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28 SECONDS THAT CHANGED F1 HISTORY





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THE HEROES BEHIND THE SCENES

OBODY who saw Romain Grosjean's dreadful fiery accident at the Bahrain GP could ever have dreamt that he would survive. Firstly, the impact itself was so violent that it was on the very edge of the driver losing his life through that alone. Then there was the blazing fire from which he miraculously emerged. While his hands were burnt, everybody acknowledged that Formula 1 had got lucky.

The fact that he survived to tell the tale is testament to a number of factors, all related to the FIA's safety initiative. So perhaps, on this occasion, F1 made its own luck?

The most obvious advancement to which he owes his life is the Halo. It was not that long ago that the device was criticised for spoiling the looks of the car, but now noone notices it. Grosjean, ironically, had been one of the Halo's critics. Not any more.

There were human heroes too. Had it not been for the ultra-fast reaction of Dr lan Roberts rushing to Grosjean's aid, and medical car driver Alan van der Merwe helping the effort to extinguish flames on his overalls alongside the other fire marshals involved, the result would have been far worse.

Elsewhere in this magazine, you can read about the challenging development of the race suit itself. That Grosjean was able to survive for almost half a minute in that fireball, then clamber out, is down to the work that has been done over the years to improve its design and material. The testing work that goes on behind the scenes is quite phenomenal.

Not that long ago, such an accident would have claimed the life of the driver. As an industry we owe a great deal of gratitude to all the scientists, physicists and other backroom people who have developed the race suit.

Research into safety standards does not end there. I am sure there will be lessons learnt from the accident when the FIA/ F1 investigators have completed their work. There is no finger of blame here, just a continuing learning curve that will improve safety for future racing drivers.

Time moves on and I'm sure the F1 cars in a few years' time will be so advanced that those being raced now will seem historic by comparison.

William Kimberley EDITOR



RIGHT Grosjean survived a 53G impact and being trapped in the flames for 28 seconds

28 SECONDS THAT CHANGED THE COURSE OF F1 HISTORY

Mark Skewis reports on the quest to learn lessons from an accident that sent shockwaves through the sport

HE 28 seconds in which Romain Grosjean was engulfed in flame, struggling to extract himself from the survival cell of his Haas, will change Formula 1 forever.

The claim might sound melodramatic, as befits 'The Miracle of Bahrain', but it is also true. The FIA investigation will run through the remarkable events in the forensic detail which led to many of the safety innovations that combined to save Grosjean's life in the first place.

The accident raised so many worrying questions: why the car penetrated the barrier, why it caught fire and why it snapped in half, will be chief among them. But the fact remains that what could have been recorded as one of the sport's darkest days will actually go down as one of its best.

While it is true that a huge element of good fortune was involved – "What I simply can't fathom out is how he stayed conscious throughout given the 53G deceleration within a very few metres, including partly passing through the barrier and its uprights," marvelled Sky F1 analyst Martin Brundle – there is a strong case for the fact that on this occasion Formula 1 made its own luck. So many of the aspects that combined to save Grosjean, such as the Halo frontal cockpit protection, helmet, HANS, safety harness, protective clothing, survival cell, headrest and the in-car extinguisher system, are products of a movement that has gathered momentum since the dark events of 1994, when F1 lost Ayrton Senna and Roland Ratzenberger at Imola.

DATA IS KING

Data collection will be at the heart of the FIA's investigation and in Formula 1 there is more data instrumentation than in any other championship. FIA researchers will be able to gather data from the various video streams, including a High Speed Camera which faces the driver and films at 400 frames per-second to reveal in slow motion what happens to him during the accident.

Data will also be gathered from the in-car Accident Data Recorder, which will reveal the speed and forces on the car, and the in-ear accelerometers that are





moulded to fit inside a driver's ear canal to measure the movement of his head in a crash.

Analysis will also include chassis integrity and the safety barrier performance for an impact of that energy and trajectory. It will also assess the role of the track marshals and medical intervention team.

FIA Safety Director Adam Baker said: "As with all serious accidents, we will analyse every aspect of this crash and collaborate with all parties involved. With so much data available in Formula 1, it allows us to accurately determine every element of what occurred and this work has already begun. We take this research very seriously and will follow a rigorous process to find out exactly what happened before proposing potential improvements."

HALO SILENCES CRITICS

For all the questions that as yet remain unanswered, there is one point around which there is no debate: the Halo saved Grosjean's life.

Ironically, he had been one of the drivers arguing against its introduction – something of which FIA president Jean Todt gently reminded him when he visited him in hospital the day after the crash.

"There is absolutely no doubt the Halo was the factor that saved the day – and saved Romain," commented F1 managing director Ross Brawn.

Grosjean, in a video message from his hospital bed on the night of his accident, admitted: "I wasn't for the Halo some years ago, but I think it's the greatest thing that we brought to Formula 1 and without it I wouldn't be able to speak to you today."



ABOVE As he escaped amazingly from the Bahrain GP inferno, Romain Grosjean had an image from a safety video rushing through his mind "I'm like 'Oh, shit, I'm like a running fireball'. The image, we've seen a video from the FIA, they did a test, they put someone on fire and he runs around just to show the overalls were strong. I've got that image, I've got fire following me"

Romain Grosjean

Read about that FIA safety work on Page 34

Strange now to think that the Halo was reviled by so many as being counter to the DNA of Formula 1. That same DNA, presumably, formed by so many drivers not having walked away from such ferocious accidents.

The Halo device was tested extensively at Cranfield Impact Centre during its development by the FIA prior to its adoption. Dr James Watson, manager of the centre – one of just two FIA-approved test centres in the world, used for crash-testing Formula 1 cars – said: "The Halo device, along with other safety features on the latest F1 vehicles, has made a tremendous difference in protecting drivers in accidents. In the event of an accident, it is imperative to preserve the survival space around the driver and the Halo device forms part of that critical zone.

BELOW Stringent new tests for racewear clothing had been introduced a few months earlier

"Prior to the introduction of the Halo in 2018, we >





conducted compression tests on the device from various scenarios to establish its suitability. Static tests on the Halo were taken to a load level that would be the approximate equivalent mass of five large typical SUV vehicles resting on the device!"

RAISING THE BAR

"For me it wasn't quite 28 seconds, it felt more like 1m 30s if I'd put a time on it," said the Haas driver, speaking to media after his return to the paddock.

You can read elsewhere in this magazine about the challenging work that has taken place behind the scenes to improve the fire endurance of the three-layer driver overalls - and, crucially, other equipment such as underwear and socks. Those changes have been nearly 20 years in the making and had only been introduced at the start of the 2020 season. Ironically, Grosjean was equipped by Alpinestars, the first manufacturer to have committed to the new standards.

The tests for the new protective clothing

standards require that the racesuit material must withstand a direct flame for a minimum of 12 seconds, while the underwear, socks and balaclava must withstand a minimum of five seconds, the shoes 11 seconds, and gloves 11 seconds with exception of the palm which must withstand eight seconds.

Incredibly, Grosjean was immersed in flames for 28 seconds. "We always try to exceed the base standard," said an Alpinestars spokesman. "And in this instance, it has served us well, because when you do the calculations, Romain was exposed for longer than the minimum requirement.

"There's only so much you can do though and fortunately, we don't get too many of these fuel cell breaches and fires. But when we do, we're going to do everything we can to learn from it and develop our products."

Initially, when the new clothing standards were introduced, some drivers complained that it made them feel hot, but they'll be thankful now.

TOP Medical delegates assist Grosjean after his miraculous escape

RIGHT The High Speed Camera in the cockpit is a safety innovation introduced recently. It faces the driver and films at 400 frames per-second to reveal in slow motion what happens to him



Taking the next step

ALTHOUGH not named, there has been a lot of misinformation and uninformed speculation about the fuel leakage and fire in Romain Grosjean's fiery accident at the Bahrain GP. ATL has felt obliged to publish the following statement:

'Following the accident involving the Haas F1 Team car #8, driven by Romain Grosjean, Aero Tec Laboratories (ATL) would like to state its position on the accident and investigation. At this point in time it would be wrong for ATL to provide comment regarding the fuel leakage that caused a fire to ensue following the car's impact with the barrier. ATL engineers have begun investigating the cause and drawn initial conclusions from the evidence currently at hand which has been shared with the FIA and Formula 1. ATL will be working with the FIA to ensure that all facts are understood with containment and corrective actions put in place at the appropriate time to reduce the risk of such events occurring in the future.

'All parties continue to strive to ensure that the safety fuel bladders are integrated into the survival cells of all vehicles in such a way that the risk of fire in such an incident is mitigated wherever possible. It has been demonstrated that the FIA process of investigation of such accidents leads to effective risk mitigation in the future by various means. ATL wishes to support any advancements that may come from the lessons learned as part of this investigation.

'This ethos very much aligns with ATL's own continuous improvement and safety-centric culture. Formula 1 uses safety fuel bladder materials homologated to the highest standard, FIA/FT5; a standard which has been applied to more and more series worldwide. This standard has proven effective in the harshest of environments and accidents including the World Rally Championship. To provide context, the standard far exceeds that of the highest aviation standards.'



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10 MOTORSPORTS PROFESSIONAL



BELOW Audi's 2022 challenger could become the Dakar poster-boy

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Audi to spearhead Dakar tech push

AUDI'S shock switch to cross-country rallying could help establish the Dakar Rally as the latest go-to event in which to showcase alternative drivetrains.

The German manufacturer concedes that it faces one of its "greatest challenges" when it competes in the famous event for the first time in 2022 with an innovative prototype.

Its alternative drive concept will combine an electric drivetrain with a high-voltage battery which can be charged as required while driving via an energy converter in the form of a highly efficient TFSI engine.

Audi's 2022 entry could well be a stepping stone to other technologies, such as hydrogen, and the rally organisers are poised to announce new initiatives. They will, it says, "back the technological revolution ushered in by makers, teams and crews eager to test their technological solutions against the most extreme conditions on Earth."

"The story of the Dakar is the story of the pioneers who have flocked to the rally since its inception in 1979 and tamed the African deserts, crossed the Atlantic to tackle the vast expanses of South America and, last year, discovered Saudi Arabia and the Middle East," a statement said.

"The 2021 edition will see the rise of a new breed of pioneers who are also set to venture where no-one has gone before: developing low-emission electric vehicles capable of winning the rally."

Two other outfits are laying the

RIGHT Horn and Despres are collecting data in a Peugeot DKR ahead of a hydrogen assault on the Dakar Rally groundwork for an eventual assault with a hydrogen-powered car. Five-time Dakar winner Cyril Despres and his colleague, the adventurer Mike Horn, will gather data in their Abu Dhabi Racing Peugeot 2008 this year with a hydrogen design their ambition for 2023.

Likewise, Guerlain Chicherit's GCK outfit will run an ex-Peugeot 3008 DKR chassis, fitted with an electric drivetrain, in selected rally raids this year. It has pencilled in running selected stages in a hydrogen car by 2023 and a full attack in 2024.

Understandably, though, it is Audi's announcement that has stolen the headlines. Its intent was revealed by the announcement that the project will be carried out in collaboration with Q Motorsport GmbH, founded by Sven Quandt and his two sons Thomas and Tobias. Quandt's X-raid team has redefined rally-raid standards, winning the Dakar Rally five times. It has triumphed in the FIA World Cup for cross-country rallies 11 times.

"We want to continue demonstrating the brand's slogan 'Vorsprung durch Technik' in international top-level motorsport in the future and develop innovative technologies for our road cars," said Markus Duesmann, Chairman of the Board of Management at Audi AG. "The toughest rally in the world is the perfect stage for this.

"Formula E has accompanied the transformation phase at Audi," said Duesmann. "Today, electromobility at the four rings is no longer a dream of the future, but the present." The Audi e-tron is a bestseller in many markets. With the RS e-tron GT, Audi will soon bring its sporty spearhead onto the road. And as early as 2025, around 40 percent of sales are expected to be achieved with purelyelectric vehicles and plug-in hybrids.

"This is why we are taking the next step in electrified motorsport by facing the most extreme conditions," said Duesmann. "The many technical freedoms offered by the Dakar Rally provide a perfect test laboratory for us in this respect."

































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Porsche and Audi LMDh projects to revive Group C glory days

ENDURANCE racing looks to be heading towards another golden era after both Porsche and Audi revealed that they will enter IMSA's LMDh category.

With Peugeot and Toyota already committed to the ACO's Le Mans Hypercar category, which will run in parallel with LMDh, fans are set for a manufacturer contest unparalleled since the days of Group C.

The German giants' entry to the LMP2based LMDh series also paves the way for the creation of a new generation of turn-key racecars. Inevitably, comparisons have been drawn to the era when customers could purchase a Porsche 956 or 962 and stand a chance of beating the manufacturer teams.

Crucially, LMDh will utilise a spec hybrid unit and control electronics – with an output of 500 kW (680 hp) – where the ACO's Le Mans Hypercar rules will see the likes of Peugeot and Toyota develop their own systems. Porsche acknowledged that the cost-conscious nature of the US series was an attraction.

"The new LMDh category allows us to fight for overall victories with a hybrid system at the Le Mans, Daytona and Sebring classics – without breaking the bank. The project is extremely attractive for Porsche. Endurance racing is part of our brand's DNA," explained Oliver Blume, CEO at Porsche AG.

With IMSA and the ACO having agreed on a Convergence programme, for the first time in more than 20 years it will be possible to fight for overall victories with identical vehicles at endurance races around the world.

Michael Steiner, Board Member for Research and Development at Porsche AG, added: "In the medium term, Porsche focuses on three different drive concepts:

> LMDh allows us to fight for victory at Le Mans without breaking the bank"

RIGHT Audi last raced in prototypes in 2016

fully electric vehicles, efficient plugin hybrids and emotional combustion engines. We want to represent this trilogy in both the development of our cuttingedge road cars and in motorsport.

"We use the all-electric drive to contest the FIA Formula E as part of our works commitment, and the highly efficient and emotional combustion unit in GT racing. Now, the LMDh class closes the gap for us. There, powerful hybrid drives – like the ones that are mounted in many of our brand's models – go up against each other."

Steiner also called on the ACO and IMSA to use advanced fuel technology, which is a central pillar of F1's sustainability drive.

"If the regulations eventually allowed the use of synthetic fuels, then that would be an even greater incentive for me in terms of sustainability," he said

Many manufacturers – including Acura, BMW, Cadillac, Lexus and Mazda – have been linked to LMDh, but have been wary to commit with budgets severely impacted by the COVID-19 pandemic. Now the hope is that Porsche and Audi's decision will persuade other potential entrants to firm up their plans.

"We have our customers' wishes in mind as much as the company's future strategy, which is clearly focused on electrification and carbon-neutral mobility," said Julius Seebach, the incoming Managing Director of Audi Sport GmbH.

"This is why we are intensively preparing to enter the new sports prototype category LMDh with its highlight races, the Daytona 24 Hours and Le Mans 24 Hours. The most important message for our fans is that motorsport will continue to play an important role at Audi."



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Formula E exodus "a wake-up call"

FORMULA E must learn the lessons from its first manufacturer exodus, Mercedes has warned.

The German giant reaffirmed its commitment to the series, but cautioned that changes must be made in the wake of Audi and BMW's withdrawal.

"I think there is, with these kind of decisions, a little bit of a wake-up call," admitted Mercedes motorsport boss Toto Wolff. "Let's analyse why BMW and Audi have left. Let's see this as something that we need to learn from and improve from there. There's an opportunity for the series to learn something from the situation and improve.

"So we will get the message, learn the lessons and make it stronger from here. There is always an upside in moments like this. These situations are there to improve series, and improve the show."

Audi's departure – as part a root and branch review of its motorsport activities – is perhaps understandable. While its Dakar programme came as a surprise, its preparations for LMDh did not: endurance racing is part of the company's DNA.

BMW's exit, however, is far more concerning. Having been instrumental in the growth of Formula E over the past seven seasons, the manufacturer said it had "essentially exhausted the opportunities" that came with the all-electric series.

Costs are said to have quadrupled since Formula E's inception. They are, said Wolff, an important issue to tackle going forward. In many ways, it might have been more reassuring had BMW just blamed rising costs. But it didn't.

"BMW Group has always used Formula E as a tech lab for production," it said. "The same engineers who develop the drivetrains for electric production vehicles are also responsible for the drivetrains in the race cars. Examples of the successful transfer of technology between the Formula E project and production development include new findings regarding energy management and energy efficiency, the transfer of software for power electronics from racing to production, and an improvement in the power density of the e-motors."

But a brutal pay-off lurked within its official statement: "When it comes to the development of e-drivetrains, BMW Group has essentially exhausted the opportunities for this form of technology transfer in the competitive environment of Formula E."

The BMW Group remains committed to its electric revolution. It planned to have put one million electric vehicles to Formula 1," Wolff explained. "It's maybe not as pure a racing competition as Formula 1, and it does not have the global appeal that F1 has, but FE has its place.

"It stands for electric mobility. It stands for urban entertainment. It has an event character with a single-day format, and it has developed as it should have developed as a racing start up.

"One must not forget that the series is only a few years old, compared to 70 years of F1. And I think we need to give it time to develop."

The Mahindra team committed to the series' Gen3 regulations last month. At present, however, nobody else has followed suit.



RIGHT BMW is pulling the plug on its works team

on the roads by the end of 2021. The goal is to increase this figure to seven million by 2030, of which two-thirds will be fully-electric. However, the shift of strategic focus towards a scaling of global production has no place for Formula E.

This is Formula E's first experience of the boom-bust pattern that comes hand-inhand with manufacturer support. Both sportscar racing and Touring Car series have long learned to adapt to such situations.

The recent sale of the Venturi Racing Formula E team, to an investor group that had previously considered Formula 1, suggests that Formula E still retains a strong lure. Andretti remains keen to continue in the series after BMW's withdrawal, and Audi's technology will still be available to customers.

"FE attracts a totally different audience

"We see Mahindra Group as a key player in the future of mass-market electric vehicles," said Jamie Reigle, Chief Executive Officer of Formula E. "It's a testament to the shared purpose of Formula E and its partners that we have one of our founding teams, Mahindra Racing, already committing to Gen3 in anticipation of the 2022/23 season. Gen3 brings with it an unparalleled opportunity for innovation from a sporting perspective on the track and technological advancement on our roads."

"The Gen3 race car will further establish the principles that have made the championship successful," said Jean Todt, FIA President. "It is positive to see a founding team continue with us on a shared mission to develop electric vehicle technology and promote sustainable mobility."





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UK expert's role in Supercars battle revealed



THE role played by a UK-based advanced engineering specialist in last season's Supercars championship has just been revealed.

With Australia's premier series effectively down to just two manufacturers, Ford and Holden, D2H Advanced Technologies worked intensively with the Supercars championship organisers to develop their pre-season performance testing regime.

D2H analysed and redesigned the Vehicle Control Aerodynamic Testing process (VCAT) to promote technical parity in vehicle performance throughout the grid and encourage the close racing associated with a tightly governed series.

"The aim of the VCAT test process is to enhance the championship's racing thrills, by ensuring the manufacturers' performance levels are closely aligned," explained D2H **LEFT** The Supercars series is renowned for its close racing

aerodynamics engineering director, Chris Hebert. "Part of this is to overcome the aerodynamic advantages inherent in the design of differing bodyshells.

"The Supercars organisers asked us to use our experience to help update the VCAT process using best-in-class technology, to keep pace with aerodynamic developments generally and eliminate undue competitive advantage. Results in 2020 would suggest that we have been successful in doing so."

The company's solution involved the aerodynamic simulation of both manufacturers' cars before the test event, reducing the duration of the event itself. "Our simulations were extremely accurate when compared to the VCAT tests, which is both gratifying and useful: we were able to anticipate aspects of each car's performance beforehand, cutting time down at the test event," said Hebert.

Part of the VCAT process developments devised by D2H included the design, manufacture and implementation of a ride height control system for the test cars of the two manufacturer homologation teams. This ensured absolute uniformity of vehicle set-up throughout the test by controlling the test vehicles' ride height

"The ethos of the Supercars Championship is based on technical parity, not sporting parity, and on any given day, the best driver supported by the best team, which adapts quickest to various track conditions, can win. Results in 2020, with excitingly split podiums, would suggest that the evolution of the VCAT process is helping to achieve this through technical parity between each of the brands within the series," said Australia Supercars head of motorsport, Adrian Burgess.

"For 2020, we were keen for VCAT to encourage data sharing so that it was not only the two homologated teams involved which would benefit from physical testing. The aim is to accelerate the learning curve of all teams – whatever their budget – achieving parity and ensuring that the team which makes best use of available data can support its drivers to the fullest degree. It's important that, come race day, privateers can have a shot against the homologated manufacturer teams which provides closer, more thrilling and unpredictable racing."

The data sharing referenced by Burgess relates to the complete service provision of D2H. The company ran the latest VCAT using a team of its own engineers and completed its own data capture. This data was made available to all teams for further analysis.

Penske champions Ferrari IndyCar move

INDYCAR owner Roger Penske is leading the quest to entice Ferrari into IndyCar as the series' third engine manufacturer.

The US single-seater championship introduces a new generation of hybridpowered engines in 2023 and is ramping up its efforts to alleviate the pressure on its two existing engine manufacturers, Honda and Chevrolet.

"I'm personally championing, alongside

(IndyCar president) Jay Frye, developing a process with Ferrari," Penske told the *Indianapolis Star*. He also revealed that he had phone conversations with Ferrari last month. "Have they made a decision? The answer is, 'Not yet,' but they're definitely interested in coming," he insisted.

Ferrari has admitted that it is evaluating IndyCar as one of its options as it seeks to relocate staff in the onset of Formula 1's budget cap.

Since last running in IndyCar in the 1952 Indy 500, Ferrari has hinted multiple times at making a return to the series. The most visible came in the mid-1980s, when the company went to the trouble of designing and unveiling a car for CART – the Ferrari 637 – and partaking in serious, at times public, conversations with Bobby Rahal, the 1986 Indy 500 champ.

Both Honda and Chevrolet have indicated that they would be prepared to share a certain amount of information with a potential new engine supplier.

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Extreme E awards smart power deal

AS preparations for radical new racing series Extreme E get underway, Power Logistics has been appointed to deliver its award-winning sustainable temporary power solutions to the five races planned this season.

Extreme E will see electric SUVs competing in extreme environments around the world which have already been damaged or affected by climate and environmental issues.

"Securing a contract with Extreme E, which is committed to delivering on its net-zero carbon goals, is testament to the reputation that Power Logistics has built as a market leader in sustainable temporary power solutions," said Power Logistics' Managing Director Mike Whitehouse. "This is an exciting opportunity to work closely with and learn from some of the world's leading experts and pioneers in sustainability not only in sporting events but the wider community.

"The sustainable innovation driven in a racing series such as Extreme E is often transferred into the domestic market and road vehicles. We're hoping to emulate that within the provision of temporary power for events."

The contract will see Power Logistics deliver a comprehensive electrical support package that

encompasses the team garages and the wider paddock area, along with support structures, broadcast compound and production areas. Amongst the services supplied will be electrical designs, HVO compatible generators and an experienced team of electricians who will travel to each of the five races.

The standout element of the project is the design of bespoke cabling and distribution equipment that incorporates a smart power monitoring system, built specifically to meet Extreme E's requirements. The new racing championship is pioneering hydrogen fuel cell technology, supplied by AFC Energy, which will enable the series' fleet of SUVs to be charged utilising zero emission energy. Power Logistics' electrical cabling and distribution system will work in tandem with AFC Energy's system to incorporate the car charging network.

Power Logistics will also implement extensive power monitoring of the energy and fuel usage of all touring elements at each race circuit. Detailed analysis of car charging and utility circuits will provide vital information, in minute detail, both in real time and postrace, to allow the organising team to make informed decisions and deliver on its sustainable objectives. **ABOVE** Extreme E plans to be a leader and a pioneer in showcasing green technologies

EY to help drive electrification and climate agenda

EY intends to support Extreme E in its commitment to minimise its series' footprint and create a positive legacy.

The organisation will develop a Social and Environmental Impact Assessment framework. EY teams will help identify local companies to undertake the assessment in each race location and provide them with the necessary guidance and support. This will enable Extreme E to offset any unavoidable effects via local legacy projects. EY teams will also develop pre- and post-racing carbon accounts including identifying and calculating Scope 1, 2, and 3 emission sources to support carbon offsetting agreements.

Alejandro Agag, Founder and CEO, Extreme E, said: "We are incredibly pleased to collaborate with EY on this important initiative, which will enable Extreme E to assess and understand its impact and, as a result, implement legacy programmes which provide environmental and social support tailored to specific local needs.

"EY already has developed a long-standing relationship with our sister series, Formula E, and they have many years of experience in the areas of sustainability and mobility. The expertise they provide is globally respected. Extreme E is a forward-thinking and innovative championship and together we believe we can gain and share some truly tangible and actionable insights."





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VW terminates its works motorsport activities

THE Volkswagen brand is to terminate its factory motorsport activities as part of its "transformation to the mobile electric era". The Volkswagen Motorsport GmbH workforce will be integrated in Volkswagen AG.

"The Volkswagen brand is on the way to becoming the leading provider for sustainable e-mobility. To this end, we are pooling our strengths and have decided to terminate the Volkswagen brand's own motorsport activities," said Dr Frank Welsch, Member of the Board of Management with responsibility for the ABOVE VW's competition department ruled World Rallycross Development Division.

"The deep technical expertise of the motorsport employees and the know-how gained from the ID.R project will remain with the company and will help us put further efficient models from the ID. family on the road."

Volkswagen Motorsport GmbH, based in Hannover, employs 169 people who will be integrated in Volkswagen AG in Wolfsburg over the coming months.

Over five decades of motorsport, VW's competition department became synonymous with the heyday of Formula V, in the 1960s and 70s, and forged a reputation in Formula 3. Its productionready vehicles such as the Polo, Golf and Scirocco enjoyed success at racing circuits, rallycross tracks and in rallying.

The brand's greatest achievements include three Dakar Rally wins with the Race Touareg (2009-2011), four Rally World Championship titles with the Polo R WRC (2013-2016), two TCR International titles with the Golf GTI (2016, 2017), and three Rallycross World Championship titles with the Polo (2017, 2018, 2020). Volkswagen Motorsport successfully made the transition to e-mobility from 2018 with the fully-electric ID.R, which holds five international records.

"For decades, the Volkswagen Motorsport GmbH team brought the brand a string of major sporting successes," acknowledged Wilfried von Rath, Member of the Board of Management with responsibility for Human Resources. "We are delighted that we are able to preserve jobs, especially in these challenging times, and will be offering all employees a transfer contract."

Warning over "fuel and oil war"

MERCEDES team principal Toto Wolff has welcomed Formula 1's push for sustainability but warned against the risk of a "fuel and oil war".

The sport's new powertrain rules are currently a hot topic of discussion, with the introduction of synthetic fuels seen as a crucial part of F1's plan to become the acceptable face of ICE research and development.

"It's very clear that batteries are getting ever more efficient, and that energy reconversion is happening," Wolff said of the direction the rules should take. "I think more sustainable fuels, whether it is synthetic fuels or something else, can be very interesting.

"But they need to be looked at with our fuel and oil partners, of course, because we don't want to have an escalating fuel and oil war, as interesting as it would be for all of us to push boundaries. So it's about the right compromise."

An engine freeze for 2022 now looks increasingly likely as F1 prepares for life after Honda's exit. Mercedes and Ferrari have both indicated their support for this course of action, while Red Bull views it as essential to its hopes of retaining the hybrid Honda powerplant after the manufacturer leaves at the end of the season.

F1's big three are all in favour of reducing costs, while agreeing a new power unit that would appeal to OEMs.

"I think it's important to design a power unit that considers where the world goes, having more electrical propulsion," said Ferrari boss Mattia Binotto. "And this needs to be done within a cost business case that is sustainable for F1, also from a financial side."





LEFT Past meets future as the Hispano Suiza brand joins Extreme E

Historic name returns to racing in 2021

A LEGENDARY marque has returned to motor racing for the 2021 season, with Hispano Suiza entering a team in Extreme E.

Celebrating a famous milestone and 100 years from André Dubonnet's win in the George Boillot Cup, behind the wheel of the H6 Coupé in Boulogne, the Hispano Suiza brand will return with a team formed in association with the energy drink brand Xite Energy.

"Today we must think about electromobility and sustainability," said Sergio Martínez, CEO Hispano Suiza. "We have to be very aware that the world is changing and we must all fight to reduce our carbon footprint before it's too late."

The squad will be led by team manager Juli Mundet Caballero, a renowned Spanish engineer who has worked in different areas within the automotive industry, both in the product and R&D and competition departments. He began his professional career at the Nissan Technical Centre in the gearbox and transmission departments, and in recent years he has worked at the High Energy Physics Institute in Barcelona, as chief engineer. Since 2010 he has served as a race engineer in various competitions, including the FIA World Rallycross Championship.

"I welcome the legendary Spanish brand Hispano Suiza, founded in 1904 by the Suqué Mateu family, to the Extreme E Championship," said Alejandro Agag, CEO and founder, Extreme E. "True to its tradition and racing history, this time, it returns to motorsport looking to the future, to the electrification of mobility.

"I am convinced that the Hispano Suiza team will honour the great tradition of their name, and will be a formidable competitor in our championship, the most remote sporting event on the planet."

The Hispano Suiza legend

BETWEEN 1904 and 1938, the one name inextricably linked to Hispano Suiza was Swiss engineer Marc Birkigt. He was responsible for every motor that bore the name Hispano Suiza, with the one exception of the chassis frame employed for the Junior Model H.S.26.

During that period, the brand's Voiturette cars scored three consecutive victories in the George Boillot Cup, an endurance race. As the person accountable for nearly 50,000 aero engines, he also made an enormous contribution to the allies' air supremacy during World War 1.

Birkigt also built the "Sardine", an exceptionally narrow frame with a wind-cheating tandem body, for the 1912 racing season, powered by a 3.0-litre T-head supercharged engine.

Birkigt did show an entirely new V8 Hispano Suiza engine at the 1946 Geneva Show. However, it was felt that the climate was not then suitable for the introduction of a motor of this calibre in an austerity-stricken Europe. Birkigt subsequently retired to the environs of Lake Leman in Switzerland, dying in March 1953 at the age of 75.

KW automotive acquires Reiger Racing Suspension BV

REIGER Racing Suspension BV, a leader in the off-road racing damper market, has been acquired by KW Beteiligungsholding GmbH.

Reiger components will continue to be manufactured at the Dutch company's headquarters. The outfit's founder, Gerard Seesing, will remain active in the company.

Founded in the Netherlands in 1977, Reiger Racing Suspension has built an impressive reputation in the development and production of dampers for the highly competitive off-road motorsports market. Numerous manufacturers rely on the dampers and suspension components produced at the Dutch plant in Hengelo for their rally raid, rallying, rallycross and motocross market needs.

Back-to-back FIA World Rally Championship title wins with M-Sport/ Ford rank among the company's biggest successes, along with five outright wins on the gruelling Dakar Rally. All but one of the



ABOVE The deal will see the Reiger brand rolled out to North America

top 10 finishers in both the car and truck categories at last year's Dakar used Reiger.

The deal sees KW automotive further expand its reach in the performance suspension industry and extend the KW brand to a new segment of customers. With the acquired knowledge, intellectual property and innovations, new aftermarket off-road damper products for trucks and SUVs will be developed under the Reiger Racing Suspension brand. KW automotive's manufacturing and logistics structures will manufacture and ship the product worldwide.

The Reiger Racing Suspension brand will be unveiled to the North American market in late 2021.



XCELDYNE LLC, a premier titanium valve and valvetrain component manufacturer, which services top motorsports teams around the world, has secured the assets of steel valve and valvetrain component manufacturer Movaltec Sarl.

"This transaction of the France-based company further

The deal makes Xceldyne the leading valve and valvetrain component supplier globally.

increases Xceldyne's global motorsports valvetrain

BELOW Both Xceldyne and Movaltec have footholds in the top tiers of racing, including IndyCar



market share. It provides tangible evidence of our focus and commitment to the motorsports industry and our never-ending efforts and passion to improve the performance and reliability of race engines," said Corey Smith, Co-Founder and CEO of Xceldyne.

"Relocation to the United States facility will allow us to efficiently expand the premier steel valve and valvetrain components business across all motorsports disciplines," Smith added.

"Our established relationships with many of the European race teams will allow Xceldyne to expand brand recognition across the globe," commented Jean-Charles Marteau, Co-Founder and General Manager of Movaltec.

The integration of both companies is expected to be completed by the end of January. Marteau will join the Xceldyne team and fulfil the role of Director of Engineering and Manufacturing Technologies.

The partnership enables Xceldyne to realize its full potential designing and manufacturing valves and valvetrain components from concept to reality.

Going into 2021, Xceldyne's expanded product offerings will consist of titanium and steel valves, finger followers, rocker arms, roller lifters, bucket tappets, spring retainers and locators, valve locks, lash caps, valve guides, XTS Timing Systems, PSI valve springs, Spin fuel pumps and wrist pins.

BMW parts with RBM and Schnitzer

BMW'S long collaboration with the iconic RBM and Schnitzer squads has become a casualty of the premature end of the DTM's Class 1 era.

Schnitzer Motorsport has been one of the most influential and successful teams in the world of international GT and touring car racing since the 1960s – always with BMW race cars. The squad has also been instrumental in shaping the BMW brand in terms of sportiness and dynamics.

"BMW was our life and our passion," commented Herbert Schnitzer jun, Schnitzer's Team Principal BMW Team. "We very much regret that, given the changes in motorsport, it is no longer possible to continue the cooperation with BMW Motorsport. However, we obviously understand and respect the decision. We are proud that we Schnitzers have, ogether with BMW, shaped international motorsport for so many decades."

The switch to a customer-based DTM also brings down the curtain on BMW's successladen 25-year relationship with RBM.

"It is a great shame, but we respect the fact that BMW Motorsport is unable to continue the collaboration with us as a works team," commented Bart Mampaey, RBM's Team Principal. "BMW has always been at our side, from the very beginning to the final curtain in the DTM, and our relationship will remain a strong one, even if we are no longer a works team.

"Times are changing and we are all facing a challenging future. At RBM, we will initially reduce our racing activities. However, that does not mean this is the end of our motorsport chapter."

BMW Team RMG, that previously was one of the works teams in the DTM and celebrated two drivers' titles with Marco Wittmann, will serve as a development team for the new BMW M4 GT3 in the future.



ABOVE Outright victory at Le Mans in 1999 with the V12 LMR was a standout moment for Schnitzer

BTCC ups success ballast

SUCCESS ballast will be raised for the 2021 Kwik Fit British Touring Car Championship. The move is part of a series of rules tweaks which also relate to the qualifying format and tyre options.

A maximum success ballast of 75 kilograms will be reintroduced, up from the current 60 kilograms, returning the series to the levels it featured between 2015-18.

Originally, the figure was reduced because it was judged that the ballast was too heavy a penalty to carry in a closely-packed field. Now, however, TOCA believes that cars demonstrably carry success weight far more capably and competitively than before.

The 2021 series could mark the final hurrah for success ballast. The intention is that from 2022, when Cosworth's hybrid technology is introduced, the hybrid system can be used for performance balancing.





LEFT A wide turbo-spec lightweight body is being used for the first time in the Cup car

Porsche unveils 'best 911 GT3 Cup car ever'

PORSCHE has unveiled the latest generation of the world's top-selling racing car: the new 911 GT3 Cup.

The spectacularly styled Cup car is the first racing version based on the current 992 generation and the first makes-cup racer of the sports car manufacturer to feature a wide turbo-spec body.

Producing around 375 kW (510 hp), it exceeds the output of its immediate

predecessor by 25 horsepower. Moreover, the new GT3 Cup can run on synthetic fuels, which significantly lowers CO2 emissions under racing conditions. The lap times of the completely new Cup 911 should be slashed by a good one per cent, depending on the track layout.

"The 911 made history as the baseline model for the Carrera Cups and the Porsche Mobil 1 Supercup – no other racing car has found as many satisfied customers since 1990 as the 911," said Michael Dreiser, Director Sales Porsche Motorsport. "The new 911 GT3 Cup now starts a new chapter. Our goal is to pass the 5,000 mark in production over the coming years."

"We wanted to position the new 911 GT3 Cup even more as a professional racing car, while also making it more costeffective for the teams to run," explained project manager Jan Feldmann. "We were particularly successful in achieving this thanks to its striking appearance, the improved suspension and intelligent solutions for electrical details. The handling of the new 911 GT3 Cup is noticeably more precise and even more fun. With its improved performance and the optimised cockpit, it's the best Cup car that Porsche has ever built."

From the start of the 2021 season, this racer will be campaigned in the Porsche Mobil 1 Supercup as well as the national Porsche Carrera Cups in Germany, France, Asia and Benelux and for the first time in North America.

Delivery to teams will begin in February 2021. The new 911 GT3 Cup is available with immediate effect at a price of 225,000 Euros plus country-specific taxes.

Peugeot reveals details of WEC powertrain

PEUGEOT Sport and TOTAL have revealed the main technical characteristics of the HYBRID4 500KW powertrain for its new Hypercar, which it will use to compete in the FIA World Endurance Championship.

The French manufacturer has leveraged its experience of endurance racing (V12 and V8 908s) and the World Rally Championship (four cylinders) to develop a new 2.6-litre, twin-turbo, 90-degree V6. Positioned behind the driver, this 500 kW/680 hp powerplant will tip the scales at 165 kg and drive the rear wheels.

"We initially considered a single turbo, but that would have prevented us from achieving our engine's centre of gravity target," said François Coudrain, Peugeot Sport's WEC Program Powertrain Director. "A twin-turbo V6 block offers the best trade-off between technology, weight, packaging of the engine's ancillaries, reliability and performance."

The sequential seven-speed (plus reverse) gearbox will be controlled by steering-

wheel-mounted paddle shifters, and the brake-by-wire system developed by Peugeot Sport will also be managed electronically. Optimal energy management, both under acceleration and during energy recovery (capped by the regulations at 200 kW), will consequently be key to the car's performance and efficiency.

Cooling fluids and engine/gearbox lubricants will be tailored for endurance racing by TOTAL, while the high-density, high-power and high-voltage battery (900 volts) was developed jointly by Peugeot and Saft, a TOTAL subsidiary. Saft is bestknown for its work with Ferrari in F1.

A front-mounted 200 kW MGU will drive the front wheels and benefits from the team's experience of developing electric motors and management systems for production cars. PSA Motorsport's experience of the WRC and Formula E will contribute to the development of the software employed to manage the computer and energy systems.



LEFT The policy of sharing information between Groupe PSA's different motorsport departments has paid dividends in developing the HYBRID4 500KW powertrain

23

"A BATTERY IS LIKE A LIVING OBJECT - IT *REMEMBERS* **WHAT YOU'VE DONE"**

With battery technology key to the seismic shift towards electrification, **Chris Pickering** talks to the US CEO of a battery pioneer that deals with some of the world's most demanding customers

AST your mind back to 2012. Lewis Hamilton was already a World Champion with five seasons of Formula 1 under his belt, Toyota was back at Le Mans and the FIA had just announced its plans to launch an allelectric race series called Formula E. In that context, nine years really doesn't seem like a very long time.

Why nine years? Well, that's how long those of us in the UK have until the sale of

conventional petrol and diesel road cars will be banned. Hybrids will continue to soldier on in some form until 2035, but even their days are numbered. Suddenly the mass-adoption of electric vehicles – for so long a mirage on the horizon – seems very real and very close.

Admittedly, that's just one market in a vast global industry, and there's some debate as to whether this highly ambitious target will actually be met. But it's indicative of a seismic shift towards electrification in road cars, which will have to be reflected in motorsport if we want the sponsorship dollars to keep rolling in.

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By far the most challenging aspect of an electric vehicle to engineer is its battery. Electric motors are cheap, light and based on well-proven technology. High power, high energy batteries, on the other hand, are an emerging technology that will decide the success or failure of electric LEFT The battery system used on the F-35 fighter plane was initially tailored to F1 requirements

BELOW Groupe PSA and Total, of which Saft is a wholly-owned subsidiary, have just created Automotive Cells Company, a joint venture dedicated to the development and manufacture of high-performance batteries in Europe. Peugeot's forthcoming Le Mans Hypercar offers the perfect showcase for their advanced technology battery solutions motorsport in the coming years.

One of the pioneers in this arena is Saft, a wholly-owned subsidiary of Total. Headquartered in Paris, with R&D centres in France and the United States, it was one of the first battery suppliers to work on F1 KERS systems – establishing partnerships that endure to this day.

Saft itself will neither confirm nor deny its involvement with any individual teams. But it is well-known within the industry that its battery expertise was at the heart of Ferrari's first KERS system. Indeed, it was presented with a Scuderia Ferrari Innovation Award for its work in this demanding field.

The company's high-performance Li-ion technology is known to have been utilised in the energy recovery system by as many as five teams during F1's current hybrid era.

"Our activity in F1 started back in 2006 with sampling high power cells for evaluation, we manufactured the first production cells in 2008 and raced for the first time in 2009," recalls Annie Sennet, CEO of Saft America and executive vice president of the company's Space and Defense division.

"Lithium ion batteries were still relatively new at that time and Saft was known to be one of the leaders in high power

The better you can get at predicting what your battery has experienced, the better you can optimise it for the future"



applications, so an F1 team approached our R&D centre in Bordeaux. Our colleagues there referred it over to us here in the United States where we were working on high power projects for the US Department of Defense."

The brief was basically to provide very high power from a small, rechargeable cell. The closest thing that Saft had on its shelves at the time was a battery system used on the F-35 Joint Strike Fighter, so this was taken as a starting point and tailored to the F1 requirements.

One of the eventual defining requirements was that the cells had to operate at unusually high temperatures in order to minimize the heat removal requirements of the cooling system. Over the years, Saft has been able to progressively push the maximum operating temperatures up further still, enabling teams to minimise the impact to aerodynamic performance that would otherwise be required from a larger radiator for the cooling system.

"In the defence world, everyone wants things that can work at low temperatures, the same for aerospace. For motorsport, we suddenly had a lot of people coming to us and saying, 'How hot can you go?'" comments Sennet. "The other big difference is the timescale. With the Department of Defense you might get five years to do it; with Formula 1 it might be six months."

Much like internal combustion engines, batteries have a sweet spot where they operate best. Higher temperatures can actually boost performance, but the challenge then becomes durability.

"Developing an electrochemistry that could operate and also be recharged at very high temperatures was a really big leap in technology. It relates a lot to the thickness of the electrode and the electrolyte formulation," Sennet explains.

This comes down to the fundamentals of battery chemistry. A voltaic cell works by allowing electrons to flow from one electrode material to another via an external circuit, thus producing a current. To balance out the flow of negativelycharged electrons, positive ions (liberated at one electrode and absorbed at another) must flow through the electrolyte within the cell. The composition of this material is key to the lithium ions' ability to move back and forth within the cell, and it can degrade over time.

"These electrolytes are organic, so they tend to degrade faster at higher temperatures. It's like leaving an apple out in the sunshine as opposed to putting it in the fridge," notes Sennet.







ABOVE Research into solidstate batteries, ideal for EVs and energy storage applications, puts the industry on the path to what has long been considered the 'Holy Grail' of Li-ion battery design: using metallic lithium

LEFT Saft's F1 involvement predates Ferrari's first victory with a KERS system at Spa in 2009



ABOVE Annie Sennet, CEO of Saft America, says this is an exciting time for the industry

RAPID EVOLUTION

Formula 1 battery design has evolved rapidly since KERS first appeared. The original regulations, drawn up for the 2009 season, outlined a modest system that was an optional addition to the 2.4-litre naturally aspirated V8 engines used at the time. The power output was capped at 60 kW (80 bhp) and the energy storage system – a battery in most cases – was not allowed to release more than 400 kJ of energy per lap (equating to 6.67 seconds of use at full power). Saft's customer was one of four constructors to run a KERS system during the 2009 season.

Although technically still legal in 2010, the Formula One Teams Association agreed not to use KERS. But the concept returned for 2011, and so did Saft. Although the energy allowance remained the same, the new regulations increased the minimum weight limit by 20 kg (to 640 kg), tipping the balance firmly in the favour of the KERS-equipped cars. The rules remained the same for the next three seasons, during which time KERS established itself as an Developing an electrochemistry that could operate and also be recharged at very high temperatures was a really big leap in technology"

accepted part of F1. Elsewhere, the frontrunners in LMP1 sportscar racing had switched to hybrid power from 2012, strengthening the technology's grip on international motorsport.

The big change in F1 came in 2014 with the introduction of the current 1.6-litre V6 regulations. These saw a complete rethink on the powertrain philosophy, with a far more complicated energy recovery system (ERS), including multiple motor-generator units that would be a core part of the design.

The power of the MGU-K – analogous to the old KERS system – alone doubled to 120 kW (161 bhp). Furthermore, it was now joined by a second heat energy recovery system (MGU-H) that was theoretically unlimited in terms of **>**



ABOVE Saft's pouch cell for demanding applications

power. This on its own would place tougher demands on the battery, but the capacity also went up by a factor of 10 – the cars being allowed to deploy up to 4 MJ per lap and harvest as much as 2 MJ.

RIGHT A Saft employee monitors pouch cell operations

"Once KERS became ERS it placed much bigger demands on the battery system," comments Sennet. "We managed to push the power capability further than we initially thought would be possible, but we've also been able to provide more energy. Power and energy don't necessarily go hand in hand: they typically work at odds in terms of electrode designs and material choices. So to push both of those, while reducing weight, and to develop that in a compressed timescale, is very challenging."

Another milestone came in 2018 when a revised set of regulations limited the teams to two batteries per driver per season. This

High power, high energy batteries are an emerging technology that will decide the success or failure of electric motorsport" put an even greater emphasis on battery life. "It was a cakewalk in comparison when you could change the battery six or seven times a season," jokes Sennet.

The durability challenge relates not just to the chemical and structural design of the cells, but also the hardware and software used in the battery management system (BMS). Once a relatively simple device to monitor the state of the battery and provide basic safety features, this is now a hugely sophisticated piece of engineering in its own right, collecting vast quantities of data and applying complex algorithms to manage the cell as effectively as possible.

"The better you can get at predicting what your battery has experienced, the better you can optimise it for the future," comments Sennet. "A battery is like a living object – it remembers what you've done to it. No two races are the same, so you need to know what it's been through.

"For instance, if you have a cold race or a hot race; a tight and twisty circuit versus one with lots of long straights; it all wears on the battery differently. But as long as you can track that and characterise it you know how much the battery has







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got left to give."

While battery chemistry might be new to F1 teams, datalogging is very much familiar ground. "I'm constantly amazed by our motorsport customers when they show us the data from the battery," notes Sennet. "They'll say, 'This was a rainy race in Canada' or something like that and there is an appreciable difference in the data. That's a reflection of the mentality in motorsport – if it's over-designed by even a few percentage points, they want to know what they can get out of that."

This competitive spirit has driven a constant process of evolution. Saft began with a development of one of its existing cell designs – an evolution of which continues to be used in some motorsport applications today. Since then, the company has also developed a prismatic pouch cell using the same basic chemistry, which is said to offer improved weight and space-efficiency, cost benefits and safety advantages.

LOOKING TO THE FUTURE

Saft is still heavily involved in F1 ERS systems, but it has also begun branching out into additional racing series, expressing interest in allelectric and hybrid racing series as the opportunities arise.

The company's background in F1 has provided it with an ideal starting point for these new challenges. "At the end of the day, it all comes down to the customer's requirements. Everyone has targets for power, energy, how many charge and discharge cycles it needs to last for, what packaging volume it needs to fit into, and what temperature it needs to run it's not just in the applications but in the customers. We work with NASA and we work with racing customers, and we see the same type of people and the same approach to innovation at both."

When it comes to road cars, the hottest topic in battery development at the moment is solid state cells. These still use the same principle as other forms of lithium ion, but – as the name implies – they use a solid electrolyte as opposed to

With the Department of Defense you might get five years to do it; with Formula 1 it might be six months"

at," comments Sennet. "At the beginning of our work in Formula 1, the very high temperature, high power requirements were something we hadn't really seen before, but between aerospace, defence and racing I think we've covered pretty much all the possible combinations now." Synergies between these various sectors still exist, she says: "It's remarkable where some of these similarities occur. There are parallels even between the F1 systems and the extreme environmental conditions encountered in deep sea drilling. And the traditional liquid or polymer materials. "Solid state is definitely going to help with high energy demands, and there are benefits in terms of safety and cost, so I can see a lot of interest from road car manufacturers," comments Sennet. "It's not necessarily so much about high power, though, so it's hard to say if it'll have as much impact in racing. We still have plenty of way to go with other forms of lithium ion – the term covers a broad range of chemistries, it's not like NiCad

or nickel-metal hydride where they were







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Complete library of cad drawings and 3D models available at: www.aurorabearing.com essentially one technology."

Which option is used in each motorsport application will depend on the regulations and the duty cycle that's involved. The batteries used in a fuel cell vehicle, a hybrid and a fully electric racer will vary considerably, on top of which you have different requirements for race duration, price and long-term durability. It certainly won't be a one-size-fits-all solution.

Even at the top end, though, Sennet believes that the lessons learned from racing will be able to be fed back directly into mainstream applications: "Some of the special tailoring that we do for motorsport might not be transferable to high volume applications, but the basics absolutely can be transferred. The

electrode design, the chemical composition, the manufacturing processes are directly applicable."

In fact, low volume projects in motorsport and defence can be a great enabler for these technologies, she points out: "Road cars face so many more challenges in terms of the production volumes and the labyrinthine safety regulations, so it provides a great platform to develop new ideas before they have to face those challenges.

JNDER

There are a lot of programmes out there to turn defence products into commercial products. In many instances, the commercial market wouldn't have been able to overcome the high entry costs, but you can test something out in much smaller volumes in motorsport or defence and then apply that to mainstream applications. We refer to it as the race to be second."

Who knows, maybe by 2030 Lewis Hamilton will be on his 18th World Championship and a 51-year-old Kimi Räikkönen will be looking forward to his 28th season in Formula 1? Whatever happens, you can bet that battery technology will play a far greater role in the sport than it does today.

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33



"RUNNING FIREBALL"

As he escaped miraculously from the Bahrain GP inferno, Romain Grosjean had an image from a safety video rushing through his mind. **Marc Cutler** reveals how the FIA's new protective clothing standard, introduced last season, raised the safety bar

T the 2018 Punta Del Este E-Prix Audi driver Lucas di Grassi was fined \$10,000 and given three penalty points on his racing licence for not wearing the correct fireproof underwear. Some observers claimed that the penalty was harsh but di Grassi immediately accepted it.

"It was a mistake on my part," he said at the time. "It was a decision that I took today because of the extreme heat and I ran out of underwear, and I didn't think this would be an issue. But of course I must be aware that I should wear compliance [kit] during a race."

There is a reason di Grassi didn't protest the penalty when others around him did – he knows these rules are there for the safety of him and his fellow drivers.

From 2020, all drivers in Formula E, Formula 1 and the World Rally Championship (Priority 1 driver and co-driver) had to pay more attention to what they wore. The FIA released a new Protective Clothing Standard (8856-2018) which is mandatory for drivers in those championships, and for Formula 2, the World Endurance Championship, World Rallycross and the FIA World Touring Car Cup from this season (2021). This means that drivers can only wear clothing – race suits, underwear, gloves, shoes – that has passed new stringent tests.

LIGHT YEARS AHEAD

These latest developments in protective clothing have been almost 20 years in the making, with the new standard developed by the FIA alongside leading racewear manufacturers to ensure the highest levels of safety. In previous years, drivers would wear heavy suits, but in recent years they have moved to more advanced materials such as Nomex – a lightweight artificial fibre solution. These used to be homologated under the 8856-2000 ► "I'm like 'Oh, shit, I'm like a running fireball'. The image, we've seen a video from the FIA, they did a test, they put someone on fire and he runs around just to show the overalls were strong. I've got that image, I've got fire following me"

Romain Grosjean

This article is republished with permission from FIA's AUTO magazine

RIGHT The image running through Romain Grosjean's head as he escaped in Bahrain. Under a new FIA standard that was introduced for 2020, race suits have to be able to withstand direct flame for at least 12 seconds









standard, published 18 years ago, but the new update has necessitated a major upgrade in all racewear.

The new FIA Standard 8856-2018 offers several advances by enhancing the tests that each piece of clothing must pass. One major improvement has been to what is called Heat Transfer Index (HTI), which has increased by 20 per cent.

Nuno Costa, the FIA's Head of Competitor Safety, says this was key when transitioning from the previous standard, to help protect drivers against direct flames and second-degree burns.

"The problem we had with the previous

standard is that while we were doing heat transmission on the overalls and gloves, for underwear, balaclavas, socks and shoes we only had a requirement with the density of the material," explains Costa. "Along the years the drivers started to wear materials better adjusted to the body for comfort, so density was not relevant anymore."

The move away from using dense materials in favour of slim-fitting race suits is partially down to drivers wanting to save on weight in the car. In F1, racewear manufacturer Puma developed a new and lighter race suit that weighs just 650g, while Lewis Hamilton has been known to The test on drivers' suits was challenging. The suit had to meet the new standard while still having the same materials, weight and breathability'"




ABOVE Romain Grosjean walks away from the scene of his accident, having unwittingly demonstrated the value of the FIA's stringent new test on flameproof racewear ask Puma to check every single bit of his racewear to save weight.

Underwear has been a key focus for the new standard because it is now part of the heat transmission test, which means it has to meet a whole new set of requirements.

"What we decided to do for the new standard is to introduce a new heat transmitting test on underwear," says Costa. "We are stretching the materials to represent the way vests and pants are being worn by the drivers in the car. So even if the driver wears a material that is stretched we can still ensure that we are giving the right protection."

This has made the new underwear standards particularly difficult to pass as it involves testing heat transmission under stretching while the garment has a flame applied to it for a minimum of five seconds to achieve a temperature rise of 24°C.

It's one of the key areas that manufacturers have struggled with because of the tension that the ►



ABOVE Alpinestars was among the leading racewear manufacturers that worked hard in their laboratories to meet the new standard

RIGHT Extensive stretch panels ensure that the Alpinestars WRC suits are as flexible as possible RIGHT Materials used in various race garments were frametised as part of the FIA's new criteria

underwear is put under during the test. This is partly down to how they make the underwear, which has prompted manufacturers to find new technology to produce it.

"It's more about the knitting of the material, not so much about the type of material used now," explains Costa.

CHALLENGING ENVIRONMENTS

The strict design requirements that each manufacturer must adhere to are part

of what makes the standard rigorous, which is why each piece of protective clothing is subjected to these tests. The HTI test stipulates that a driver's suit must withstand a direct flame for a minimum of 12 seconds, while the underwear, socks and balaclava must withstand a minimum of five seconds, the shoes 11 seconds, and the gloves 11 seconds with exception of the palm which must withstand eight seconds.

This has proved a major challenge for the manufacturers. Nico Buzzatti, Quality

Manager at racewear manufacturer Alpinestars, explains: "The HTI test on the drivers' suits was the most challenging of the tests we experienced. We had to ensure that the suit was able to meet the more rigorous standard while still keeping the same low weight, by continuing to develop new materials, and ensuring that they still delivered the same high levels of breathability for which we are known."

Modern race suits are light and breathable to improve the comfort and safety of **•**

LEFT Underwear material had to be stretched as well as made to withstand direct heat for a set period of time





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drivers in the car. The dilemma was how to maintain this while meeting the new tougher standards.

"If the overalls are too thick the drivers may start getting fatigued because of the lower breathability level of the garment," explains Costa. "That is why comfort is so important, the overalls need to be still wearable for the type of events that we have in FIA championships."

As racing drivers are competing at high speed in a precision environment they can often feel even the slightest bit of discomfort in the cockpit. This is why Alpinestars works with drivers to provide bespoke clothing to manage this.

FREEDOM OF MOVEMENT

"Often the driver's body shape and the structure of the seat causes discomfort, so we will move the position of a seam by 1 mm or 2 mm to combat this," explains Buzzatti. "We also make the suits extremely breathable by incorporating honeycomb structured linings and, where possible, strategically-positioned breathable stretch panels located in the lower back, crotch, and underarm areas which provides more freedom of movement."

These demands can be slightly different for

Often the driver's body shape and the structure of the seat causes discomfort, so we move a seam by 1-2 mm"

rally drivers because they often work on the car during stages, spending a large amount of time leaning over or even laying on the floor which can be a rough and dirty surface.

"The main focus for Alpinestars is to ensure that a suit will be as flexible as possible for rally drivers," says Buzzatti. "Our WRC suits feature extensive stretch panels on the lower back, crotch and knee area for optimal levels of comfort."

DANGERS OF PROLONGED USAGE

Under the new standard each piece of clothing will only have a validity period of 10 years according to the FIA, after research demonstrated that the clothing may lose its safety performance following prolonged usage. To ensure that each product purchased and worn by drivers on a race weekend is genuine, there will be a new marking system in place that makes it easier than ever for officials and National Sporting Authorities to identify original products.

In the future, there are also plans to have a helmet extrication system in the driver's balaclava. This will enable a helmet to be removed from the driver's head without transmitting loads to their neck and in turn reduces the chances of causing further injury.

"Until now there wasn't standard requirements to approve products that reduce the loads transmitted to the neck while removing the helmet," says ABOVE & LEFT The new standard applies to race suits, but also to underwear and balaclavas, plus gloves, socks and shoes

> **RIGHT** Alpinestars was the first manufacturer to pass the tests for all of its pro-level racewear products

Costa. "For that reason, the FIA Medical Commission asked the safety department to come up with design requirements and performance assessments."

Even though fires such as the one in Bahrain are not usually a sight seen in top-level motorsport these days due to advances in car design, Costa believes this does not mean there should be a relaxed attitude towards protective clothing. The new standard gives drivers access to the safest race suits they've ever worn, with a minor cost increase, and their improvements demonstrate how the FIA is constantly evolving safety research in these areas.

Manufacturers have already homologated a number of products to the new standards with the FIA. Ironically, Alpinestars – which supplies Grosjean's racewear – was the first of the manufacturers to pass the tests for all of its pro-level products...



Tough Stuff

Protective racewear clothing must pass the following tests to meet the FIA's demanding new standards

TEST	ТҮРЕ
Flame Resistance	Material is subjected to a direct flame for a prescribed amount of time.
Heat Transmission	Material must withstand a direct flame for a minimum of 12 seconds, while the underwear, socks and balaclava must withstand a minimum of five seconds, the shoes 11 seconds, and gloves 11 seconds with exception of the palm which must withstand eight seconds.
Heat Transmission for Undergarments	Material is tested to see how it performs when fixed on a surface and stretched, then subjected to heat.
Mechanical Resistance	Test to see how much the material bends and stretches under load.
Thread Flame Resistance	Test to see resistance of sewing thread on exposure to a flame.
Tensile Strength of Structural Seams	Strength of seams tested using a tensile-testing machine.
Tensile Strength of Shoulder Handles	Strength of shoulder handles tested under tension, which is increased gradually until rupture.
Dimensional Change	Material tested to see the dimensional change when subjected to washing and drying procedures.
Convective Heat Resistance	Convective heat resistance properties of non-textile materials tested with a temperature of 260°C.
Glove Fingers	Flame-resistance of the seam of the fingers of the glove is tested.

REDEFINIG EFFICIENCY

Formula E has propelled the science of race transmission design and development into a new era. **Chris Pickering** talks to the supplier instrumental in the reigning champions' back-to-back double title success

LECTRIC drivetrains are ushering in a whole new era in motorsport. With radically different operating speeds and torque curves, the well-established rules that govern the design of internal combustion engine gearboxes no longer apply. Instead, a new breed of transmissions is evolving at breathtaking pace – led by those in Formula E.

Ricardo has seen both sides of the coin. The UK-based company is an active supplier to teams in Formula 1, sportscar racing and rallying, with motorsport experience stretching back nearly a century. It has also been working on Formula E gearboxes since 2016, becoming the official transmission supplier to the DS Techeetah team at the start of Season Five in 2018. Since then, the team has won both the drivers' and constructors' championships two seasons on the trot, making it one of the most successful outfits in the series to date.

Outwardly, there's not much to a Formula E transmission. Although the rules still allow up to six ratios, the teams have all now converged on a single-speed configuration with no shifter mechanism to worry about. The development journey that's brought them to this point, however, has been far from straightforward. And in a series where every last drop of energy counts, transmission efficiency is one of the most significant areas of development.

To understand how Formula E's transmission technology has evolved, and what the future has in store, we spoke to Steve Blevins, project manager for Ricardo's motorsport division.

"It's not starting from scratch as such, but a lot of what we've learnt from traditional motorsport gearboxes no longer applies," he comments. "Efficiency has always been the key driver in Formula E, and minimising power loss is the main aim of the powertrain design."

Before we get on to what makes that possible, let's start with a quick look at the history of the series. In the first season **ABOVE** Ricardo's Formula E transmission has evolved with a laser-like focus on driveline performance and efficiency

of Formula E (2014 to 2015), all cars used the same five-speed gearbox from Hewland with a pneumatic paddleshift system. This was part of a completely spec mechanical package, which included a common electric motor for all the teams and a standard battery from Williams Advanced Engineering.

From Season Two to Season Four, the rules were opened up to allow manufacturers to develop their own motor, inverter and transmission packages. At the same time, the power output from the battery was progressively scaled up from 150 kW to 180 kW in race mode (200 kW in qualifying mode). The first thing that the teams did was to reduce the number of ratios, with a variety of one, three and four-speed units in circulation during this period. To illustrate the thought process behind this, Blevins turns to one of Ricardo's earlier motorsport transmission projects – the gearbox on the Peugeot 908 endurance racer.

TALKING THE TORQUE

"There's a similarity between diesel engines and electric motors in that they both produce a lot of torque," he explains. "It's not always a foregone conclusion that more torque means fewer ratios, though. When we first began discussing the 908, the customer originally requested a five-speed gearbox, but we came back and proposed a six-speed unit."

The logic behind this is best shown with the thrust curves. These are plots produced by multiplying the engine's torque curve through the gearbox ratio to show **>**

A lot of what we've learnt from traditional motorsport gearboxes no longer applies" the tractive effort at the tyre contact patch through each of the gears. The same graph features a line for theoretical maximum power through each of the gear and speed combinations, along with a drag curve.

"When you look at the differences between third, fourth and fifth gears, the gaps between where the maximum power and tractive effort curves meet are quite small, but reviewing first to second to third, the gaps are quite big," he notes. "In this instance, switching to six speeds reduces the size of those 'power loss' areas quite considerably." The same set of curves for a hypothetical Formula E drivetrain has a very different shape, due to the torque curve of an electric motor. Here, instead of five or six distinct peaks with power loss areas between them, there are a series of near-rectangular zones with a large amount of overlap.

"The torque curve of an electric motor is very different to an internal combustion engine – even a very torquey one like a diesel," comments Blevins. "In this example, at 100 mph you could achieve basically the same effect in any one of three different gears. That means that you're carrying around a lot of hardware that's unnecessary."

By this point – around the time that Ricardo first began looking into Formula E – most of the teams had moved to a twospeed layout, although there were still a variety of different options. The big change came in Season Five (2018 to 2019) with the introduction of the Gen2 Formula E car, and with it, a whole new technical package.

A new 54 kWh battery from McLaren Applied Technologies offered nearly twice the energy capacity of the previous unit, allowing the drivers to complete a full





ABOVE LEFT TO RIGHT A full dynamic model

is generated from Ricardo's SABR software model. Combined with an FE model of the casing, the dynamics of the system can be studied to check on rib pattern placement race distance without swapping cars. Maximum power supplied by the battery (in qualifying trim) jumped from 200 kW to 250 kW, while maximum regeneration under braking went up from 150 kW to 250 kW. This extra power pushed the curves further along the speed range, which would create even more overlap on a multi-speed transmission. Instead, the manufacturers unanimously switched to a single-speed configuration.

"Not only is the power density of the battery very different with the Gen2 car, but it enables the manufacturers to fit motors that are far more powerful. It's night and day different, and it means we can do it all with a single ratio now," comments Blevins.

EFFICIENCY GAINS

Season Six (2018 to 2019) saw the twin motors setups that had previously been used by some teams banned. Since then, all the cars have used a single motor driving through a single-speed transmission, but that doesn't mean that they're all following the same design philosophy. There's still the question of whether to use a transverse or longitudinal motor installation, which has impacts on the packaging and the underbody aerodynamics.



Meanwhile, inside the gearbox, it's all a question of efficiency.

"Drag reduction and mechanical efficiency are the most important areas," comments Blevins. "We've been looking at special bearings, low friction seals and how we control the oil within the gearbox. Alongside those, there's the ongoing process of weight reduction and durability improvements. The guys at DS are completely focused on making efficiency improvements and are open to pushing the boundaries in all areas. We are using some expensive technologies in the gearbox to make what we see as some marginal gains in efficiencies, but they see these as being quite cost effective when reviewing the overall powertrain efficiency."

In the case of the bearings, the benefit is not so much the friction reduction, but their ability to run with very little lubrication, he explains: "Unlike our other motorsport applications, we don't pressure feed all of the bearings; for **>**



LEFT Ricardo has partnered the DS Techeetah team to back-to-back drivers' and constructors' titles some we rely on the oil mist within the gearbox to lubricate them. The gears are still pressure-fed, with jets straight into meshing points between them, but that's done primarily for cooling. Overall, it means less lubrication drag and less power consumed by the oil pump. We're not quite at the stage where we could run a gearbox dry yet, but we probably would if we could."

One of the fundamental challenges with electric motors is their operating speed. Peak input speeds can be up to around 30,000 rpm and the secondary shaft is also spinning well above the speeds normally seen in a combustion engine application.

HIGH SHAFT SPEEDS

"Engineering a gearbox is quite difficult at those sorts of speeds," comments Blevins. "The input gear is quite small and light, so that's not a problem in itself, but the shaft speeds are so high that even with low-drag seals we need to be careful to avoid generating too much heat. It's really about bearings, seals and lubrication on the input side. The secondary shaft has got a much larger gear attached, and it's still rotating at maybe 10,000 rpm, so that's more about controlling vibration and inertia."

Ricardo uses its own in-house software package, SABR, to carry out analysis on the gears, shafts and bearings. This

RIGHT Steve Blevins is project manager for Ricardo's motorsport division



ABOVE & BELOW Ricardo's GEAR and SABR software enable it to analyse vibration across the casing at different shaft speeds. The colours (from blue to red) show the extent of the vibration, with the natural harmonics of the gears clearly visible as a series of diagonal lines



15000 Retational speed [rem]

allows the engineers to look at things like shaft deflection and casing loads. These are then fed into a second package known as GEAR, which models the interaction between the gear pairs. Its inputs include oil level and viscosity, allowing the engineers to calculate the oil losses, total efficiency and the power loss.

"We're trying to spread the contact stresses as much as we can across the centre of the tooth, making sure that it doesn't move too far towards the tip as the gears rotate. That's important, because if we can control the stress it's possible that we could run a thinner, lighter gear," notes Blevins.

There's also a vibration issue to consider, he explains: "People don't necessarily associate NVH-type studies with motorsport, but noise comes from vibration, which is wasted energy. GEAR and SABR can talk to each other, and combined with an FEA model, they can be used to look at the vibration across the casing at different shaft speeds. The casings are less than 2 mm thick, so it's the ribs that provide most of the stiffness. All the surface of the casing is really doing is **>**

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KIMBERLEY MEDIA GROUP LTD holding the oil in."

These vibration characteristics are shown on a colour plot with frequency on the Y-axis and shaft speed on the X-axis (See page 46). The colours (from blue to red) show the extent of the vibration, with the natural harmonics of the gears clearly visible as a series of diagonal lines.

The extent of the vibration will depend on factors such as the design of the gears, the shafts and the casing. By modelling these effects, the engineers can find a solution that reduces the total amount of vibration. The end result is that they can generate a 2D map of gearbox losses across the full range of torque and input speed conditions. "A lot of the low rpm stuff is proportionally more draggy due to things like lubrication losses and seal drag. There's definitely a sweet spot in the middle," notes Blevins.

Ricardo has a suite of in-house test facilities to validate these models. One of the most useful is the 5E rig – used in two-wheel drive form for Formula E, but so named for its ability to place e-motors on all four wheels, plus a fifth for the transmission input. The input machine delivers 520 kW and theoretical 1,000 Nm of torque. However, for high-revving EV applications a 3.9:1 step-up drive is used, increasing the input speed to a maximum of 30,000 rpm and providing a maximum input torque of 250 Nm at 19,300 rpm. High-speed torque meters on the output shafts provide a resolution of 0.02 per cent.

"Our test engineers have a bit of a competition going as to who can get a test requirement with the highest input speed," jokes Blevins. "Formula E broke

Drag reduction and mechanical efficiency are the most important areas" that record at around 28,000 rpm when we first started working on it, but some of the electric road car motors are above 30,000 rpm now."

Unlike the road car units, the Formula E gearboxes only have to last for a few thousand kilometres. Each transmission is sealed at the first event of the year, with the drivers allowed two gearboxes per season. In theory that means that the teams can balance the mileage between the two, but they have to consider the possibility that something will happen to the first 'box, leaving the driver to do most of the mileage on the second.

"We're assuming that each car will do about 2,500 km per season," comments Blevins. "That's not like a Le Mans car where you know that you've got 6,500 km in a race week and maybe a 10,000 km service interval. In some respects, that makes Formula E easier from a durability perspective, but we're chasing efficiency gains measured in fractions of a percent." These incremental gains can be the









FEATURES

Back-Mounted - Back-mounting your seat to the rollcage at the shoulder level provides improved safety during sideways and oblique impacts, reduces driver fatigue and enhances driver feel of the car. Mandated by the FIA for GT3 in 2019.

FIA 8862-2009 - The 129 Series seats are all tested and approved to the FIA's highest possible seat standard which simulates a deceleration of 70G!

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difference between winning and losing in a series like Formula E. They put the transmission developers right at the centre of the action, making it a particularly satisfying project to be involved in, says James Oakenfull, Head of Motorsport at Ricardo: "Formula E is vastly different to Formula 1 in terms of how we work with the teams. Fundamentally, F1 teams are looking to outsource high-precision manufacturing. As an external supplier you might put forward a slight radius change or a surface finish consideration, but the designs are largely made-to-print. Formula E, on the other hand, requires a partnership in the true sense, due to the challenges of optimising concepts like single-speed drivetrains that are still in their infancy. It's a really exciting challenge."

THE FUTURE

The future of Formula E transmissions will depend on how the regulations evolve. The Gen3 car – originally slated for introduction in 2022, but now likely to be delayed by at least a year due to COVID – promises a big step up in technology. It will be a lighter, faster car with a generator unit (referred to as a reducer) on the front axle. The extra energy recovery provided by this system will enable the power output to jump to 350 kW – 100 kW more than the Gen2 cars and well over twice the power of the original Series One machines.

Although the reducer will be supplied as a 'spec' unit to all teams, it will have a significant impact on the duty cycle of the gearbox, Blevins explains: "When it comes to the Gen3 cars, we'll have to start from scratch, looking at the new regulations, but it's likely that the basic philosophy will stay the same. We might have to look at putting in bigger shafts, wider gears or more stiffening due to the extra power, but the chances are that it will still be a single-speed transmission with thin wall casings and follow a ABOVE SABR is a proven shaft, gear and bearing conception and design package. It allows the performing of sensitivity studies to determine the effect of different geometric features, bearing types and gear positions, with immediate results

MICHELIN

similar design philosophy to our current design."

The fundamental layout of the Gen3 transmission will also depend on the motor characteristics. Even by EV standards, the current DS motor operates at quite high speeds. This requires a significant gear reduction to reach the appropriate road speed, which is why the single-speed transmission uses two-stage reduction. The decision to use a transverse motor layout stems partly from the packaging requirements of this twostage system. If, for instance, the team was to switch to a low rpm motor concept, it might favour a single reduction step packaged in a longitudinal layout.

That's purely conjecture at this stage, with the focus at the moment very much on Season Seven, which is about to kick off in Santiago. The hardware for that season is likely to then roll over into Season Eight before the Gen3 car arrives for Season Nine.

Electrification is rapidly taking hold in other areas of motorsport too. Hybrid powertrains have been common in endurance racing for the best part of a decade, but they're set to take another step forward with the forthcoming Le Mans Hypercar (LMH) and

MOHIE

DS AUT



LEFT Ricardo's Head of Motorsport James Oakenfull

BELOW In a series where every last drop of energy counts, transmission efficiency is one of the most significant development areas Daytona (LMDh) categories.

"The driveline for the reducer on the front of a Le Mans Hypercar is basically the same as a Formula E gearbox, but the requirements are different as the regulations restrict power in LMH," comments Blevins. "There's no point having a massively efficient gearbox if the amount of power that you can capture is restricted by the rules – you're better off focusing on other areas. Formula E, in contrast, is very much an efficiency-driven series. That philosophy defines much of the gearbox."

Even within Formula E there are competing philosophies, such as transverse and longitudinal layouts, which can play a decisive role in the car's performance. Factor in all the other categories that are moving towards electric and hybrid powertrains, and it's clear that transmission design will be far from a 'one size fits all' solution.



BTCC NETS ANOTHER SAFETY FIRST

Chris Pickering reports on a collaboration with Cobra Seats and Schroth that has transformed the BTCC's demanding wish-list for a seat net into a reality

otorsport safety has come a long way since the arrival of seat belts and bag tanks in the early seventies. Nonetheless, you can still hear a sharp intake of breath in the paddock when something like Bobby Thompson's BTCC crash at Croft last year takes place.

Having slid wide at the Jim Clark Esses, Thompson's Audi dug into the grass and somersaulted half a dozen times before coming to a rest upside down. He emerged moments later, somewhat shaken but otherwise unharmed, thanks in part to a new safety innovation that had recently been introduced to the





ABOVE The seat net is an innovative solution that combines safety and practicality

LEFT Bobby Thompson's dramatic accident at last year's BTCC meeting at Croft provided a superb illustration of the seat net's worth



championship: the seat net.

At first glance, you might assume these perform a similar role to a traditional window net, but their benefits extend far beyond that. While window nets primarily serve to prevent the driver's limbs from being thrown out of the window during a crash, seat nets also provide additional support to the head and shoulders, as well as guiding the occupant back into the seat. The end result is that they provide a load path to transmit forces away from both the driver and the seat itself.

In accidents such as Thompson's, it's all about preventing the driver from moving around too much, as Mark Dunsford, managing director of Cobra Seats, explains: "It's been shown that



you can withstand a higher G-load in an accident if there's less movement. The seat, the harness and the FHR [the frontal head restraint or HANS device] all play a part in that, but they all work best in certain directions. The seat has a lot of lateral strength and rigidity around the head, shoulders and torso, while the FHR provides protection in a forward collision. If you get a collision at an oblique angle it falls between the main axes of the FHR and the seat, which tends to result in a lot of movement." It was this problem that led to the idea of using nets as an additional restraint system. They not only help to protect against off-angle impacts, but they also provide better visibility than a traditional window net. Plus, there's less likelihood of the net geometry being damaged or distorted in a severe accident.

The idea was enthusiastically embraced by the FIA and introduced to a number of series, including what was then the World Touring Car Championship and V8 Supercars. It also caught the attention of ► the British Touring Car Championship organisers TOCA. However, there was a snag. With its wide range of different vehicle architectures and the use of a manual gear lever (as opposed to a wheelmounted paddleshift), the BTCC required far more flexible geometry than the existing seat net design was able to provide.

Undeterred, TOCA technical director Peter Riches began hatching a plan to develop a universal solution. He approached Dunsford, whose company supplies more than half the BTCC grid as part of a joint venture with New Zealand company RaceTech, while harness manufacturer Schroth was brought in to provide R&D expertise. Together,





LEFT An additional vertical strap, affectionately dubbed 'the Riches control strap', enables the mid-point of the net to be raised

BELOW & RIGHT The cut and thrust of the action is part of the BTCC's attraction, so the series has worked tirelessly behind the scenes to constantly improve safety standards





they set about analysing the challenges posed by the series.

"There were two main issues that we needed to overcome with the BTCC seat nets," comments Dunsford. "The first was compatibility with a manual gearshift, because the net impinged upon that in the original [WTCC-style] design. The second was that it's hard to get the alignment of the net to work well to a single point in a typical BTCC car. We first looked at this about four years ago. Peter [Riches] and I met with Schroth and took a few nets to Silverstone, and it was just impossible. You couldn't operate the gearshift and the angle of the nets was too low to meet the FIA requirements."

At the time, just one car on the grid was found to work with the standard nets, so the group set about creating their own. "We raided the Schroth parts bin and went down to West Surrey Racing to play around with different options," he continues. "The problem with the geometry of the original nets is that they were really intended for GT cars with reclined driving positions, so the front mounting point was too high on a BTCC car, which is more upright." It was at this point that they came up with what has been affectionately christened 'the Riches control strap'. This is an additional vertical strap that raises the mid-point of the net, while still allowing the forward mounting point to run to the cross beam on a touring car's roll cage. An additional strap was introduced to pre-tension the net, drawing it away from the gear lever and reducing the slack that could otherwise allow the driver's arms to move further in an impact.

FOUR-POINT DESIGN

The end result was a collection of four links (including the leading edge of the net itself) running to a central point. Once again, the group went back to the Schroth parts bin and found the solution in a buckle that was originally intended for a road-approved four-

RIGHT The design improves visibility compared to a window net because it sits just below the level of the driver's side wing mirror



point harness.

"The buckle that we use is strong enough to take the full crash loads mandated by the FIA, and it has a discreetlypositioned button that you can't press unintentionally," explains Dunsford. "It's also got a very clever design that eliminates the backlash found in some buckles, so you don't have to re-tension the net once it's clipped in."

Crucially, the new design was found to fit the whole BTCC grid with adjustment to spare, so with the basic concept proven, it was sent to Schroth's R&D department for drop tests. The next challenge was to convince the FIA to rewrite the safety standards governing seat nets to allow the new universal design to be implemented. Doing so involved another comprehensive series of tests at DEKRA's test facilities.

"We had to consider every possible eventuality in order to get the safety



BELOW Where

existing seat nets

universal solution, the

whole BTCC grid with

adjustment to spare

new design fits the

didn't provide a

We had to consider every possible eventuality: we literally tested it inside out and back to front"

standard changed," comments Dunsford. "That's not just all the different load cases and fitments if it's installed correctly, but also what happens if a team or driver gets it wrong. We literally tested it inside out and back to front."

The thoroughness of the tests was partly down to the wide range of different applications that their creators had in mind for the new nets. Beyond the professional teams and drivers of the BTCC, it's envisioned that this concept could be applied right down to club level, including tin-tops and open sports cars.

"If this is going to be cascaded down to other series it can't just be something for professional teams. It has to be something that an amateur driver working in their own garage can fit," comments Dunsford. "Instructions are provided in the kit, detailing the alignment that's required for the straps. In most cases, these can simply be looped over the cage and fed back through a buckle, as you would with a harness. Even the front mount can generally be fed through an air vent to pick up the ►



Cobra: The Seat Of Champions

In the last ten years, Cobra race seats have crossed the BTCC finishing line in first place more than any other seat.

Evolution Survival of the Taller seats – responding to changes

in harness geometry and ergonomic demands

he binnacle of otorspo

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BELOW BMW's success last season means that all of the last 10 BTCC Manufacturers' Champions have chosen to use Cobra seats front bulkhead without any serious fabrication." In fact, seat nets could be particularly applicable in lower-budget national series, Dunsford points out. Many of these categories allow seats that have been approved to the older FIA 8855 specification that involves lower impact loads.

"We've tested 8855-compliant seats to destruction and we know that you can usually get them to break by adding another 50 to 70 per cent on top of the loads required for the certification test," he explains. "With a seat net carrying part of the impact, you can double those loads. It's a very simple and costeffective solution."

BTCC PROVEN

The development and approval process took several years, but the new universal seat nets made their debut in the BTCC at the start of last year's COVID-delayed season. Initially, there was a degree of cynicism from the drivers, but that soon went away once they'd tried the finished net design, Dunsford recalls.

"We've got a great relationship with a number of the drivers in the BTCC. They're all very proactive on safety, so they were very supportive of what we were trying to do, but they were also worried about things like the possibility of catching their elbows in the nets if



LEFT The control strap lifts the front attachment point up to the desired level and triangulates the load between the cross-car beam and the front roll hoop of the cage above the windscreen

BELOW The effective and highly adaptable design provides an opportunity to cascade the use of seat nets down to all levels of the sport they have to collect a big slide," he comments. "But when we finally got them in the cars they were really impressed. It improves visibility massively compared to a window net, because it typically sits just below the level of the driver's side wing mirror."

The BTCC's successful seat net initiative is indicative of the growing momentum to improve standards in this area. Sir Patrick Head, President of the FIA Safety Commission, presented an updated safety standard for entry-level competition seats at December's meeting of the World Motor Sport Council. The next generation of seats will incorporate an attachment point for safety nets. Their lower cost should also make it easier to roll out safety nets across other categories.

"Driver seat nets represent a significant advance in motorsport safety," maintains Riches. "We knew that if we could develop a

FF This concept could be applied right down to club level"

highly adaptable solution, which could be installed without any modification to seats and cages in competition cars, it could be a game-changer."

Seat nets were made mandatory in the series from the Thruxton rounds in September. Just under a month later, Thompson's spectacular incident at Croft provided a vivid demonstration of why the nets were introduced. And that's just the start of the story. Work is currently going on to investigate the possibility of fixing the nets directly to the seats, further simplifying the installation process of what is already a truly universal design.



WORKING FASTER AND SMARTER

With the legislative net tightening on wind tunnel testing, **Chris Pickering** finds that the pressure is on to extract better data, quicker

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RIGHT Titles might be won on the racetrack but, with aero development king, the seeds for success are sown in the teams' windtunnels. Cosworth's tools have been honed to enable teams to conduct fast, accurate and repeatable aero testing



teams continue to invest heavily in the technology.

The wind tunnel facilities themselves are evolving too, with increasingly sophisticated data acquisition and greater use of automation allowing engineers to work faster and smarter.

"It's all about getting better data quicker," comments Max Lotto, technical manager at Cosworth Electronics. "Productivity has always been important, because it's expensive to run or hire a wind tunnel, but the key driver at the top end of motorsport is the regulations. In F1, for instance, there's a limit on the number of runs and the total time that a given team can spend in the wind tunnel, so there's a strong incentive to make the most of that time."

Although perhaps better known for its in-car electronics, Cosworth was one of the first motorsport companies to develop bespoke motion control and data acquisition systems for scale model wind tunnel testing. Back in the 1990s, engineers from what was then known as Pi Research pioneered the concept of packaging the data acquisition hardware inside the model. (This allows the information to be digitised virtually at its source, rather than relying on long cables that can introduce noise and errors.)

Since then, the company has established itself as one of the leaders in the field – supplying every single Formula 1 constructors' champion since 2000, as well as working with some of the biggest names in NASCAR and IndyCar.

Although wind tunnel testing of full-scale vehicles is more accurate, testing on scale models is often conducted due to cost or regulatory reasons. In the case of Formula 1, the teams are restricted to 60 per cent scale models and a wind speed of up to 50 ms-1. The models are fantastically **•**



intricate pieces of engineering in their own right, built to faithfully replicate every detail of the real car and withstand the aerodynamic loads they produce.

The model's attitude and position within the wind tunnel is controlled by electric or hydraulic actuators, driven by the motion control system. This has the job of

Combining the accuracy and repeatability of the digital world with the authenticity of physical testing" ensuring that the model is presented at the right position relative to the air flow and the moving ground plane. The more recent versions of Cosworth's CMC motion controller use a laser alignment system to provide closed loop positioning that can compensate for any deflection in the model or the motion system in real-time.

"Positioning the model with very high accuracy is vital for repeatability," notes Lotto. "You need to be sure that the results are directly comparable from one day to the next. This allows smaller changes to be evaluated." In terms of data

acquisition,

the priorities are generally to capture the forces and moments acting upon the model, and to record the pressure distribution in key areas. The former is achieved with sophisticated electronic balances based on strain gauges, while sensor arrays connected to a series of pressure tappings are used for the latter.

Each pressure sensor array (often known as a scanner) typically measures 64 points and there are generally four, six or eight of them on the model, giving hundreds

> of individual channels. These have been measured electronically for decades, but the ►

ABOVE & TOP Cosworth's ESG16 module (top) accurately digitises readings from aero balances at 24 bits and up to 2 kHz. The EAl32 hardware expansion module offers up to 32 high precision, high speed +/-10V analogue inputs in a standalone and rugged IP67 aluminium housing

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sensors have improved continually, as have the test procedures.

"Fifteen years ago, it was common to measure the data in a quasi-static way," comments Lotto. "You might position the model, record the data over 10 or 20 seconds, and then move it to a different position. Rates of 1 to 10 Hz were fine for that. These days, there's a lot more interest in looking at the [turbulent] wake from the models, so you need to be able to sample at hundreds or even thousands of Hz across a large number of channels."

One of the biggest changes is that improved hardware and greater test automation has allowed the quasistatic approach to be replaced with a dynamic test process. Here, the model is continuously moving, enabling it to cycle through a pre-programmed range of vehicle attitude in a vastly reduced amount of time.

"It's not quite the same as a real-time lap simulation, but it allows all the key conditions for a given circuit to be evaluated in one process. You define the parameters for the test offline and then essentially just press play," says Lotto.

Tech transfer

IT'S not just motorsport that has continued to push the development of wind tunnel technology. Aerodynamic optimisation is playing an increasingly important role in road car design in areas ranging from drag reduction to aeroacoustics.

"Our exposure to motorsport culture makes us very reactive and receptive to innovation. A lot of that is also very relevant to road cars, particularly with regards to wind tunnel productivity," comments Max Lotto, technical manager at Cosworth Electronics.

"As road cars head towards electrification, OEMs are very keen to look at potential aero efficiency gains and the powertrains are a lot quieter, which puts more emphasis on wind noise."

THE CFD ELEPHANT

So what does the future hold for wind tunnel testing? "I think the elephant in the room is still CFD," comments Lotto. "There's no doubt that computer models are becoming more powerful, but the general view tends to be that a wind tunnel remains a better, more physical simulation. I think manufacturers will continue to use wind tunnels, even if it's primarily for validation, but ultimately it will come down to what the regulations allow them to do in their particular series."

Aside from the regulatory aspect, the relationship between wind tunnel testing and CFD is largely **•**

BELOW Originally developed to meet the demanding needs of the modern Formula 1 wind tunnel before branching into other automotive applications, Cosworth's Diablo is PC-based software for data acquisition and control. Modular, flexible and scalable for a wide range of applications, it provides a high degree of automation for test cells



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RIGHT The control room of the Dome windtunnel, which uses the latest Cosworth hardware and the CMC for motion control and Diablo software for test scheduling and data acquisition

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FF There's a lot more interest in looking at the wake. Where 15 years ago rates of 1 to 10 Hz were fine, now you need to be able to sample hundreds or even thousands of Hz"

New solutions

THE COVID-19 pandemic has pushed international companies like Cosworth to develop new solutions for dealing with overseas customers.

Unable to reach Japanese racecar constructor Dome, for instance, engineers from the Cambridgeshire company devised a way to update the organisation's motion control system from 6,000 miles away.

"Traditionally when we're looking at upgrades for a facility we go through a commissioning exercise, installing the new system and fine tuning it on-site," explains Max Lotto, technical manager at Cosworth Electronics. "This time we couldn't do that because it coincided with the first peak of the COVID-19 crisis, so instead we focused on preparing the hardware so it could be supplied as a 'plug and play' package. That worked straight out the box, and we were able to deploy the software successfully using remote access and a webcam."

The resulting productivity improvements are said to have resulted in a time saving of 40 to 50 per cent per move within the wind tunnel, with a total reduction in test duration of 15 per cent.

"We're now facing the challenge of commissioning a new facility for another customer and we're planning to do it the same way," notes Lotto. "It enables us to continue working while there are travel restrictions in place, but it also helps with the long-term goal of reducing our carbon footprint."



symbiotic, he points out: "CFD is good for visualising flows if you want to do a detailed study on a particular area, but preparing and running a simulation of the full vehicle can still take a long time. Until recently, there's been no doubt that it was faster to build parts, put them on the model and run them in the wind tunnel. That's still a simulation – you still have walls in the wind tunnel and other approximations that don't exist in real life – but it has historically been a better option than CFD."

PARTICLE IMAGE VELOCIMETRY

He points to mainstream automotive applications, where major OEMs are continuing to commission new wind tunnels, despite generally working with simpler shapes that should be comparatively straightforward to simulate with CFD. The complex geometry of modern single-seaters, on the other hand, plays more to the strengths of wind tunnel testing.

Advanced visualisation techniques such as particle image velocimetry (PIV) have allowed aerodynamicists to see flows within the wind tunnel in unprecedented detail. Another approach – made possible by multi-directional probes capable of



detecting flow direction as well as velocity – is to use a robotic arm to map out the wake. This can be done with the same motion control system that underpins the model, Lotto notes.

For now at least these technologies are enabling wind tunnel testing to keep pace with CFD development. Sophisticated hardware and software have combined the accuracy and repeatability of the digital world with the authenticity of physical testing. You could say it represents the best of both worlds. ABOVE & BELOW Cosworth Electronics is working with some of the biggest names in IndyCar (above) and NASCAR (below)



FERODO'S NET PROFIT!

It might have been a COVID-shortened season for Ferodo Racing but, as William Kimberley discovers, the year wasn't a wasted one

ITH the metaphor during a difficult 12 months for everyone, Sergio Bonfanti's motto has been 'When the fisherman can't go out fishing, he uses his time to repair his nets', and that is just what Ferodo Racing has been doing. "What I mean by that," says Bonfanti, who heads up

Ferodo Racing, "is to do things that we normally don't have time to do. We used our time to prepare new projects for the near future and enhanced the quality of service we can give to our customers, while getting out there on the racetracks as soon as it was possible. That way, we could make our name stronger for when



Low energy Medium energy

Max energy

ABOVE Ferodo performed well in its Italian GT3 Championship heartland

LEFT Distributors are helping customers with their data-driven analysis



we return to some sort of normality."

The company's technical focus last year was mainly in the area of GT3 and GT4 racing. It performed car validation and concentrated on the Italian GT Championship, a market very close to it, but also targeted other championships in which GT3 and GT4 cars were racing.

"You can study all kinds of literature and think you know everything, but the added value when you get your hands dirty in the field is unbelievable," stresses Bonfanti.

"We thought we were alright with the rear materials for cars with ABS, but in reality there was quite a bit of fine-tuning which led to a new material for the rear calliper that is replacing the DSUno. Hitherto it was regarded as the best in the Ferodo Racing range, with the performance remaining exactly the same throughout the pad's long life. It is formulated to provide a very flat friction profile at a medium/ high level of friction. The pad compression is very low, always, and so pedal travel is short and consistent."

Another part of Ferodo Racing's focus has been the TCR and BTCC-type of cars. Ed Little, Ferodo Racing's technical manager, and his team, spent at least six months finetuning the DS3.12 compound. It now has a higher level of initial bite, leading to the DS4.06, the new sprint material offering

LEFT The pandemic

offered the chance to fine-tune compounds



fresh opportunities in touring car racing. The emphasis in 2020 was on a new range of racing materials offering fresh opportunities in heavy duty racing where Ferodo has lost market share in the last few years. Ferodo Racing has been developing DS3.12, a high output, heavy duty circuit compound that has been created for top level GT racing during the course of the last three years. Its main characteristics are the highest friction coefficient and bite in the Ferodo Racing range and reproducible and stable performance up to 850°C under all pressure and speed conditions.

"The amount of time we put into researching the DS3.12 has left us with an incredible amount of knowledge and information that we can bring as a solution when there is a need," says Bonfanti. "We believe that we've been adding value to the motorsport teams in the last year, but there's more to come in 2021.

"There's a high level of interest in them in all forms of racing – from national, continental and worldwide teams – so there will be a wider range of cars using this new compound."

Sales of these new materials are to be managed through distributors offering key services such as stock holding, where it adds value by holding stock and not continually ordering just-in-time. "Their job is also to help customers optimise products via data-driven analysis," notes Bonfanti. "We are also planning online training seminars for brake data analysis.

"We want to expand this concept by taking it into our distribution network. We are going to organise a quarterly event with webinars where we explain and show and teach our specialists in exactly the same way as we do at the racetrack, thereby expanding the number of experts in the field.

"The same concept has been used for the TCR front development and this is what we are doing on the racetrack. It is what we are going to encourage with our partners, so they are doing more of the same. It's of real added value for them as they become more than just a dealer: they are building their knowledge and applying it."

In Biblical times, mending the net was a means of repairing and cleaning the nets, not particularly satisfying at the time but reaping dividends later on. Ferodo Racing is following the same route and coming up with fresh materials.

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MIXING THE PAST WITH THE FUTURE

Giorgio Breda is still looking to the future, more than 40 years after starting his motorsport adventure. By **Mark Skewis**

IORGIO Breda is, by his own admission, a pain to work with! It's a frank assessment, offered with typical humour, by a man with extensive experience in motorsport, pushing for the very best.

"I'm a terrible pain," he confesses. "I demand a lot from people around me. For me, it's normal to give 150% and I demand the same from other people. It's the way I always used to work at the racetrack, when we were in the middle of a big problem in Qualifying or something like that, and now, even back at the factory, I still work like that. I don't know any other way. I believe this approach makes a difference. I'm always open to dialogue, but not for this."

That commitment was a key pillar in the foundations of Breda Racing, a company that has become a reference point for manufacturers and team leaders in the motorsport sector and beyond. Such dedication is hardly a secret, for anyone who has ever worked with the company knows of it, but what *might* come as a surprise is that the organization's rise from humble beginnings wasn't always based around such a clear vision.

"At the beginning, we didn't have a well-defined growth plan," admits Giorgio Breda. "Like many companies, we worked hard, tried to express our best, to work well, but without thinking we would eventually end up reaching so high. We experienced unstable years, as does everyone, then the results came and we could see the fruits of our effort and commitment."

With motorsport having been his passion since childhood, Giorgio began his racing career in the 1970s as a mechanic, then as a track technician in several different championships. He rose to the role of team manager in the '90s, working with drivers who would carve out reputations in Formula 1, IndyCar anbd sportscar racing.

Breda Racing was born out of that passion, his desire to work in a sector that is renowned for its instability. He involved his bother, Roberto, in that ambition, but the company is about far more than its family members.

"Many people know Breda Racing is Giorgio and Roberto Breda, but it is also about other people – some very experienced, others new arrivals – without whom we would not have reached the levels we have ," Giorgio admits. "Breda Racing was born as an extended family and even if the company is now a bit bigger, we try to work with this relationship approach." As you can see in the pictures, Giorgio always wears the company uniform. A small detail, perhaps,

> LEFT Breda engineers design and produce many pieces of high-quality equipment the public will never see





For me, it's normal to give 150% and I demand the same from other people"

but important. "My place is with our guys, in the Engineering department, or in Production," he notes. "I'm one of them."

WHAT DOES BREDA DO?

So, what does Breda Racing actually do? The Italian company has two distinct activities. The first, because it was the first to be born, is the production of mechanical components on customer designs. The company provides its vast experience in manufacturing: milling, turning, bending and welding, to create small masterpieces that clients will fit into their cars. This expertise is not just confined to motorsport, for Breda also works with limited series automotive car manufacturers.

"The second activity in terms of time, but which I always hold first in my heart, is the design and production of motorsport equipment," says Giorgio.

The company began with the production of motorsport equipment and over time that range has increased. Some of it might, to the outside world, perhaps be defined as 'standard, but even those items **>**





ABOVE & LEFT Giorgio Breda has transferred the committed approach honed at the racetrack (above) to the factory are still adapted to meet each car's spec or customer's individual requirements. Over the years, Breda Racing has come to specialize in the creation of highquality equipment for motorsport's upper echelons, designing an impressive array of items such as pit gantry, pit stands, garage overheads and scrutineering platforms with integrated weighing systems.

"They are sophisticated items, designed to a high level with our way of thinking, devoted to excellence. I feel proud every time I see them on TV," explains Giorgio. "But in addition to what we internally call the 'Big Monsters', we design and produce items of equipment of the highest level that the public never sees because they are hidden inside and behind the garages of the numerous motorsport championships across the world: refuelling equipment, set up systems , air lifters, weighing equipment...

"We are proud to have very prestigious names among our customers but we are also proud of every new team – be they small, medium or large – which approaches us because they are interested in our work and in our equipment. We give each of them the utmost care and attention, not only to the equipment that we provide but also to the relationship with each customer. This is an aspect to which we dedicate particular attention."

We design and produce equipment at the highest level that the public never sees"

LOOKING FORWARD

There is an old motorsport adage that to stand still is to go backwards. That belief has underpinned the glory won by some of the biggest names in the sport's history.

In years gone by, any journalists arriving at the most successful F1 teams, like Williams and McLaren, with notebooks full of questions and heads full of dreams, were always destined for disappointment if they expected the outfit's founder to look back mistyeyed on past glories. Men like Frank Williams and Ron Dennis only ever concerned themselves with tackling the next problem or exploiting the next opportunity. Likewise, ask some of the sport's most revered designers what their best car was, and they will tell you without fail: "The next one!"

That same attitude fuels Giorgio Breda's

work. Sure, he reflects on past projects from time to time, for the experience gained is invaluable. The pain still burns if they were failures, but it is important to learn any lessons and apply that hardwon knowledge in the future.

"I always look forward," he insists. "I see more than some people think, and sometimes I have to give up so much, otherwise we would never go forward. I push on until I get the result I want, and I push all the people around me – including the younger generations – to do the same, with passion for excellence."

The 2018 campaign marked Breda Racing's 30th anniversary. Thirty years of precision work, always improving its methods and continually optimising the equipment it produces. In short, three decades of always giving its very best to every customer. So what is the key to Giorgio's seemingly indefatigable quest for improvement?

"Sure, I have times when I want to quit, like everyone does," he admits. "Luckily, something always comes to my aid and refreshes my motivation. I love motorsport, I love my job, I love what I'm doing and the results the company has achieved. I still get a buzz when people work well and with motivation... this is my power source."

> LEFT Breda is active in many disciplines, from F1 to grassroots



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The story of how a near-dilapidated Austin A-has become the car to beat in its class

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WHY HEAD FOR THE EXIT SO SOON?

Manufacturers are stampeding towards electrification, so why are both Audi and BMW about to leave Formula E? **Sergio Rinland** explains



COUPLE of months ago, Honda dropped the bombshell that it would withdraw from Formula 1 at the end of 2021. The reason given was that F1 no longer helps with the next electrification image that Honda wants to project.

On the flip side of the coin, Formula 1 duly revealed that it will stick with the Hybrid ICE package for the foreseeable future. The jury is out on this decision.

Last month came two more worrying announcements: Audi and BMW will both leave the fledgling Formula E at the end of season seven. How comes? They only arrived a few years ago, with great fanfare, to develop and promote their image and EV technology (they said). Electric vehicles, they argued, were where the future lay. No doubt about that!

So, why leave now when they are flat out manufacturing electric vehicles in all sectors? Now that after 2021 the Formula E third generation car will allow further technological development? Now that the UK will only allow EVs after 2030?

The reasons behind the withdrawal of Audi and BMW are different, but there is a connection between the two. Ingolstadt is redirecting its motorsport efforts towards the Dakar Rally with a series hybrid and perhaps hydrogen, and to LMDh. The logic for the Dakar involvement is that there its engineers will have more freedom to make a difference with their developments, and have more road car relevance. All good there and a good contrast with FE, where the only component of the car with which they can make a difference is the MGU – and, truth be said, not much of a difference.

On the other hand, its assault on LMDh, one of the least 'developable' series in motorsport, seems to be motivated only by marketing. LMDh is well promoted in the US, a market where Audi wants a bigger share, and it will have a chance of winning Le Mans if the ACO and IMSA get the Balance of Performance (BoP) right! BELOW The beating heart of Audi's FE challenger is the new MGU05 motor-generator unit. Weighing less than 35 kg, it boasts 97 percent efficiency Two very dissimilar race series.

From Munich we hear a different story: 'its engineers have nothing else to learn from Formula E'. Surprised? Not really, particularly now that its race towards the electrification of its fleet is going full steam ahead – or shall we say 'battery ahead'?

We tend to say that OEMs in motorsport come and go. Yes, that is true, but there is more to it in this case. Formula E had so many aspirants that it had to limit its entries to 22 cars. Well, now it risks only having 18 after 2021, unless up and coming OEMs (Korean, Chinese perhaps?) come to fill the void.

The biggest limitation of EVs is energy density. To compete with hydrocarbons, the industry is investing billions in battery and hydrogen fuel cell developments (and rapid battery swap systems). Could this be one of the reasons these OEMs are leaving FE? The only technology that FE does not allow the OEMs to touch (in the name of economy), is precisely the only technology they would be interested in developing.

Yes, racing cars need power density battery chemistry where road cars need energy density chemistry: different, but within the same family of technologies.

The only component allowed to be developed in Formula E is the MGU. Electric motors, in general, have an efficiency in the region of 94%, if not better. Audi claimed its new 35 kg MGU is 97% efficient – a huge improvement, believe me!

But it's only 1% or 2% of the whole car (which, by the way, they cannot touch either!), so is it worth it?

The other area of motor development is weight. Reduced weight is achieved by using, as Tom Walkinshaw used to call them, "unobtanium" materials you will not find in your road car in a million years. So, it is not surprising that Audi and BMW feel they are at the end of their tether with Formula E.







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