Purpose Driven

A report on the Contribution of Motorsport to Health, Safety & the Environment

Commissioned by the FIA | Created by FUTERRA®

#PurposeDriven

Foreword by President Jean Todt

Ladies, Gentlemen,

Motorsport has always participated in the progress of society, particularly in terms of technology and innovation to improve health and safety as well as to protect our environment. Advances on the racetrack find their way to the road, helping to preserve lives and the planet. This has probably never been as clear as in the response of the community to the global pandemic this year. And while motor racing is back on track, providing entertainment for its millions of fans, it remains a laboratory for a better future.

At the FIA, we wanted to collate and highlight this contribution as we move forward. So, we commissioned the innovation consultancy Futerra to research and publish this comprehensive and first-of-its-kind report. It brings together twenty-six motor sport innovations with a positive impact on health, safety and the environment. Indeed, the motor racing community has created much greater value than generally known.

We hope to inspire engineers, technicians and visionaries all around the world to push the technical boundaries and never accept the status quo.

In a changing world, faced with important challenges, it is necessary to go further. This is why we launched the #PurposeDriven movement, to federate and amplify the initiatives that help us achieve our objectives in terms of health and safety, environment, gender equality, diversity, inclusion and community development.

With my most heartfelt wishes for your continued safety and health,

Jean Todt,
FIA President

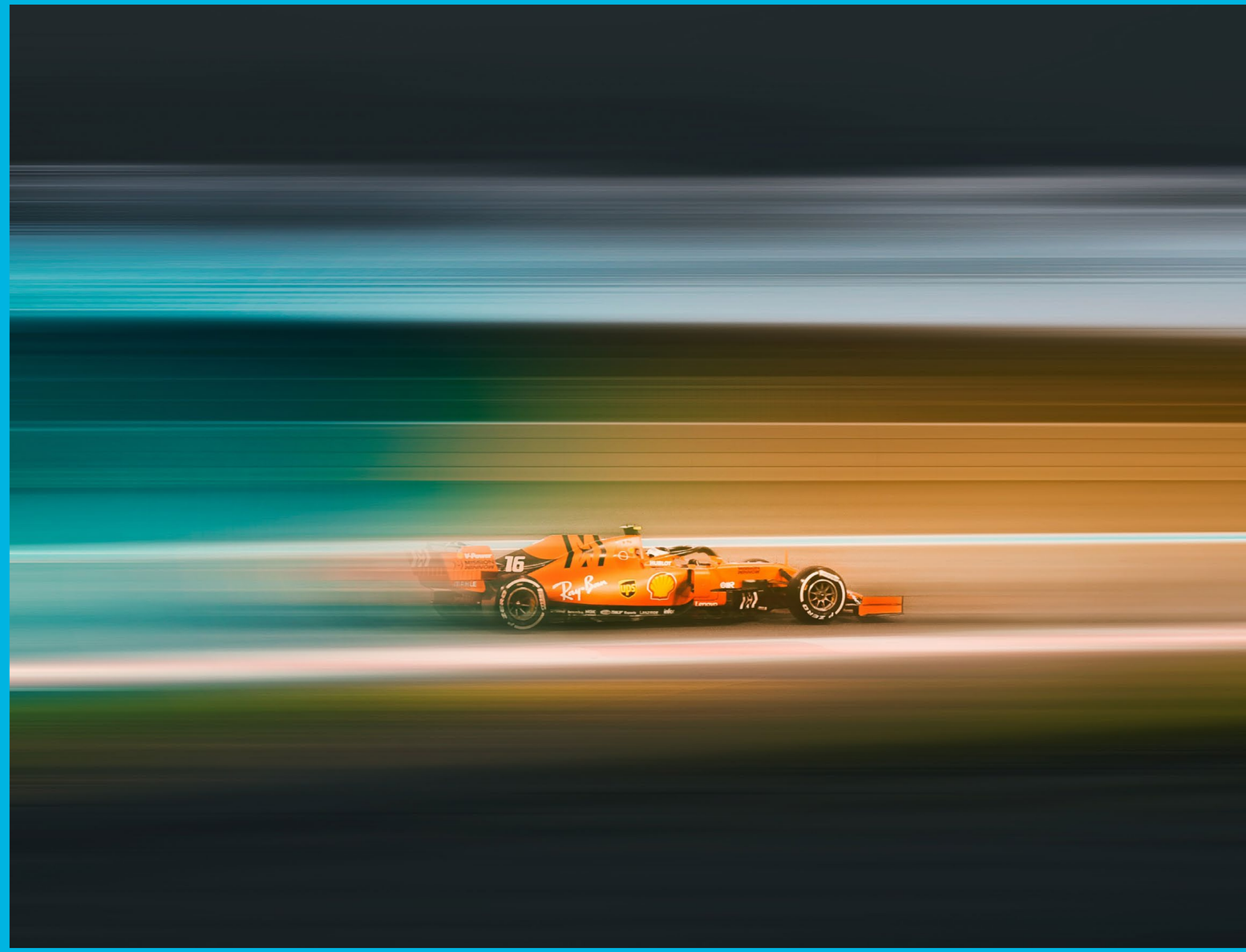
INTRODUCTION

For over 100 years, motorsport has been a source of constant innovation in an ever-changing world. And yet, motorsport's positive contribution to society in that time has not always been recognised.

Take the rearview mirror. Now a feature in every roadcar on the planet, the technology was popularised in racecars in the early 1900s - an invention of cunning drivers seeking a competitive advantage. From that day forth, everything from reversing to overtaking was made instantly safer.

Even a safety feature as fundamental as the seatbelt can be traced back to racing: racecar drivers were the first to truly wear belts to protect against internal injuries. Other famous innovations, like disc brakes, originated in other industries (in this case, aeronautics), before being rapidly adopted and accelerated by motorsport, and ultimately reaching roadcars.

But motorsport's contribution to society goes far beyond the trickle-down effect of decades-old technology. It goes far beyond the road. And it can go even further and faster in the years to come, inspired by an existing track record of driving innovation and enabling change.



This report is a first step towards a new future for motorsport, fuelled by history and driven by purpose.

The report consists of twenty-six handpicked stories of motorsport's positive impact upon society and the environment. The stories are just the tip of the iceberg; they do not catalogue every single example of technology transfer or lateral thinking over the years.

What they do is provide a curated series of compelling case studies, across a broad cross-section of society. Our stories take us from supermarket aisles to operating theatres, across a varied cast of engineers, drivers, doctors and dreamers. From promising prototypes with the potential for scale, to established tech that has already changed the lives of millions.

The stories are organised into six broad themes:

01
BETTER HEALTHCARE

We examine motorsport's many contributions to better healthcare, beginning with the recent response to the Covid-19 pandemic.

02
GREENER LIVING

We look at examples of technology and knowledge transfer that have positively affected society at large - sometimes in surprising ways, spanning electric bikes and airline seats.

03
SAFER MOTORISTS

We focus on improved safety on public roads, ranging from motorcycle helmets to safety simulations to the work of the FIA Foundation.

04
SUPERIOR ELECTRIC

We examine the future of electric mobility. Whether accelerating charging speeds or improving energy management, motorsport is rapidly pushing the sector forward.

05
HYPER EFFICIENCY

We then move on to motorsport's relentless pursuit of hyper efficiency. In this section we find stories about transforming tyre technology, perfecting internal combustion, and the science of moving further while using less.

06
ALONG THE ROAD

We look further along the road, tracing the trajectory of game-changing new fuels and revolutionary manufacturing techniques; and we discuss the unparalleled influence of motorsport in winning hearts and minds.

The stories can each be read in isolation, or in any order.

But together, they constitute a document that is the first of its kind: a collection of motorsport's societal contributions to date, in one place. Not as a monument to admire - but as a foundation to build upon.

From saving seconds on the track to saving lives on the road; from inspiring eco-friendly innovation to accelerating sustainable mobility; these stories can set us on the road to a truly Purpose Driven future.

METHODOLOGY

This report has been created in partnership with Futerra*, an independent global change agency, to provide a rigorous and third-party expert opinion on the positive societal or environmental benefits that motorsport has contributed to society.

Working in collaboration with the FIA, Futerra identified a long list of stories to potentially include within the report through a mixture of extensive desk research (industry conference outputs, white papers, trend reports, news articles and scientific literature), a workshop with a group of expert FIA stakeholders in Geneva, and a series of expert stakeholder interviews with some of the leading voices from within the motorsport world.

In both the workshop and the interviews, experts were asked to provide specific examples that they have been involved with or come across within the motorsport world that evidences how motorsport has positively impacted society or the environment, in the past, present or is predicted to in the future.

*Futerra is a global change agency with offices in New York, London, Stockholm and Mexico City. Established in 2001, Futerra works with the world's largest brands, breakthrough entrepreneurs and national governments on the logic of sustainability strategy and magic of creative ideas. Futerra believes that, in order to build a better world, we must first imagine one. The company is majority female owned and a certified BCorp.

THE EXPERT STAKEHOLDERS ENGAGED WERE:

Adam Baker
FIA, Safety Director

Alexandre Gueschir
FIA, Marketing Director

Alexandre Turpin
Williams Racing, Business Manager

Andrew Wheatley
FIA, WRC Category Manager

Bruno Famin
FIA, Director of Operations

Prof. Burkhard Goeschel
FIA, President of the Electric and New Energy Championship Commission

Clive Bowen
Apex Circuit Designs, Founder and Director

Garry Connelly
FIA Environmental Delegate

Stefano Domenicali
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Prof. Gérard Saillant
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Michael Shearer
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Oliver Ciesla
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Pascal Vasselon
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Peter Wright
FIA, Consultant

Simon Larkin
WRC Promoter, Event Director

Simone Perego
FIA, Project Officer and Manufacturer's Commission Coordinator

Thomas Riedel
Riedel Communications, Founder and CEO

This story long-list was then narrowed down to a final shortlist of stories based on the following criteria, with stories that met all 4 criteria being included within the final report:

→ Motorsport Link
Can we credibly say that the prime driver of innovation stems from the motorsport industry or was substantially advanced by it?

→ Credibility & Relevance
Is this innovation being used today and has it been deployed by a credible source?

→ Societal Benefit
Does this innovation bring significant value to society (social and/or environmental)?

→ Impact & Scale
Has this innovation been used widely, or does it have the potential to have impact at scale?

The final shortlist of stories were written using the details provided from the interviews and workshop, as well as expert third party sources.

To verify and ensure credibility of each story, a minimum of 2 independent sources were used as evidence, with a particular focus on using identified sources outside the motorsport world to remove any form of bias or conflicted interests. Each story was then run past an internal FIA review committee for final review and sign off before being published in the report.

BETTER HEALTHCARE

01

AT A GLANCE

01 At the start of the COVID-19 pandemic, specialist respiratory devices were in short supply in the UK

02 Project Pitlane used F1's technical expertise to manufacture more devices at speed and at scale

03 A Mercedes-UCL team delivered 10,000 devices to the UK government within a month, and their designs have been used in 105 countries

RACING AGAINST A PANDEMIC

Sometimes no one knows what's around the corner.

In 2020, COVID-19 changed the world forever. The FIA quickly spearheaded a drive to raise funds in a #RaceAgainstCovid charity auction, with proceeds benefiting the International Federation of Red Cross and Red Crescent Societies (IFRC) global response to COVID-19. The sale featured 95 astonishing collectible pieces and VIP experiences, donated by the global automotive and motorsport community, and raised almost two million Euros for the cause.

But motorsport was also able to draw on its unique strengths: technical expertise and rapid problem solving ability. With the competition calendar halted indefinitely, some of the world's finest engineering minds turned to a new task.

Under the leadership of F1 Chief Technical Officer Pat Symonds, "Project Pitlane" gathered seven F1 teams to coordinate the rapid production of respiratory devices for the National Health Service.

It was the kind of challenge that motorsport throws up every day. Short lead times. Tight deadlines. Technical complexity. And unrelenting pressure to deliver.

And it wasn't long before Project Pitlane produced its first of several successes. »

“...in the midst of an unprecedented fight, motorsport added a small yet valuable weapon to the world’s armoury.”

» This particular innovation came courtesy of Mercedes High Performance Powertrains –the same team that produces the engines that have triumphed in six consecutive FIA Formula 1 World Championships. In collaboration with UCL Mechanical Engineering, the Mercedes team reverse-engineered a specialised breathing aid for manufacturing at scale.

The aid is a type of Continuous Positive Airway Pressure (CPAP) device, which helps Covid-19 patients with lung infections to breathe when an oxygen mask alone will not do the job. What’s more, CPAP devices ensure that mechanical ventilators are used only for the most severely ill patients.

As the pandemic broke out, it became clear that CPAP devices were extremely scarce in the UK. With infections rapidly rising, the Mercedes-UCL team worked non-stop on a CPAP device that could be rapidly manufactured in the numbers required.

It took them less than 100 hours. Five days after the team’s initial meeting, the first of their new devices had been produced. And it wasn’t long before they had produced Mark II, which has shown up to 70% reduced oxygen consumption in healthy volunteer assessments.

By mid-April – just one month after the team had assembled – Mercedes fulfilled an order for 10,000 devices from the UK government. Machines normally used for F1 components were used to make the devices. In fact, the entire High Performance Powertrains tech centre was repurposed for production.

What’s more, the design was offered up freely to anyone who wanted it. A package was provided including technical designs, material and tool specifications, and fabrication times. The Mercedes team – whose work would usually be shrouded in the hyper-secrecy of the pitlane – saw their efforts fuel a tremendous open source response. As of the end of May 2020, UCL have approved access to the designs from 105 countries spanning all corners of the Earth.

Of course, the device was just one of a great many contributions from many different industries, across the globe. But in the midst of an unprecedented fight, motorsport added a small yet valuable weapon to the world’s armoury.

COLLABORATION IN A CRISIS

Sometimes life throws a monstrously complex problem at you, and immediately demands the solution. Do the impossible – and do it fast.

The Covid-19 pandemic made such demands on almost every industry. But it was a level of pressure that was familiar to the world of motorsport, where engineers are used to developing and deploying solutions all season with unparalleled speed.

McLaren's response to the crisis exemplifies motor-sport's ability to innovate at pace. As part of the Ventilator Challenge UK consortium, they drew on their ability to think creatively and efficiently under pressure - and applied it to a national health emergency.

It was a complicated undertaking. The consortium combined major manufacturing, medical and specialist tech companies including all eight UK-based Formula 1 teams. Each company was given a specific task to focus on, in order to make ventilator production as efficient as possible.

While Penlon and Smiths Group oversaw the ventilator designs, McLaren's role was to focus on component manufacturing. Additionally, the McLaren group helped deploy planning, project management and purchasing teams to procure all parts to help ramp-up production. »

02

AT A GLANCE

01 The Ventilator Challenge UK consortium brought together companies to manufacture ventilators for the Covid-19 pandemic

02 The McLaren Group produced over 70,000 complex parts and 15,000 ventilator trolleys

03 Formula 1 teams contributed to an effort that achieved "20 years of normal production in 12 weeks"

» They were able to use their expertise to fill gaps in the ventilator supply chain, machining the most complex parts at their “machine shop”. Within five weeks, they had produced over 70,000 such parts – with zero quality defects.

They also played a humble - but equally crucial - role. When ventilators are transported and utilised, they need to be stationed on bespoke trolleys. McLaren promptly cleared their build bay, where prototype test vehicles are made, and set about both designing and producing the trolleys.

At one point, up to 70 people were working on the project, breaking the process down into sub-assemblies for everything from the lids to the base unit, to the castors for the trolleys to roll on. (No word on the trolleys’ top speed.)

The scene was perhaps surreal. At a time of year when the teams would normally be working flat out on getting vehicles ready for Formula 1, the cars were covered up. Instead, all that manufacturing expertise was poured into the swift construction and delivery of 15,000 trolleys to fulfil a government order.

At one point, the consortium as a whole was producing 400 ventilators a day. As Mark Mathieson, Lead Partner for Technical Services at McLaren Racing put it: “We achieved over 20 years of normal production in just 12 weeks.”

Every motorsport competition involves complex multi-stage manufacturing and delivery processes. Some roles are headline-grabbing. Some roles, less so. But when the world needs a well-oiled machine, motorsport understands the value of every cog and castor.

03

AT A GLANCE

01 In healthcare, real-time data collection can help keep track of patients' vital signs

02 McLaren used their expertise in data to help monitor seriously ill children at Birmingham Children's Hospital

03 Over 1,000 children were cared for using McLaren's analytics platform, which has also been used to help people with neurological disorders

KEEPING FINGERS ON THE PULSE

Over the course of a normal Grand Prix, everything from hydraulic pressure to tyre temperature is constantly being assessed, generating more than a billion pieces of data from hundreds of sensors on each car.

It all feeds into a system designed for constant learning and improvement with every race – sometimes with every lap.

But it's not just the cars that are being monitored: the drivers are, too. Every driver wears an array of sensors to keep their team up to speed on their vital signs. And that kind of real-time monitoring has value far outside the world of motorsport.

Within healthcare systems, real-time data collection can help gather more information for making diagnoses, as well as allowing doctors to keep a constant eye on the condition of seriously ill patients.

Which is why, in 2015, McLaren teamed up with Isansys Lifecare for a pioneering research study at Birmingham Children's Hospital. The project, which was the first of its type in the world, »

» involved using sensors to keep tabs on the vitals of seriously ill children.

At this hospital, the traditional method for measuring vitals had been manual monitoring – stopping by patients every one to four hours to plot out numbers on paper charts. Not only was that an inefficient system, it wasn't comprehensive enough to capture all the data available. It was also particularly tricky to gather information from the patients themselves, as young children are often unable to verbalise what they're feeling.

Isansys and McLaren's Real-Time Adaptive and Predictive Indicator of Deterioration (RAPID) system provided heart rate, breathing rate and oxygen level monitoring. All data was transmitted via Bluetooth to the Isansys gateway near the patient's bedside, offering a real-time display of vital signs. From there the data was sent to McLaren's unique analytics platform, Lifeinsight.

The platform had already been used in clinical trials run by pharmaceutical company GlaxoSmithKline. In those trials the platform monitored patients recovering from strokes or managing neurological disorders such as motor neurone disease.
One stand out study involved processing vast amounts of data from a discreet device worn on the base of the neck. The device was so small it could be worn under clothes - and even left in place for showering.

Within the RAPID system, Lifeinsight's role was to process data in real-time and relay it back to hospital staff similar to the way McLaren would keep tabs on a driver during a race. Immediate alarms would be triggered if a child's baseline levels took a sudden downturn.

The sensors did all the talking, so that the children didn't have to. And in stark contrast to conventional, bulky, wire-entangled devices, these sensors comprised just three pieces of wearable technology: an ankle strap and two sticky heart rate monitors. No wires necessary.

After three years, the project had successfully monitored the health of over 1,000 children, with plans to rollout the technology further. The sensors allowed for vital check-ups to be taken care of, with no need for patients to stay in bed, strapped up to terrifying machines. Which in turn allowed the children the freedom to do what children do best: play.

TRANSPLANTING TECHNOLOGY

There are few fields which rival motorsport for its combination of technical complexity, human skill, and unforgiving pressure. Medical surgery is one such field.

And though the goals of motorsport and medicine are very different, the cost of an error can be equally serious.

In 2015, McLaren Applied Technologies announced a partnership with the University of Oxford to improve patient care and treatment for serious conditions. Perhaps the most eye-catching initiative was a Formula 1-inspired innovation for training surgeons, built using sensor technology.

The training process for new surgeons can be highly expensive. Monitoring and optimising skill acquisition can save both money and time. McLaren were well suited to the task, thanks to years of experience in expert simulation, predictive analytics and sensor telemetry (their F1 cars wear over 300 sensors during a race). Along with their colleagues at Oxford, they developed a wireless, battery-powered sensor for managing surgeons' skill acquisition.

The sensor could be placed on a surgeon's elbow during a procedure, producing data for real-time analysis and feedback. The sensors tracked movement of hands and wrists, »

04

AT A GLANCE

01 Training surgeons is an expensive and highly specialised endeavour involving a degree of guesswork

02 McLaren Applied Technology and the University of Oxford used wireless sensors to train new surgeons through monitoring their skill acquisition

03 The project was part of a wider partnership to enhance patient care and medical outcomes through data management and predictive analytics

» allowing for a trainee to be objectively evaluated on vital attributes, including dexterity and speed.

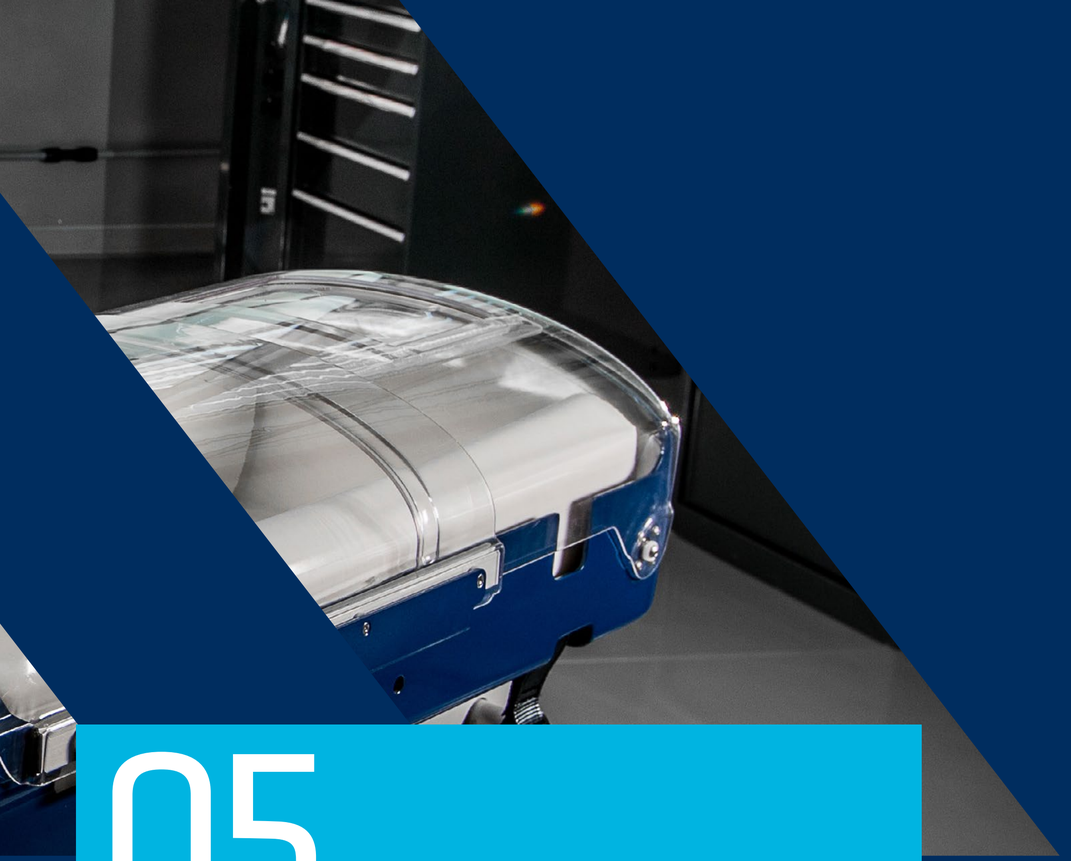
Surgery is similar to playing a musical instrument in one aspect – experts are able to make extremely small movements to achieve complex outcomes. The new sensors were able to track the size of surgeons' movements, so that their training could be adjusted to match their current level of precision.

A cohort of experienced surgeons were evaluated at the same time, allowing analysts to set a data -driven standard for best practice. The trainees' progression could then be predicted in relation to this standard, and development targets would be set accordingly. It's just one aspect of a wide-ranging programme that could reduce the guesswork still present in many areas of medicine.

As Ron Dennis put it, discussing McLaren's partnership with the University of Oxford: "Just like Formula 1, clinicians are always trying to push the boundaries of science, constantly exploring the art of the possible and driving innovation in process and procedure."

And it's exploring the art of the possible that could make the difference between life and death. In the operating theatre, as on the track, every movement matters.

"Just like Formula 1, clinicians are always trying to push the boundaries of science, constantly exploring the art of the possible and driving innovation in process and procedure."



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THE WORLD'S SAFEST CRIB

A human being is never more vulnerable than during the first few minutes of their life.

Unfortunately, many babies need immediate medical treatment after emerging into the world. And if that treatment cannot be delivered on the spot, the newborn will be rushed to a hospital with the appropriate facilities. According to the UK's Neonatal Transport Group, there were 7,773 such transfers in the UK in the 12 months up to June 2019.

Transporting newborn infants is notoriously difficult. It's not just that they're physically fragile. They need a continually visible, easily accessible, temperature regulated environment.

Conventional transport incubators can do the job - but they also carry a whole host of risks and problems. They need a dedicated power supply to provide essential heat for newborns, and such power sources are not always readily available. They can weigh as much as 120kg, which make them very difficult to secure to a standard ambulance. And if that ambulance is involved in a crash or road accident, these cumbersome incubators can break free. The result can be serious injury or even death. »

AT A GLANCE

01 Newborn infants sometimes require emergency transportation in a visible, accessible, temperature regulated environment

02 Conventional incubators can weigh up to 120kg, require a power source and are expensive

03 Williams helped adapt carbon fibre design from Formula 1 to build a lightweight, secure, cost-effective pod

"...the same thinking that protects our fastest drivers can also protect our most precious passengers."

» The challenge was to provide a lightweight, strong device that could transport infants while keeping them warm, secure, and protect them in the event of an unexpected impact that might normally jeopardise key life support systems.

Williams Advanced Engineering stepped up. As an arm of the Williams Formula 1 team, their engineers were used to solving similar problems. After all, safe transportation at speed is a cornerstone of motorsport.

Working with Advanced Healthcare Technology (AHT), the motorsport experts spent two years developing the Baby Pod 20, using Formula 1 derived design to massively improve an existing device called Baby Pod II.

They made the Baby Pod 20 from the same carbon fibre safety cells used for the chassis of a Formula 1 car. The pod is strong enough to withstand even a 20 G-force crash, yet it weighs only 7kg on its own, meaning that it can be carried by a single person. The strapping system uses the same kind of high-tensile webbing that is found in motorsport, helping to keep the baby completely secure. It requires no electricity supply, and can attach to any transport stretcher in an ambulance, car or helicopter. It also features a sleek, sliding viewing lid, allowing easy access to the newborn, without obstruction, even in a tight space.

On top of all that, the Baby Pod 20 is substantially cheaper than a standard incubator. So far, the devices have been used by the Intensive Care Ambulances at Great Ormond Street Hospital, and also by the Children's Acute Transport Service, the largest dedicated children's intensive care transport team in the UK.

It's perhaps an unexpected use of tech that was originally used for ultra high speed competition. But as it turns out, the same thinking that protects our fastest drivers can also protect our most precious passengers.

OPERATION PIT STOP

In a medical operating theatre, coordination can be a matter of life and death. But coordination isn't just about the incisions and decisions made during surgery. It's also about what happens immediately afterwards.

In the early 2000s in England, one of the riskiest moments of an operation came after it was finished: in the journey from the operating room to the intensive care unit (ICU). Sometimes patients were rushed to the ICU before necessary machines, like ventilators, had been set up for their arrival. Sometimes patients were transferred without the correct instructions for further treatment.

Thousands of these "handovers" occur every day, and a mistake during any of them can have life-altering or even fatal consequences.

But in 2003, a new procedure for handovers emerged from an unexpected source.

At Great Ormond Street Hospital, which treats 100,000 children each year, two doctors sat down at their end of their shift to watch a Formula 1 race together. Paediatric chief Allan Goldman and surgeon Martin Elliot were both racing fans, but this was the first time they noticed something startlingly familiar. Their complex, high-stress patient handovers had an unlikely parallel, and it was unfolding right before their eyes on the television screen: The pit stop. »

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AT A GLANCE

01 Handing over patients after operations is a complex and stressful process, and mistakes can have serious consequences

02 Great Ormond Street Hospital benchmarked their handovers against the pit stop techniques of Ferrari's Formula 1 team

03 Their new procedure, born directly from motorsport, resulted in increased patient safety and decreased error rates

» There, amidst the white heat of a Formula 1 race, a crew was able to fit and lift tyre jacks, loosen the wheel nuts, remove the tyre, replace it with a fresh one, tighten the wheel nuts again and drop the jacks across four wheels - in a matter of seconds.

The doctors first invited McLaren to offer insights into pit stop choreography, and then actually visited Ferrari in Italy, to observe a pit crew handoff live.

They quickly learned that a strict routine was essential. The predictability of a well-drilled routine meant that problems could be anticipated ahead of time. There was a rhythm and order to pit crew movement; much like a dance. Crews would practice their own role to the point of perfection. And though everyone had their own task, the “lollipop man” would wave everyone in and maintain overall situational awareness.

What’s more, every member of the pit crew usually carried out their task in calm silence, in contrast to the chaotic stream of conversation during a hospital handover.

Following the trip, the hospital team videotaped a handover of their own, and sent it back to Ferrari for review. With the feedback they received, the hospital put together a new handover protocol. It was a protocol born directly from the methods of motorsport.

Tasks and responsibilities were strictly allocated; every handover had a clear sequence and order; communication was limited to the essential; safety checks were introduced and risk assessments were performed beforehand. The process was standardised, rather than tackling each handover on an individual basis. And for the first time, a single person - the anaesthetist - was given the job of stepping back and looking at the big picture, effectively acting as the handover’s lollipop man.

The new procedure was studied over a two-year period to see if it would actually make a difference in practice. And it did. Not only did the average number of technical errors fall by 42%, “information handover omissions” fell by 49%.

Many transfers to the medical world involve some innovative piece of tech, but this was purely about transferring knowledge. It was about knowing how to organise a team, at speed and under stress, so that they make minimal mistakes.

Of course, post-operative handover is ultimately one part of a much bigger medical process; just as the job of a pit crew is to help their team win a much bigger race. But in their own way, both the pit crew and the handover team are examples of organised human beings at their best: as models of discipline, precision and grace.

GREENER LIVING

07

PUTTING WASTE ON ICE

The massive supermarket refrigerators that keep food and drink cool are huge consumers - and wasters - of energy.

They're open all day for the public's convenience, which means cold air is constantly escaping into the aisles. That in turn means more energy is needed to keep the fridges at the necessary temperature.

It's a problem without an obvious link to the world of motorsport. But in a characteristic display of innovative thinking, Williams Advanced Engineering found both a link and a way to help.

Consider the rear wing of a Formula 1 car. Though designs have changed and evolved over the years, the purpose has remained constant: to manipulate airflow.

The Williams team, in collaboration with aero and thermodynamics specialists Aerofoil Energy, came up with a simple but ground-breaking device. They developed an Aerofoil, inspired by their race-car's rear wing, that could be attached to each shelf of a refrigeration cabinet. The aerofoil would direct cold air back into the fridge, reducing lost air and therefore saving wasted energy.

In early lab tests it drove significant reductions in energy consumption, and was subsequently trialled in 2015 with Sainsbury's, the UK's second largest supermarket chain, across 50 of their stores. »

AT A GLANCE

01 Supermarket refrigerators keep food and drink cool but lose cold air and consume huge amounts of energy

02 Williams Advanced Engineering and Aerofoil Energy invented a Formula 1-inspired Aerofoil to direct cold air back into the fridge

03 The Aerofoils are now used in all Sainsbury's stores, cutting energy consumption by 15%, and saving more than 8,700 tonnes of CO_2 each year

» The trial was such a success that Sainsbury's soon announced plans to roll out the Aerofoil across every single one of its UK supermarkets - either retrofitting to existing fridges, or fitted as standard going forwards - as part of their plan to become a net zero carbon business by 2040.

This year, Sainsbury's fit its 400,000th Aerofoil to fridges in its newest store - meaning that all of its convenience stores and supermarkets are now fitted with the Formula One-derived technology.

The Aerofoils have cut the power use of Sainsbury's fridges by 15%, which equates to a CO_2e saving of more than 8,700 tonnes each year.

On top of that, food stays cooler for longer, which prevents it from spoiling, which in turn reduces food waste. And the aisles stay warmer - in fact, aisle temperature increased by up to 4°C.

The landmark 400,000th Aerofoil fitting at Sainsbury's was also another milestone: the millionth Aerofoil installed anywhere in the UK. After Sainsbury's successful trial, other retailers had followed suit - including the UK's largest supermarket chain, Tesco.

All thanks to technology originally honed for high stakes and high-speed competition - a far cry from the mundanity of a supermarket shelf. Yet the energy saving is indisputably massive. It might not be motorsport's most exciting contribution to society. But it's certainly the coolest.

THE GREAT DATA RACE

There is an invisible force which powers modern motorsport, gives teams a competitive edge, and requires immensely complex technology to use. And that force is data.

The FIA Formula 1 World Championship has allowed for telemetry data to be used since the1980s, when teams would send data in bursts as the vehicle passed the pit lane. Now data is constantly being transmitted from the cars' electronic control units, about every conceivable variable, from engine power to temperature status to aerodynamic load to fuel levels. The more data you have, the more valuable it is. And a continuous flow of data allows you to make specific decisions in real-time, rather than waiting for each lap to pass.

Every vehicle totals several gigabytes of sensor information during a race, and the race team in the paddock needs this information continuously to make their adjustments and fine-tuning. Each team on site also continuously exchanges data with its remote garage - an operational centre situated back at the team's HQ, where engineers can keep watch on all aspects of a race. On average, that data amounts to 350 Gb per race weekend.

Car-to-pit connectivity becomes essential. In 2017, Mercedes and Qualcomm used a system of two »

08

AT A GLANCE

01 Formula 1 manages and transfers huge quantities of data, with an average of 350GB exchanged between each on-site team and their remote garage every race weekend

02 The need for speed means that wireless technologies have been pushed to new frontiers, helping pave the way for 5G connectivity

03 Acceleration of this technology could help smart cities, smart cars, and remote working

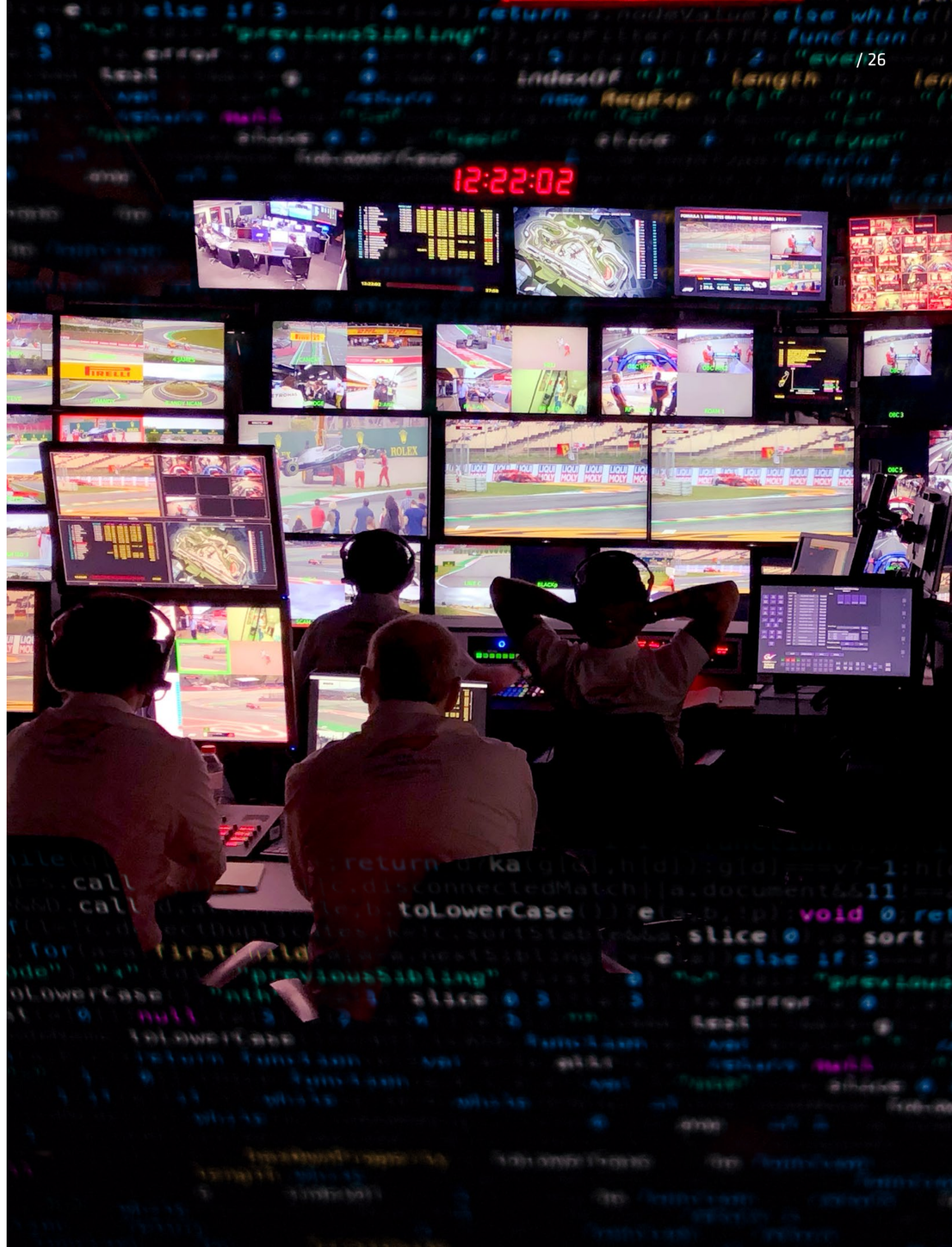
» high-tech wireless technologies, switching automatically to a higher frequency - offering greater bandwidth - while the race car travelled through the pit lane. Once the car was within four metres of the garage, it would switch to a rapid uplink, transmitting the data from the car to the garage at download speeds of up to 1.9 Gb every second.

The partnership began as a series of field-trials - a necessary step in the evolution of such technology. But the end goal was to develop the technology with an eye on the consumer market, using F1 as an ultra-fast, ultra-punishing Research and Development (R&D) environment. It's the kind of technology that will be useful in future smart car and smart city applications, with future fleets of autonomous vehicles requiring instant connectivity to function. And of course, in a world where entire industries are now working remotely, any advance in wireless technology could potentially benefit millions.

What's more, the technology and its hardware were tested in the most extreme and unforgiving environments before being expected to last for years in consumers' cars. That includes being exposed to the elements - be it the humidity of Singapore or the extreme heat of Abu Dhabi. The fact that motorsport can push tech to the absolute edges of what is physically possible with hardware, let alone digitally with software - massively drives and accelerates development.

By using motorsport as a laboratory for rapid data transfer and connectivity, Qualcomm said it can "assist in further developing technologies and applications that can be potentially used for safer road vehicles, as well as the pursuit of the wireless garage".

As ever, motorsport is all about the pursuit of speed - but in this case, the kind of speed that could benefit your laptop as much as your car.



09

REINVENTING TWO WHEELS

When we talk about technology transfer from racetrack to road, our imagination usually remains on four wheels. But in recent years, the contributions of motorsport have trickled down even to the humble bicycle, and specifically to the electric kind.

Demand for electric bicycles has surged across Europe in recent years, with city dwellers looking for a speedy - but environmentally-friendly - alternative to roadcars, while still wanting the independence they can't get from public transport. They also increase the distance people are willing to commute by bike. And for less physically capable riders, having a bit of power beneath the pedals makes cycling more accessible.

But as with any emerging technology, there are obstacles to be overcome before widespread adoption. The electric battery has to be powerful enough to propel the vehicle at speed, but not so heavy that it makes the vehicle bulky - it's not a motorcycle, after all. Battery range is another consideration, as people want to cover large distances without fear of losing power. »

AT A GLANCE

01 Electric bicycles offer sustainable mobility at speed, but are often heavy, clunky or difficult to store

02 Williams Advanced Engineering worked with Brompton to design and manufacture a foldable electric bike

03 The new vehicle represents a new kind of compact, lightweight mobility solution, derived from Formula E tech

» And there's a more serious issue, which is that customers in cities often lack safe places to keep their bikes.

Foldable bicycle specialists Brompton - the UK's largest bicycle manufacturer of any kind - thought that their vehicles might offer a solution. Their core product was already lightweight and easy to store at home. They just needed a way to integrate a motor and battery into the frame.

Which is where motorsport comes in. In this case, the team at Williams Advanced Engineering.

In the ABB FIA Formula E Championship, the challenge is to maximise range and efficiency while minimising size and weight (characteristics which are also essential to a foldable electric bike). And the Williams team brought years of knowledge to the task. In fact, they were the sole supplier of the battery system for the entire Formula E grid since the fully-electric series started 2014, until the end of its fourth season in 2018.

The team knew how to build a battery that could propel cars at speeds up to 225kph, but remained practical in terms of safety, aerodynamics, range and charging times. That expertise stemmed in turn from their experiences in Formula 1, following the introduction of new batteries and battery management systems into the sport in 2009.

Together Brompton and Williams set about taking electric racing battery technology and integrating it into a bicycle. It took them five years of trial and error. But ultimately they created a world-first: a two-wheeled electric mobility solution powered by Formula E technology.

The bike features a 300Wh battery, which weighs only 2.8kg, and can be removed and carried separately. Which makes it easier to use, considering the entire bike only weighs 16kg. Lightweight, durable and compact, it represents the future of electric cycling.

As for providing range, the motorsport experts poured their know-how into maximising the battery's output. The result: 50 miles on a single charge. More than enough for a commute or two. Or ten.

This pioneering partnership represents just the beginning of an exciting new era for sustainable transport in our cities. So, as Formula E technology becomes more and more commonplace on the road, don't forget - the road includes the cycle lane.

FLYING IN THE DRIVER'S SEAT

Though motorsport is all about speed on the ground, its technology transcends the tarmac.

By about 38,000 feet, in one case.

Planes are responsible for about 2% of total global emissions. The airline industry is therefore keen to find ways of drastically increasing efficiency, and a key part of that is reducing the weight of their aircraft. That meant looking outside the aviation world for lateral solutions.

Last year, JPA Design and Williams Advanced Engineering announced a partnership to develop new seating for commercial aircraft, inspired by Formula 1 materials. The new kind of seat chassis and mechanism will be made with Williams' proprietary lightweight technologies, RACETRAK and 223 - similar to those they use for racecars.

Most aircraft seating designs today feature cast or machined aluminium. Seat manufacturers don't have enough experience of lighter composites when it comes to producing primary support structures for their seats. Put simply, the know-how isn't there. And until recently, there wasn't a need for that know-how. But new aircraft will increasingly be expected to deliver major improvements in fuel efficiency to meet environmental targets. Consequently, the internal structures need to be as lightweight as possible. And across millions of flights, every kilogram counts.

In contrast to the conventional designs, the Williams-JPA seat design is created with a monocoque configuration which uses carbon »

IMAGE CREDIT: JPA DESIGN AND THE CABIN INTERIOR, WILLIAMS ADVANCED ENGINEERING

10

AT A GLANCE

01 Commercial aircraft seats are currently made from heavy aluminium because manufacturers have little experience of lighter composites

02 Williams are developing a new kind of Formula 1 inspired seating using carbon fibre composites to reduce weight by 5% per seat

03 The resulting savings from planes' fuel would be 942,000kg of CO_2 a year across a dozen planes, from just a 4kg weight saving per seat

» fibre composite moulding, drawing on Williams' many years working with it as a primary material for their racing teams. The composite provides the main support structure, which means that the traditional metallic sub-frame can be eliminated, resulting in an approximate 5% reduction in seat weight.

That might still sound like a small percentage. But to put it in perspective: replacing all business class seats with this lighter product on only a dozen long-haul planes would translate to saving 942,000kg of CO_2 and $195,600 in fuel per year, based on a 4kg weight saving per seat.

Despite the high-flying ambitions of the project, it is rooted in some of the same variables that motorsport has to contend with every day. Space. Weight. Safety. The task of balancing the three.

The two companies have been joined by British Airways and SWS Certification in establishing a consortium, supported by Airbus and with funding from the Aerospace Technology Institute. The goal remains to design, develop, manufacture and deliver a new, comfortable lightweight structure that can be used for premium cabin airline seats - and to push hard for recycled materials and reduced component counts throughout. As ever for tech transfer from motorsport, the sky is the limit.

11

AERODYNAMIC ARCHITECTURE

In motorsport, change is always in the air. Aerodynamic innovation is key to victory, and the tools for achieving it are more sophisticated than ever.

Wind tunnels have been used for years to blow wind over an object within a controlled environment. However, they're expensive, time intensive and incredibly energy intensive. Computational Fluid Dynamics (CFD) can do essentially the same thing, but within a computer simulation.

Much the same way that restrictions on fuel flow have spurred huge efficiency gains, innovation in CFD has been driven by constraint. For years, FIA regulations put a cap on the computational capacity available to Formula 1 teams, measured in teraflops. As a consequence, teams were forced to try and squeeze every last bit of performance out of what was available. Those regulations were recently removed, which means that having become extremely efficient at using CFD, teams are now able to let loose - potentially leading to greater advancement than ever before.

CFD allows teams to virtually analyse their design from every possible angle - and even from "impossible" angles that wouldn't be visible in real life. It allows for predictions to be made before even a single prototype has been developed. And in the long run it allows for rapid design cycles, with minimal downtime - a necessity between races. »

AT A GLANCE

01 Aerodynamics are fundamental in many industries, but wind tunnels often bring problems of scale and expense

02 As the FIA's premier championship, Formula 1 has provided a supreme testbed for innovation - and CFD innovation has been accelerated by F1 investment, time and competition

03 CFD technology refined in F1 can now be used in surprising ways for society, for example in regulating wind spill from skyscrapers

» For two decades, F1 teams have invested huge quantities of time and money into CFD development. Teams have sponsored the development of CFD techniques and research programmes. And while commercial CFD providers are ultimately responsible for inventing the technology, F1 has undoubtedly helped accelerate it to where it is today.

It might seem like quite a specialised kind of technology. But in fact, CFD innovation can be applied in almost any field where gas or liquid flow is involved. That can range from air conditioning to wastewater treatment to...more unusual problems.

For example: solving wind spill from skyscrapers. It's an issue most people haven't heard of. Yet wind spilling off tall structures is a major problem in urban environments, and wind funnelling around buildings can create uncomfortable or even dangerous conditions for pedestrians below. Planning authorities often require evidence that wind spill will not cause these sorts of issues.

Traditionally, architectural teams would use wind tunnel testing of scale models (built to only 1/250th of the size), much like F1. However, scale effects make it extremely difficult to accurately quantify the real world impact of a full size building.

Which is where CFD comes in. At Wirth Research, led by former F1 team owner and CFD pioneer Nick Wirth, motorsport expertise is essential to making architectural calculations.

Such as when the Wirth team consulted on the design of 22 Bishopsgate, a planned 278m, 62-storey tower in the City of London. Once it's completed, it's due to be the 2nd tallest building in London. "Downwash" wind from the proposed building was due to batter adjoining roads and pavements, creating unpleasant conditions for pedestrians.

Wind tunnel testing of all the solutions, even if possible, could take months. Instead, Wirth ran innovative "high-res" CFD simulations of 25 variations of designs before identifying the most effective. All within three days.

Wirth proposed a variety of novel measures to deflect, absorb and dissipate the "downwash" winds around the building, which directly helped the building secure planning. Since then, the team has worked closely with the architects to keep improving on their CFD-based solution.

"This technology has been refined at the coal face of F1 design and can offer insight and a level of detail that no wind tunnel can achieve," the Wirth Research team commented.

As computational power grows, and digital modelling becomes more accurate, this kind of flow analysis will become even more common, across a range of industries. All born out of the whirlwind of innovation that is motorsport.

SAFER MOTORISTS

SETTING THE STANDARD

The current generation of Formula 1 helmets are, without doubt, the safest helmets to ever shield a human head. And now the FIA is regulating for their use across many competitions, including the FIA World Rally Championship.

These are helmets that can withstand a falling 10kg weight from a height of five metres. They can withstand a 225g metal projectile fired at 250km/h. They can be exposed to 790C° flame and self-extinguish once the flame is removed.

The FIA 8860-2018 standard outlines more of these safety and testing levels. The standard was the result of over ten years of research, co-funded by the FIA Foundation, and marks an improvement on top-level helmets which were already considered the safest in the world.

Ground-breaking work has also been done for young drivers and children. The conventional idea had been that a young driver helmet should simply be a smaller version of an adult one. But through research funded by the FIA Foundation, that thinking was upended.

The central finding was that young drivers require lighter, softer helmets that also compensate for their smaller and weaker necks. Within two years of intensive research and development, a new youth helmet standard was created for the physique of two age groups, based on the 8860 standard for safety. »

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AT A GLANCE

01 The FIA 8860-2018 helmet standard set a new bar for safety in motorsport competition

02 Two major helmet safety projects are underway for society at large: Firstly, to create a new international safety rating system

03 Secondly, to distribute a low-cost, high-standard motorcycle helmet to save lives across the globe

“One reason these companies are interested in partnering with us is they see the work of the FIA as a potentially disruptive force in the market and they want to be the first to benefit from what we are aiming to achieve in what is already quite a crowded commercial space.”

» Now, this world-class helmet expertise is being applied where society needs it most: for the protection of motorcyclists.

One of the key objectives of the UN Decade of Action for Road Safety is to reduce motorcycle casualties by encouraging the use of safe helmets. The UN found that up to 3-4 million deaths might result from motorcycle crashes between 2008 and 2020, and as many as 1.4 million of those fatalities could have been avoided with the proper use of safe helmets.

Therefore, one FIA project involves creating a new, international rating system for helmet standards. In a sense, it would be similar to rating systems widely used for roads or road vehicles. The project will build on motorsport’s vast knowledge in the area, as well as the FIA’s experience of using Mobility Clubs to advocate road safety.

The goal is to empower consumers to compare and choose their own helmets by focusing on safety criteria. Through the use of FIA labels, consumers will be able to understand the relative safety performance of different helmets, and recognise the role of the FIA as a global advocate and standard-bearer for safety.

Alongside this project sits another initiative. It’s perhaps the single most important of the FIA’s public safety initiatives, in terms of potential impact: the creation of a low-cost, high-standard motorcycling helmet.

The helmet is intended to be available in emerging nations, where motorcyclists are most at risk of injury or death. Asia specifically is home to about 240 million motorbikes, mopeds and scooters - 80 percent of the world’s total. But the majority of countries in the region allow for the use of helmets which provide lower protection compared to the UN’s helmet standards, which are mandated across Europe and in 79 countries across the world. Often that’s due to sheer expense, or the fact that UN regulation helmets are not specifically designed for the heat and humidity of the typical Asian climate.

And a low-quality helmet can be as dangerous as none at all, as observed by the UN in a 2016 Motorcycle Helmet Study: “A low quality helmet might give the rider a false sense of protection. In case of a crash, a rider using a low quality helmet could get more severely injured or even killed.”

So, President Jean Todt laid down a challenge to the FIA Safety Department: create a low-cost, high-standard helmet to be used across the globe. More specifically, it should be available at a wholesale price of 10 US dollars, comfortable to wear in hot and humid countries, and certified according to the UN’s helmet regulation (UN Reg.22.05).

The challenge was a unique one. As FIA Safety Director Adam Baker commented: “If you consider the various product characteristics – cost, ventilation, weight and safety performance – it’s a combination that hasn’t existed before. The market forces didn’t naturally produce a product of this type because in the majority of countries where you have the UN Reg. 22.05, the price range of helmets on the market is well above the $10 US wholesale price point, and in lower-income countries you don’t have the requirement for UN Reg. 22.05.”

Baker and his team first looked at European helmets that were already lightweight with good ventilation, and refined the design to make it more affordable without diminishing its safety performance.

Working together with Spanish helmet manufacturer NZI, FIA safety engineers soon manufactured a helmet that could be produced at an affordable price and still pass the UN safety tests. Thousands of these helmets have now been produced for field testing, in order to ensure that they are fit for purpose in hot and humid climates. »

» The FIA's Mobility department has started testing the first batch of helmets across several countries, working with FIA member clubs, road safety agencies and local stakeholders to promote the helmets to a cross-section of motorcycle riders.

The next step: partnering with manufacturers to produce their own version of the low-cost, high-safety helmet. The FIA recently agreed a deal with Steelbird, a helmet manufacturer based in India who already produce an approved helmet for the country, and is discussing a similar programme with a Vietnamese helmet manufacturer. It's an effective way for the new helmet to penetrate a market through an existing supplier.

As Baker added: "One reason these companies are interested in partnering with us is they see the work of the FIA as a potentially disruptive force in the market and they want to be the first to benefit from what we are aiming to achieve in what is already quite a crowded commercial space."

With President Todt and the FIA advocating for more countries to mandate UN Reg.22.05, more markets will require an affordable, wearable helmet that can meet the standard. The FIA's present and future partners will be well positioned to satisfy that demand.

There's a long way to go, but astonishing progress has been made in helmet safety in just a few years, thanks to the work of many sharp minds. It's a huge step towards keeping motorcyclists safe all over the world. And it's another reminder that the most valuable technology in motorsport is the one inside the helmet: the human brain.

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AT A GLANCE

01 Devastating spinal injuries can often occur in crashes both on racetracks and roads

02 The FIA teamed up with Toyota, using THUMS to simulate the human body in virtual crash testing, in order to discover the cause of such injuries

03 Motorsport's unparalleled crash data continues to help improve the already world-class THUMS software

A MODEL FOR SAFETY

Five hours into the 2012 Le Mans 24 Hour race, Antony Davidson's car collided with another vehicle, somersaulted, and hit the barriers head-on. Davidson escaped the horror crash with his life but had a severe injury in the form of crushed vertebrae.

The FIA had seen this kind of injury before, in a Le Mans car the previous year. Guillaume Moreau had injured one of the same vertebrae, also from a frontal impact.

It's an issue that isn't confined to motorsport. Over 6,500 spinal injuries occur in car crashes every year in the US, according to the National Spinal Cord Injury Statistical Center. There's a reported tendency for these injuries to occur in frontal impacts.

The FIA was well positioned to investigate further, having driven huge advancements in motorsport safety as well as road safety. The problem is that the spine is almost impossible to research using traditional dummies. Dummies are not intended to feature faithful models of the human spine. Instead, they house a basic mechanism that doesn't flex beyond adjusting seat posture. Real world correlation is sorely missing. And what's more, physical crash simulations are hard to repeat, with numerous, highly precise variables involved each time. That lack of replicability means that it's difficult to get accurate results.

So, the FIA teamed up with Toyota to use its Total Human Model For Safety (THUMS) software, a computer model that represents the human body. The software uses Finite Element (FE) modelling to simulate how individual bones and organs react in the event of an accident. THUMS is one of the world's most powerful simulations of the human body in any field, featuring almost two million elements in its model - but like any data model, »

» the quality of output is governed to an extent by the quality of input.

Specifically, THUMS requires highly detailed, real world cases of high-speed impact. The more detailed the cases, the more useful the analysis that THUMS can provide. And this is where motorsport is able to provide data in detail that would be impossible for the real world.

In a major competition, every vehicle and driver is instrumented, and there's often video footage of the accident. These are essentially real life crash dummies, which allows models to be compared with humans to deliver more accurate results. The on-board Accident Data Recorder (ADR) allows for unparalleled data recovery after an incident. Sometimes there's even high-speed video footage of driver dynamics. Detailed medical information is usually available after an accident. And the driver generally takes part in post-accident investigations, including MRI scans.

These resources together represent a data goldmine for THUMS, and have already contributed to the development of the system.

Following the Davidson accident, the FIA used Europe's largest MRI scanner to create scans of a driver sitting in a full-size race seat. The results of the scans were then sent to Toyota to feed into THUMS for virtual crash testing. Not only were they able to simulate the position of every vertebra, they could analyse the impact upon internal organs such as lungs, heart and liver. THUMS was also able to recreate historic crashes and compare to similar scenarios for smaller and taller drivers.

The project yielded numerous insights into preventing spinal injury upon impact. Changes were made to LMP1 regulations for 2020/21, mandating a different seating position to spread pressure between each vertebra.

Since then, the FIA has brought THUMS capability in-house, to be used by experts in biomechanics and virtual modelling of the human body. It was a move that heralded a new era in motorsport's use of the technology.

One subsequent breakthrough involved Cross Country Rally competition. Once again, research was initiated following reports of spinal injury, this time from Cross Country competitors during a heavy impact or landing.

With THUMS at their disposal, the FIA Safety Department conducted an extensive investigation into the issue. The team ran thousands of tests to examine how even marginally different seating positions could affect the spine.

After thorough analysis, the FIA found a number of risk factors that could lead to spinal injuries, and were able to identify and improve driver seating positions to help prevent such injuries from occurring. »

Toyota deserve huge credit for developing the technology, over two decades of continuous evolution and improvement, into the industry standard that it is today.

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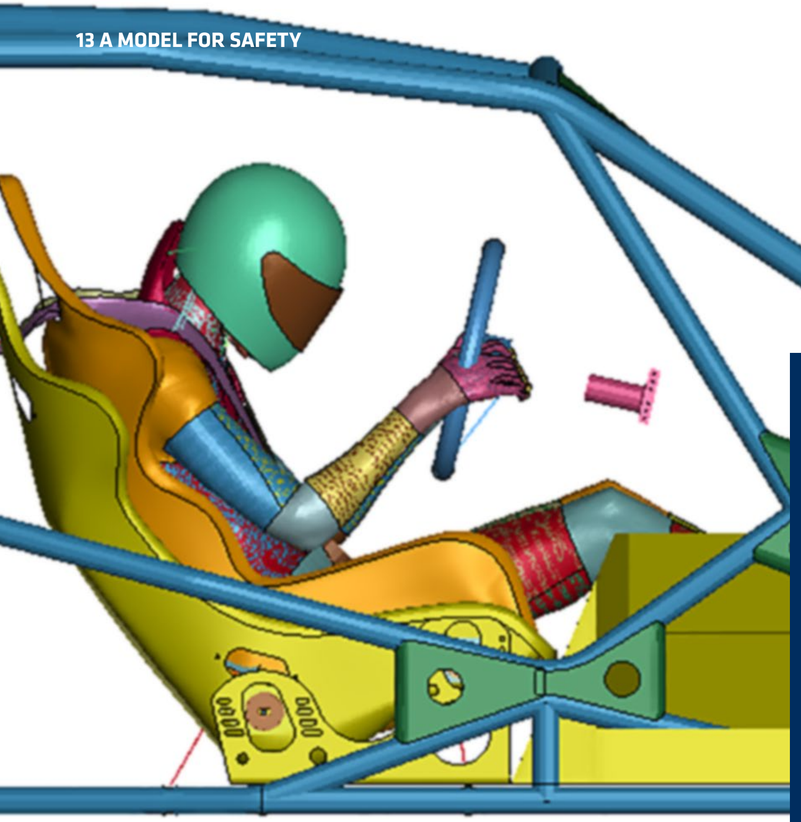

» To select just one example that illustrates the precision of THUMS analysis: the rotation of a competitor's seat. The FIA Safety team found that changing the angle of the seat from the normal upright position of 40 degrees to 60 degrees equated to a huge 22 percent reduction in the forces that translate to spinal fracture during a heavy landing.

The team's extensive findings also included detailed recommendations for changing the angles of the lap strap, crotch strap and shoulder strap of the safety harness. The research also examined how the weight of a competitor affected risk of injury, finding that a change in weight from 84kg to 74kg led to an eight percent reduction in the chances of spinal injury. All these changes can now be implemented in future regulations to protect drivers.

As Adam Baker, FIA Safety Director, concluded: "The THUMS simulation has enabled us to continually research a wide range of Cross Country accident cases, and improved our understanding to refine the best practice for the seating position of competitors in Cross Country competition vehicles. We would like all competitors and teams to understand the results of this research as even minor changes to seating position can prevent injury."

It's pioneering research that wouldn't have been possible without THUMS. And Toyota deserve huge credit for developing the technology, over two decades of continuous evolution and improvement, into the industry standard that it is today. It's currently used by over 100 companies and institutions working to develop better safety features and reduce the impact of crashes. Motorsport's role has been to help a ccelerate the software's development in a way that only motorsport can.

From 2021, the software will be available to all, so that an even greater number of experts can use it in their vehicle safety research. A rich scientific community has sprung up around the software, contributing knowledge, which will in turn improve the usability of the tech.

This rapid advancement promises to help reduce the development lead times and costs associated with collision testing for road safety. But THUMS will continue to need data on impacts at speed in extreme conditions. And in that regard, motorsport is the world's greatest database.

A FOUNDATION FOR SOCIETY

Motorsport's influence off the track goes beyond technology or knowledge. Sometimes it's about offering attention – and funding – to areas of society that would otherwise go neglected.

This is the heart of the work of the FIA Foundation. The Foundation was born directly from motorsport – it was created in 2001, through the FIA's donation of the entire proceeds from the sale of Formula 1 commercial rights at the time.

The Foundation is an independent charity which works to support an international programme of activities promoting road safety, the environment and sustainable mobility, as well as having previously contributed to motorsport safety research.

The organisation has worked on numerous impactful projects, but there are two standout partnerships that best illustrate the Foundation's capacity for good: Global NCAP and iRAP.

Global NCAP (New Car Assessment Programme) is a platform for co-operation among new car assessment programmes worldwide, and has received significant funding from the FIA Foundation over several years. The goal and aspiration of NCAP is a world free from road fatalities and serious injuries, largely through adoption of United Nations safety standards, and the application of best practice safety design in vehicles. »

14

AT A GLANCE

01 The FIA Foundation was founded in 2001 to promote an international programme for road safety, the environment and sustainable mobility

02 One of their partnerships is with Global NCAP, whose new car assessment ratings are estimated to have saved thousands of lives (an estimated 78,000 by Euro NCAP)

03 The FIA Foundation is also the primary donor for iRAP, which seeks to end the public health crisis that currently exists on our roads, with 1.35 million people dying worldwide every year

» Euro NCAP has been established for years, with most manufacturers routinely looking to achieve strong results according to the programme's rating system. In fact, over 87% of cars sold in the EU have a Euro NCAP rating and 79% achieve the top-level score of five stars. Over time, the rating system has evolved to include advanced crash avoidance systems such as electronic stability control (ESC) and autonomous emergency braking (AEB). It's been estimated that the combination of EU legislation and Euro NCAP crash ratings have saved around 78,000 lives since 1997.

And just as the EU has benefited from the life-saving impact of improved car safety, NCAP ratings and safety legislation are starting to make an impact around the world. In 2015 a study commissioned by Global NCAP showed that in just four Latin American countries (Argentina, Brazil, Chile and Mexico) over 440,000 deaths and injuries could be prevented by 2030, saving $143 billion, if they fully apply the UN crash test standards and support the work of Latin NCAP.

And having this single metric for safety has led to an interesting result: car manufacturers competing with each other to produce the safest vehicles.

Euro NCAP has also supported the launch of Green NCAP, an initiative to promote the development of clean, energy efficient cars which are not harmful to the environment. By using a star rating for both CO_2 and vehicle emissions, the goal is to stimulate competition and create incentives just as the road safety NCAPs have done.

As for iRAP (International Road Assessment Programme), the scale of their work is equally broad. In brief, their mission is to deliver safer roads for all who travel on them.

As many as 1.35 million people die a year on the world's roads. Every single day, an estimated 100,000 people suffer life-changing outcomes including brain and spinal injury, quadriplegia, degloving, limb fractures and internal injuries. IRAP seek to end this public health crisis. Astonishingly, targeting just the most dangerous 10% of the world's roads could prevent 50% of the world's road fatalities.

The FIA Foundation has been the primary donor for IRAP for more than 15 years. Through the FIA's member clubs, iRAP has been able to raise awareness of the need for action and the significant human, social and financial benefits of improving road safety.

And huge progress has already been made.

> Since iRAP's establishment, the charity has reached 101 countries around the world, analysed over 25.8 million km of road, and has trained more than 25,000 road designers, engineers, road safety practitioners and NGOs in how to make roads safer, including FIA members.

iRAP's Star Ratings provide a simple and objective measure of the level of safety "built-in" to a road for vehicle occupants, motorcyclists, bicyclists and pedestrians. Five star roads are the safest, while one star roads are the least safe. One star roads may lack features like safe turning provisions or clear traffic divisions. The iRAP global standard for road infra- »

» structure is key to supporting countries to achieve the United Nations Sustainable Development Goals and in particular, UN Targets 3 and 4 for all roads to be the equivalent of 3-star or better for all road users, which if achieved stands to save an estimated 467,000 lives every year and 100 million lives and serious injuries over the 20-year life of the road treatments.

The Bruce Highway in Australia offers just one example of iRAP's system at work. The highway used to be one of the deadliest stretches in the country. It is now one of the safest, having improved from a 2-star safety rating to 4- and 5-star, following a State and Federal Government funded upgrade. The RACQ Queensland mobility club was instrumental in community advocacy for the project. The improvements have led to an 80%+ reduction in road trauma on some sections, and annual monitoring is in place to monitor the life-saving success along the whole corridor.

And in terms of impact at scale, 10 countries have set 3-star or better policy targets at the project level including Saudi Arabia, UK, Malaysia, New Zealand, Sweden, China, Netherlands, Australia and Chile and five institutions including the United Nations, World Bank, Asian Development Bank, UNESCAP and the Millennium Challenge Corporation.

Both Global NCAP and iRAP's achievements are saving lives each and every day in communities across the world. And the FIA Foundation donor support and FIA partnerships around the world are central to this life-saving success. It's an example of the part motorsport can play beyond the track; not always in the limelight, but working behind the scenes to get things done. Like a well-drilled member of a pit stop crew, the FIA Foundation plays a key role in enabling and supporting the work of others.

SUPERIOR ELECTRIC

LEADING THE CHARGE

15

AT A GLANCE

01 The FIA Formula E Championship seeks to make electric mobility a global reality, but there are barriers to adoption

02 Regulations have forced huge innovation in energy management and efficiency

03 The next stage is making strides in ultra-fast charging, making electric more appealing than ever

As the FIA Formula E Championship begins its third generation of racecar design, it edges closer to completing its ultimate mission; namely: “to make electric mobility a global reality”.

The first generation of Formula E racecars had a simple job. Firstly, to demonstrate that electric vehicles are able to race and compete at speed. Secondly, to inspire roadcar users with a vision of having it all: the performance they are used to, without the emissions.

With that job completed, the second generation sought to showcase battery lifespan. The more that EVs can get from their batteries, the easier it is to reassure range-anxious motorists about running out of charge on a long drive.

As it is often the case in motorsport, regulations have forced innovation. Teams aren’t allowed to charge or replace their battery mid-race, and areas like aerodynamics are strictly controlled. As a result, energy management is one of the few places where teams can seek to gain a competitive advantage.

The name of the game is efficiency. The team that can get the greatest efficiency out of the electric powertrain has a better chance of winning. And advances in efficiency translate directly to roadcars. “The time frame between what we race »

» and what we see on the road is approximately 24 to 30 months," says Mahindra Racing, Team Principal, Dilbagh Gill."The racing department sits directly underneath the technical development department, and so there is always the very close hand-in-hand relationship between what we do on the track and what actually comes on the road," says Allan McNish, Audi Sport's Formula E Team Principal.

It's the same story at other automakers, with Nissan's global motorsports director Michael Carcamo calling Formula E a "high-speed laboratory for electric vehicle development". Carcamo noted that it works both ways, commenting: "We were able to directly transfer strategies from [our electric roadcar] to our Formula E program. They share the same DNA."

The third generation of that laboratory has a fresh focus. While still tackling battery management, Formula E will also seek to make strides in rapid charging. The faster batteries can be charged, the more convenient electric mobility becomes - removing a significant barrier to mass EV adoption.

Currently, Enel X provides the DC fast chargers used by every Formula E team to recharge their racecars' 54kWh batteries. They use the competition as a way to test their high-charging systems, iterating everything from the weight of the chargers to the robustness of the cable material. The nature of Formula E - a highly competitive, globally broadcast event - means that the charging systems are under unmatched scrutiny. After all, if the cars can't charge, the race can't happen. That kind of pressure only helps to refine the technology. It has to work. It has to work well. And it has to work fast.

What's more, pit stops dedicated to showcasing "flash" charging will be introduced for the 3rd generation of the FE car (due to be introduced in 2022-2023) with the ground-breaking capacity to charge at 600 kW, for 30 seconds, replenishing roughly 10% of the batteries' capacity. This will allow for longer races (which are currently capped due to battery range), as well as introducing the world to a new dimension of power for automotive charging applications.

It's one more piece of the puzzle that could help drive widespread consumer adoption. It takes a lot to convince the public to move on from a century of internal combustion. But motorsport may have found a winning formula.

BEYOND THE BATTERY

There is more to electric mobility than electricity. Building better electric roadcars is also about the transfer of new materials from the track to the road. And the ABB FIA Formula E Championship acts as a world-class testbed in that regard.

Take the BMW iFE.20, the latest Formula E racecar to emerge from the respected manufacturer. As fine a vehicle as the manufacturer has ever produced, but for the first time, featuring parts made of renewable textile fibers. In this case specifically, the flax used to make the cooling shaft.

In a Formula E racecar, the cooling system feeds air from the sidepods into the radiators via the shaft, so that it can lower the temperature of the powertrain's big guns: the motor, the battery and the electronics. Now, that vital function can be fulfilled using sustainable materials rather than carbon.

But not only is the flax more sustainable than carbon, it even provides a few competitive advantages to its well-established predecessor. Flax boasts greater absorption and impact resistance than carbon, which is a welcome bonus on Formula E street circuits, where bumps and crash barriers are commonplace. It also helps, of course, in the event of contact with other cars. BMW are already exploring how the material might be used in other racecars before ultimately reaching the road.

As well as finding more sustainable materials to use, manufacturers are seeking lighter ones. Formula E »

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AT A GLANCE

01 Electrical Vehicles need to advance more than just a sustainable form of propulsion

02 For BMW's latest racecar, they replaced carbon fiber with flax, a renewable material, for its cooling shaft

03 These and other advances underline the role of Formula E as the world's foremost platform and showcase for testing new EV materials

» teams can't change their battery or aerodynamics, so have to find weight savings elsewhere. Reducing mass translates directly into performance improvements and efficiency gains, and will pass on to the next generation of electric road vehicles. Not only that, but lightweighting strategies for EVs can mean increasing range, or reducing battery size and cost.

BMW were able to slice a chunk off the weight of their racecar motor by supporting it with composites including resins, titanium and ceramics.

The company also used its 3D printing expertise at its new $11.2 million facility near Munich to create components like a 360-degree aluminium motor casing - the first step in a plan to make 50,000 3D-printed parts a year for all of its vehicles. The rise of 3D printing makes it easier for manufacturers to optimise their lightweighting process, using exactly the right quantities of material.

These pioneering advances underline the role of Formula E as the world's foremost platform and showcase for EV materials and methods. Several manufacturers see their Formula E wing as a "tech lab" on wheels, offering the chance to road test experiments that can then be transferred to their consumer vehicles.

And the tech transfer works both ways. Within BMW, the team that has been developing electric motors, inverters, and software for the brand's consumer electric vehicles, and was selected to do the same job for the Motorsport division. It's a two-way street, with knowledge travelling in both directions. Or, rather: it's an alternating current.

GOING THE EXTRA MILE

Imagine a future in which your car could be improved overnight, without you having to lift a finger. Where manufacturers could transfer tech from racetrack to road within hours.

We're not far off that future right now. Take the example of Jaguar Land Rover's first electric car, the I-Pace. The elite manufacturer had used a race-spec version of the vehicle in their I-Pace eTrophy series, supporting the ABB FIA Formula E Championship. The competition was launched in 2018 as the world's first all-electric production-based international series. It was specifically intended to generate insights that the manufacturer could apply to roadcars. And in that regard: mission accomplished.

After two years of running the series, Jaguar were able to gather huge amounts of data from taking the I-Pace to its limits - and beyond. According to Stephen Boulter, I-Pace Vehicle Engineering Manager: "The Jaguar I-Pace eTrophy has generated a huge amount of data for us to analyse and those marginal gains, derived from competition on the track, are now being applied to customers' cars to further enhance their driving experience." »

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AT A GLANCE

01 It used to take a while for racetrack innovations to filter down to the road, usually requiring new production vehicles

02 Jaguar used learnings from their I-Pace Trophy series to improve customer models with a software update, including adding over 19km (or 12 miles) of range

03 Software over the air allows for interconnected vehicles to rapidly apply motorsport-derived upgrades with no more need to be replaced

» Consequently, they were able to make a number of changes to their roadcar model. They improved the battery capacity, allowing the battery to reach a lower state of charge than before, without any negative impact on performance, durability or drive-ability. They improved the regenerative braking system, enhancing energy harvesting, as well as increasing energy recovery at lower driving speeds. They even refined an element as subtle as temper-ature control, closing radiator vanes to enhance the car's aerodynamics.

Notably, they were able to provide gains to range, with an improvement of up to 19km or 12 extra miles on a full battery - about a 5% increase. Considering range anxiety is one of the biggest barriers to electric adoption, even a marginal range increase is significant. Every extra mile matters.

Additionally, the predictive range calculator was fine tuned. The updated algorithm allowed drivers to make a more accurate assessment of remaining range, based on their driving style.

But the most significant feature of all? Every single one of these improvements was made not by a mechanic, but via a software update at a local retailer. No changes were needed to any part - it was purely about getting the most out of the existing car and battery. And the update was completely free, positioning this not as a premium service, but as the kind of standard procedure that could be commonplace in future.

Following further updates, customers were able to receive more motorsport-derived improvements from their own home. It's a glimpse of one of the least-talked about, but potentially most significant aspects of an interconnected future. When a software update can change your vehicle over the airwaves, racecar technology could potentially reach millions of garages not long after leaving the track. Which means in future, problems like range anxiety won't have to be fixed - they'll be patched instead.

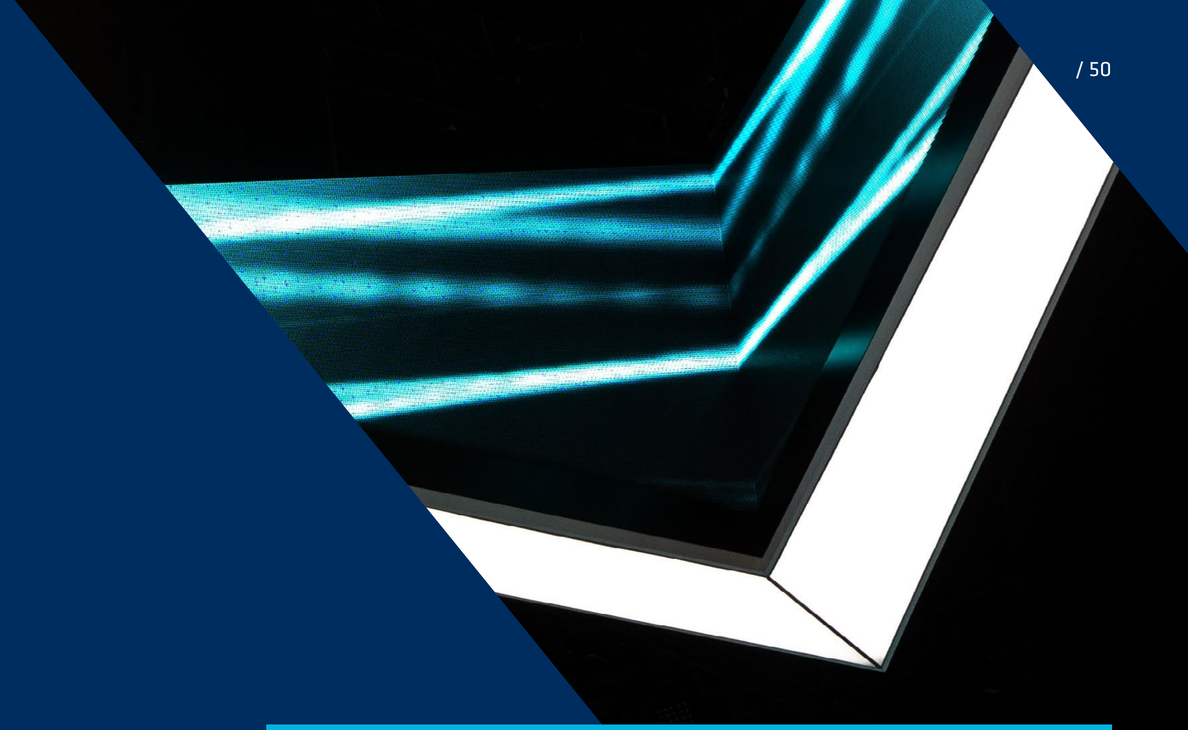
THE LIGHTNING LABORATORY

There are two kinds of speed that matter when it comes to electric mobility. How fast you can go - and how fast you can charge.

To see what's becoming possible in electric charging, just take the example of Porsche. The manufacturer has been developing pioneering electric roadcar technology for years, derived from the 919 Hybrid used over four seasons of the FIA World Endurance Championship.

In electric drive systems, the voltage level affects absolutely everything, from the design of the battery to the technology used to charge it. Porsche pushed for an unprecedented 800-volts for the architecture of the 919 Hybrid. That had ramifications for every aspect of the drivetrain. It won them Le Mans - three times in a row. But importantly for society at large, it taught the manufacturer lessons that would one day benefit roadcars: including cooling and connection techniques for the high voltage battery and electric motor.

The manufacturer now describes that famous racecar as "a rolling test laboratory [that] paved the way for the voltage level of future hybrid »



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AT A GLANCE

01 Charging at speed is a pressing need for widespread EV adoption

02 In one example, the 800-volt architecture of a race-winning hybrid vehicle was adapted for a production vehicle

03 In less than 10 minutes, the battery can provide up to 120 miles of additional range

The first of its kind in a production vehicle, the Taycan boasts the same 800V system - which allows for quicker charging than ever before.

» and electric powertrain systems". That same lightning-in-a-bottle technology is now being brought to the road in the form of the Taycan. It suggests the start of a new era for supercars, proving that you don't need the traditional cylinders and fuel tanks to be truly fast on four wheels.

The first of its kind in a production vehicle, the Taycan boasts the same 800V system - which allows for quicker charging than ever before. Almost all other electric vehicles are still equipped with 400V electrical systems - and that's generally considered to be high voltage.

In the 919 Hybrid, the battery was charged through recuperating energy from braking and exhaust gas, feeding the motor in turn. In the Taycan, charging is primarily done at home.

To increase the charge that a given EV system can accept - or the power that it can deliver - either the voltage or the current needs to be increased. If voltage is ramped up, current can be reduced, which results in a reduction in heat build-up.

This has benefits for both efficiency and constant performance, as the powertrain can be stressed for much longer (compared to a lower voltage architecture).

In addition, this kind of vehicle represents a huge milestone for electric mobility as a whole, because it allows faster and higher capacity charging without the need for huge charging cables. And the chargers that are used can be more powerful than ever - up to 350 kwH.

In less than 10 minutes, the battery can provide up to 120 miles of additional range. To go from 5% to 80% state of charge takes just 22.5 minutes under ideal conditions. It's the sort of progress that makes electric charging more and more convenient for drivers.

What started with a racecar, and has now reached a sportscar, will inevitably reach regular roadcars. And when it does, what began as lightning-in-a-bottle will become the thunder of an electric revolution.

HYPER EFFICIENCY

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BACK TO THE FUTURE

Racing is forward motion in every sense. There's rarely time to look in the rearview mirror. But sometimes it's worth pausing to consider the past, to prepare for the future.

Motorsport's contributions to society are not a new development. Take the disc braking system. Until midway through the 20th Century, racecars still used hydraulic drum brakes, prone to overheating and potentially dangerous in wet conditions. But Jaguar had noted the many advantages of the disc brake, pioneered in the aviation industry.

At Le Mans in 1953, the Jaguar C-Type boasted disc brakes on all four corners. With superior stopping performance and heat dissipation, Jaguar dominated the competition, taking the top two spots in style and shattering records in the process. It took several more years before the disc brake reached roadcars, but once it did, it took hold for good. Today, the technology can be found on almost every road on Earth.

And that's not even the oldest of motorsport's innovations. In fact, one of the most widespread contributions to society is an idea so old that it pre-dates the First World War.

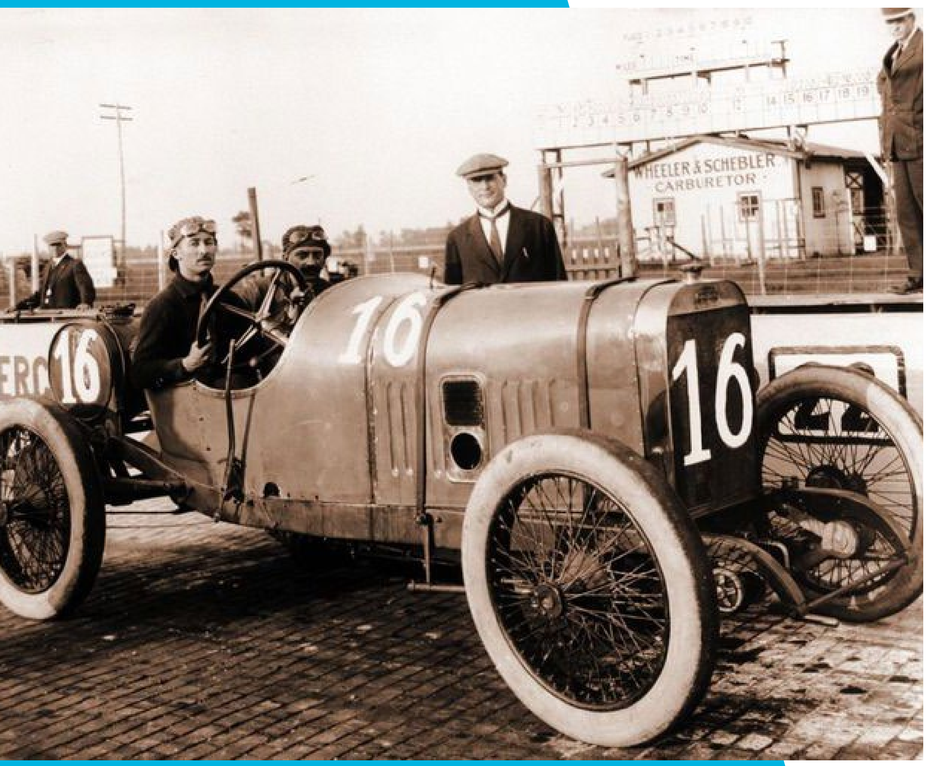
It began as a secret weapon, designed by a team of three driver-mechanics and one engine expert: Paolo Zuccarelli, Jules Goux, Georges Boillot and Ernest »

AT A GLANCE

01 Motorsport's contributions to society aren't new; they've been happening for over a century

02 The Double Overhead Camshaft was a piece of early innovation, designed for performance, that ultimately delivered efficiency to roadcars

03 The DOHC serves as an example of motorsport's enduring ability, and responsibility, to impact millions of vehicles worldwide



» with a revolutionary idea: the world's first Double Overhead Camshaft (DOHC).

A camshaft is used to open and close the valves that let air into (and exhaust out of) an engine. At the time, the camshaft was located low down within the cylinder block. In a DOHC design, the camshafts move to the top of the engine, above the combustion chamber, saving weight and complexity, and allowing for faster revs.

And instead of having a single camshaft managing two valves per cylinder, a DOHC design features two camshafts managing four. That means more power (more air into the cylinder) and less wasted energy (as it's easier to pump exhaust out).

At the time, this idea was considered so maverick that the four-man team was dubbed "Les Charlatans" by Peugeot's engineers. But it was the so-called charlatans who won the day. Their design brought Peugeot a commanding victory in the 1912 French Grand Prix, and launched an era of DOHC innovation.

While the DOHC technology from Peugeot's car was developed purely to claim victory on the track, there was an obvious benefit to be had on the road. The speed gained was the result of a jump in efficiency. So, when that same technology was applied to roadcars, those efficiency gains meant that regular motorists could enjoy more speed and more range for less fuel.

Today, the once-secret weapon can be found on almost every road in the world. It took a long time for DOHC layouts to take hold within production vehicles, finally reaching affordable roadcars in the 1950s, but eventually they became the undisputed standard. As far as the internal combustion engine goes, it's difficult to think of a single innovation that has offered more in terms of sheer efficiency. And efficiency is the key to almost everything else, including fuel savings.

But even more importantly, the DOHC is perhaps the earliest example of motorsport's unparalleled potential to make a lasting impact on society. A single piece of cutting-edge technology is still a staple on the world's roads, over a century on from its invention. One well-designed racecar can directly shape millions of roadcars that follow in its wake.

That impact is both an opportunity and a responsibility for the entire industry of motorsport. An innovation intended for a few laps on a racetrack can last a lifetime on the road. Victory is measured in seconds; legacy, in decades.

ELECTRIFYING PROGRESS

Electricity is fundamental to the future of mobility. Not just for battery-powered electric vehicles - but for the future of the internal combustion engine.

And with 2 billion conventional cars on the roads, and alternative fuels still a long way off in some parts of the world, the internal combustion engine still needs improvement.

Which is why electrified turbochargers are great news. They can dramatically increase the level of power that can be extracted from an engine for a given capacity. Which in turn can accelerate the current trend for engine size decreasing, whilst power increases.

It all comes back to optimising the mix of fuel and air in a traditional engine. The famous naturally aspirated engine draws air into the combustion chamber through a partial vacuum.

Essentially, the piston retreats, the intake valves open, and a vacuum is created which in turn pulls in the air. Turbochargers, by contrast, push air in under force into the engine.

With conventional turbochargers, the engine gets to high pressure, which in turn produces exhaust gases which spin a turbine, connected to a compressor wheel, which pulls in air and pushes it into the cylinders. But that means a lag time while waiting for the turbine to start spinning. The larger the turbo compressor, the longer that lag will be. Of course it's more efficient than a naturally aspirated engine, but not as driveable or as efficient as it could be - if only there were no lag. »

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AT A GLANCE

01 The internal combustion engine can still be improved in parallel to the inevitable rise of electric mobility

02 Using technology derived from Formula 1, the electrified turbo offers a way to eliminate lag and gain efficiency

03 Initially appearing in high-performance cars, it will eventually reach regular roadcars

» An electrified turbo can nearly eliminate that lag. Such a system uses an electric motor to keep the turbo spinning even at low rpm, when exhaust gas flow is too low to do the job. This mechanism is similar to way the Motor Generator Unit-Heat (MGU-H) functions within a Formula One racecar, taking heat from waste exhaust gases and converting it to support the turbo and reduce lag.

What's more, the motor can act as a generator when it's not required, such as when slowing down or when the driver "coasts" at speed. At that point, the spinning turbo's inertia can be captured and sent to the vehicle's battery. That's "wasted" energy that can now be put to good use.

Garrett Advancing Motion, who supply similar tech to the Ferrari F1 team, recently announced plans to launch their "E-Turbo" for mass-produced cars by 2021. And they've designed it specifically to work as a form of mild hybrid (meaning the e-turbo supplements the internal combustion engine with an additional form of energy, in the form of electricity), utilizing the motor attached to the compressor wheel of the turbo to both deploy and capture energy, which would otherwise be wasted in the exhaust pipe, further improving efficiency.

All in all, this E-Turbo system should mean a 2-5 percent fuel efficiency improvement, but can even be as high as 10 percent depending on how the system is used and in what format. The E-Turbo can also be used on a diesel engine for up to a 20 percent reduction in emissions of nitrogen oxides: a harmful pollutant which has contributed to air quality issues around the world.

All in all, this E-Turbo system should mean a 2-5 percent fuel efficiency improvement, but can even be as high as 10 percent depending on how the system is used and in what format.

This E-Turbo will initially appear in premium, high-performance cars, but the plan is for it eventually reach mainstream cars. In fact, Garrett has 10 active programs developing E-Turbos for future models in the world's three largest car markets.

Mercedes-AMG are leading the way, with a new electric exhaust gas turbocharger in the final development stages before it will be added to new production models. Having won every F1 championship during the turbo hybrid era, the manufacturer is now applying the ideas that have served them on the racetrack, to the road.

Innovation, as ever, is not binary. While development of electric vehicles continues at pace, manufacturers endlessly seek to find more and more efficiency from the internal combustion engine. It's a never-ending, decades-old quest; perhaps a jolt of electricity is just what combustion needs.

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AT A GLANCE

01 Paddle shifts were invented by John Barnard, as a way of gaining a competitive advantage through the reduction of time needed to execute a gear shift

02 The new sequential semi-automatic gear shift system ultimately reached sportscars and today has trickled down to regular roadcars

03 The technology allows for near-seamless shifts between gears, increasing performance and improving fuel economy

SHIFTING THE PARADIGM

Some of motorsport's most lasting innovations were born from attempts to gain the most marginal competitive advantage.

In 1989, racecar designer John Barnard helped create the Ferrari 640, and the first sequential semi-automatic gear shift system. He had rejected the clutch pedal and stick shift from the previous Ferrari model, feeling that the presence of the gear stick necessitated a wider monocoque, which increased drag. After further consideration, the performance advantage of having the driver hold the steering wheel with two hands at all times, became obvious.

So he got rid of it altogether. Instead, two short paddles were placed on either side of the wheel, with the left paddle taking the gears down, and the right paddle taking them up. This lead to a system which allowed for almost instantaneous gear changes.

The technology was quickly adopted, in some form, across all F1 racecars, and was soon introduced for the first time in history in a road car, being implemented in the Ferrari F355 in 1997. Today, it is more widely known as the "flappy paddle" gearbox, and has trickled down to mass production across a variety of middle of the range cars.

The transmission is semi-automatic and the computer is still able to jump in if necessary. For example, it will block the gear change if the driver upshifts or downshifts incorrectly, or presses both shifters simultaneously. »

» Quicker speeds can be reached than when using a manual gearbox as the changes are seamless, and human error is overridden by the computer. These kind of semi-automatic systems provide a significant efficiency boost for roadcars. They can be gentler on the environment, as higher gears are achieved more rapidly, with no loss of energy or fuel when in a lower gear for too long.

And it all came about from ruthlessly seeking a competitive edge. In pursuit of that edge, Barnard invented a new system, and changed racing forever. And what changed racing, ultimately changed thousands of roadcars.

GOING AGAINST THE FLOW

To truly unleash creativity - you first have to constrain it.

Never has that principle been more evident in motorsport than in the regulation of fuel flow.

At the start of the 2010s, Formula 1's famous V8 engines were renowned for producing unmatched power from a given amount of fuel. To outside observers, it may have seemed that the technology had been pushed as far as it could go. But in truth, the pursuit of efficiency wasn't slowing down – it was accelerating.

In 2014, fuel flow in the FIA Formula 1 World Championship was limited to a rate of 100 kg per hour. It was hoped this new emphasis on efficiency and energy recovery would give the sport renewed relevance to society.

The limitations seemed stifling at first. But as is often the case, limitation bred innovation.

Ruthless efficiency became the priority. Much of the public conversation revolved »

22

AT A GLANCE

01 Restrictions of fuel flow in motorsport triggered a period of rapid technological innovation

02 Among several breakthroughs across the whole Power Unit, huge gains were made in the combustion process

03 These technological advances can now be applied to road cars, potentially leading to efficiency gains wherever internal combustion is widely used

22 GOING AGAINST THE FLOW

» around energy from braking, harvesting power from exhausts and deploying that power using electrical motors. But deep in the heart of the engine lay a less newsworthy, but no less important aspect to the efficiency conundrum: combustion.

Focusing on this fundamental process soon reaped rewards, and led to the adoption and advancement of an existing – but previously ignored – technology: pre-chamber combustion.

Jet ignition replaces the conventional spark plug with a device that allows for a tiny fraction of fuel to be ignited in a pre-chamber. This combusted fuel then shoots through tiny holes along with jets of hot air, igniting the rest of the fuel as a whole. The result is an even and rapid burn that manages to generate more power from less fuel than in previous systems.

Alongside huge leaps across the rest of the Power Unit – from the turbocharger to the Motor Generator Units - this breakthrough led to the most efficient hybrid engines in the world. As of writing, they boast over 50% thermal efficiency. By way of comparison; even the most efficient road cars currently only manage up to about 35%.

The next objective for F1 is to get to 60%.
The pursuit of efficiency never ends; it only becomes more incremented.

This amazing technical achievement represents the pinnacle of internal combustion - but it has been achieved on the eve of the age of the electric car.

But while electric or hydrogen vehicles will one day sweep away combustion from our roads, others believe the process will take time. And if the internal combustion engine is to continue to play a part in global mobility for some time to come, it must do so on an ultra-low (and eventually zero) carbon basis.

That decarbonisation will be driven by two things. The first is, of course, access to low or zero carbon fuels. But the second is efficiency gains. And here is where motorsport is poised to play a significant role.

Mahle Motorsports, whose jet ignition technology powered Ferrari among others, have begun adapting their tech to roadcars. In fact, the passive version of jet ignition (i.e. not requiring a separate injection system), can be used in almost any type of pre-existing powertrain.

Maserati have recently announced their new MC20, which boasts an innovative pre-chamber system derived from F1. It's the first time a vehicle meant for the road has directly utilised this technology – and it certainly won't be the last. With F1 now the world's foremost laboratory for researching a more efficient internal combustion engine (ICE), there is huge potential for the "trickle down" effect to become a tidal wave.

Arguably, that's thanks to the artificial limitations that motorsport places upon itself. Sometimes rewriting the rules can be a game-changer, in more ways than one.

TRANSFORMING TYRES

23

AT A GLANCE

01 As much as 25% of energy consumed by vehicles is used in overcoming rolling resistance

02 Motorsport has provided a world-class testbed for tyre technology that is similar to roadcar tyres

03 The next generation of tyres will be lighter, more connected and made more sustainably than ever

Energy efficiency is a principle at the very heart of all motorsport. And when it comes to tyres, that principle manifests in minimising rolling resistance.

The fact is that as much as 25% of the energy consumed by vehicles (whether through fuel or electricity) is dedicated to overcoming rolling resistance. Minimise that resistance, and you can make huge energy savings.

The ABB FIA Formula E Championship runs exclusively on Michelin tyres, with the manufacturer having been a founding partner of the series back in 2014. They use a very specific rubber compound for the series, with the intention of eventually rolling it out to road cars.

In fact, the tyres already resemble those of a road car in terms of their 18-inch size. They boast grooves and an asymmetric pattern that allow teams to use the same tyre in both wet and dry conditions - making it easier to stay within the environmentally-friendly limit per race weekend. Drivers are only authorised to use a single set of tyres for free practice, qualifying and the ePrix itself. Only two spares are authorised, and even these tyres must come from the stock carried over from the previous race. »

» It's the sort of regulation that is partly designed to mimic road conditions more closely - after all, road car drivers don't stop to change their tyres when it rains. And the data collected on tyres during Formula E races feeds directly into the development of future road tyres - including the data collection process itself.

Last year, "connected tyres" were launched for the first time in Formula E, using embedded sensors within the competition's third generation tyres. The connected solution uses sensors inside a container glued to the tyre. The sensor monitors tyre performance and tyre pressures automatically, whatever the temperature. This method of gathering data is planned to make its way to road users.

"We developed this technology because we see some opportunities for further developments, like calculating wear prediction and grip level, which is also very interesting for road purposes" said Jérôme Mondain, Michelin's manager of Formula E activities.

In fact, with the Pilot Sport 4S tyre for roadcars, development occurred side-by-side with the track team. The tyre uses a hydrophobic silica compound developed for racing, designed to disperse water at speed. It's more evidence that tech transfer is already happening, and will continue to do so.

And the manufacturer's plan for transforming tyres don't stop there. The entire Group has been challenged to reduce its environmental footprint. By 2050, 80% of the raw materials used to manufacture their tyres will be recycled or bio-sourced, with the latter accounting for at least half of the target.

Once again, motorsport allows road-transferable technology to be put through its paces in the most extreme conditions, in order to test the very latest design thinking. And that leads to more efficient use of materials and resources, which helps deliver high performance and energy efficiency while extending the life of each tyre, ultimately reducing environmental impact. Progress just keeps on rolling.

ALONG THE ROAD

ADDITIVE ACCELERATION

The history of motorsport technology has been one of early adoption and aggressive acceleration. Identify the next big innovation - then take it into overdrive.

Take additive manufacturing, more commonly known as 3D printing. It's a technology that is widely expected to reshape the world - and motorsport has already been using it for years. In fact, not only is motorsport at the front of the 3D printing pack, it has already lapped many other industries. Renault's Formula One team purchased its first 3D printer over two decades ago.

The beauty of 3D printing is that it allows for rapid iteration with less waste, which makes it perfectly suited to the relentless demands of F1. Up to 80 percent of an F1 racecar's various parts will be redesigned during the course of a season.

With 3D printing techniques, prototypes can be produced at great speed, with near-perfect precision, in small volumes. Waste (and energy usage) is reduced, as teams are able to only make what they need. With just a few days between some races, F1 teams are able to quickly print a prototype, test it and modify it, with time to spare. »

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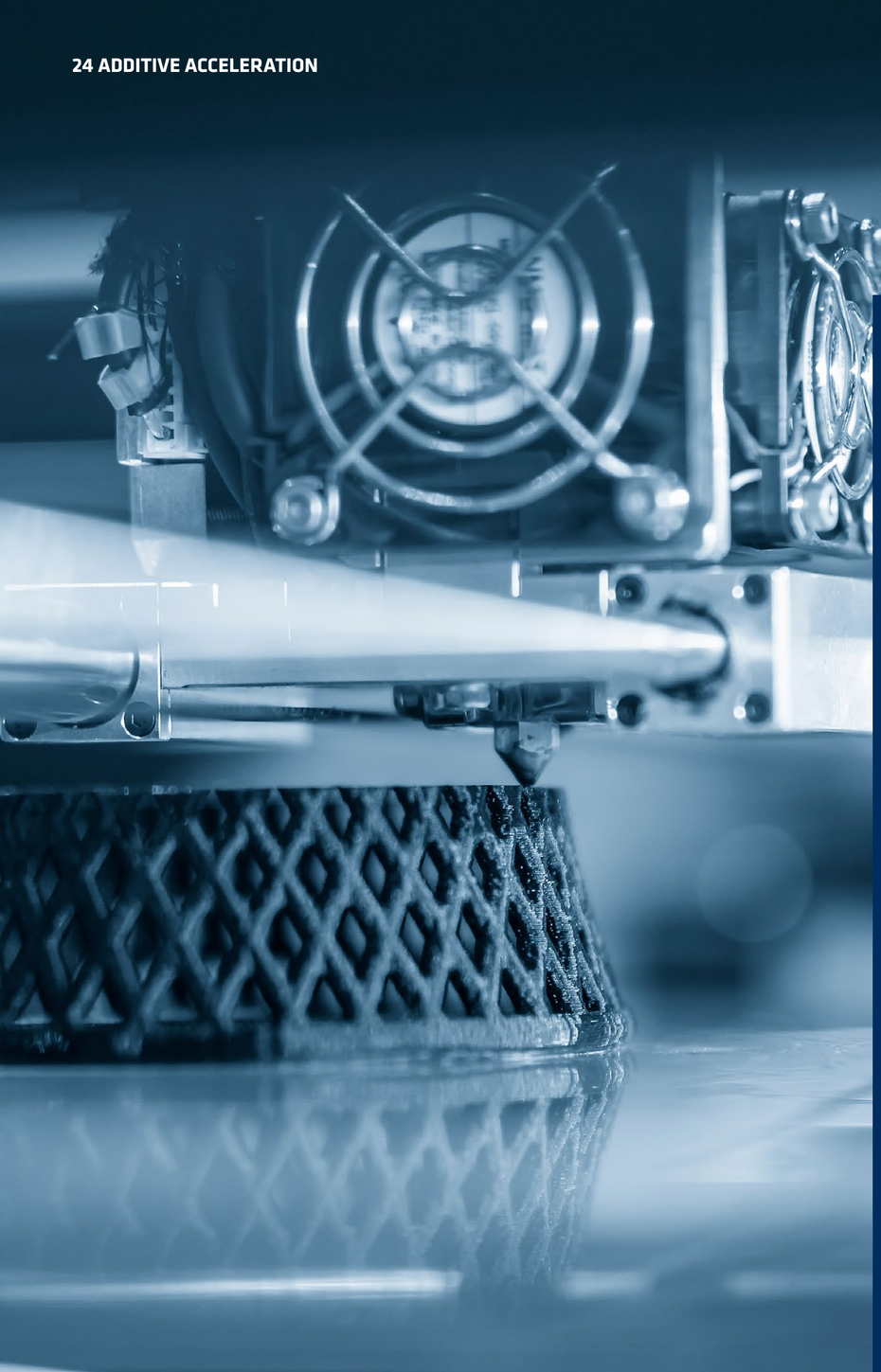
AT A GLANCE

01 Conventional manufacturing of prototype parts can be time-consuming and costly

02 F1's early adoption of 3D printing - as early as two decades ago - means teams can produce cost-effective prototypes at speed

03 Working with additive manufacturers, F1 teams are helping to accelerate the technology to the next level



» In fact, additive manufacturing can reduce production lead time by 20-25% per part - a colossal time saving across a season.

Multiple parts which would conventionally be manufactured separately, can instead be printed as a single component - a technique known as consolidation. This helps to reduce excess weight and improve stability, while keeping the car sleek and aerodynamic. And topology optimisation allows engineers to redistribute weight throughout the car, using software to design unusual parts that simply couldn't be made traditionally.

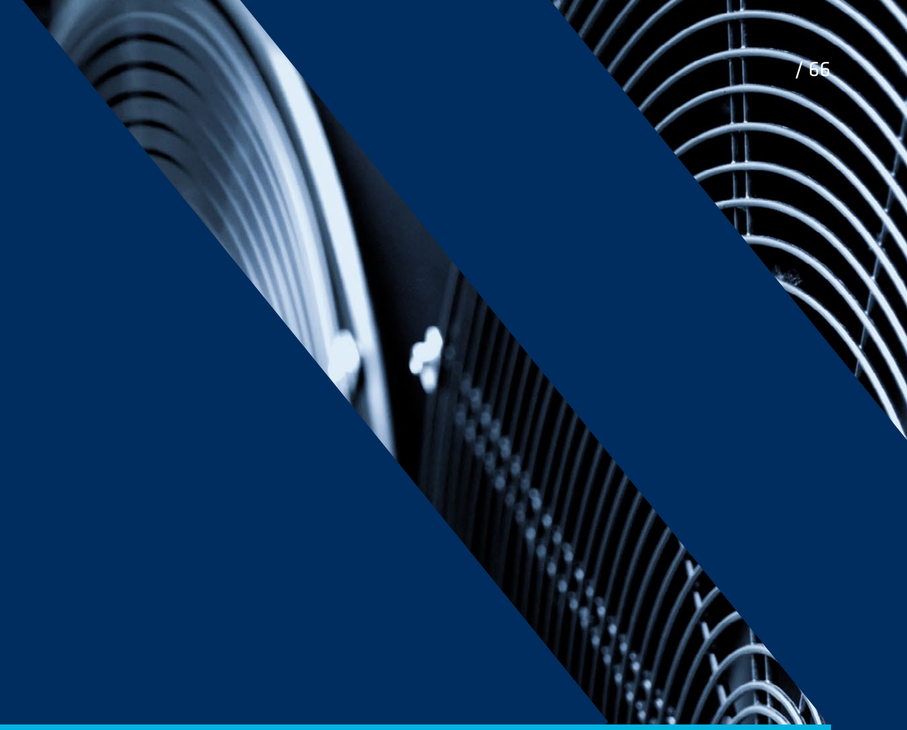
It's no surprise that more and more teams are incorporating 3D printed parts into their final cars. According to Renault, their two 2019 F1 cars each included about 100 3D printed parts at any given point in the season.

And 3D printing has not just been used for additional components, but also for core structural parts. The technology allows for rapid implementation of lightweight structures, which can help build in greater complexity, improving durability and increasing strength. For example, McLaren created a Hydraulic Line Bracket for their MCL32 racecar using 3D printing technology. The bracket was produced in just four hours - compared to the estimated two weeks it would have taken using traditional means.

This emphasis on an emerging technology will naturally benefit other industries. Recently, auto-motive giants Toyota announced that their motorsport division would be partnering with leading additive manufacturer 3D Systems to merge their expertise and move the tech forward. The plan is for Toyota's motorsport facility to become a "showcase for world-class advanced digital manufacturing". It's a huge step in building knowledge about a technology that has the power to cut waste, save energy and transform the world.

With this increasing focus on 3D printing, we're sure to see more innovative leaps forward, both in motorsport and outside it. Once again, the hunger for a competitive advantage brings a whole new dimension to cutting edge innovation.

FUELING FORWARD THINKING



Last year, the FIA and Formula 1 revealed a plan to go net zero carbon by 2030, but the inevitable question was: how?

One of the many solutions currently being pursued by F1 involves fuel. Though racecars are only a small part of the overall footprint, they are also the iconic image of the sport - and they can help showcase more sustainable fuels. Specifically, making a game-changing shift away from the fossil fuels that have powered performance for so long, and driving towards a synthetic, zero-carbon future.

Already under the 2019 technical regulations for F1, a minimum of 5.75% of the fuel used had to comprise bio-components. Under the original 2021 regulations, that proportion was increased to 10% (comprising advanced sustainable ethanol), though those rules were pushed back a year due to the Covid-19 pandemic. According to F1 Chief Technical Officer Pat Symonds, the goal was originally to get to 100% advanced sustainable fuel by 2030 - and now it seems that target may be achieved even sooner.

That's why the FIA Innovation Fund has invested in research into the creation of a 100% renewable racing fuel for a first application in Formula 1. »

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AT A GLANCE

01 Formula 1 announced its intention to go net zero carbon by 2030, which will necessitate racing with a 100% sustainable fuel in order to meet the goal

02 The FIA, through its Innovation Fund, is investing in research to help develop a 100% renewable racing fuel

03 The ambitious and exciting target is to have a CO_2-neutral fuel ready as early as 2026

» The study aims to identify the components currently existing in the chemical industry which could lead to the creation of that game-changing fuel, and to draft Technical Regulations to apply it for the 2023 F1 Championship.

“By 2023, we want to drive one hundred percent on sustainable fuel in Formula 1,” confirmed FIA Technical Director Gilles Simon.

F1’s fuel suppliers and engine manufacturers have also begun work to develop new, optimised biofuel. Interestingly, the transition to biofuels could even improve performance. Advanced sustainable ethanol has nearly three times the heat of vaporisation as traditional fuel. That produces a cooling effect for the incoming charge, which could be beneficial for the engine. That could ultimately be translated into a gain in horsepower, as just one example.

Advanced sustainable fuels come in many different forms. The first generation of biofuels were mostly made from food stock, with crops grown purely to produce fuel, which potentially had a negative effect on the food chain as well as food distribution. In a world with a rapidly growing population, it’s not ideal to use food for fuel rather than for sustenance.

With second generation biofuels, that impact is vastly reduced or eliminated. They either use food waste, such as corn husks or tomato vines, or biomass like forestry waste.

But the plan is to develop third generation biofuels (derived from algae) or alternatively, e-fuels that capture CO_2 in their production. The aim of developing these types of fuel is to ensure that they can integrate seamlessly into any petroleum-based infrastructure, without modification. In other words, anywhere you use petrol, you should be able to drop these fuels straight in without a problem. Hence the nickname: “drop-in” fuels. Here is where F1’s unrivalled technological expertise can massively accelerate progress, in the same way that it already has for hybrid efficiency.

If achieved, it’s not only the racecars that could potentially benefit. A new sustainable fuel could one day power the planes that carry the cars and equipment around the world, helping to shrink the sport’s carbon footprint.

While the carbon savings from the world’s twenty F1 cars might not seem significant in the grand scheme of things, the true impact lies in the real world application of this new tech. Over 1 billion of the 1.1 billion vehicles in the world are powered by internal combustion, and even though more sustainable options are gathering pace, there remains a pressing need to find new fuels, and fast. Motorsport has made its intention clear. Whatever happens now, the only direction is forward.

THE ULTIMATE SHOWCASE

Nothing seizes the imagination, and stirs the blood, quite like motorsport.

There is still no spectacle on Earth that offers what the major series do: mindblowing technical brilliance, breathtaking human skill, and relentless competitive spirit.

Motorsport has an unmatched platform to guide our perceptions of vehicles and engines. Where the cars go, millions of eyes follow - and millions of memories are formed. For some, that effect will be lifelong nostalgia. The roar of a V8 can carry across the years like a whisper in the subconscious. And for many, that fondness affects real decisions in ways big and small. The car they choose to drive. The fuel they choose to use. Their openness to new technology.

Here is perhaps where motorsport has the greatest power - and the greatest responsibility - to change the world.

People already see the FIA as a leading force, worldwide, on mobility and road safety. In fact, in a global survey conducted by Nielsen Sport, over 70% of respondents considered the FIA to embody excellence in road safety.

The #3500Lives initiative offers just one example of positive influence at scale. Launched in 2017, the campaign has promoted twelve “Golden Rules” for road safety around the world, seeking to reduce the road crashes which cause 3,500 deaths a day »

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AT A GLANCE

01 There are still barriers to sustainable mobility that are less to do with the tech itself, and more to do with the perception of it

02 Motorsport has a unique power to change people’s behaviour and perceptions

03 Together, the FIA’s championship formulae offer the world’s ultimate technological showcase of sustainable mobility

» worldwide. Since its inception, the initiative has been able to use unmatched public visibility at major events like Formula 1 races, as well as the voluntary help of high-profile global ambassadors and institutions like the International Olympic Committee. In 2018 alone, the campaign's messages were viewed over 3 billion times across a variety of media.

As well as advancing road safety, motorsport has been using its influence to accelerate accessible, affordable, practical and sustainable mobility.

Electric vehicles in particular have for years faced a barrier bigger than range anxiety or driving performance: coolness. More people need to be convinced that electric tech has both style and substance.

According to newmotion's 2020 EV Driver Survey report, 64% of private EV owners said that technology was the main incentive for going electric, over money or the environment. And there is no better showcase for electric technology than Formula E.

Ernest & Young's 2015 report on Formula E underlines the power that it has as a platform. They calculated the championship's impact on driving technological innovation, social awareness and infrastructure investment for sustainable mobility. Their projections suggested that over 25 years, the championship could help sell an additional 52-77m electric vehicles around the world, and contribute to an avoidance of 900m tonnes of CO_2 emissions.

It helps that Formula E is the fastest growing motorsport series on the planet, with most major car manufacturers moving into the electric racing space (or already being there). And it's among the highest-performing sports platforms in the world in terms of its proportion of young fans. An average of 32.6m people tuned in globally to watch each round, up from 27.1m the year before and 18.6m the year before that.

As Formula E CEO Alejandro Agag put it: "We have shown that Formula E is more than just a race. The championship has the potential to serve as a framework for electric vehicle R&D, accelerating general interest in these cars and promoting clean energy and sustainability."

Ultimately, motorsport's global influence rests upon its ability to keep people watching. Endorphins. Dopamine. Adrenaline. These are the fuels that move human beings. As long as motorsport continues to generate these within spectators worldwide, it will have the platform - and the power - to shape a more sustainable future.

CONCLUSION

CONCLUSION

BEYOND THE CHEQUERED FLAG

An accelerator for present technology.
A catalyst for inventing future technology.
The ultimate laboratory for innovating under pressure, at speed.

Motorsport fulfils all these roles and more. In the preceding pages we've explored the ways motorsport has positively impacted our lives - all through the relentless pursuit of performance. We've seen the impact from the electric bicycles we ride, to the airline seats we fly in, to the tyres we travel on, to the data systems we can't even see. We've seen technological expertise honed in the pitlane and in wind tunnels, applied in hospital wards and atop skyscrapers.

Some of these benefits were intentional applications of skills and knowledge. Others were incidental side effects of competition. But now, for the first time, all the strands of motorsport are being tied together in a single unified purpose. The goal is to responsibly accelerate motorsport's positive contribution to society.

» IMAGINE IF...

Williams' motorsport-derived airline seats were rolled out in business class in every A350 in operation.

> That could result in carbon savings of 26,768 tonnes of CO_2e annually.

And that's just one small example of many, demonstrating the sky-high potential of motorsport-derived innovation.

As we enter into an age of unprecedented uncertainty, there are five lanes of progress where motorsport is poised to continue leading the way.

FIVE LANES OF PROGRESS

1. KEEP SAFETY FIRST

In the week before this report was launched, safety in motorsport was brought dramatically to the forefront of popular consciousness, due to Romain Grosjean's horrific accident at the F1 Bahrain Grand Prix. Afterwards, the driver credited his miraculous survival to his vehicle's protective Halo cockpit canopy. But beneath the Halo, sits an equally remarkable piece of technology: the helmet.

We've explored two major helmet safety projects which may dramatically increase safety for motorcyclists across the world. First, the effort to create a new international safety rating system; and secondly, President Todt's push to distribute a low-cost, high-standard motorcycle helmet to save lives across the globe.

We've seen how Global NCAP's car assessment rating are estimated to have saved thousands of lives; and we've studied iRAP's mission to end the public health crisis that currently exists on our roads.

The FIA's premier competitions and the FIA Foundation have shown that safety for a few, in extreme conditions, can translate to safety for millions, on everyday roads.

2. SUPERCHARGE ELECTRIC

Like the thunder that comes before lightning, Formula E could be the herald of electric technology taking the world by storm.

With every successive season, the competition has grown into its role as the world's premier showcase for electric mobility at speed. Manufacturers are increasingly treating their Formula E wing as an invaluable form of innovation-on-wheels, offering the opportunity to test electric roadcar technology in the most extreme conditions. And a growing number of drivers are charging their electric vehicles every day, using technology perfected on the track.

With charging becoming faster, materials becoming lighter, and batteries lasting longer, motorsport is working at the very frontier of electric mobility. Whatever the future holds, this is one race that is only just getting started.

IMAGINE IF...

That sort of seismic change could save as much as 1.5 gigatonnes of CO_2 tailpipe emissions annually

Half of the cars in the world fleet were replaced by electric cars by 2050, using technology accelerated by motorsport.

That sort of seismic change could save as much as 1.5 gigatonnes of CO_2 tailpipe emissions annually - a staggering number roughly equivalent to the entirety of Russia's CO_2e emissions.

3. ADVANCE THE HYBRID

Hybrid technology remains a hugely important part of the bigger picture. Coupled with the development of advanced sustainable fuels, it has the potential to significantly improve air quality and reduce emissions. F1 is now the world's foremost laboratory for that research. As long as we continue to need the ICE and its successors, we need F1 to lead the way on both engine efficiency and sustainable fuel development.

F1's legendary power unit provides a formidable engine for change. With the announcement that 2026 will see a new, redeveloped hybrid unit, innovation has become a fundamental necessity rather than a mere competitive advantage. Once, 50% thermal efficiency was a barrier that seemed unsurpassable. Now, it's in the rearview mirror. The next goal: 60% - and perhaps even higher.

4. SIMULATE THE FUTURE

Motorsport continues to push the envelope for what is possible - in the virtual world as much as the real one.

The FIA has already used THUMS to simulate the human body in virtual crash testing, drawing upon an unrivalled dataset from decades of highly-monitored races. The future promises even more precise safety simulation, as new sensors and metrics continue to be developed.

And it's not just in safety that motorsport is accelerating simulation technology. We've seen how CFD technology can be applied in surprising ways for the benefit of society, for example in regulating wind spill from skyscrapers. Now, with talk of an end for F1's famous wind tunnels, simulation of all kinds, including CFD innovation, will need to be ramped up even further. In order to retain a competitive edge, teams will need to take simulation technology to hitherto untapped levels of performance - and that deepening of virtual knowledge can only be a good thing for the real world at large.

IMAGINE IF...

Millions of cars were to shift to zero carbon fuels, of the type being developed by the FIA and Formula 1?

Imagine if all petrol and diesel cars in the EU were to make that revolutionary shift. Such a change could help shrink the EU's entire carbon footprint by as much as 6.49%, or 291 megatonnes.

To put that into context, it's the same as 1.16 billion miles of the average passenger car.

Such a change could help shrink the EU's entire carbon footprint by as much as 6.49%, or 291 megatonnes.

5. CHANGE THE WORLD

The biggest promise of all remains the development of game-changing, world-altering sustainable fuels. The use of synthetic fuels, capturing carbon from the atmosphere during their manufacture, would shift mobility as we know it. The exhilaratingly ambitious target is to have such a CO_2-neutral race fuel ready as early as 2026.

The next generation of fuels is now on the horizon. Sustainable propulsion may arrive faster than anyone ever expected. But such speed is, of course, what motorsport does best.

Led by the FIA as guide and standard bearer, motorsport will now move as one community towards a better future.

That includes the principles covered in this report - promoting technological innovation and transferring its positive effects to society at large; and influencing and inspiring positive behaviours through supporting safer and cleaner mobility.

And just imagine what that better future might hold, if we took the innovations catalogued here and applied them at scale. Of course, there is a long road to travel before the dreams of sport can become reality for society. But this report represents a foundational step towards a better future. A future where motorsport is not driven only by performance - **but by purpose.**

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