestlé Group and former chairman of Formula One, Member of the London Technology Club Advisory Board

Although **Formula One** is primarily in the sport and entertainment business, it also plays a key role in the development of new technologies and their application to mainstream life. It's a flywheel: great racing leads to large audiences, large audiences mean brands are keen to pay to be a part of it, brands mean sponsorship revenues, sponsorship revenues lead to healthy teams and faster cars, which leads to better technology and racing... and so on.

In my previous role as Chairman of F1, I knew the flywheel above was the key. That is the role of F1's owners: to facilitate great racing, unlock fan access and experiences, nurture the health of the teams and ensure that F1 is applying its innovations to stay relevant to the real world. I would say, though, in past F1 days, the sport was more fragmented and perhaps more short-term in its thinking. Currently, while the teams will always fight in the spirit of competition and the jockeying for position, there is a sense that F1 feels more collective and aware of its various interdependencies for its overall health. Perhaps the more macro headwinds of electrification and climate change are presenting challenges that focus everyone on the sport as a single entity, rather than as pure competitors when the lights go out on race day.

Watching recently from the sidelines, I see how F1 owner **Liberty Media** has positively shepherded the

sport. Through dynamic, collaborative and transparent leadership, F1 has undergone a number of cultural changes. The sport's owners have been quick to recognise the need for the sport to be a spectacle, at the cutting edge of technology, exhilarating and relevant. There are now, in a world that knows it has urgent issues in climate change, two more priorities for the sport: sustainability and responsibility. It is clear to see that the environmental impact of the sport is a consideration for every decision made and every initiative undertaken. The target of Net Zero Carbon by 2030 is ambitious but must now be met by F1 if it is to remain a credible pioneer and platform for global companies.

F1 has always been both a magnet and an incentive for cutting-edge technologies to play a part in racing. Teams are relentless in their pursuit of performance gains and therefore always look for the bleeding edge to beat competitors. It really is the fastest R&D lab in the world, and one does look to F1 to see the future in technology. Thanks to this report, we all get a glimpse together.

Thank you, London Technology Club, for publishing this report and continuing to provide us with thought-provoking insights around technology. It's amazing to think that the club has now published 14 reports since 2019, all providing the ideal stimulus for the community to convene and consider opportunities. I look forward to the next season in both F1 terms and London Technology Club's reports and events!



Introduction: Technology and the Pinnacle of Motorsport

"If you no longer go for a gap which exists, you are no longer a racing driver."—Ayrton Senna

Formula One (F1) is the pinnacle of motorsport and one of the truly global sporting platforms. F1 has a cumulative yearly TV viewing audience of over 2 billion people and an average race attendance nearly every two weeks of over 200,000 live spectators. Some race weekends attract over 450,000 racegoers. There are two driving forces in Formula One: commercial and engineering.

Welcome to the London Technology Club

The London Technology Club is an exclusive community of family offices, private and institutional investors, venture capital firms, technology experts and pioneers. The club combines hard to access co-investment opportunities, education, and relationship-building opportunities in the tech sector under one live and digital umbrella, providing access to competitive VC funds with attractive returns.

We organise events with leading technology visionaries, entrepreneurs and investors. A number of prominent international investors are members of our Advisory Board, such as Martin Gilbert, co-founder of **Aberdeen Asset Management** and chairman of **Revolut**; June Felix, CEO of **IG Group**; Jim Mellon, chairman of **Burnbrae Group**, Peter Brabeck-Letmathe, chairman Emeritus of **Nestlé Group** and former chairman of **Formula One** and Noor Sweid, General Partner of **Global Ventures**.

Engineering is about the relentless pursuit of performance gains. There are, on average, over 1,000 staff behind the scenes per team, all hyper-focused on every aspect of racing to ensure that the drivers receive the best possible race machinery each race weekend. F1 is hypercompetitive, which is a useful tool for technological progress and innovation. Teams push the boundaries of performance to achieve even milliseconds in race performance gains. It's a goal that can often be applied as much to mainstream life as to racing.

Regarding commercial forces (mainly in the form of sponsorships), Formula One has received over \$30 billion from sponsors over the past 15 years. For the 10 teams currently in the sport, that means a stable of over 250 different sponsors looking to assist them to reach optimal performance and carve out their unique story. For tech innovators, F1 is almost a place where you can't afford to not be in some way, shape or form.

As you will see from this report, Formula One and the teams involved have always done well to position

themselves to provide a marketing platform that brands want. They also try to stay ahead of the curve, allowing companies to tell narratives that fit with the time. Looking to the future, Formula One's owner Liberty Media and the teams can see a world of increased accountability. Younger fans coming through will certainly hold them to account. Therefore, sustainability—both environmental and financial—is a huge topic for the sport. To date, 7 of the 10 teams have already pledged to meet Net Zero by 2030. In its efforts to stay relevant, the sport has always had to ensure that it provides the ultimate research and development (R&D) testing ground that can then be applied to mainstream life—especially to the automotive/transport industry. F1 innovations transferred to automotive OEMs and engineering can often impact hundreds of millions of people. For example, F1 has since 2009 has been at the forefront of developing hybrid engine and powertrain technology. Competition breeds innovation. F1 has always looked to apply its innovations to the real world for mainstream impact to be relevant for R&D budgets.

For increased financial stability and to close the gap between the teams, a recent cost cap and measures brought in from the forward-thinking owners and governing body have helped F1 teams focus on making the best decisions they can to develop the car most efficiently. F1 is now all about cost-effective high performance. There is no more throwing money at problems and trying multiple routes and ideas.

Engineers and finance departments must make the most out of a finite (albeit still quite healthy) resource.

As you will see throughout this report, the ability to embrace and harness cutting-edge technology for teams to steal performance gains ahead of their competitors is key in F1. Creative engineers like to find ways to interpret the rules to innovate and find greater levels of performance, adding extra spice to an already cutthroat industry. It used to be that the governing body would have to play catch-up. But technology is now available to those creating the regulations too. Fans continue to demand more technology for more immersion and deeper F1 experiences, especially since the behind-the-scenes human stories are as interesting to fans as the on-track action is. The technologies born in F1, applied in the real world (such as drop-in fuels) are the holy grail for the sport. Sponsors pay millions to be involved. And, more recently, such technologies offer potential for the planet. F1 is the epitome of testing technology solutions at pace.



Simon Pavitt
London Technology Club
Chief Operating Officer



Contents

Navigate the report by clicking on each title or subtitle

01 Introduction

- 1.1 A vision summary: A future day in the life of a Formula One team owner
- 1.2 The Formula One market

02 Optimising the Car and On-Track Performance

- 2.1 Future power units, weights and composites
- 2.2 From natural fibre seats to anti-spy steering wheels
- 2.3 Data transfers and driver performance

03

- 3.1 Driven by data
- 3.2 AWS to stay ahead of the teams
- 3.3 Blockchain for governance
- 3.4 Big tech and Formula One
- 3.5 Man and machine learning
- 3.6 Simulations and digital twins
- 3.7 LTC Spotlight on: *How High Performance computing Can Keep F1 At The Cutting Edge Of Technology & Within The Boundaries Of Fair Competition*, by Mark Fieldhouse & Dr Gareth Hobson

04

- 4.1 Driver's eye
- 4.2 Pioneering digital advertising on race cars and beyond
- 4.3 Race predictions for fans
- 4.4 F1 experiential
- 4.5 LTC Spotlight on: *From F1 to Mobile Digital Out Of Home*, by Mark Turner

05

- 5.1 F1 and the environment
- 5.2 The potential of sustainable fuels
- 5.3 F1 and hydrogen
- 5.4 Final word

01 Introduction

“Every two weeks 100 million viewers watching live on tv see how your product performance fares directly against the competition”

Summary: A vision for the future?

Written by Simon Pavitt, London Technology Club

This, in our humble opinion, is a typical day not too far away for an F1 team owner:

From a team owner’s perspective, F1 has become much more collaborative after the ‘Mr E’ (Bernie Ecclestone) days. I know, as the owner of one of the last remaining ‘privateer’ teams, my chance of success is relatively low—over 100 teams have built cars in the F1 World Championship since its inception in 1950 and failed. It’s a tough tough sport.

The sport’s master owners have learned a lot from the US sports models, such as franchise and draft pick systems, and have looked to assist the teams when it comes to long-term financial stability. They want the teams to not only survive but thrive. Without healthy teams that are aspirational to fans and relevant for sponsors, there is no healthy sport.

I have seen my investment into the team be slightly de-risked by recent regulations that any new team must pay a \$200 million fee to enter the sport. The fee is split evenly between existing teams through what is called the F1 dilution fund. This has effectively placed a minimum price tag on my team. Coupled with the sliding scale for aerodynamic testing based on a team’s success on track, the sport is trying to close the gap between teams to give everyone a chance and make racing competitive.

It makes me nostalgic to think of the old ‘garagiste’ days, with mechanics tinkering to try to find performance gains. Now, in modern F1, the most advanced engineering is by done on or by computers rather than by people holding tools. F1 is as much about the Monte Carlo Simulations AI runs in between races as it is the Monte Carlo track. These days, we look for computing, not just engine horsepower. Just as in other real-world businesses, technology

often makes the difference in a market defined by milliseconds in performance.

With sustainability at the top of the global motorsport agenda, I look to make sure that we as a team are squeezing the absolute maximum out of a limited resource. My focus is on where the biggest performance bang will come for your buck. The world is watching us, and we need to continue to implement sustainable, low-carbon practices to remain relevant to young fans and sponsors. I won’t lie, though—I am still driven to beat my competition first. But we all feel a bit more in it together now knowing we might be able to contribute to something bigger than just racing.

I love the fact that our F1 car is basically a perpetual working prototype. The design of the car is constantly evolving—in fact, 30,000 times over a season. Now, though, I think the car’s digital twin and all the data/generative iteration possibilities are more valuable than the car itself. One can’t rest on one’s laurels, especially when it comes to harnessing the latest technology. If you slow down development, you quickly go backwards in the racing pack.



What people forget is that, as a team, your performance is set against your direct competitors at a specific time and place 24 times a year, over every race weekend, and in front of 450,000 live spectators filled with anticipation. Nearly 100 million viewers watch live on TV see how your product fares against the competition. There is no hiding in terms of meeting deadlines—that is, the race weekend, the start of qualifying and the race itself. Your performance against others is on display in front of the world.

There aren't many companies or industries where you get direct feedback against how you compare to your competitors so regularly and transparently. In F1, you must get used to the fact that you are judged as a team by millions of fans around the world pretty much every two weeks. What a privilege!



Introduction To The Formula One Market

F1 is currently booming.

A combination of fresh, more commercially astute management, a behind-the-scenes documentary and a championship going down to the wire means that F1 is hot right now.

Liberty Media bought Formula One in 2017. Formula One Group is traded on the NASDAQ as FWONK, with ex-F1 team icons Stefano Domenicali as president and CEO and Ross Brawn as managing director of motor sport. Liberty Media is the commercial rights holder of F1. Liberty acquired F1 from the consortium of sellers, including Delta Topco (Bernie Ecclestone's company), led by CVC in 2017 for an equity price of \$4.4 billion.

F1 2021 revenues were \$2.14 billion from 22 races (averaging over \$97 million per race). It's no wonder the owners want to move to 24 races in 2023 to add a few more hundred million in revenues. EBITDA in 2019 was \$1.48 billion, of which 66.6% (approximately \$1 billion) was awarded to teams. Liberty Media retained the rest (\$480 million). Yet in 2019, after costs, loans and increased investment into the sport, F1 Group reported a loss of \$35 million. That was due to the new owners investing heavily in staff, infrastructure and new races in the future calendar. 2020 was a tough year overall for the sport, because live events were limited due to the COVID-19 pandemic. Operating income for 2020 produced a \$440 million loss. 2021 operating income, however, bounced back to \$40 million.

Essentially, Liberty Media, the owner of the sport, has four revenue streams. **The \$2 billion (percentage of overall revenue in brackets) is split across:**

- 1) TV broadcasting (35% = \$770 million)
- 2) Race hosting (35% = \$770 million)
- 3) Signage (digital, bridge and board) and partnerships (20% = \$440 million)
- 4) Hospitality and other (10% = \$220 million)

Since 2021, there has been a cap on how much teams can spend over a year. The cap was set at \$145 million in 2021, reduced to \$140 million in 2022 and will be \$135 million from 2023 onwards. Again, the sport has looked to show strong governance over this, given the sport is well known for teams' creative and extreme interpretations of the regulations. It is almost an unwritten rule or some sort of F1 omertà code that those that can work right up to the edge (but within the rules) deserve the performance gains from such innovation. Inevitably, this causes a lot of debate, often pretty heated ones, between teams and the governing body. It's all part of the excitement.

Liberty has learned from American sports to create a high barrier to enter as a team (i.e., an unofficial franchise). This is to control costs so that the teams are sustainable and to try to level the playing field in terms of performance so that all teams have a chance for success (in the hope that the results can be less predictable). It's the F1 equivalent of the US draft system in the NFL, where poorly performing teams get first dibs on upcoming future stars. Under the current F1 agreement, the lower a team finishes in the constructors' championship, the more wind tunnel time it will be allowed to use to develop the car the following year. The cost cap covers expenditure that relates to car performance: it excludes all marketing costs, race driver fees/salaries and the costs of the team's three highest-paid personnel. Time will tell if these measures lead to more unpredictable results and rewards for smart, efficient thinking compared to the old days, when the biggest chequebook equated to the fastest car.

The Liberty & Netflix effect

Netflix first covered the F1 season in 2018 and produced a behind-the-scenes documentary, Drive to Survive. The global exposure has led to a rise in popularity of the sport, particularly in the US. Netflix has confirmed a fifth and sixth series tracking the 2022 and 2023 seasons.

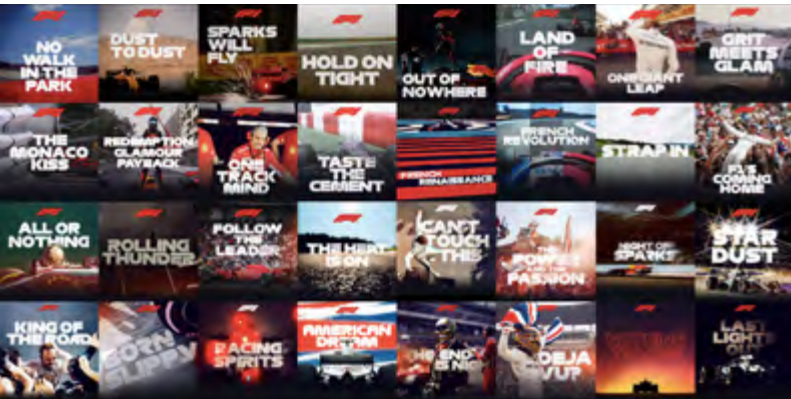
F1 viewership in the US grew by 56% between 2019 and 2020. The final race of the 2021 season saw the seventh-largest cable audience on record in the US. The average US TV viewership in 2021 was 949,000 per race, and that number increased to seven figures in 2022. The inaugural Miami GP on ABC generated an average viewership of 2.6 million, the largest audience yet in the US for a live F1 race. It is probably not a surprise that ABC/ESPN signed a new multi-year contract worth a reported \$100 million a year, compared to less than \$10 million a year in the previous deal.



Now four Netflix seasons in, F1 has capitalised on this newfound love in the US by introducing a second US race to the calendar, with Miami joining Austin. Las Vegas is due to become the third race in the 2023 calendar. Live attendance at the Austin grand prix grew from 264,000 in 2018 to over 440,000 in 2022.

The final race of the season in 2021 was dramatic, going down to the last corner in a rivalry between global superstars Lewis Hamilton and Max Verstappen. The last race drew 108.7 million live viewers, beating the usual US winner, the Super Bowl, which last reported 101 million viewers. The world has watched the drama unfold, and F1 has gone viral.

In 2022, live race attendance has smashed all records. The atmosphere at an F1 race in each host city is exhilarating.



Fans now want more content to supplement existing F1 documentaries, including films such as Senna and Rush. There is a movie coming out soon about Enzo Ferrari written and directed by Hollywood legend Michael Mann, and Brad Pitt has inked a deal to star in an Apple-backed film to be directed by Top Gun: Maverick director Joseph Kosinski, with involvement by Jerry Bruckheimer. Lewis Hamilton and his management company are also executive producers. According to Alfa Romeo's team principal, Frederic Vasseur, the Apple movie has the potential to transform the sport's popularity in the same way that Drive to Survive did:

“It could be a mega-step forward for F1 in general, that as Netflix did a couple of years ago,” he said.

The platform for sponsors

In any typical year over the last decade or so, Formula One has attracted an average of 50 to 60 new brands to the sport. In 2021, a year after COVID-19 broke out, it drew in around 125. Some teams have filled

the major partner slots and are now commanding a minimum of \$8 million per year to be a sponsor. Average deal sizes in F1 have increased significantly. Many technical partnerships have a positive impact for the entire marketplace outside of motorsports—nearly 40% of new companies entering the sport in 2022 have been US-based companies.

Performance amidst the commercial pressures

Liberty Media, the FIA and the teams exist within various, often opposing, forces:

- **Maintaining the spectacle for fans:** Close, exciting racing, wheel-to-wheel action, unpredictability of results, danger vs safety
- **Engineering integrity:** Remaining at the pinnacle of technology and innovation (particularly motorsport) but also ensuring no arms races on tech that's relevant only to F1, which could lead to financial instability for teams
- **Sustainability:** Environmental impact vs the global show, vehicle electrification now accelerating globally
- **Relevance:** Commercial sponsors pay large sums to be a part, the sport needs to remain continually relevant and provides a platform to showcase technology

F1 is a melting pot of hyper-competitive teams and drivers, sponsors, technology and innovation, not to mention political battles between the teams, owners and sports regulators. That's what makes it so compelling for all involved, including spectators around the world, whether they're watching from behind the scenes with Netflix or at the track, feeling the roar of the engines.

02 Optimising The Car On Track Performance

“Twenty years ago, it would take McLaren 4,000 hours to make each carbon fibre chassis on the McLaren F1. Now it takes just four hours for their 12C road car's MonoCell.”



F1 cars are the fastest open-wheel, single-seater racing cars, accelerating from 0–60mph in roughly 2.6 seconds, with a top speed of 372.5 km/h (231.4 mph). The cars produce over 5G of downforce so they can take corners at sensational speeds.

F1 is trying to keep financial regulations tight to reduce the overall cost for teams while still incentivising cutting-edge technological development in racing solutions. Constructors will remain limited to using three power units per car, per season. A turbo lag is expected to return, making the cars potentially harder for drivers to control—especially on corner exits—putting more emphasis on the ability of drivers to impact the overall performance, which is something that fans are always keen to see. The best drivers in the world are being tested and impacting results.

WORTH KNOWING: Although 372.5 km/h (231.4 mph) is the fastest speed set during a race, the fastest speed set by an F1 car is much higher. This record is held by Honda, which took their RA106 to the Bonneville Salt Flats in the US, a site famous for top-speed runs, to try and break 400 km/h. The attempt was unsuccessful but set a 397.36 km/h (246.9 mph) top speed, to claim the highest speed in an F1 car.

By keeping costs down via regulations, but with R&D at the core, F1 hopes to attract new power unit manufacturers. Such a move has already led Audi to confirm it's coming in 2026. Audi is acquiring a stake in the Sauber team (currently running under the Alfa Romeo brand) and has confirmed it will create the power unit at its base in Neuberg, Germany, with over 120 people working on the project. Another VW

Group company, Porsche, is considering entering in 2026. But talks are currently stalled with the Red Bull team over how much it could buy into the team. (Red Bull reportedly doesn't want to accept 50%.)

Formula One has already outlined and agreed the new regulations for 2026, with new advancement of new power unit technology, sustainable fuels and advancements towards Net Zero Carbon by 2030.

Future Power Units

High-power and high-revving 1.6-litre turbocharged V6 internal combustion engines will be the power unit of the cars. The 2026 power unit will include an increase in the deployment of electrical power of up to 50%. This continuity lets automotive manufacturers such as Mercedes-Benz and Renault know that the R&D in F1 can be applied to road cars. This is already bringing in rewards: this year, Mercedes HPP won the Dewar Trophy (awarded by the Royal Automobile Club) for bringing F1 technology to the road, as the Mercedes-AMG ONE hypercar is powered by an F1-derived, 1.6-litre turbocharged petrol engine with four electric motors and an 800-volt battery with a quoted power output of 1,048 horsepower. The technology is a direct implementation from the F1 powertrain.

More on the 2026 regulations surrounding 100% sustainable fuels will be revealed in Section Five of this report. However, from a performance point of view, the cars will use three times more electrical

power than the current F1 cars, signifying a shift closer to electric as part of the overall solution. This means over 1,000 horsepower, potentially more noise again, yet less fuel used overall. F1 is shifting from controlling the fuel flow through a maximum mass flow rate, to a maximum energy flow rate.

Weight & Composites

Weight is important in Formula 1. The heavier you are, the worse the tyre degradation and the more poorly the car interacts with the track, affecting performance. Car weight is largely affected by the composite parts of the car.

Currently, F1 cars weigh about 798 kg after eight teams voted to raise the minimum weight at the start of the 2022 season from 795 kg. F1 cars have been getting heavier recently and teams are struggling to keep down the weight. All teams in 2022 had to remove paint and expose the carbon fibre elements of their race cars—Williams, Aston Martin and McLaren in particular. Red Bull and Ferrari had already swapped from gloss paint to a more matte finish to remove some vital grams. Red Bull (and Mercedes) further altered the front wing to remove some designs. Alpine took a different route and introduced even more carbon fibre for the flooring of the car.



F1 has been a breeding ground for new composite technologies. The applied market is large—with automated industrial production of composite parts for vehicles set to double in size by 2040 to a total addressable market (TAM) of \$12 billion. Certain materials are banned currently, such as carbon nanotubes, with an expense limit on the F1 teams that puts a cap on certain types of innovation that aren't deemed to be cost-effective or potentially usable for more mainstream use. F1 teams still use over 40 different types of carbon fibre, a mixture of exotic fibres and resins.



F1 still looks to continue to drive innovation in the future of composites—with the likes of McLaren having a rich past as pioneers in composites. In 1981, McLaren revolutionised the construction of race cars with the creation of F1's first carbon-fibre monocoque. Since then, McLaren has led in the use of carbon fibre in F1 and in production road cars. Twenty years ago, it took 4,000 hours to make each carbon-fibre chassis for the McLaren F1. Now, it takes just four hours to produce the MonoCell at the heart of McLaren's 12C road car.

The future for composites is almost certainly bio-sustainable raw materials so that less petroleum-based materials are used in the car. It's possible that regulations could force F1 to innovate in certain directions.

Innovative companies on the cusp of impacting F1 materials include:

ICOMAT: is a leading British company focused on lightweight materials for the automotive sector. Many straight-fibre composites are made up of three layers and are heavy, expensive and limited. ICOMAT has produced the world's first machine capable of fibre steering. Its patented Rapid Tow Shearing (RTS) can provide two layers of curved-fibre composites. ICOMAT has produced the world's first defect-free, fibre-steered rocket structure (compared to attempts by **NASA**, **Concordia University**, the **Delft University of Technology**, etc), enabling a step change in rocket structure weight and efficiency. ICOMAT unlocks the performance of composites that enable the lightest aerostructures while simultaneously drastically reducing cost.



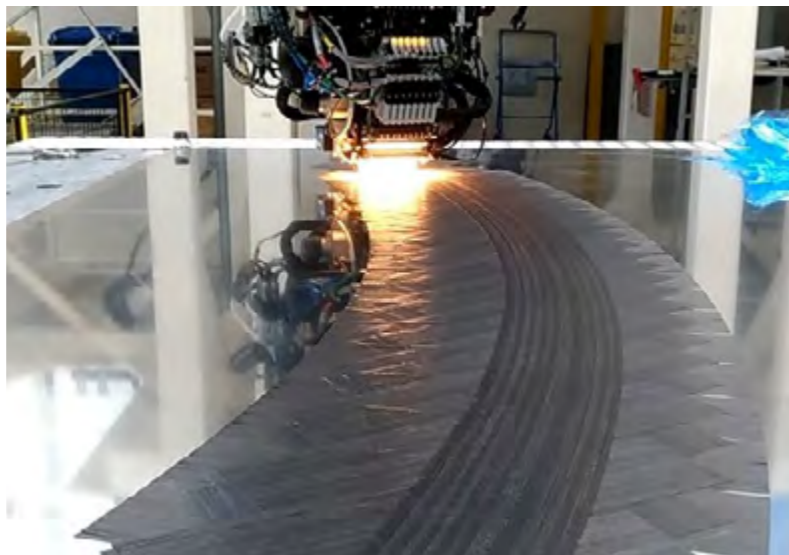
Today, parts are built by stacking straight-fibre layers at different angles to balance the properties in all directions, but structures are never loaded equally in all directions. The company has developed and patented Rapid Tow Shearing (RTS), a cutting-edge technology that enables the placement of carbon-fibre tapes on curved paths. Unlike other fibre-steering technologies, it is completely defect-free. It deploys state-of-the-art shear deformation processing to steer the path of the tapes, eliminating gaps, material buckling and wrinkling. The technology is

1 | AJE Powertrain

perfect for the complex shapes and load paths of automotive components, enabling engineers to create high-performing, lightweight components that meet stringent standards. Stronger than steel yet lighter than aluminium, carbon-fibre reinforced polymer (CFRP) is used to manufacture everything from Formula 1 racing car bodies to wind turbine blades, high-end sports equipment and aircraft wings. With rapid-tow shearing, a tape-laying head can actually curve each ply in a continuous, carefully controlled way. This means continuously shearing fibre tapes so that they can tessellate perfectly, with no gaps or overlaps.

Another company with interesting potential for F1 in the future is **AJE Powertrain**¹. A British startup, AJE Powertrain has developed the British Engineered Sintering Technology (BEST) to process titanium powder into automotive components. It uses material waste from the aerospace industry and a two-step process to manufacture lightweight titanium components. This lightweight material also finds applications in the construction and the medical sectors.

CeraCarbon: Dutch startup CeraCarbon manufactures an industrial-grade material that combines the wear-resistant properties of ceramics and lightweight carbon fibre. The resulting material is significantly stronger and more durable than carbon fibre. The startup produces lightweight front forks for high-performance racing.



From Natural Fibre Seats To Anti-Spy Steering Wheels

Working with specialist **Bcomp**, McLaren has also innovated an F1-first, natural-fibre racing seat that's sustainable and lightweight. Lifecycle analysis reveals the seat has 85% lower CO2 emissions than conventional seats. It represents the beginning of the future of natural-fibre composites. Teams will continue to explore where flax fibres could be used intelligently in the car to reduce weight and cost while maintaining and, in some cases, improving performance.



Red Bull introduced a steering wheel system that lets drivers avoid sharing sensitive information with their competitors. The system allows drivers to see data on their own screens, but statistics displayed by the steering wheel are completely unreadable to the in-vehicle camera. The system is designed to avoid revealing important data such as the vehicle's gear, battery charge and brake balance, among other metrics that can be used to analyse rivals.

2 | Data transfers to the outside world

Mercedes, meanwhile, give Lewis Hamilton credit for his part in helping it to shave 250 grams off its steering wheel design by slicing off the base of the handgrips where they meet the centre puck, removing an unnecessary part due to the way he holds the wheel while racing.



Data Transfers

F1 continues to accelerate the wireless data transfer capabilities as speed over the air creates speed on the track.

Being able to transmit data wirelessly while the car travels is key for teams to understand performance at the track. When within four metres of the garage, the car transmits data at breakneck download speeds. One gigabyte of data takes less than five seconds to be transmitted. Such technology developed by the likes of **Qualcomm** is being applied to smartphones, enabling a more reliable connection and much quicker download and upload speeds. The technology could also be used by connected cars to communicate with the outside world².



The future is teams fitting optical, infra-red tyre monitoring systems onto the car as standard to get a comprehensive picture of how different tyres are working and understand their respective single-lap and race performance. Getting the tyre data from the car as fast as possible is important, because the car will be stationary only in or in front of the garage for a few moments. In the past, the team would either have had to sacrifice track time to download this data or engineers would have had to wait until after the session to access the data.



Mercedes F1 team partner Qualcomm has developed the technology for the consumer market and used F1 as a high-speed R&D environment, putting its product to the ultimate test. In the future, similar technologies will come to your smartphone, allowing for much faster download and upload speeds and a more reliable connection. Or such technologies might be used in connected cars to enable them to communicate with the outside world.

Qualcomm packed more than 30 years of mobile invention into a purpose-built wireless data solution that helps Mercedes solve a data transfer problem in Formula 1. Qualcomm has one eye on the future: a time when cars will be able to connect to one another, the road and virtually everything else.

Driver Performance

Every driver must wear biometric gloves. Each glove has 3mm sensors sewn into the palm of the glove fabric. The driver's vital signs can be monitored and recorded. The optical sensors detect pulse oximeter (i.e., the amount of oxygen in the blood) as well as pulse rate. The information is sent to the roadside medical teams in real time. It enables them to know the status of the driver in rescue operations. The drivers place the gloves on a charging mat before the race. First debuted in 2018, the gloves are now commonplace among drivers. Further monitoring is planned in the future, such as respiratory rate and temperature. With the likes of **Rockley Photonics** creating silicon photonic sensors, this will only increase in terms of what can be monitored and relayed back for further real-time insights on the performance of the driver.



03 Optimising F1 Performance Off-Track

“The demand for computing horsepower as well as engine: pivotal moments in F1 are now driven by data.”



Driven By Data

Formula One teams today are very data-driven organisations. Each F1 race car has 300 onboard sensors generating more than 1.1 million data points per second, transmitted from the cars to the pit. The high-tech sensors that modern F1 cars contain make them the most connected cars in the world. The 500 gigabytes or so that are produced at the track from 18,000 streams of data, captured over the course of a race weekend, are also just the tip of the iceberg. Then there is the evolution of the car: a single season can see 30,000 design changes across teams.

A team’s factory produces about five to 10 terabytes of data every week. Over the course of the year, the amount of data reaches over 350 terabytes. The data requirements can be applied: whether a team is trying to determine and predict if a Formula One power unit is about to fail, or whether a road car needs to be serviced soon, the solutions are transferable.

F1 teams have leaned heavily into technology partners to find competitive advantages through data. Consider the current World Champions: Red Bull Racing. Whether it’s the AT&T network transmitting data from the circuit to the team’s operations centre in Milton Keynes in just 300 milliseconds, or the software solutions from Siemens enhancing the production of composite parts, Red Bull Racing relies on its partnerships. Its title sponsor is Oracle, providing OCI (Oracle Cloud Infrastructure) for the highest levels of performance, scalability and security.

The benefits of the cloud are numerous, but it gives Red Bull a lot more flexibility when approaching data analysis, not to mention the substantial cost savings compared to the more traditional method. “The more computing horsepower you can provide, the more accurate your results are going to be,” adds Ariel Kelman, executive vice president and chief marketing officer at Oracle. “This is one of the things with the cloud, where it costs the same amount of money to run 1,000 servers for one hour as it does to run one server for 1,000 hours.”

F1 is as much about managing risk as it is going on the attack. Therefore, its approach is similar to what a lot of the largest banks in the world do with cloud platforms: running large-scale Monte Carlo simulations for trading positions to figure out the risk. F1 teams run simulations on race strategy and predictions around performance. Red Bull runs Monte Carlo simulations predominantly before race weekends to discover the probability of different outcomes during a Grand Prix to inform the race strategy.



All teams are using cloud technology partners.

Mercedes

AMG Petronas—HPE (Hewlett Packard Enterprise)

“In F1, we use data on our relentless search for performance, across all functions of the team—both at the track and at the factory,” said Toto Wolff, team principal and CEO of Mercedes-AMG Petronas Motorsport.

“With the support of HPE, we can better process and analyse that data, enabling our team members to do what they do best—from the early stages of conceiving a competitive car to the final moment of the car setup on a race weekend.”

McLaren

Dell Technologies HPC & Splunk



“We use HPC to conduct complex computational fluid dynamics (CFD) studies on the airflows around the digital twin of a proposed part before deciding whether to test it with rapid prototyping with 3D printers ready for wind-tunnel testing,” said Edward Green, principal digital architect for McLaren Racing, in a blog post. “In other words, we have the ability to test a part under widely variable conditions before it actually exists, which saves valuable time and expense.”

Ferrari

AWS & Palantir



“Throughout our storied history, Ferrari has had racing and innovation at our core, and now we look forward to applying AWS machine learning, advanced analytics and high-performance computing across the company to deliver deeper insights and even more powerful cars,” said Mattia Binotto, principal of Scuderia Ferrari. “Data analysis plays a vital role in Formula 1 and being able to count on an excellent partner such as Palantir can make all the difference. Tasks that just a few years ago would take several minutes of calculation can now be carried out in a few seconds, thanks to solutions that have been in use through this partnership.”³

Alpine Renault

KX Insights (using Microsoft Azure Cloud)

“With billions of data points being captured at the track and at the factory, it is critical to have a cloud infrastructure that is agile and can enable tools such as KX Insights to deliver information in real time,”⁴ said Mike Downey, tech lead for sports, Microsoft.

³ Ferrari and Palantir partnership
⁴ Mike Downey quote

Aston Martin

Cognizant Technology Solutions



Cognizant is a tech behemoth in the fields of cloud, big data, AI and various other digital verticals. Its motto is “intuition engineered”. Intuition is the ability to draw conclusions instinctively without the need for conscious reasoning. Cognizant’s mission is to help the Aston Martin F1 team make lightning-fast, high-accuracy decisions.

“Decisions are made in the blink of an eye, so the ability to learn and adapt quickly is vital. Being able to monitor all cars on track to provide detailed information and guidance from the pit wall is what will set teams apart,”⁵ said Nico Hulkenberg, Aston Martin reserve driver.

AWS To Stay Ahead Of The Teams

Formula One works together with AWS in two main areas: data analytics and visualisation for F1 fans (the latter is covered in the next section of this report). The car design for the 2021 season was developed using a computational fluid dynamics (CFD) project to simulate the aerodynamics of cars while racing. The project ran for six months using Amazon Elastic

⁵ Nico Hulkenberg quote
⁶ AWS computational fluid dynamics project

Compute Cloud (Amazon EC2) C5n instances, which according to AWS are “are ideal for high compute applications... that can take advantage of improved network throughput and packet rate performance”⁶. In the end, the project delivered performance equivalent to that of a supercomputer for a small fraction of the cost. It enabled the sports owners to stay ahead of other teams and set rules that encouraged less drag and facilitated more wheel-to-wheel racing.

“This project with AWS was one of the most revolutionary in the history of Formula One aerodynamics,” said Pat Symonds, chief technical officer of Formula One. “Nobody designs a car to come in second, but for this CFD project we were looking at how cars perform in the wake of another, as opposed to running in clean air. We have been able to use AWS technologies to understand the incredible aerodynamic complexities associated with multi-car simulations.”

For Rob Smedley, director of data systems at Formula One, the project achieved a new level for computing firepower: “It’s mind-blowing the amount of power that we could call upon. At one point, we had something like 14 concurrent jobs, running on 7,000 cores, with 2.4 billion cells of Navier-Stokes equations, all calculating concurrently,” Smedley says. “That will give us a lot of insight as to how the teams develop. What is their rate of development? What areas are they developing? It will let us see how the 2022 car evolves once we give it to the teams. That insight will then allow us to help the FIA tweaking the regulations going forward.” The AWS partnership allows F1 to use artificial intelligence (AI) and machine learning (ML) to set the future rules and stay ahead of the teams.



Blockchain For Governance

Computing might not be just for setting regulations, either. It could also be a strong force in governing the existing rules, such as budget caps. The budget cap in F1 is being strongly policed by the FIA. In the past, the most successful teams were able to throw money at problems to secure performance. The top F1 outfits operate parallel teams on design ideas to find the best solution, compared to the bottom F1 teams, which have to choose which problems to focus on and how to squeeze the most out of a limited resource. Having a yearly budget means that teams need to think about capex much more strategically. With big outlays such as IT infrastructure eating into a budget, teams prefer opex over capex.



The future could be blockchain-based supply chains that—because of their transparent and irrefutable nature—would enable the FIA and sport to follow expenditure and parts usage. Another way to keep teams within constraints could involve providing each with HPC tokens or access to one supplier such as Silicon Valley’s Rescale. Rescale has 97 processors to choose from, assisting in the compression of time to get results through faster, more efficient analysis. High-performance computing provides more workload runs. Teams can now ensure they are working with the fastest, most bleeding-edge processors. The staff can be trained on the Rescale system rather than having to keep up to date on processing developments. Something that could take 12 hours to analyse might now take only 45 minutes, allowing more time to run more simulations or more time to put the insights found into action. Each team could be given certain

levels of simulations and analysis. Or, as with other areas such as wind tunnel time, lower-achieving teams could be given more HPC time.

Major Tech Harnessing F1

We include here a few other major tech players in F1 such as **Juniper Networks**. Aston Martin Racing uses Juniper’s technology trackside to enable its competitive and R&D communications for events globally. As part of the partnership, Juniper will supply an agile and highly automated network platform across the team’s new technology campus, due for completion in early 2023. The team hopes that the partnership will lead to an improved form of secure networking, with the California-based, multinational corporation expected to supply secure, cloud-based wired and wireless networking solutions that can withstand the sophisticated, data-intensive requirements of a Formula One team operating across multiple continents.

Lenovo is another notable tech multinational involved in F1. Lenovo technology is used across the Formula One organisation, both at its base and at races. Lenovo’s hardware devices, along with high-performance computing and server solutions, are integrated throughout the organisation’s operations. From running powerful on-premises data collection solutions to producing higher-quality content and supporting broadcast applications, the Formula One and Lenovo collaboration is due to provide a better experience for fans. Plans to use Lenovo’s next-generation technology, such as augmented and virtual reality, are in motion to provide more ways to fans to engage with the sport. We look forward to seeing how that will come to life.



Man & Machine Learning

AI coming in

The sport's governing body (and fans) are keen for human elements of the sport to remain. In the past, when drivers started asking for and receiving advice about certain elements of driving, the FIA stepped in to ban radio communications relating to the performance of the driver and car. Yet, given the millions of data points collected, AI has other potential applications for evaluating car and driver performance. In fact, there isn't a team in F1 that isn't bringing in AI and machine learning into their design offices and strategy departments.

One benefit is the ability for teams to insert random data to test arbitrary modifications in simulations. These quasi-strategies widen the net for finding potential novel solutions. Just as AI is identifying novel or counterintuitive strategies (consider, for example, Deepmind's AlphaGo becoming Go World Champion), F1 teams are exploring predictive capabilities with the potential to deliver surprises in race scenarios.

As AI matures, it will become the common go-to tool for race strategists' decision making. As the F1 teams' AI models become better trained, the FIA will soon need to look at how much analytics can be done this way instead of using human engineer intuition or race craft. The teams want bulletproof decisions, although some fans might prefer the occasional bad decision to mix up the grid and create disruptive moments in races.



AI at the teams

Alpine and Williams Racing has already begun to approach AI in its F1 technology. It is using ML and analytics to help make predictions and decisions during races. It has also begun to use AI help to build its cars. In the past, Honda has used IBM's Watson Internet of Things (IoT) capabilities for automotive insights to analyse the hybrid engines it supplied to Scuderia Alpha Tauri.

Red Bull is using AI to help understand and plan race strategy. Computers could also offer guidance on setup choices at a race weekend, and might even help lead car designers with development directions—especially given that decisions on how resources are deployed are increasingly driven by efficiency.

Christian Horner, principal of Red Bull Racing, says,

“ Making the best decision you can to develop your car cost efficiently—so cost-effective performance—is absolutely crucial for us as we move forward with the lack of testing. This year, we have had three days of testing, and no other sport would have such a small amount of practice. So the way that we analyse the data is crucial for us.”

Simulations With Digital Twins

The challenge for many teams ahead of each race weekend is recreating the conditions and prepping the drivers for the nuances of each track. Driver simulators have existed since the early 2000s, but—as with everything in F1—things evolve. Enter the new Ferrari simulator, which many believe is a generational leap. Bristol-based Dynisma installed the latest at Scuderia Ferrari's Maranello home. The simulator has helped with two key challenges: latency and widening the bandwidth to ensure that the feedback between the simulator, driver and engineer is as responsive as possible⁷.



Beyond driving and tracks, F1 components also now come in virtual forms in the computer simulator. The engineers know the size and specs and the physics of how each component behaves. The program computes how a new component interacts with every other component in the model. That data is fed to the simulator, where the driver then tests it. So the challenge that F1 teams now have is understanding any discrepancies between the computer models and reality. Each team builds a detailed computer model of the circuit and the performance of all the other cars in the race.

⁷ Ferrari's F1 simulator

Simulations can be run to model possible scenarios and predict outcomes. McLaren, for example, calls this a decision-support system: for every scenario, the computer helps the team to pick a strategy that will result in a positive outcome. During the race, teams continue to run simulations from their HQs.

All teams are looking to apply 5G, IoT and data analytics to build digital twins of their F1 cars. They also want to harness AI and machine learning, fuelled by real-time and past performance data.

The future for both sports owners and teams is generative design development with major rules set in a resource-efficient manner, in addition to making much greater use of AI-driven data analytics across the board.

According to Geoff McGrath, vice president of McLaren Applied, we have reached a point where “the data coming off the physical product is worth more than the product itself.” He calls it the “metaproduct”. The extreme environment of yesteryear was the track, and the extreme environment of the future is the virtual domain. The role of F1 technologists within teams is to correlate the two.



LTC Spotlight on: How high performance computing can keep F1 teams both at the cutting edge of technology and within the boundaries of fair competition, by Rescale's Mark Fieldhouse, General Manager EMEA & Dr Gareth Hobson, Senior Account Director EMEA

In Formula 1, High Performance Computing (HPC) has been used for many years for CFD (Computational Fluid Dynamics). This computational technique is all about the movement of fluids around solid objects and can be applied to aerodynamic development for vehicle performance enhancement. In terms of competitive advantage, aerodynamics remains possible the biggest performance differentiator in the sport and has been the case for years. That makes it a heightened point of focus for the FIA (the sport's governing body) and its regulations.

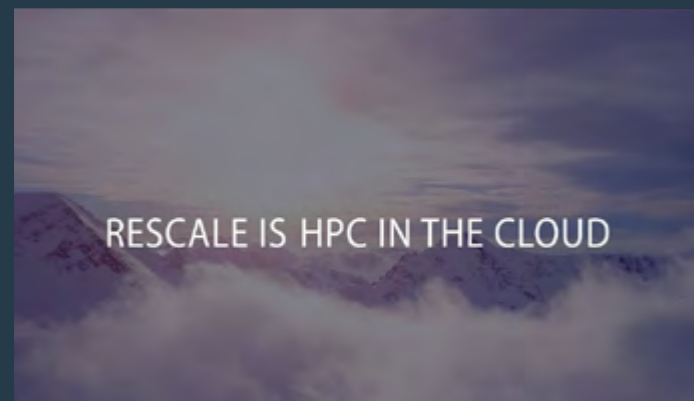
Wind tunnel testing is still the primary and most reliable mechanism to test the aerodynamics of the car because this is the best correlation with reality. Wind tunnel testing is hugely expensive. It is said that the most expensive car in the world is a Formula 1 car; the second most expensive car in the world is the wind tunnel model of a Formula 1 car... CFD is used extensively in conjunction with the wind tunnel whereby, year-on-year, the accuracy of CFD improves. However, for now wind tunnel testing remains the gold standard.



FIA regulations for many years have limited the amount of hydrodynamic development that teams could do with restrictions in place around wind tunnel access (such as wind tunnel hours and the number of runs). Its' attempts to limit the amount of CFD/ aerodynamic computations being carried out by teams have been difficult to impose with the kind of rigour desired. An equation was developed based on compute power known as TeraFLOPS (FLOPS are Floating Point Operations per Second). The key factors in the equation were:

- the number of compute cores
- the duration of each simulation
- FLOPS/cycle
- clock speed

However, it didn't work well because teams, in concert with chip designers, produced specialist chips and software that slowed down the chips so that the equation would permit a lot of simulations! In 2017, a new iteration of the equation used was introduced to control the amount of CFD development, but it has always proved a difficult thing to regulate effectively.



Today, the FIA has moved to limit the budgets of teams in order to level the playing field. Formula 1 teams are having to modify how they test; contained within that overall budget is what they spend on wind tunnel testing and CFD/hydrodynamics. It could prove very effective at managing the amount of CFD computation, provided that there are realistic costs associated with it.

A lot of F1 teams use on-premise computing or private cloud for their CFD needs. These are effectively the same thing - restriction to a fixed set of computational assets or cores. It's still very difficult to police these environments.

Rescale, as a provider of HPC in the Cloud, has the potential to provide the FIA and F1 teams a common environment for monitoring and regulation enforcement within this budget-limiting regime where costs are transparent and dictated by the market. These financial controls could be driven by a top down approach, with the Rescale platform providing tight management, distribution and reporting on those budgets.

Rescale is independent of both the providers of computational software and the cloud solution providers (CSPs). Rescale provides a Software-as-a-Service solution for HPC and ensures that everything in the software and hardware stack works and is secure.

Most importantly, from the point of view of FIA regulation, there are budgetary and financial controls built into the platform. All core-hours are logged and charged (each has a rate based on its performance, memory etc. which is set by the market - i.e. it's the same for everyone). So, a budget could be allocated by the FIA to each team and they could consume core-hours on a variety of infrastructure compute cores to suit their workloads and disclose their usage to the FIA consistently.

The benefit for an F1 team is that they have access to the software they need (provided they have licences) and most importantly access to a large range of compute cores from leading CSPs. Right now, the cloud service providers (CSPs) are investing heavily in this area - they are waging a small war between themselves to deliver infrastructure on their promises of scalability, availability and flexibility. This includes Graphical Processing Units (GPUs) that are finding increasing application in Computer Aided Engineering. The detail, as ever, is where the complexity lies. There would have to be a transition period as F1 teams come out of contracts for existing private clouds or retire on-premise hardware. In addition, budgets would need to be set or perhaps left open with the overall team budget being the final limiter.



Technological benefits of using Rescale would also accrue to the teams. Of course, innovating faster with security and control is key but, as mentioned above, Rescale works with a number of CSPs and this permits our multi-cloud users to access a wide range of utility and specialist cores on demand, at unlimited scale and availability. The benefit for a Formula 1 team is choice in their access to the latest infrastructure available from the CSPs with which Rescale works. Rescale enables effective benchmarking of workloads so that, at any time, a team can make choices about cost/performance and sustainability of their CFD runs; whether to run on the fastest and most expensive infrastructure because time is of the essence, or whether to run on slower, cheaper infrastructure because budget is critical.

Rescale is an organisation with a wealth of experience in HPC, including from the world of performance cars and Formula 1. Typically, Formula 1 teams are relatively small vs large enterprises and hyper focused on what they do. Rescale's platform is supported by experts who understand the complexities and are there to assist. In addition, the platform provides Service Levels that are guaranteed. Rescale delivers the platform that connects the CFD software to the infrastructure and makes sure it works. Small, focused Formula 1 teams can get on with the business of engineering, rather than managing the technology stack.

Rescale works with partners such as NVIDIA to enable engineers with just a few clicks to deploy and run advanced technologies using AI and other HPC workloads that are optimized for NVIDIA GPUs available on major CSPs. These are technologies and techniques relevant to a significant trend; the development of digital twins. These are models of systems, rather than discrete components and can be used to predict performance and the impact of changes on design. Perhaps the third most expensive car in the world could be the digital twin of a Formula 1 car?

About Rescale

Rescale is high performance computing (HPC) built for the cloud to empower engineers while giving IT security and control. From engine development to vehicle aerodynamics, industry leaders are bringing new product innovations to market with unprecedented speed and efficiency with Rescale, a cloud platform delivering intelligent full-stack automation and performance optimization. IT leaders use Rescale to deliver HPC-as-a-Service with a secure control plane to deliver any application, on any architecture, at any scale on their cloud of choice.

Rescale's mission is to empower anyone to accelerate innovation to deliver engineering and scientific breakthroughs that enrich humanity.

www.rescale.com



04 Optimising Fan Engagement

"We look at anything we can do to get behind the car, open up the car and humanise it."



Formula One has continued its strong growth from previous years, seeing a 35% increase in cumulative followers and a 19% increase in fan engagement across drivers, teams and the series.

On social media, Formula One, F1 drivers, teams and the series account for 28% of the total followers across motorsport (333 million), 54% of the fan engagement so far in 2022 (4.8 billion) and 65% of the sponsorship value generated for brands (\$360 million).

It's amazing to think that just five years ago, F1 had no digital media department—it had global appeal, but no digital footprint. F1's new owners quickly ramped up digital with initiatives such as an F1 YouTube channel, releasing historic footage with repackaged stories, both short and long form, relaxing rules to let teams and sponsors film during the race weekends in certain places for their own content.

With the success of Drive to Survive, the sport realised that letting fans get closer to the drivers and maintain the personal dramas before, during and after races drove up engagement.

This has hugely affected the way F1 directs its content, especially over a race weekend. According to Deane Locke, director of broadcast and media, Formula One, "We look at anything we can do to get behind the car, open up the car and humanise it. We get this amazing thing through team radio, hearing our drivers at stress, and we get to interview them while they're hot and sweaty getting out of the car."

There have been a number of innovations to bring fans closer to the action.

Driver's Eye

In 2021, F1 experimented with a mini camera positioned in the lining of a driver's helmet. Fans were delighted to see an extra dimension and a new perspective of what the driver experiences in the cockpit. The test was successful and has been rolled out to all drivers with **Bell Helmets** throughout the 2022 season. The camera is positioned at eye-level on the left side of the helmet.



The Driver's Eye is the FIA-homologated micro-camera (8 millimetres in diameter and weighing 2.5 grammes) positioned at eye-level on the protective padding on the inside of the driver's helmet.

WORTH KNOWING: Previous innovations have included more safety feature-led implementations, such as driver-facing cameras introduced in 2016 to see what happens inside the cockpit during a crash, and an accelerometer introduced in 2014 and integrated into drivers' earpieces to gather accurate data on the forces acting on the driver.

Pioneering Digital Advertising On F1 Cars & Beyond

Sponsors' logos have been an ever-present part of Formula One cars since 1967, when **Shell** placed its logo via a sticker on the Ferrari 312 F1 cars. The prized asset in sponsorship deals is the graphic or painted logo to represent the brand's association and partnership. Until now, the only dynamic innovations in F1 in terms of branding have been on the sidelines. Digital perimeter boards were introduced to football in 1995 in Spain and LED boards came to the Premier League in 2006. In F1, there has been the digital pit straight and digital overlays, where side-line perimeter boards act as green screens so that different branding can be transmitted on the live broadcast feed to different regions. For example, fans in Thailand might see **Singha Beer**, while in the Netherlands they might see **Heineken**. But until now, dynamic branding that can be changed in real time has never been part of the action. Enter **Seamless Digital**.



The company has been able to digitise a race car and other F1 assets. The digital displays are seamlessly integrated into the surface of the car and can dynamically change branding and messaging throughout a race weekend. The first team to adopt the system has been McLaren, which first ran the system during the 2022 Austin GP weekend. The first brand to use the system was **Google**, which switched through various **Android**-related messages.

4.2 | Pioneering Digital Advertising On F1 Cars & Beyond

The technology provides a glimpse into the future of motorsport marketing and beyond. The teams and brands will be able to connect to fans in new, creative ways and communicate situationally relevant messages. Being able to change branding in real time on a Formula 1 car will give greater flexibility and value to teams and partners not to mention new ways to engage fans.

The patented hardware, and software allow branding to change in real time via triggers activated from the car's CAN bus system. There are several scenarios over a race weekend that the system can recognise and respond to accordingly, ensuring that what is displayed on the race cars is flexible and situationally relevant.

Seamless Digital is the brainchild of highly respected and trusted Formula One entrepreneur and inventor Mark Turner. The company's pioneering technology platform enables digital out-of-home (DOOH) advertising to be applied to mobile items.

The system is:

- **Lightweight:** The total mass of the two-display seamless digital system used by McLaren is 190 grammes.
- **Resilient:** Seamless Digital and McLaren undertook extensive lab testing, and ran the system during track sessions on one of the most demanding areas of the F1 car running flawlessly
- **Aerodynamic:** The integrated hardware conforms to the shape of the existing surface with no step between the transition, resulting in zero aerodynamic degradation.
- **Low power consumption:** Exceptionally low power consumption is achieved through the display architecture. This results in no measurable performance deficit when used in a racing application. In everyday mobile DOOH applications, this means a small lightweight battery can provide the system with over 48 hours of power.

“The technology will really allow our partners to maximise their reach, while enjoying a level of flexibility in key messaging that’s simply never existed in F1 before,” says Matt Dennington, executive director of partnerships at McLaren Racing.

“We’re proud to be able to push the boundaries for partners.”

“F1 branding can be such a powerful marketing and fan engagement tool, so we’re excited to be the team helping to take the next step forward,” says Lou McEwen, executive director of brand and creative at McLaren Racing. “Allowing a partner to change their branding dynamically, including key messaging, and linking it to broader campaigns will open the door to even more opportunities to think creatively and bring our partnerships to life.”

Digital technology that's putting high performance first

“First and foremost, we are fans of the sport of F1,” says Mark Turner of Seamless Digital. “Having worked in F1 and built strong relationships for over a decade, this is the start of a very exciting project for myself and all the team at Seamless Digital. We want to make sure that our product is enhancing a race team. We have tirelessly iterated the system to reduce the total mass to F1 levels of performance. We want to be a net positive to McLaren, the sport and F1 followers. It’s been quite a journey already with McLaren and we look forward to further iterations and uses of the displays...”



As a tool for teams and sponsors, we can’t wait to see the marketing creativity it fuels, but we will also ensure that it remains a discerning product with high-performance engineering at the heart.”

Other companies looking to enter this space to bring new digital branding solutions to F1 include Lightz, which provides cutting-edge LED illumination technology that creates real-time updated, geo-location-specific advertising opportunities within the wheels of cars. The viewing experience can be enhanced with race information displayed on parts of the track. Displayed data could include top speed, race position, tire type, last pit stop and much more.

Race Predictions For Fans

Alongside its partnership with F1 to help set the regulations outlined in Section 3 of this report, AWS also focused its technology on enhancing the fan experience. It aims to give fans insights to make race predictions and explain split-second decisions and strategies adopted by teams during races. Amazon SageMaker and F1’s data scientists are training deep learning models with more than 65 years of historical race data on Amazon S3 cloud-based object storage. Amazon SageMaker deploys advanced machine learning in real time that pinpoints how a driver is performing—this creates talking points for broadcast commentary and digital platforms. F1 insights powered by AWS graphics are added to the TV feed.

“Our work with F1 demonstrates how advanced stats can elevate the fan experience by revealing the tactics and strategies behind even the most seemingly straightforward elements of a race,” said Darren Mowry, director of business development at AWS EMEA.

The potential is, in a few years’ time, fans will have complete reliance on data analytics to help them understand Formula One racing at a deeper level. For some, this is exciting. For others, it’s daunting. It will make it possible to visualise the important role that the technical teams play in this behind-the-scenes game of chess.

Oracle, in helping Red Bull Racing, has also vowed to improve fan engagement. Its early focus has been on the team’s loyalty programme, with each fan receiving a personalised experience depending on what they interact with based on Oracle’s data tracking. Over the years, this has been discussed as a chance to create a whole new fan engagement experience.

GOOD TO KNOW: *It’s not just TV directors who are looking to be more immersive. In the Codemasters F1 game, the player is now given more options to control the race. Codemasters named this the “Immersive Option”, which effectively means that players have to do certain things for themselves. In contrast to this is the “Broadcast Option”, where these immersive events are replaced by video sequences in which the player does not have to do anything.*

F1 Experiential

Formula 1 has joined forces with Kindred Concepts to launch the first F1-licensed premium experiential venue of its kind: F1 Arcade. The first venue opens to the public in November 2022 near St Paul’s, London. Global expansion plans are expected to be announced.

The immersive, state-of-the-art F1 racing simulation adventure comes with 60 motion F1 simulators enabling guests to experience the thrill of racing. F1 Arcade is designed to give fans a new opportunity to connect to the sport.



The concept has been created by Adam Breeden, the pioneer of competitive socialising. He has had proven and consistent worldwide success in fuelling the phenomenal rise of competitive socialising, with notable venues including Flight Club, Bounce, Hijingo, All Star Lanes and Puttshack. The team has used its track record in the space to ensure that F1 Arcade will maximise fun, competition and excitement.



F1 Arcade will feature bespoke racing simulators designed especially for the venue, featuring motion and audio-visual effects to fully immerse guests in the race. The experience will be complemented with a digital ecosystem, including a personal driver profile and an experience currency. The venue will also host enhanced experiences on Grands Prix weekends. Expect a franchise model to roll out globally quickly.

F1 is also planning a travelling exhibition and immersive experience covering the past, present and future of the F1 World Championship called The Formula 1 Exhibition. The Exhibition will include historic artifacts and new commissions and will use access to the film archives at F1 to deliver an immersive and interactive journey. Dates to be announced.

Teams are looking at direct fan relationships and highly tailored digital and real-life experiences. There won’t be a team marketing department that’s not looking at the future of its media platforms and considering how to get fans closer and provide more immersive experiences with the likes of VR.

LTC Spotlight on: From F1 To Mobile Digital Out of Home, by Mark Turner, CEO and founder, Seamless Digital

Introduction

Marketing is a subtle dance between the communicator with their message (a company with a brand, product or service), the receiver (the consumer's attention, potential buyers) and the context (the medium, the time, the place and where this communication happens).

Technology has impacted all parts of this marketing dance. For example, media has been digitised, revolutionising the way we consume content, which is now often on demand via multiple devices in a market of fragmenting audiences.

The Modern Marketeer & Technology

According to Mark Read, CEO of the world's largest advertising group [WPP](#), "Marketing is a technology problem."

Undoubtedly, the modern marketer needs to understand technology. Yet, according to media provocateur Tom Goodwin in his book *Digital Darwinism*, the evolution of consumer behaviour and the proliferation of technology across society is evolving faster than many companies' ability to adapt.

Still, the fundamentals in marketing remain true, so the modern marketer has foundations to work from. However, as I shall explain, technology can also help evolve execution—for example, within the context of sports sponsorships. In this article, we apply this to F1 sponsorships.

The classic model for marketers has been the purchase funnel (or some variation, such as the path to purchase, consumer loyalty loops, buyer's journey, etc.). At the top of the funnel is the broadest net to capture as many leads as possible. A brand starts its journey with awareness first: getting a brand seen and known. Common marketers' wisdom is that you need a consumer to see your brand at least 5 to 7 times (impressions) for people to remember you, to create brand awareness.

Sponsorships have been a key tool in this top-of-funnel phase of many brands' playbooks. It's about your logo being seen regularly—for example, in F1, a global sport and audience, visible across 20+ weekends throughout the year. Brands want to appeal to a large, highly engaged audience, looking to get their logo seen regularly by as many people as possible around the world (albeit with a certain audience demographic in mind, of course).

The next layer down the funnel is brand understanding. This is about trying to communicate something about your product, service, brand values and so on. Where you attach your brand in terms of context and association says something about

your company. In the context of F1, companies are often looking for the association with the pinnacle of innovation, speed, technology, drama/excitement and luxury, for brands to dial up and leverage.

Next, after a person (i.e., the possible buyer) is aware of your brand and understands your offering, they can move into the consideration phase. Once your brand/product/service has a share of their mind, they can now consider you as a one of their options when thinking about buying. This might be the CTO of a large company thinking about buying software, seeing that that company successfully works with an F1 team and makes a performance impact there—leading to the conclusion that they should consider it for their business too. Sponsorships have always told such technology integrations and B2B partnership narratives well.

Of course, next comes conversion. In the context of the funnel, these are activities that push the consumer closer to, and convert them into, a sale. Marketing has always been about finding ways to accelerate progression and not lose relevant consumers in the funnel. The more they are kept in and pushed through the funnel, the greater the chance for conversion to sales.

Within the sponsorship world, rights holders and asset owners such as F1 teams have innovated around what assets they provide in a partnership—whether that's where to place the partner logo on the car, driver time for content creation or hospitality. Of course, hospitality and a chance to invite potential buyers to a hard-to-access experience is a useful sales tool used for consideration/conversation, e.g., time to explain to a buyer why your product is better than a competitor's or is a superior solution for their needs. Technology is usually part of the narrative or content, not the tool. On the sidelines of the action, technology has more recently played an important role. For example, in football, digital perimeter boards enabled football teams and leagues flexibility and dynamism. It's funny to think that, not so long ago, perimeter boards were wooden, static boards unable to change without use of a pot of paint or vinyl. The evolution to digital

LED allowed changes in real time during a match. It allowed movement and creativity. Think about [Wrigley's Extra](#) taking the extra time minutes in a game—it's moving the pitch-side asset from pure brand visibility to brand understanding. [Standard Chartered](#) bank, the main sponsor of Liverpool Football Club, is a well-known logo and brand (especially in Asia). Thanks to technology, it could now message audiences not just with its master logo, but with sub-brands within the company, increasing peoples' understanding of its private bank or its charitable partnership with Seeing is Believing on the digital perimeter boards. Brands in football could not only have their brand logo visible, but could display multiple logos with different messages due to the technology.

The sidelines of F1 have again evolved via technology. Digital pit straights and garages provide more brands with dynamism and flexibility. But these are the sidelines. Fundamentally, they are not in the action. Developments such as digital overlays enable F1 to change what brand audiences see based on the viewer's location. This is an evolution enabling more precision and efficiency for brands (a brand that operates, say, in only one market or one region doesn't need all regions and the world to see it). It also means that rights holders could diversify the access and breadth of potential partners. This provides brands the benefit of being able to access more relevant moments and enables rights holders to leverage finite assets more effectively.



For consumers on the sidelines, having brands on TV that aren't on the track in reality is one thing. But fans will not want that on more 'sacred' parts of the action. Imagine a situation in which the iconic brand of **Marlboro** wasn't on the Prost-Senna McLaren's and instead, things were overlaid or amended post-race? How would you know which brand was the authentic part of the iconic action? What was true in the moment? In an age of trust dilution with the likes of deepfakes, consumers don't want every aspect of shared experiences to be altered.

When it comes to branding in the action, technology has played a limited role to date. With F1 teams, the technology (a sticker) is—to put it politely—antiquated at best. Tech companies would brand the monitors used in the garage, driver partners might brand the driver's helmet to reinforce the driver association (e.g., Dutch brand sponsors such as **Jumbo** placed a brand on Verstappen's helmets to reinforce their Dutch roots). A sticker is, of course, highly inflexible. The position is set and that's that. It has a role, as mentioned above, at the top of the funnel and part of the way down. But increased flexibility could mean being able to display the right brand in the right moment, adding additional relevancy to the situation.

Which brings us to Seamless Digital: Technology enabling what we call increased situational relevancy.

We've developed a proprietary technology that has enabled digitisation in F1. Our software and hardware enable the physical changing of branding on the car and other F1 assets, in real time. Technology provides a new tool to the asset owner (e.g., an F1 team) and its partner brands. It's providing something new to marketing in an iconic sport: situational relevancy. Being able to change branding and messaging means increased precision on which brand is shown when and in which context for consumers. This might be done throughout an F1 weekend, not just during the on-track action. Think coffee and brands associated with taking a break during a pit stop, or breakdown companies at the time when cars malfunction on the track, or car insurance brands visible when the safety car is used. Airlines traditionally haven't wanted to be on F1 cars when an accident happens, which makes sense. The technology allows brands to disappear so they aren't associated with a specific negative moment. But for every brand that might not want to be in a certain context or situation, there are others more relevant that do!



For brands that already have high existing brand awareness (like the world's most valuable brands do), they now want to move further down the funnel. For example, from displaying sub-brands or brands within a company's stable (think multinationals **Unilever** or **P&G**) or products (think Google with **Android**, **Chrome**, **Google Workspace** and **Maps**), making sure the brand is in the right place for the right association at the right time can fuel or reframe better brand understanding for a consumer.

Technology in this case is helping solve a marketing problem. It provides increased precision for brands to be in the right moment and to flex their messaging to be relevant to the situation, enhancing their brand and moving the audience further down the funnel to purchase.

To go back to quoting author Tom Goodwin, "Relevance is wonderful."

Through our technology, relevance can be much more situational, flexible, proactive, reactive and real-time. Relevancy increases saliency, which in turn increases the impact and efficacy of sponsorship spend.

Our technology enables sponsors and rights holders to have more flexibility on which brand or message gets displayed and when, which increases precision around placing brands truly in the action and in the right moments.

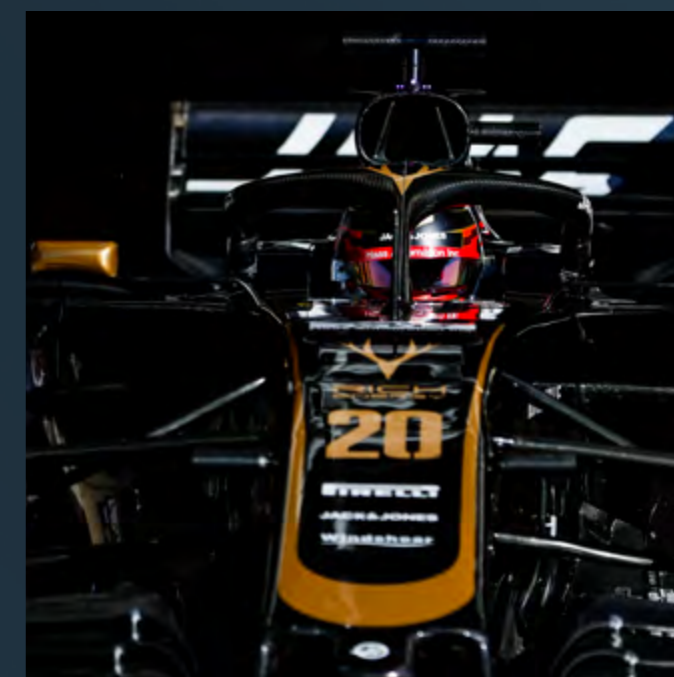
Technology is fuelling a better sports sponsorship dance between the message, mind and medium.

About Seamless Digital

Seamless Digital is the brainchild of highly respected and trusted Formula One entrepreneur and inventor Mark Turner. The company's pioneering technology platform enables digital out-of-home (DOOH) advertising to be applied to mobile items. The patented hardware, and software allow real-time control of digital media inventory across networks. The result is situational relevancy for advertisers, providing content and information that is specific

to the location, time and audience. The seamless integration means the lightweight reflective displays are invisible when not in use, allowing them to remain completely camouflaged within their original environment.

Seamless Digital is proud to partner with McLaren, a world-class technology company rich in a history of innovation and technical collaborations. And together, we are proud to showcase this technology within F1, signifying the start of a new era of mobile digital out-of-home (MDOOH).



Seamless Digital is part of **Silverstone Paint Technology** (SPT). Founded in late 2008, the business has grown to become the largest paint facility within Formula One—and the all-round market leader for high-performance paint technology and coatings. This season, 70% of the F1 grid is served by SPT.

SPT's leading-edge technology has led to the company becoming Official Technical Partner of **INEOS Grenadiers** (formerly Team Sky) and to high-performance projects with **Tour de France**-winning bikes and **British Cycling's** gold medal haul at the Rio Olympics.

www.seamlessdigital.com

05 Sustainable F1

“There isn’t a conversation we have now with partners, existing or prospective, that doesn’t have an element of sustainability to it.”



Like many organisations, F1 has a carbon footprint that is driven largely by travel and logistics, which make up 72% of its baseline footprint. Racing fuel, on the other hand, represents less than 1% of total emissions. However, when you think that there are nearly two billion cars on the planet, it is an area where F1 could have the largest multiplier effect on the world’s highest contributor to CO2 emissions: the global transportation sector.

Underpinned by billions of dollars of investment, F1 has spearheaded the rapid design and development of cutting-edge technologies that have improved the safety, performance and efficiency of not only F1 race cars but also everyday vehicles. There are many examples of the hyper-competition of F1 leading to innovations that have been applied to mainstream road cars—for example, active suspension, paddle shifters, hybrid drive trains and the carbon-fibre chassis.

F1 has been clear that its long-term health and even survival is linked to sustainability on two levels. So far, we have spoken about the longer-term financial stability of teams and the sport, with cost cap measures and the Dilution Fund. Next, we consider the sport within the context of environmental sustainability.



F1 and The Environment

The sport has set clear goals to ensure that F1 remains at the forefront in solving problems we all face:

- Net Zero by 2030
- Sharing carbon reduction activities from across its’ sporting community to ensure that everyone understands how the wider sport is coming together to set and achieve our Net Zero goals
- Continuing to switch to more efficient logistics and travel arrangements on air, sea and land
- Continuing to review its’ processes as the standards for carbon reductions evolve at pace

***WORTH KNOWING:** One slightly alternative argument provided by some in the sport has been that 100 million people sitting at home each weekend watching the racing rather than driving their cars has a positive impact, thus reducing more emissions globally compared to what the sport emits on its own.*

F1 has been clear that its approach to sustainability should mirror its on-track mindset and should see the sport investing in R&D that addresses our greatest challenges. F1 has been vocal about its 2030 Net Zero goal, which includes powering cars with 100% advanced sustainable fuels.

F1 recognises the long-term need to lead the way in sustainability:

“Sustainability is something that is really important to our partners,” says Brandon Snow, F1 managing director, commercial and marketing. “They want to know how we can work with them to support their aims and that they are able to make a contribution to our goals, as we align on concrete initiatives with them. There isn’t a conversation we have now with partners, existing or prospective, that doesn’t have an element of sustainability to it.”

The circuits have looked at their efforts. Solar panels that create enough year-round energy to offset the entire Grand Prix have been installed at Paul Ricard (France) and the Circuit Gilles Villeneuve (Canada), while the Circuit de Catalunya (Spain) and the Sakhir International Circuit (Bahrain) are 100% renewably powered.

The Potential Of Sustainable Fuels

There is growing consensus among regulators, automotive/aviation executives and fuel industry leaders that sustainable liquid fuels will play a key role, alongside electrification, in achieving Net Zero goals for passenger, road freight, aviation and maritime transport. F1 sees a large opportunity to develop and lead the automotive sector in advanced sustainable fuels while tackling existing drawbacks to first-generation biofuels. Since 2022, Formula One mandates E10 fuel (a mixture of 90% fossil fuel and 10% ethanol) for the teams.

Internal combustion engines (ICEs) will continue to be essential to air and sea travel, as well as to the haulage industry. By spearheading the development of 100% advanced sustainable drop-in fuels (fuels that can be used in existing everyday vehicles and infrastructure), Formula 1 can play its part in making

an enormous impact on the global transport sector’s greenhouse gas emissions.

The pace of electrification is accelerating and advances in connectivity technology are changing the ways cars are used, fuelled and built. Naturally, the belief is that moving towards either hybrid or fully electric vehicles will reduce carbon emissions. But cleaner air is not the only reason to make the move. From an automotive performance engineering perspective, the hybrid power units that are being used in F1 have a mind-blowing ability to convert fuel energy into engine power.



2026 Regulations

It is not clear whether there is an exact solution in place yet, but there is intense research and testing by Formula 1 and partner **Aramco**. The fuel will mean no new fossil carbon will be burned, with carbon instead to be derived from non-food sources, from municipal waste or even out of the atmosphere. The aim is for its rollout to be across the world’s existing automotive fleet.

F1’s 2026 Technical Regulations are being specifically designed to support the growth of road-relevant technologies and will considerably influence the R&D and innovation spend of the F1 teams and their OEM parents. Aramco plans to introduce the use of sustainable fuels in both Formula 2 and Formula 3 championships from 2023 using the feeder championships to test and develop these fuels. Fuels will be laboratory-created, using components that

come from the carbon capture scheme, municipal waste or non-food biomass, while achieving emissions savings relative to fossil-derived petrol of at least 65%.

There are many challenges to overcome. The key one, apart from simply creating enough fuel to power the F1 grid, is creating a fuel with a punch worthy of the pinnacle of motorsport.

F1 Teams and car manufacturers are also working on sustainable fuels

Mercedes

Mercedes’ Formula 1 team has pledged to spend millions of euros on so-called sustainable aviation fuels (SAFs). The company said it would partner with an energy company to invest more than €4 million in refineries to produce waste-derived fuels, in an effort to reduce the environmental cost of motor racing on several continents⁸.



Aviation accounts for more than 25% of Mercedes’ projected carbon footprint. The use of SAF means it will be able to achieve close to a 50% reduction in its personnel’s air travel footprint. It will also continue to offset remaining aviation carbon emissions with Gold Standard (GS) offsets while Mercedes works with the industry to scale SAF availability⁹.

⁸ Mercedes’ environmental pledge
⁹ Mercedes working to scale SAF availability
¹⁰ Porsches’ green energy investment



Porsche and Siemens

Porsche has been rumoured for a while to be entering Formula One. It is committed to e-fuels and sees F1 as a faster-paced R&D platform. The answer to Formula 1’s quest for a way to go greener without losing the primal thrill of traditional engines could arrive with synthetic fuels from a joint venture involving Porsche and Siemens. The new Haru Oni project in Punta Arenas is expected to produce 130,000 litres of what Porsche calls eFuels—synthetic fuel created by splitting water into oxygen and green hydrogen, then combining CO₂ with the green hydrogen to produce synthetic methanol, which is then converted into eFuel, which can be used in regular combustion engines.

Porsche R&D chief Michael Steiner told journalists, “We have been in talks with Formula 1, and we would be able to give them a share, but not just now in the beginning. It’s not a huge amount. We are in talks.” The company is pushing the industrialisation of eFuels with an investment of around €20 million in a pilot plant to provide a proof of concept and prepare this technology for the large scale. The plant was also funded by **Siemens Energy** and **ExxonMobil** but is being built and will be operated by a Chilean startup called **HIF Global**. Porsche also announced that it was investing \$75 million to buy a 12.5% stake in the startup¹⁰.

F1 & Hydrogen

“Maybe hydrogen is the route that F1 can take, where we keep the noise, we keep the emotion, but we move into a different solution.”—Ross Brawn, managing director, motor sport, Formula One Group

Hydrogen has become something of an enigma. Once viewed as the fuel of the future, it hasn't taken off in the way that battery electric vehicles have. Its many technical problems—the cost of production, the energy required to make it, the nitrous oxide produced by burning it or its inefficiency by volume—have all prevented it from clearing the launchpad¹¹.

The motivating force behind hydrogen is to keep the emotions and sound in F1 by using hydrogen combustion engines instead of much quieter electric fuel cells.

Red Bull is set to work with French racing car constructor **ORECA** to create what's known as the H24 concept, which aims to run a hydrogen class of cars at the 2024 Le Mans 24 Hours. But according to F1 CEO Domenicali, hydrogen is not the answer for F1 (not at the moment, anyway). Instead, its plan for a sustainably-fueled hybrid is one that ticks boxes for teams, manufacturers and sponsors¹².



McLaren's Zak Brown, on the other hand, says that hydrogen is being considered by many teams: “The challenge that we have is to make sure it is safe and

¹¹ Is hydrogen the future of formula 1?

¹² Sustainability-fueled hybrid

¹³ Is hydrogen safe and powerful?

[we] can produce the amount of power that's required to be able to do the lap times that we do, and hydrogen is very much on the table.”¹³

Notable startups/companies working on synthetic fuels

Zero Petroleum



Often, former F1 team engineers stay within the orbit of F1 in some way, shape or form. Ex-F1 designer Paddy Lowe is the founder of **Zero Petroleum**. The company is dedicated to the production of 100% fossil-free, petroleum-based products (fuels and chemicals) that are synthesised by the recycling of water and atmospheric carbon dioxide using renewable energy, with a particular focus on the aviation industry

Prometheus

Notable startups working on synthetic fuels include the first electrofuels unicorn **Prometheus**, the manufacturer of carbon-neutral fuels intended to remove CO₂ from the air and turn it into gasoline and jet fuel. **Fixing CO₂** is a developer of environmental technology designed to convert carbon dioxide into fuels and chemicals. The company's technology combines electrochemistry and renewable energy to turn carbon dioxide emissions into valuable products, closing the carbon loop and enabling organisations to use carbon dioxide in useful forms. Others to keep a close eye on are **Agora Energy Technologies**; **Caphenia**,

which turns biogas into renewable synthetic fuels; **Synhelion**, which produces solar fuels to decarbonise transportation; and **Ineratec**, which provides modular chemical plants for power-to-X and gas-to-liquid applications and supplies sustainable fuels and products. The **KIT** (Karlsruhe Institute of Technology) is exploring ways to convert hydrogen from renewable electricity and greenhouse gases such as CO₂ into e-kerosene, CO₂-neutral gasoline, clean diesel or synthetic waxes, methanol or SNG.



Carbon Capture

Patrick Symonds (chief technology officer of Formula 1, ex-CTO of Williams Grand Prix Engineering), is excited about the promise of carbon capture, even if the technology is still at an early stage.

“Carbon capture is a method that actually we're quite keen on,” he says, “because it takes the carbon directly out of the air. It's in its infancy, but there are plants doing it; there's some in Canada, there's one in Switzerland that's quite large, there's some in South America that are quite large. So it is doable, and I think in 20 years' time, actually there'll be quite a lot of it around. But it is very, very experimental.”



Why not reduce the F1 calendar?

F1 future calendar

Environmentalists say because synthetic fuels and biofuels still produce carbon dioxide, they continue to drive global warming and therefore cannot be a long-term solution. A challenge to sports owners is that more races around the world means more emissions impact. Currently, the calendar isn't the most efficient because the promoters often don't want back-to-back races in the same regions. For example, the Malaysian GP suffered when the Singapore GP was held the previous week.

F1 is said to be taking action to regionalise its calendar, which will help improve freight and travel logistics. This will be an ongoing process in the years to come to ensure that we are travelling efficiently as a World Championship. However, this didn't seem to be a consideration when it announced the 2023 season, which included 24 races for the first time, a record number in the sport's calendar. The calendar certainly doesn't reflect an effort to keep consecutive races close geographically.



F1 managing director Brawn has categorically ruled out reducing the number of races to cut emissions. He says bringing the races to countries around the world is part of what makes the championship great, but he acknowledges there is also a financial imperative.

“At the end of the day, we're a business, we have to generate income to make this whole thing work, and, obviously, the more races we have, the more profitable it is,” he says.



Final Word

As this report has shown, technology is a core part of F1's DNA. One huge technology elephant in the room for F1 is the automotive market's shift to electric vehicles. So when might F1 switch to electric batteries?

Well first, by developing advanced sustainable fuels, F1 will be advancing the capability of battery technologies as part of the F1 hybrid powertrain, which is critical to the sustainable growth of the electric vehicle (EV) market. There are hints too of revolutions to come in overall battery technology, which could be pivotal when F1 moves to its new engine rules era from 2026.

But with current technology, F1 couldn't go fully electric because the cars would need a six- or seven-tonne battery to last a race distance.

14 The future of Formula One

According to Ross Brawn, managing director, motor sport for Formula One Group:

“ I don't think it [the future of F1] will be battery. The nature of electric-powered cars is now what Formula 1 wants, but who knows what the fans in 20 years want. We want fans to be proud of our sport. We can't have a sport which is seen as a dinosaur and out of step. We will always be mindful of that. We don't want [drivers] looking at power conservation modes and trying to make the battery last long enough to get to the end of the race or saving the battery up so, in the last five laps, they can really go for it. That doesn't seem to engage the fans.”¹⁴

It's also not something that F1 necessarily has control over. Formula E holds a 25-year exclusive electric racing licence, so in theory there can be no electric F1 until 2039 at the earliest. But Liberty Media's parent company is Liberty Global, which incidentally owns Formula E. All roads lead to a certain Dr. John C. Malone, the chairman of the board of Liberty Media Corporation and Liberty Global plc. The future of F1 and FE together is something to watch closely...



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