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"You'll feel naked without it!"

Revolutionary Aeroscreen transforms IndyCar

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Ambitious goals

As will be seen in our lead News story, all the major motorsport sanctioning bodies are heading for a hybrid future, albeit from different directions. However, the message is the same: the internal combustion engine still has a long future ahead of it, not just in motorsport but in automotive as well.

At the same time, urban toxic fumes need to borne in mind. This is where Formula E in particular plays such an important role, as it shows how motorsport is addressing such challenges.

The diesel engine is still in the crosshairs, though. A report published in the UK in mid-October says that the level of nitrogen dioxide (NO_2) produced by diesel engines has fallen by a third at the roadside in central London, from 87 micrograms to 57 micrograms per cubic metre, since the introduction of the Ultra Low Emission Zone (ULEZ) in October 2017. It is still well above the legal limit of 40 mcg/m^3 but that is partly due to the diesel black cabs being exempt from the charge.

This is a great message but we must be careful that battery electric vehicles aren't regarded as the only solution across the country, as the ICE, especially when attached to a hybrid system, is still really the answer for the short and medium-term. This is why it is so encouraging that all the major championships are now turning to endorsing hybrids.

At the same time, the fuel companies will continue to play a massively important role. In Formula 1, the easiest way to reduce carbon dioxide (CO_2) emissions, says Dr Wolfgang Warnecke, Shell's chief scientist for mobility, is to use more advanced biofuels, that are made from non-food biomass, such as plant materials and waste and which do not compete with food production for land.

"Shell is using new advanced biofuels in our Formula 1 fuels for Ferrari, and we support using even higher concentrations in the future, of around 20 per cent compared to less than 10 per cent today," he told *Inside Energy*.

Ulrich Baretzky, head of engine development at Audi Motorsport and also co-chairman of the RACE TECH World Motorsport Symposium, said Audi has set itself the ambitious goal of successively achieving a reduction of about 30 per cent of vehicle-specific CO_2 emissions by 2025. This will be achieved by using the more climate-friendly high-performance fuel developed by Aral that has a composition of 50 per cent of high-quality renewable components derived from waste materials. Even so, in terms of its properties, it meets the quality standards of the "Aral Ultimate 102" fuel that has been prescribed in the DTM since 2005. It has a CO_2 reduction potential of more than 30 per cent compared to gasoline purely based on mineral oil.

As Baretzky has said: "We did not have to make any modifications to the DTM engine and have not had the slightest problem on the test bench so far. Consequently, we are proving that low carbon fuels are also suitable for racing engines." RT

William Kimberley
EDITOR

Getty/NASCAR

ABOVE Leading figures within NASCAR accept it is only a matter of time until its flagship series adopts hybrid technology

NASCAR joins rush towards hybrid future

William Kimberley looks at how the top levels of motorsport are aligning themselves with hybrid technology but coming up with different solutions

LONDON, UK: Hybrid assist is the immediate future, that is the message coming from Formula 1, NASCAR, IMSA and IndyCar. All four sanctioning bodies for the top level of the sport have committed to the principle, although in different ways.

As Chase Carey, chairman and CEO of Formula 1, said in a speech at the IAA Frankfurt Motor Show in mid-September, the Formula 1 hybrid engine will be a major part of the future solution to reduce carbon emissions from vehicles.

"The Formula 1 hybrid engine is the most efficient in the world and has a critical role to play to address the wider global environmental issue," he suggested. "I think the solution to the environmental situation is going to be many and not just one and while I appreciate electric has got the attention and has hit a sweet spot at the moment, I think electric will be part of the solution, but has issues such as battery disposal that still need to be addressed."

NASCAR has also floated the idea of using about 200 hp of hybrid assist. It is a series that used carburettors until 2012, but is still determining how it would use hybrid technology.

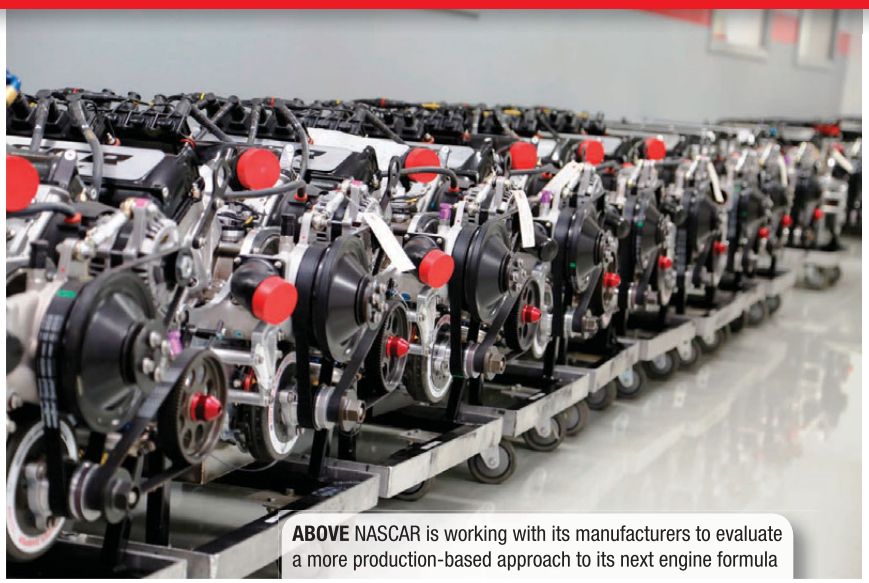
IDEAL IMPLEMENTATION

"We travel the world visiting other sanctioning bodies and are not ignorant to the fact that the world is going towards more hybrid technology," said John Probst, NASCAR's senior vice president for racing development, in an interview with *TechCrunch*.

He said hybrid tech would likely be used in parallel with internal combustion engines to add power rather than solely improve mileage. He gave as an example how it could possibly provide a kind of strategic supercharge that could be used to provide extra power to complete a pass. What is also being considered is using pure electric power during caution periods and pit stops as a 'quiet time' for people attending the race, essentially giving them an opportunity to communicate and relax.

"Hybrid technology might not be best suited for oval tracks so many associate with stock car racing," Probst conceded. "It might be better served on shorter circuits, and those with more turns for braking where regenerative braking systems would put the hybrid systems in the spotlight."

However, there has been some concern expressed by teams about the extra costs of incorporating this hybrid technology. NASCAR is therefore considering a spec system where all cars would have the same system with no modifications or development allowed.



ABOVE NASCAR is working with its manufacturers to evaluate a more production-based approach to its next engine formula

"This is all purely speculative right now," a NASCAR Cup engine builder told *Race Tech*. "With 12V electric systems it is hard to imagine how a 200 hp hybrid system would work. NASCAR must therefore simultaneously entertain the thought of higher voltage systems for the cars. There has been some talk about 48V systems, but nothing definitive at the moment. Of course, this would require new electronics for all the existing systems in the car, again a cost issue.

"However, I'm excited by the idea provided it is implemented correctly! The hybrid system will be in addition to a new engine formula, which is also undefined currently. Again, NASCAR is working with Chevrolet, Ford and Toyota to identify something more production-based, in other words less expensive, but there isn't a single formula that works across all manufacturers. I hope we don't end up with a Balance of Performance (BOP) series where the winner is determined by the manufacturer who best navigates the system politically and through driver sandbagging."

EXPERT INPUT

Outgoing IMSA president Scott Atherton confirmed in June that the next generation of Daytona Prototype international (DPi) race cars, which will begin competing at the start of the 2022 IMSA WeatherTech SportsCar Championship, will use hybrid power. "IMSA is working with our current and interested OEM partners and also with input and insight from the Environmental Protection Agency (EPA) and the US Department of Energy (DOE) to finalise those regulations," he said.

Its efforts to introduce hybrid powertrains for its Daytona Prototype internationals in 2022 could also serve a secondary purpose that benefits NASCAR. As reported in *Racer.com*, IMSA's plans to source, test, and introduce battery-based kinetic energy recovery systems (KERS) with its next-generation DPis is drawing significant interest from parent company NASCAR, which has taken an increasing role in IMSA's DPi 2.0 planning sessions. According to different sources, IMSA's KERS initiative is going in a new direction where NASCAR will rely upon its sports car series to carry out a significant portion of the hybridisation workload that will eventually appear in the Monster Energy NASCAR Cup Series.

IndyCar is also planning to switch to 900 hp hybrids in 2022. In partnership with Chevrolet and Honda, it will implement a single-source hybrid system that it says will provide key enhancements ranging from competition to safety. In addition to allowing drivers to restart their cars from the cockpit, the system will increase the horsepower of the push-to-pass system and potentially improve the pace and overall time of races.

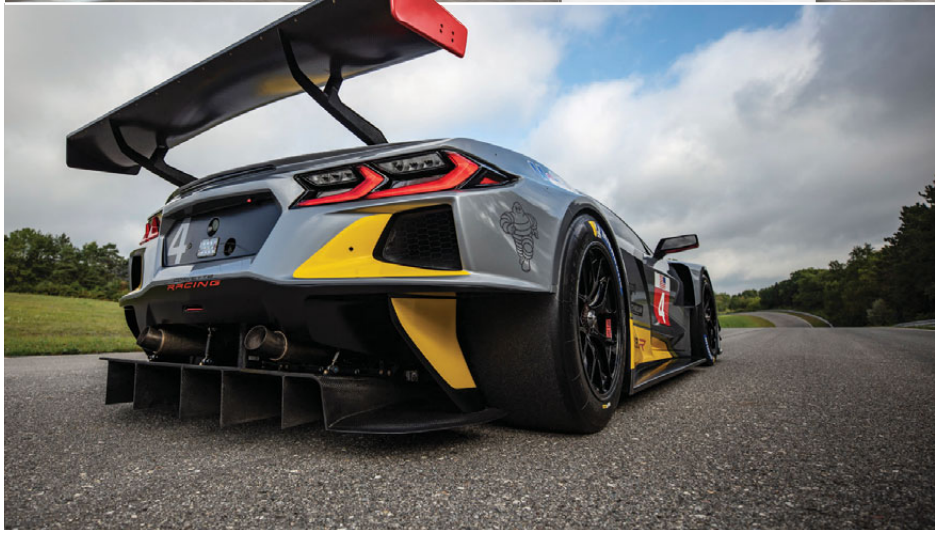
"It's an exciting time for IndyCar with the forthcoming evolution of the cars and innovations like the hybrid powertrain being incorporated into the new engine," said IndyCar president Jay Frye. "As we move toward the future, we will remain true to our racing roots of being fast, loud and authentic, and simultaneously have the ability to add hybrid technology that is an important element for the series and our engine manufacturers."

IndyCar's dilemma over how exactly to introduce hybrids is mirrored across the Atlantic, where the World Rally Championship, British Touring Car Championship and DTM have all recently revealed plans for hybridisation to feature on their future cars. Like IndyCar, all three series will utilise control components in order to avoid the spiralling costs experienced by teams when F1 and the World Endurance Championship went hybrid.

With even NASCAR's top players accepting that "it is a case of when, rather than if" hybrid technology is adopted, 2019 is likely to go down as the year that climate change finally forced its way irrevocably onto motorsport's radar.

"We believe the hybrid engine and fuel technologies can play a big role, a leading role, in addressing the issue of carbon emissions," said Carey. "We believe the solution will be a path of many rather than one cure-all." RT

ABOVE F1 is evaluating new fuel technologies as it seeks to showcase more environmentally sustainable credentials



ABOVE & BELOW Corvette offered a sneak preview of its new mid-engined race car

New look and new chapter for Corvette Racing

William Kimberley looks at Chevy's first clean sheet racecar design since the C5.R debuted in 1999

ROAD ATLANTA MICHELIN RACEWAY, GA: The radical new Chevrolet Corvette C8.R is due to have its maiden race in the 2020 24 Hours of Daytona in January. It replaces the previous-generation C7.R that competed in the WeatherTech SportsCar Championship as well as World Endurance Championship. Prior to its debut at the Rolex 24 at Daytona, the new car performed a demonstration lap at the Road Atlanta Michelin Raceway ahead of the 22nd annual Petit Le Mans race in mid-October.

The first clean sheet race car design since the C5.R debuted in 1999, the C8.R is based on the roadgoing C8 Corvette, and is Chevrolet's first mid-engined race car to compete in IMSA's GTLM class.

The C8.R uses a production 2020 Stingray chassis structure which is then modified to meet race series requirements. The new race-prepared chassis structure is significantly stiffer and lighter than its predecessor, the use of computer analytics making it possible to start its design well in advance of any production Corvette components being available. Nevertheless, GM says it shares the highest percentage of production parts compared to any previous generation race car it has developed.

The engineering and design teams produced thousands of 3D-printed rapid prototype parts for chassis and wind tunnel testing. The use of these development tools has resulted in a race car with improved aerodynamics and vehicle dynamics, increased stiffness and better weight distribution. Chevrolet's Driver in the Loop simulator was also heavily utilised to evaluate numerous chassis and aero design concepts.

The 5.5-litre normally aspirated V8 engine architecture remains the same to comply with IMSA's engine displacement rules. It produces 500 hp and 480 ft/lb of torque and is mated to a new compact Xtrac 6-speed sequential gearbox that has been developed to provide room at the rear of the C8.R to package the race car's diffuser.

The C8.R also features a single centrally-mounted radiator located in the area used as the front storage compartment on the production Corvette. Ultra-bright racing headlights have been packaged on the race car where the radiators are located on the production car.

Riding on 18-inch Michelin Pilot Sport GT competition tyres and with a lower centre of gravity and more even weight distribution on the wheels, Corvette Racing has worked closely with the tyre company. Together, they have optimised the tyre compound and construction to best support the unique traction needs of a mid-engine race car.

"We have looked forward to racing a production-based mid-engine Corvette for a long time," said Jim Campbell, Chevrolet US vice president of Performance and Motorsports. "The debut of the C8.R is the result of immense collaboration between GM Engineering, Propulsion, Design and the Corvette Racing team. As Corvette Racing enters its third decade of competition, we're excited to begin the next chapter."

Corvette Racing will field two cars, one with the traditional yellow colour livery and another with a new silver livery. The latter is inspired by the colour used on iconic Corvette concepts such as the 1959 Corvette Stingray Racer, that pushed the envelope both in design and on-track performance, and the 1973 Chevrolet Aerovette.

"Since the mid-engine race car is such a revolutionary vehicle, we felt it would be fitting to honour Corvette Racing's legacy with both a redesigned, modern livery along with a traditional livery in Corvette yellow," said Vlad Kapitonov, lead creative designer, Chevrolet Performance Cars. "Both liveries pay homage to Corvette's racing storied heritage, as well as the impressive engineering and design milestones that led to up to this extraordinary race car."

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SEAT's 670 hp Cupra e-Racer takes to track

William Kimberley

BARCELONA, Spain: The SEAT Cupra e-Racer, the world's first fully electric Touring Car, has been put through its paces and completed its first full-speed laps around the Montmeló Circuit in Barcelona.

The car was handled for the first time by Mattias Ekström. With more than 25 years of experience in different Touring Car, rallycross and karting competitions, he is now working closely with the team of engineers and technicians to fine-tune the fully electric race car to compete in the new ETCR race format in 2020.

The 670 hp electric racer has a top speed of 268 km/h (167 mph) and is capable of reaching 100 km/h (62 mph) in just 3.2 seconds and from 0 to 200 km/h (124 mph) in 8.2 seconds. The e-Racer delivers creditable performance despite its 450 kg battery pack that SEAT says is as powerful as 9,000 mobile phone batteries connected at the same time.

ABOVE The Cupra e-Racer was driven by former DTM and WRX maestro Mattias Ekström

Delivering 300 kW of continuous power, reaching peaks of 500 kW, its four motors combined reach 12,000 revs compared to 6,500 on a petrol-powered race car, and all with a single gear. Aside from its batteries, it resembles existing Touring Car silhouettes, albeit with more power delivered in near-silence.

"What I'm really looking forward to is being able to control and harness all the car's power," said Ekström prior to the Barcelona test. "I think the biggest challenge is getting used to driving with no gearbox and without the roar of the engine as a reference for knowing, for example, how fast to go when taking curves."

After driving the car, he said: "It felt really good, especially when reaching full power coming out of the slow corners on the circuit. I really enjoyed the first lap. The second also went well, although I began to notice that I was forcing the rear tyres. I still need some time to get used to the sound of the engine; it's much quieter than any other I've driven before, and I'm a very emotional driver. In addition, I have to pay close attention to energy management in each lap; that's essential with an electric race car, almost as important as its speed."

"I hope to be able to help the Cupra team with my experience and the feedback from the car's steering wheel to make it faster, but at the same time, make it more consistent and easy to drive. Once we begin competing with the Cupra e-Racer, we have to keep our eyes on the victory and to do that we must be well prepared.

"Winning is everything to me; it's the same with the Cupra e-Racer as with any of the other cars I've competed with, so my dream is to win and be the champion. I want to put Cupra on the podium of global motorsport." RT

Magelec Propulsion wins ETCR powertrain contract

SHANGHAI, China: WSC Group, owner of the TCR and ETCR brands, has chosen Magelec Propulsion to design, develop, manufacture and supply the inverter, motor, and gearbox for ETCR, the first electric multi-brand Touring Car racing category, that will start in 2020.

"The team at Magelec Propulsion is delighted to be able to bring our products and electrification expertise to ETCR," said Craig Daniel, CEO and founder of Magelec Propulsion. "With the experience and know-how brought together from electric motorsport and on/off highway vehicles, we're excited to work with the team at WSC Group to continue the progress of electric motorsport and inspire mainstream electric vehicle adoption."

"Magelec and Craig Daniel's successful entrepreneurial background highlighted that we have the right partner to launch this pioneering category," said WSC president Marcello Lotti. "The company's capabilities speak for themselves. We are proud of this agreement that associates Magelec's powertrain system with a new and ambitious brand like ETCR. We are delighted to work with someone who understands cost control, which is key to successfully growing new forms of motorsport." RT

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Kreisel wins World RX electric tender

Hal Ridge

COLOGNE, Germany: Electric kits for the World Rallycross Championship's top-flight electric transition will be supplied by Austrian company Kreisel, it was revealed after the most recent FIA World Motor Sport Council meeting in Cologne.

Having won the FIA's tender process, Kreisel will develop and supply a kit that can be retro-fitted to existing-type World RX Supercars, not a dissimilar concept to that being used for World RX's new electric support series, Projekt E, next season (see RT228).

Kreisel's World RX kit, which will be used from at least 2021 to 2024, will include a 250 kW motor on each axle, two inverters and a "state of the art 52.65 kWh battery with an innovative cooling system," said an FIA statement, "developing 500 kW (680 hp)".

The first prototype will be shown to teams and interested parties in March before going on sale the following month. The kit will be priced at €300,000 with an additional €100,000 for four years support: "which is lower than the price of current ICE power units over the same period," continued the statement.

The FIA plans to run both electric and ICE cars together from 2021 as part of a staggered introduction for the machines to take over at the sport's highest level. It is a similar concept to that used by the Andros Trophy series last winter, before the Alps-based ice racing series fully adopted electric cars for the forthcoming season.

Cologne's WMSC meeting also revealed that QEV Technologies has won the bid to develop the arrive-and-drive concept for the new FIA Junior eRX Championship, also set to get underway in 2021. The Spanish outfit will develop four-wheel drive, tubular spaceframe chassis machines with a 32 kWh battery developing 250 kW. The class will be limited to 20 cars as a first international electric step into rallycross, which will run at six European-based rounds of World RX and cost €150,000 for the season or €30,000 per race. RT

ABOVE The new electric kits can be retro-fitted to existing World RX Supercars

Extreme E car begins intensive testing

Hal Ridge

CHATEAU DE LASTOURS, France: Extreme E's new 1650 kg, 2.3-metre wide ODYSSEY 21 electric SUV machine has begun intensive off-road testing, with a number of different drivers getting behind the wheel of the Spark Racing Technology-designed and built car.

Extreme E has revealed the car's peak output as 400 kW (550 hp).

A trio of Swedes, World Rallycross' Timmy and Kevin Hansen, and Touring Car racer Mikaela Åhlin-Kottulinsky, undertook early running at the infamous Chateau de Lastours test venue in France last month, run in conjunction with tyre testing with the series' tyre partner, Continental.

ABOVE The ODYSSEY 21 electric SUV was run at a venue used for WRC tests, offering a direct benchmark

Controlled parts provided to teams by Spark Racing Technology will include the powertrain, with a battery produced by Williams Advanced Engineering. The chassis is constructed of a niobium-reinforced steel alloy tubular frame, as well as crash structure and roll cage. Key areas of the bodywork will be able to be adapted by teams to make them aesthetically similar to their road-going counterparts.

"We've used the track here, where WRC and Dakar cars have tested, to test the performance and comfort of the car," said Theophile Gouzin, technical director of Spark Racing Technology, of the car's second ever outing following its maiden public run at the Goodwood Festival of Speed.

"We're entering the unknown," he said. "We'll go step-by-step, slowly increasing power and speed as we go. You think the limit is far but you try to reach it slowly and with confidence.

"At Goodwood, we only ran in a two-wheel drive configuration with Formula E motors. Now we have four-wheel drive and two motors – one front and one rear – with five or six times the torque." RT

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ZF appointed Powertrain Partner to Mahindra Racing in Formula E

William Kimberley

BANBURY, UK: Mahindra Racing, which has been part of the Formula E racing series from the start, scoring four victories to date, announced that ZF Friedrichshafen had been appointed as the new "Official Powertrain Partner" at the start of Formula E's season 6.

It brought to an end ZF's relationship with Venturi Formula E, with which it had a successful technology partnership with its first electric driveline for Formula E. In addition to being on the podium several times, it was able to celebrate its first victory in Hong Kong. However, that has now ceased as the team has become a customer team of the Mercedes-Benz EQ Formula E team.

"The first two races in season 5 were very challenging," said Sven Behrens, director of motorsports at ZF Race Engineering. He is referring to the very poor start of the season with Felipe Massa finishing in 17th place and team-mate Edoardo Mortara in 19th place for the inaugural Ad Diriyah ePrix, followed by Mortara and Massa finishing 13th and 18th respectively in the Marrakesh e-Prix.

Then the corner was turned, as spotted by Dilbagh Gill, Mahindra Racing's CEO and team principal. "His feeling was that we weren't very competitive in the first two races and realistically we weren't at our best, but then we made an incredible jump and had become really competitive, which was the point when Mahindra changed their mind about us," said Behrens.

"We had a good relationship with the Venturi Formula E and when HWA became a customer team from Venturi with our powertrain, we learnt more things, sometimes from a different perspective. We are still working on the suspension side and dampers with our customers, including Venturi and Mercedes in Formula E, but to drive the story on with our drivetrain development with Mahindra Racing is a very good activity for us."

In line with the new partnership, ZF branding will adorn Mahindra Racing's M6Electro cars from this season onwards. "What we love is the way that the ZF story has been told on the car and the team shirts itself with the double blue light line (beside the ZF logo) which is ZF's colour and we thank Mahindra for doing it in such a way," said Behrens.

"They call it '#passioneering', which is a great term because you need engineers who have a passion for motorsport, so the description is perfect."

Work is underway for the design and manufacture of the electric driveline for the 2020/21 season. In addition to the electric motor, development includes both a single-gear, highly efficient transmission and power electronics on a silicon carbide basis for the Formula E drivetrain that will be used in volume production in the near future to increase the efficiency and range of electric drives. It is an example of how motorsport is helping the development of products and technologies that are destined for mainstream automotive applications.

ZF Race Engineering is also now working with Japanese chipmaker Renesas. It supplies Mahindra Racing with the ISL78714 Li-ion battery management system that provides accurate cell voltage and temperature monitoring, along with cell balancing and extensive system diagnostics to protect 14-cell Li-ion battery packs while maximising driving time and range for hybrid and electric vehicles. It also provides the RH850/P1M MCU to form a complete 70-cell evaluation platform for external balancing.

"There's a great deal of feedback into series development but there's also many things coming from series development into Formula E," observed Behrens. "One example is the inverter. As we developed last year's drivetrain, we worked with a different semiconductor partner and now everyone involved in that development is also involved in series development. It's the same thing on production development for the silicon carbide semiconductors which helps boost production development. It meant it was the perfect fit for both sides."

The first race of the season starts with a double-header at the Diriyah E-Prix on 22-23 November. RT

BELOW Mahindra has forged an alliance with ZF Race Engineering for the new Formula E season

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IMSA expands initiatives for its IMSA Green Racing programme

William Kimberley

DAYTONA BEACH, FL: International Motor Sports Association (IMSA) has announced that it has further expanded initiatives for its IMSA Green Racing programme. It follows on from the announcement earlier this summer that the sanctioning body was focusing on ways to return to the Green Challenge Level. It announced that it had become an affiliate of the EPA's SmartWay program and hopes to become the first racing series to attain Green Racing Cup status, which is the highest level of environmentally responsible racing.

The EPA recently bestowed a 2019 SmartWay Excellence Award on Michelin for outstanding environmental performance and leadership. Michelin SmartWay verified tyres have been determined by the US EPA to provide an estimated fuel savings of three per cent or greater, relative to the best-selling new tyres for line haul trucks, when used on all three axles. These fuel-efficient truck tyres offer low rolling resistance and can be used with lower-weight aluminium wheels further to improve fuel savings.

IMSA has been working closely with a number of other companies to explore the use of available technologies to transform energy into opportunities, and continues to seek ways to implement innovative engine and fuel technologies to help obtain this status. Initiatives include the use of Michelin fuel-efficient truck tyres, aerodynamic features on the tractors and trailers and Mack Anthem tractors' use of the MY engine using SmartWay technology to improve fuel efficiency, reduce emissions and save money within the transport sector.

Tractor aerodynamics include an aero profile and aerodynamic bumpers and mirrors. A SmartWay tractor and trailer annually save 2,000 to 4,000 gallons of fuel and reduce CO2 emissions by up to 20 per cent as compared to similar trucks on the road.

The goal of these collaborations is for IMSA to have electric production vehicles from its manufacturer partners serve as hot lap and pace cars at its events. IMSA foresees using solar-powered stations to charge these vehicles in the future. This technology could be used in the IMSA paddock to charge generators or possibly have a racecar use this plug-in feature," said Atherton.

With the mobility landscape moving swiftly to electric and hybrid technology, IMSA has already announced the next generation of its top racing class – Daytona Prototype international (DPi) 2022 – will have a hybrid powertrain. The sanctioning body also continues to explore the possible adoption of ETCR (fully electric TCR) and eProtoype platforms in the future.

"These EPA SmartWay initiatives are an important component of the ever-evolving IMSA Green Racing Programme," said outgoing IMSA president Scott Atherton. "It is easy to see the monetary savings SmartWay provides and by adding in the reduction to our environmental footprint makes this something every team in our paddock should be exploring for their use.

"There are new ideas in this space daily and IMSA is keeping track of these advancements. It's no secret the mobility field is focused on alternative forms of energy with most of these efforts revolving around electric and hybrid technologies. IMSA's conversations with top companies in this sector have led to more innovations on how we can better utilise these advancements throughout our paddock." RT

Changes at the top

John Doonan, who was previously the director of motorsports for Mazda North America Operations where he developed the overall strategy and managed Mazda's motorsports programmes in North America, has been named the next IMSA president, replacing **Scott Atherton** who retires at the end of this year. RT

Next-gen NASCAR makes on-track debut at Richmond

DAYTONA BEACH, FL: After more than two years of development from concept to reality, NASCAR's next generation car hit the track for the first time for a two day test at Richmond Raceway.

The hotly-anticipated car, which is scheduled to make its racing debut at the 2021 Daytona 500, will honour the series' roots with street-style bodies, while incorporating new vehicle technology and innovation.

"This is an important milestone for the Next Gen car and the future of stock car racing," said John Probst, NASCAR senior vice president of innovation and racing development. "There are so many new systems on the car from the front to the back that our main goal with this test was to log laps and put miles on them. The test has met – and even exceeded – our expectations, and we are well on our way to developing the final iteration of the car."

ABOVE Current-gen NASCARS will race for another year, but a successful first test means they are on schedule to be replaced in 2021

The car used during the test was one of just two prototypes in existence. The other prototype has been undergoing wind tunnel testing.

"We have a very comprehensive test plan," Probst added. "We will be doing extensive wind tunnel testing to ensure liftoff speeds are appropriate before moving to larger tracks. As we move into 2020, we will begin testing on intermediate tracks, superspeedways and road courses." RT


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The RACE TECH World Motorsport Symposium has become an institution since it was first established in 2005 both influencing and impacting the politics and development of technology and engineering in the motorsport and the automotive sectors - leading to new series, such as Formula E. These two days in London at the Institution of Engineering & Technology (IET) gather the industry's leaders and influencers to discuss how technology will shape the future of the sport and in turn influence engineering sectors across the globe. A must-attend event for the motorsport and transport community.

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WITH SUSTAINABILITY, VISIONARY and FORWARD LOOKING being the watchwords when it comes this year's World Motorsport Symposium themes, **Pat Symonds**, F1 Chief Technical Officer, and **Yath Gangakumaran**, F1's Director of Strategy and Business Development will be revealing some breaking news and expanding on the announcement of the F1 sustainability programme. They will be covering issues such as how ultra-low carbon sustainable fuels are to be introduced to F1 and how the next generation of engine and fuel will be designed to work in harmony to achieve a highly efficient carbon neutral power unit plus the holistic view F1 is taking of the sustainability of our sport and introducing, for the first time to a forum such as this, some of the visionary projects that will put F1 at the forefront of sustainable sports. Delegates at the World Motorsport Symposium at the IET in London on 3/4 December will be the very first to hear the details in person.

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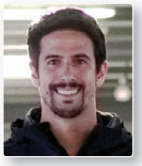

ANNOUNCING OUR KEYNOTE SPEAKER

LUCAS DI GRASSI Formula E champion, Roborace CEO, Environmental Advisor to the UN

Shaping the future of motorsport

THE CHAIRMEN

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Director, Audi Motorsport
Engine Development, Audi AG

JOHN ILEY
Founder and Director,
Iley Design Limited

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Chief Technical Officer
Motorsport Division,
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Director of Strategy and Business,
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ABOVE Nikolas Tombazis, the FIA Head of Single Seater Technical Matter, chats to Evolution Measurement founder, Paul Crowhurst, at his stand at WMS18

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ABOVE Dialma Zinellia and DALLARA win Racecar Aerodynamicist of the Year, Integral Powertrain win Race Powertrain of the Year & Bcomp Ltd wins the Most Innovative New Motorsport Product of the Year

Nominees and winners will be announced at the World Motorsport Symposium Champagne Drinks Reception and Networking Awards Dinner on the evening of Tuesday 3rd December 2019 at the Millennium Hotel, London Kensington in front of key influential leaders in the motorsport and automotive industry.

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PROGRAMME

Tuesday, 3rd December 2019

Theme of the day: Touring Cars and new engines, GT and Balance of Power, F1's sustainability programme, and alternative fuels.

9:00 – 9:15

- **Opening statement and welcome by WILLIAM KIMBERLEY**

Editor in Chief, RACE TECH Magazine

9:15 – 9:45

- **WELCOME TO THE WORLD MOTORSPORT SYMPOSIUM BY THE CHAIRMEN**

ULRICH BARETZKY, Director Audi Motorsport Engine Development, Audi AG &
JOHN ILEY, Founder & Director, Iley Design Ltd

9:45 – 9:55

- **WELCOME by NIGEL FINE**

CEO, Institution of Engineering & Technology (IET)

9:55 – 10:15

- **KEYNOTE speech by LUCAS DI GRASSI**

Formula E Champion, CEO, Roborace, Special Advisor to Formula E & UN Environment Clean Air Advocate

Keeping Motorsport relevant

10:15 – 10:45 COFFEE BREAK

10:45 – 11:05

- **Presentation by ULRICH BARETZKY**

Director Audi Motorsport Engine Development, Audi AG

The DTM is entering a new era in 2019. What does the new concept of the popular touring car series with turbo instead of naturally aspirated engines promise?

11:05 – 11:45

- **Panel session:** *The new-look DTM cars and what it means for Touring Cars*

11:45 – 12:05

- **Presentation by NICOLAS AUBOURG & TIM MALYON**

Head of Performance & Simulation, FIA & Head of Research, FIA

Technical Approach to BoP (Balance of Performance) in GT championships

12:05 – 12:45

- **Panel session:** *Technical Approach to BoP in GT championships*

12:45 – 13:00

- **TECH TALK by MATTHIAS DANK, AVL**

Global Business Segment Manager Racing

Powertrain Effeciency - the next step

13:00 – 14:00 LUNCH BREAK

14:00 – 14:20

- **Presentation by PAT SYMONDS & YATH GANGAKUMARAN**

Technical Director & Director of Strategy and Business, F1

The F1 sustainability programme

14:20 – 15:00

- **Panel session:** *The F1 sustainability programme*

15:00 – 15:30 COFFEE BREAK

15:30 – 15:50

- **Presentation by VINCENT BEAUMESNIL**

Sports Director, ACO

CO2 and emissions in motorsport. Are hybrid technology, alternative fuels and hydrogen technology the answer to the long-term future of powertrains, and what role can motorsport play in A. developing them and B. marketing them?

15:50 – 16:30

- **Panel session:** *Are hybrid technology, alternative fuels and hydrogen technology the answer to the long-term future of powertrains, and what role can motorsport play in A. developing them and B. marketing them?*

16:30 – 16:45

- **Resume of the day**

Wrap-up from **ULRICH BARETKZY** and **JOHN ILEY** on conclusions from both morning and afternoon sessions

Wednesday, 4th December 2019

Theme of the day: New motorsport road map, robot cars and AI, rapid prototyping, CFD post processing and the application of machine learning in motorsport.

9:00 – 9:05

- **Opening statement and welcome by WILLIAM KIMBERLEY**

  Editor in Chief, RACE TECH Magazine

09:05 – 9:30

- **WELCOME TO DAY 2 OF THE WORLD MOTORSPORT SYMPOSIUM BY THE CHAIRMEN**

  ULRICH BARETZKY, Director Audi Motorsport Engine Development, Audi AG & **JOHN ILEY**, Founder & Director, Iley Design Ltd

9:30 – 9:50

- **Presentation by STEVE SAPSFORD**

  Managing Director, SCE

  New motorsport roadmap, including IC engine efficiency and low carbon fuels

9:50 – 10:30

- **Panel session:** *The future direction of motorsport*

10:30 – 11:00 COFFEE BREAK

11:00 – 11:20

- **Presentation by BRYN BALCOMBE**

  Chief Strategy Officer, Roborace

  Robots that want to race: Mainstream or Minority?

11:20 – 12:00

- **Panel session:** *Does the conventional racing car face an uncertain future? Will mainstream motorsport go the way of horse racing over the next 20 years due to revolutionary concepts like Roborace and other A1 series coming into mainstream motorsport?*

12:00 – 12:15

- **TECH TALK by Bcomp**

12:15 – 13:15 LUNCH BREAK

13:15 – 13:30

- *How motorsport is embracing rapid prototyping, 3d printing and advanced manufacturing*

13:30 – 14:00

- **Panel session:** *How motorsport is embracing rapid prototyping, 3d printing and advanced manufacturing*

14:00 – 14:20

- **Presentation by WILLEM TOET**

  Professor, Aerodynamics Specialist & Senior Sales Manager at Sauber Aerodynamik AG

  CFD Post Processing

14:20 – 15:00

- **Panel session:** *The importance of understanding just what you are seeing when it comes to aero analysis and how it can be applied practically to a physical model*

15:00 – 15:30 COFFEE BREAK

15:30 – 15:50

- **Presentation by MARC HILBERT**

  Team Lead: Machine Learning in Engineering and Production Technologies, Volkswagen AG

  The application of machine learning in assisting the race driver in managing more and more complex drive systems – development, limits and test experience.

15:50 – 16:30

- **Panel session:** *The application of machine learning in motorsport*

16:30 – 17:00

- **Resume of the day**

  Wrap-up from **ULRICH BARETKZY** and **JOHN ILEY** on conclusions from both morning and afternoon sessions

NB. The programme is subject to change

Daimler AG

ABOVE When it comes to fuels and lubricants, the marketing might of Lewis Hamilton can help transform public perception

A *BENIGN* CONSPIRACY?

With Formula 1 and Le Mans both eyeing the use of synthetic fuels, **Chris Ellis** explains the game-changing developments that could strengthen motorsport's hand

THESE days, there are malign conspiracies left, right and centre, so it is a rare pleasure to expose a benign one. And, for once, it is *not* being led by those who proclaim: "There is only one way – mine!" I'm British, so if I claim the French government has already taken one of the key steps necessary to limit Climate Change, you will know I really believe it! It has gradually removed fuel tax from E85 so that it now costs less than *half* the price of diesel.

Why is this relevant to motorsport? Because the FIA is based in Paris, and Le Mans is the home of the Automobile Club de l'Ouest, 'owners' of the World Endurance Championship (WEC), and they have already decided that the fuel used in WEC next year must be '> 15% bio basis', as the first step towards replacing fossil fuels. The game is changing fast, though: the recent dramatic fall in the cost of solar energy will have a big impact on the production of synthetic fuels, potentially making them capable of replacing *all* fossil fuels in most applications much sooner than forecast.

BROTHERS IN ARMS

A decade ago, the French government (whose Prime Minister then was Francois Fillon, amateur racing driver and elder brother of the current President of the ACO) started to reduce the fuel tax on E85. Now, in more than 1,100 filling stations across France, E85 costs less than half the price of essence (aka petrol). And the car manufacturers are also beginning to react enthusiastically, at last. For example, buy a new Ford Kuga, pay only an extra hundred euros, and it will come off the production line as a full 'flexifuel' vehicle, capable of running on anything from regular up to E85. And lower registration fees will more than pay for it.

Of course, the Fillon brothers probably didn't realise 10 years ago how their conspiracy would play out so well, but they should be delighted now! And congratulated.

If flex-fuel is implemented incompetently, mpg can fall by as much as 20% when running on E85. However, Ricardo explained years ago how EBDI (Extreme Boosted Direct Injection) can deliver parity on fuel consumption *with diesel*.

E85 can also produce higher peak power than petrol, as the best of the latest E85 upgrade kits already do.

E85 is attacked by the Greens and others because most of it is currently produced using land that could be growing food, or supporting forests. However, it is now possible to produce E85 cheaply without using any arable land, just by combining carbon dioxide extracted from the air with hydrogen from electrolysis, powered by low-cost electricity from renewables and nuclear. Let's call this 'R85'.

The cost of producing 'benign' liquid fuels will be dominated by the cost of producing hydrogen, now that the price of CO2 extracted from the air is well below a hundred dollars a ton. In an excellent paper, Siemens has predicted that hydrogen will soon cost as little as $1.5/kg where the cost of solar has dropped to 3 cents per kilowatt-hour. But '3 cents/kWh' was quoted before the results of the Portuguese government's recent auction were announced, claiming a new world record of less than 1.5 euro cents per kWh, and with a dozen of the larger contracts averaging around two euro cents per kWh. So we can expect similar prices across southern Europe soon, with lower distribution costs for the locally produced fuels, and greater energy security. Synthetic fuels shipped in from sunnier climes should prove even cheaper.

So here's a (conservative?) forecast, based on continuing improvements in the efficiency of solar panels, and further reductions in prices as volumes continue to climb: many sites across southern Europe will be delivering solar power at 1.5 euro cents/kWh or less by 2025. This should mean the cost of hydrogen will have fallen to around one euro per kilogram by then. And hydrogen represents only some 20% of the mass in a kilogram of ethanol. So the hydrogen in a litre of R85 could be costing less than 20 euro cents by 2030.

Of course, this does NOT mean the pump price of R85 will be anywhere near 20 cents per litre – it just shows how much margin there should be to cover CAPEX, OPEX, distribution costs, profit, etc. The accountants in 'Big Oil' should now be working up an appetite for this, as a marvellous business opportunity. Just flush out some of the diesel tanks!

So what should the ACO propose to the FIA now, given the latest forecasts? Simple – just replace '> 15% bio basis' in 17.2.1 of the 2020 WEC regulations with '< 20% fossil-fuel by volume' for 2022. This will allow the fuel provider some discretion, but basically points towards R85.

In my article 'Do Hybrids Properly...' in this June's edition of Race Tech, I suggested Liberty Media should provide the same synthetic fuel (specifically, 'R25') to all the F1 teams from 2021. Since then, Chase Carey, during a recent briefing for Wall Street analysts, revealed: "We are working aggressively on things like synthetic fuels, working with the oil industry as a whole on synthetic fuels, bio fuels, hydrogen fuels." So we should hear soon the precise 'solution' chosen for 2021, as a first step towards the eventual use of a 'near-perfect' liquid fuel produced entirely with energy from renewables and fusion.

Not only will this remove the environmental stigma from motorsport in general, but it should stop the over-regulation of fuel consumption in WEC. Why would the rich owner of a hypercar give a fig about the heavy fuel consumption of a 6-litre V12 if it was doing no damage to the environment? And the minor weight penalty of the fuel needed for F1 to have 'desirable' engines again may increase lap times by three tenths, but who will notice? Or care?

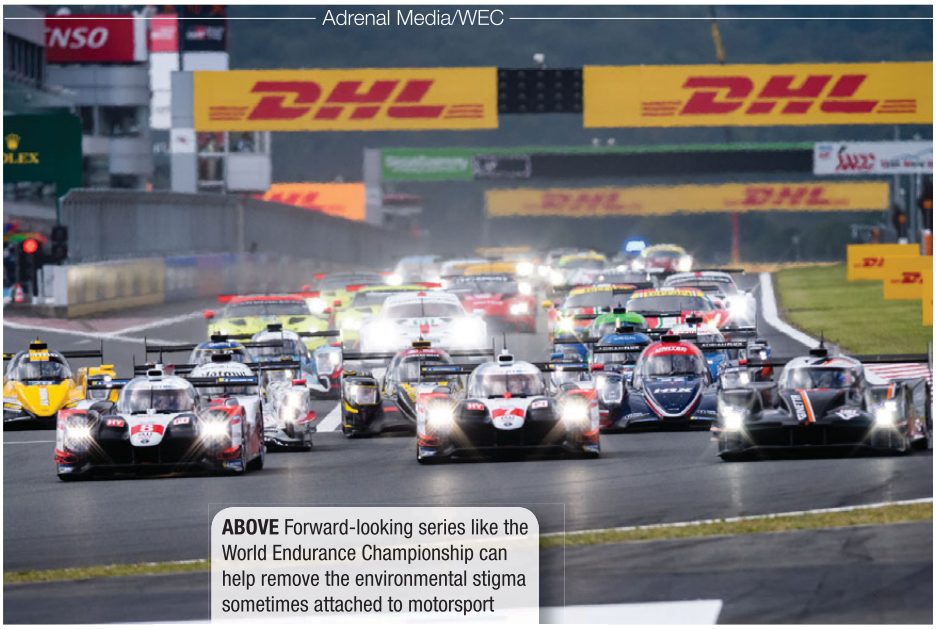
Using liquid hydrogen in F1 and at Le Mans could work well, but would be misleading because almost no one is suggesting using it on the road, not even in big trucks. However, compressed hydrogen makes good sense in heavy-duty vehicles, preferably powering fuel cells. But volume constraints and the lack of refuelling infrastructure for hydrogen will favour liquid 'renewable' fuels for most other road vehicles, which is why F1 and WEC should adopt them.

France will lead in this area because of the 'big stick' it holds – very high taxes on petrol and diesel. Hopefully, we will soon see France show the rest of Europe what the big sticks they also hold can do, when wielded intelligently. The next step I expect it to take, probably next year, is to insist that all new vehicles with SI engines must be 'flexifuel' by 2022, consequently capable of running on any mix of E85 and conventional essence. Naturally, the 2020 WEC regulations carry no mention of diesel anymore…

What will succeed yellow vests in Paris? Green vests, for renewable fuels, rather than blue, for electricity? RT

> **"Dramatic developments potentially making synthetic fuels capable of replacing *all* fossil fuels sooner than forecast"**

Adrenal Media/WEC



ABOVE Forward-looking series like the World Endurance Championship can help remove the environmental stigma sometimes attached to motorsport

"You're going to feel naked without it!"

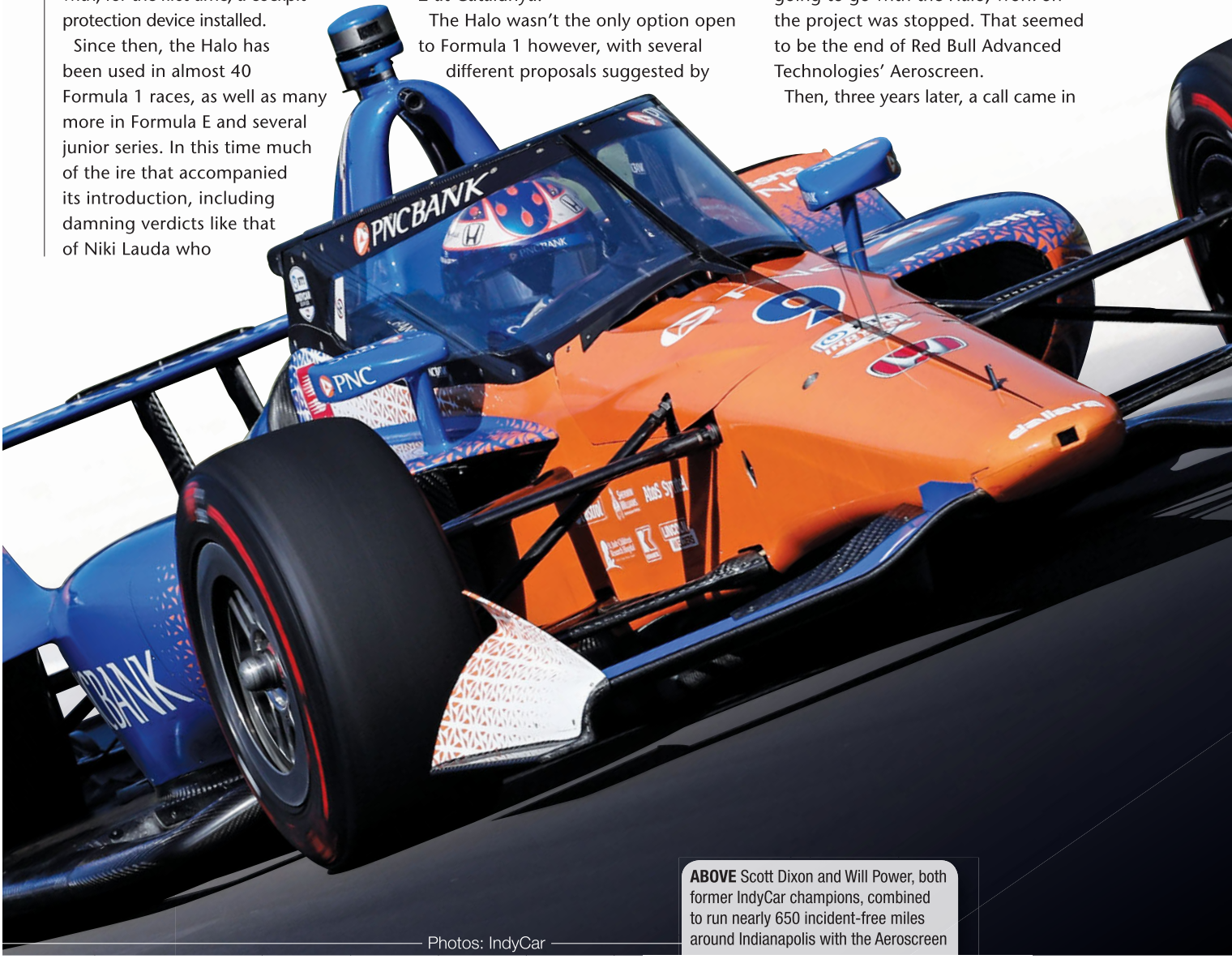
That was the verdict of former IndyCar champion Will Power after testing the new RBAT-designed Aeroscreen for the first time. **Alan Stoddart** reports on the introduction of a device that makes IndyCar drivers safer than ever before

MOTORSPORT changed in Australia in March 2018. After a long and gruelling debate and an extensive testing and development phase, single seater cars in a premier series raced with, for the first time, a cockpit protection device installed.

Since then, the Halo has been used in almost 40 Formula 1 races, as well as many more in Formula E and several junior series. In this time much of the ire that accompanied its introduction, including damning verdicts like that of Niki Lauda who said it had "destroyed the DNA of an F1 car", went away. Halo proved it was a necessity in several dramatic incidents, such as those involving Charles Leclerc at Spa and Tadasuke Makino in Formula 2 at Catalunya.

The Halo wasn't the only option open to Formula 1 however, with several different proposals suggested by different teams. Among them was the Aeroscreen concept, put forward by Red Bull, and tested by Daniel Ricciardo at 2016's Russian Grand Prix. However, when it became clear that F1 was instead going to go with the Halo, work on the project was stopped. That seemed to be the end of Red Bull Advanced Technologies' Aeroscreen.

Then, three years later, a call came in



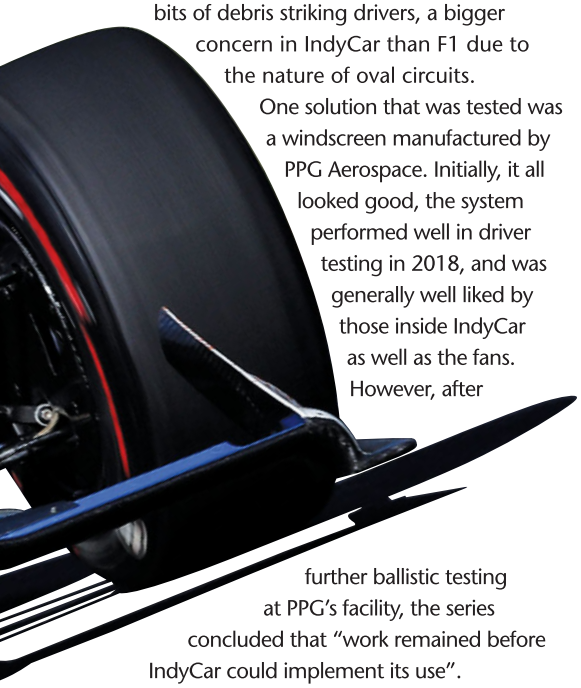
Photos: IndyCar

ABOVE Scott Dixon and Will Power, both former IndyCar champions, combined to run nearly 650 incident-free miles around Indianapolis with the Aeroscreen

from IndyCar president Jay Frye.

"He contacted me through Jonathan Wheatley, our sporting director, and said, 'Look, we need to do something, we want to launch something at the 500 in May, we liked what you did before, what can you do?'" recalls Red Bull Advanced Technologies commercial development officer Andy Damerum.

IndyCar had, after all, been looking to implement some form of cockpit protection for some time, with the loss of Justin Wilson, who was struck on the head by part of a front wing at the Pocono Raceway in 2015, providing an ultimate tragic impetus for change. The Halo was quickly rejected, because of concerns about the device's band at the top impeding visibility on ovals, difficulties with mounting it on the IndyCar chassis, and fears that it would not prevent bits of debris striking drivers, a bigger concern in IndyCar than F1 due to the nature of oval circuits.



One solution that was tested was a windscreen manufactured by PPG Aerospace. Initially, it all looked good, the system performed well in driver testing in 2018, and was generally well liked by those inside IndyCar as well as the fans. However, after further ballistic testing at PPG's facility, the series concluded that "work remained before IndyCar could implement its use".

With IndyCar keen to implement something, and the PPG windscreen not a viable option, the series then turned to another project it had been working on with chassis maker, Dallara: the Advanced Frontal Protection system. Despite appearing as nothing more than a titanium spike bolted onto the chassis centreline ahead of the cockpit, to withstand the extreme loads that could be placed on it, significant reinforcement had been added to the Dallara chassis. The AFP was first raced in early May at the Indianapolis Grand Prix, and crucially, was always referred to as the first phase of a more complete system, or as Frye put it at the time: "It'll do X, the other things we are working on will do Y and Z".

ABOVE A look through the Aeroscreen from a driver's perspective. Scott Dixon simulated laps at Long Beach, Indianapolis, Texas, Iowa and Barber with no visibility issues

Now, six months later, the next phase of IndyCar's cockpit protection system is undergoing strenuous track testing, and by all accounts is proving successful, with Chip Ganassi Racing driver Scott Dixon suggesting it was already race-ready after he took it for its first on-track outing. Reactions were similarly positive for those behind the Aeroscreen's development, with Damerum happy that it "worked extremely well" right away.

These positive reactions after testing are testament to the work that Red Bull Advanced Technologies put into the Aeroscreen behind the scenes.

"We had done a lot of work with the F1 Aeroscreen back in 2016," explains Damerum. "So, we had already learnt a lot about internal reflections from the track, from signs, and from the top surface of the monocoque, which needed to be matt black otherwise it would reflect on the inside of the screen.

"We also had met with anti-reflective coating suppliers and learnt what to put on the inside and what to put on the outside of the screen. We learnt from our experiences with the Halo as well, about parts needing to be matt black to stop the driver's eyes being drawn towards it.

"We drew down on the knowledge from the time when we were working on the F1 project."

All of the work that had been performed did, however, still have to be incorporated into the spec Dallara chassis that is used in the American series. One of the biggest changes was to the mounting of the Aeroscreen at the front of the cockpit. In the original F1 concept from 2016, the frame at the top was supported at the sides, with struts either side of the driver, where the mirrors would have been. This setup wasn't possible on the Dallara chassis, which wasn't strong enough in those areas. Fortunately, the reinforcement that had been added to the chassis for the AFP spike did offer the required strength, and provided the ideal place to mount the Aeroscreen. At the rear, meanwhile, the device attaches to a slightly modified roll hoop.

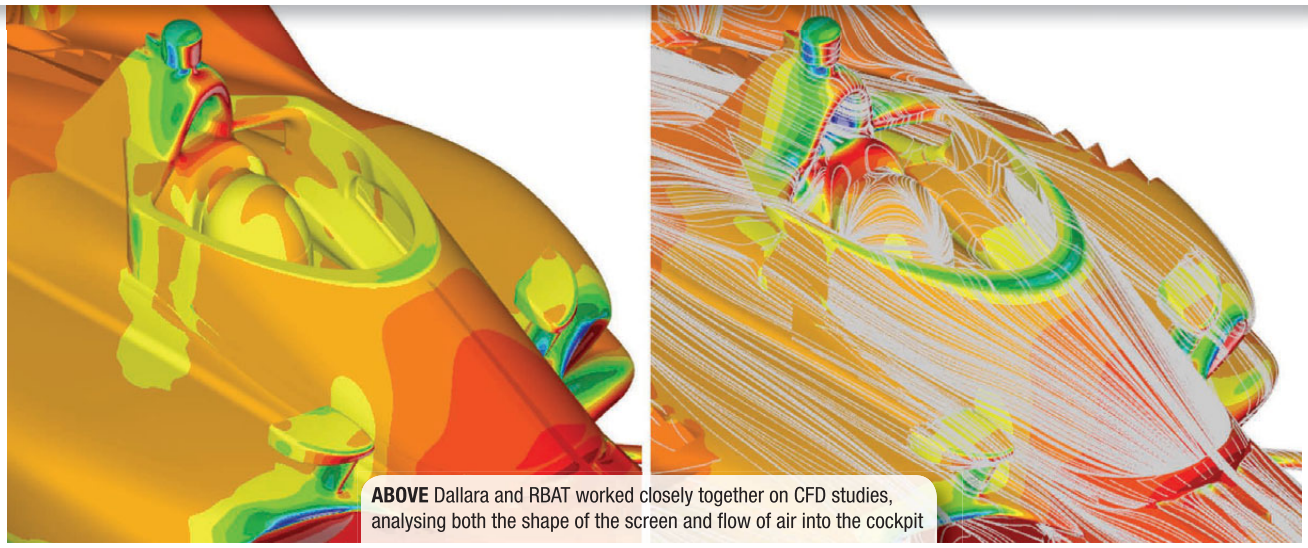
CAREFUL ADAPTATION

Ensuring these modifications could be successfully made was often a question of geometry, says Damerum. Considerable effort went into finding the strongest points on the chassis and adapting the structure of the Aeroscreen to match them. It was also a matter of not spoiling the carefully honed aerodynamics of the Universal Aero Kit.

"We had to do a lot of simulation work with Dallara on the CFD side," says Damerum. "They had a CFD model, so we worked closely with both them and IndyCar to make sure that the shape of the screen was aerodynamically balanced.

"The CFD study also looked at the risk of turning 90 degrees, so on the windscreen we have implemented the wicker, which is a carbon strip which goes up the windscreen and helps stop the car flipping over at 90 degrees, so that had a reasonable effect. Those are the sort of studies that we had to undertake in CFD."

Another of the focuses of the CFD work was managing airflow into the cockpit. From a driver perspective, this was one ▶



ABOVE Dallara and RBAT worked closely together on CFD studies, analysing both the shape of the screen and flow of air into the cockpit

of the few areas of the PPG screen which was identified as needing work, with the pressure differential between the inside and the outside of the cockpit causing some buffeting, while the lack of airflow also made the drivers uncomfortable.

"For this there was a reasonable amount of back and forth between us and IndyCar and Dallara," Damerum adds. "It is an area that we are still working on. We have almost got there with various ducts to the driver, but at the moment air is getting to him, but down at his chest. In the initial tests the air was attaching to the windscreen and going over the top of his head, but now the air is going in there, it is just a matter of time before we have it sorted out."

There were some other potential issues that were assessed in CFD and simulator testing that were also examined during the device's track testing. These included concerns about how the titanium and Perspex structure would affect the balance of the car, and in particular how adding a certain amount of weight high up on the car could bring the weight distribution forward and cause particular stress on the outside front Firestone tyre at ovals. As it happens, these fears were unfounded and some drivers, such as former IndyCar series champion Will Power, actually suggested the feel of the car was improved.

"It actually makes the car more forgiving," he explained after the first test at Indianapolis Motor Speedway. "This car, when it was built, came with too rearward weight distribution, so everyone has done all they can to move it forward.

"So it actually puts the car in a pretty good window in my opinion of weight distribution, and with a few adjustments it worked pretty well."

The drivers were also very positive after the second running on-track, where another potential issue was confronted. Critics of windscreen concepts have often suggested that rain could be a problem, and could significantly hamper drivers' visibility compared to running with just a helmet, but again, the opposite seems to be true.

After his run in the wet, Simon Pagenaud, another former champion, Tweeted that the car "felt great in the wet," adding that "visibility might even be better than it would with the helmet alone as water seemed to disperse better on the Aeroscreen."

One explanation for the Aeroscreen's success on these points is the sheer amount of planning and preparation that has been carried out by Red Bull Advanced Technologies and IndyCar during its gestation.

Driver extraction is, for example, one of the main concerns when it comes to any kind of cockpit protection device. The opening itself is smaller than the cockpit, while the elevated sides make getting to the driver more difficult. The Aeroscreen presents problems even compared to the Halo, which at least allows safety crews to put their hands through the openings at the sides to reach the driver.

"We have been working hard all the way through this process," explains Damerum. "We had a working group from IndyCar and Dallara, and part of that was the IndyCar safety team, so they have been involved every step of the way.

"This carries on from when we were doing work on the F1 Aeroscreen, when we worked quite closely with the safety team for the FIA. That was when we worked out how they would be able to take the device off. So one of the bits of equipment that could be used would be the Jaws for Life, so, as we did with the F1 canopy, we actually designed the top frame so that the Jaws for Life could easily cut through a certain part of it to take the frame off in a timely manner ▶

BELOW New meets old at Indianapolis, as Scott Dixon's Aeroscreen-equipped Dallara streaks past the Pagoda. Both drivers lapped at a top speed of over 224 mph. Neither reported issues with visibility, head buffeting or car handling

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should there be an accident."

What's more, it isn't just the device itself that is prepared for all eventualities. The procedures surrounding it are also being refined to accommodate the screen.

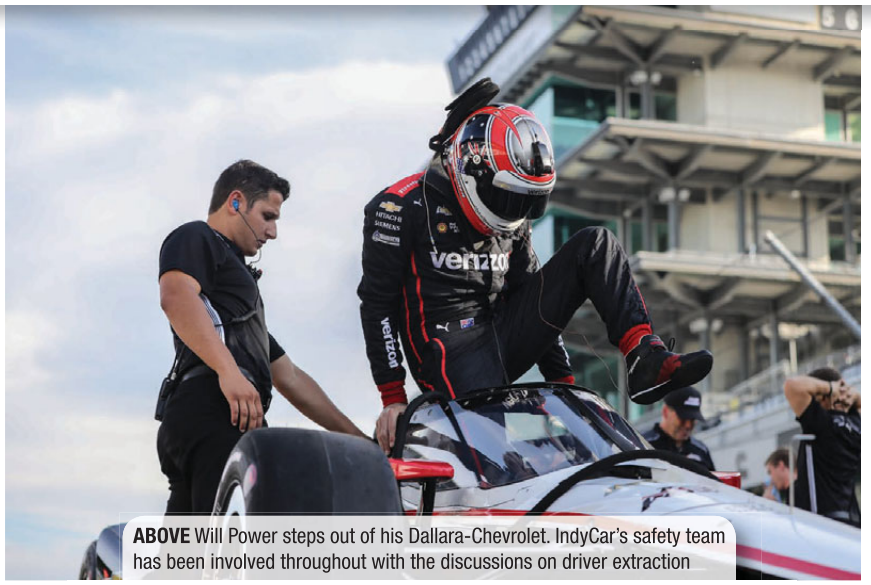
"I was talking to the IndyCar safety guys recently, and they said they were already working on it," Damerum says.

"At the moment when they are extracting a driver they put a carbon frame down the back of the driver and they use that to take him out. But they are looking at some new devices now, where they are effectively strapped onto the frame, and then the driver can be lifted out of the top. So IndyCar is definitely looking at it and I think there are things that are going to be implemented for the 2020 season."

Of course, all of this is moot if the screen doesn't do the job it was intended to do and protect drivers in the event of a collision, whether that is a collision with a small dense projectile or an entire car crashing down from above.

HOLDING STRONG

Because the Aeroscreen was originally developed for Formula 1, it has been designed to meet the stringent requirements of that series. This means that structurally it can handle the same 150 kN as the Halo, which, as Mercedes AMG F1's technical chief James Allison noted, is "roughly the weight of a London double decker bus". The teams must prove this strength through analysis, while the actual on car test *only* goes up to 100 kN, which is still the equivalent of more than 10,000 kg.



ABOVE Will Power steps out of his Dallara-Chevrolet. IndyCar's safety team has been involved throughout with the discussions on driver extraction

With the Halo and the structure of the Aeroscreen being so similar, with both using a titanium hoop above the driver and a central support on the centreline, it is no wonder they are similarly capable when it comes to static loads. What sets the Aeroscreen apart, is of course the polycarbonate shield.

To test the effectiveness of this windscreen, it will be subjected to a range of ballistic tests. These will include firing a tyred wheel at the canopy at more than 220 kph, as was done with the original F1 screen, but will also include an aerospace-derived test known as 'the silver bullet' which sees projectiles of different weights fired at the screen at different speeds. The F1 Aeroscreen already passed some similar tests, with Red Bull even releasing footage of that device deflecting a 1 kg projectile that was hurled at it at 230 kph.

As such Damerum is confident that the further tests won't pose a problem for the safety device.

ABOVE IndyCar president Jay Frye hails the device as "a total industry-changing driver safety solution"

"The main criteria for the Perspex is that it doesn't shatter," he says. "You don't want bits of it going into the driver's face on impact, so it can't shatter.

"Looking into that was some of the work that we did with various different thicknesses of screen that we were doing in 2016. We worked out with the manufacturer how thick it could be and what we could get away in terms of thickness. So because of what we have gone for, we believe it should easily be able to take the ballistic tests that it will be subjected to in the next couple of weeks."

Damerum's confidence, as well as the success in testing from the very first laps at IMS, may make you wonder why this solution wasn't implemented sooner. Damerum says the explanation for this is very simple: "IndyCar didn't speak to us any sooner."

IndyCar had tried several options over the last few years, but there were always hurdles, whether it was the lack of anywhere to mount the Halo, its perceived impact on visibility, or the failure of the PPG screen in ballistic tests, something always stopped a device being used in anger. Red Bull Advanced Technologies, meanwhile, was already well prepared.

"We had the information here, so from start to finish this project took us five months," he says.

"IndyCar were over the moon with that, they liked the way we pushed it along because they hadn't been seeing that progress with some of the other projects that they had. I think they were quite keen on the way we operate at Red Bull Advanced Technologies, because it's the same as the way we operate on the F1 side."

Because of this success, the project is now considered over for Red Bull Advanced ▶

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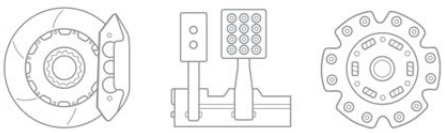

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ABOVE The device looks way sleeker from the above and side views than it does from the front

Technologies. "It worked out of the box, which means there are no changes that need to be made to the hoop, and there will be no changes to the Perspex screen, because these are now in manufacture," says Damerum.

"And although we have been involved with working with suppliers, and assisting IndyCar with the suppliers, we will have nothing to do with the manufacture; our role was just as a design consultancy.

"The only things left to do are some things that Dallara wanted to try, such as some internal gurneys or ducts or pipework. There are also some little deflectors and fairings being tested on the top edge of the hoop to try and deflect the air in various ways, but these are little add-on parts which are no big issue really.

"So it is really complete as it is, and we are into manufacture so we can get it out to the teams for January."

Reception to the Aeroscreen has been largely positive from fans, a group IndyCar is obviously keen to keep on side. The response from the armchair experts of the internet has tended to fall into the surprisingly moderate mould of 'it's different, but we accept it on the grounds of safety', although of course there were some more extreme views: from the succinct "absolutely disgusting" of one Twitter commentator, to Reddit user Dollar-menubuffet's view that it "looks awesome, like a damn fighter jet!"

One of the other most common opinions immediately voiced by the Twitterati though, was that the somewhat divisive look of the device could be improved in future, by being better integrated into the chassis of the next generation Indycar.

Although giving nothing away, Damerum also gave the impression that this possibility is something RBAT would be open to.

"We found it a really interesting project working with IndyCar, and so far they have been pleased with the progress…

"So, if we can we'd like to retain the partnership we have with IndyCar, but who knows, we will see how it progresses over the coming weeks and months. Our part of this project is complete, but we are keen to see how Indy takes this forward, and to see what else we can do to work with IndyCar moving forward."

Cockpit protection has been an issue in IndyCar for a long time, but luckily, it seems the Red Bull Aeroscreen could be the long-term solution the series has so dearly sought. RT

ABOVE Andy Damerum, RBAT's commercial development officer, looks over the installation of the Aeroscreen at Indy

ABOVE A polycarbonate laminated screen includes an anti-reflective coating on the interior, an anti-fogging device through an integral heating element and tear-offs

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WHY FORMULA E VENTURED INTO THE VALLEY TO CLIMB A MOUNTAIN

Motorsport turned to Silicon Valley to help conceive the battery that has revolutionised Formula E. **Craig Scarborough** investigates

MANY now freely admit they never expected Formula E to last for five races, let alone five seasons. Having confounded the doubters, the all-electric race category enters Season 6 later this month – and it continues to capture the imagination of the fans and major motor manufacturers alike.

The gameplan has always been to carefully control development, in order to level the playing field and prevent an expensive arms race. To that end, the battery was a specification part for each of the first four seasons. As long as that remained the case, the championship's detractors had ammunition: embarrassing car swaps were required mid-race.

Last season marked a massive breakthrough, though: the dramatic new Gen2 car gained a battery doubled in energy, able to last the whole 45-minute race. A triumvirate underpinned this technical triumph. The collaboration between McLaren Applied Technologies, Atieva and Murata brought two new companies into the motorsport arena. It also created an advanced new battery pack that not only transformed Formula E, but dispelled some big myths in the process.

Even at a formative stage when Formula E was barely proven at the racetrack, it was thinking forward with a roadmap for future development. This helped the Gen2 car significantly, as it was clear from early on that a new battery would be part of the specification. Thus, the tender process was scheduled to allow the winning bidders two years to develop the battery. While this was far in excess of the timescale afforded to the Gen1 battery developer, Williams Advanced Engineering, this was still, in reality, a tight deadline.

McLaren Applied Technologies (MAT) was already part of the first generation of the FIA Formula E car supply chain. It had developed the Motor, Inverter and ECU for the Season1 car and the TAG400i ECU remained a widely adopted unit even in Season5. Although eager to bid for the Gen2 battery

Audi AG

tender, MAT could not go it alone. Instead, it approached Atieva.

But who *was* Atieva? It initially became known for its expertise in battery technology. Subsequently, its direction has changed towards being an electric car company, under the Lucid banner, with its Lucid Air prototype currently under development. Peter Rawlinson, Atieva's CEO, explains: "Lucid is a fledgling electric car company. Our first product is an electric saloon: it's luxury, it's California cool. It starts production in Arizona at the end of next year and will be available in Europe a couple of years later."

Rawlinson himself is no local to the Golden State, rather a British engineer with a background at Lotus, Jaguar and Tesla, where he was chief engineer on the Model S.

As MAT rightly identified at the project's inception, neither a road car battery business nor a motorsport expert could achieve the objective alone. "Our partner is an expert in battery technology and battery packaging," says MAT Motorsport Business Director Rodi Basso. "Their expertise is in a different domain. I believe this would not have been possible without their know-how, combined with our domain knowledge: technical expertise in understanding the mission profile, boundary conditions, validation and support at the track."

This partnership split the job between the design and manufacturing, headed by Atieva in the USA, and MAT's development of track support facilities and team procedures in the UK. Each partner has battery solutions in production, so the design of the Gen2 battery was a two-way affair, as Basso explains: "It was designed from a blank sheet, but as you know you have different approaches to steer towards a decision. You can start from the cell and build all the processes that take you to the battery, or you can start from modules tested and validated that take you to the battery. We went for the second option, based on a chemistry that was the cutting edge of the technology available as an energy source."

"When we looked at the technical spec of the battery pack, it was clear to us with a short time to the start of the race series that we didn't have the luxury of time to develop a cell and cell chemistry, then industrialise it," explains Rawlinson. "What we wanted to do was identify a cell and cell chemistry that was already in production, that matched the DNA profile of the series."

This task relied upon Atieva's expertise in battery technology and its huge database boasting hundreds of cells and cell chemistries. Matching the requirements of the FIA brief to the database brought up the answer. "It was a cell from Sony, who are now called ▶

> *"It's widely misreported that the doubling of energy storage was a result of advancing cell technology"*

ABOVE Formula E races into its sixth season this month with a stellar cast of manufacturers. Audi, which will campaign its e-tron FE06, has revealed plans to achieve 'company-wide climate neutrality' by 2050

Murata," says Rawlinson. "In terms of its energy, its discharge rate and recharge rate, which is important for regenerative braking, it almost perfectly matched the requirements that we had received from the FIA technical team."

With the cell supplier now identified, the trio went ahead with the bid for the supply of the FIA Formula E Gen2 battery, and won. Yet even given this head start, the scale of the task was still daunting admits McLaren Applied Technologies' Basso. "The state-of-the-art technology allowed us to achieve the result, but the known unknowns were quite big, so the level of risk we were undertaking was exciting and quite frightening at times!" he reveals.

The split of expertise between the three companies was crucial in delivering a battery that would achieve a 100% reliability record in its first season.

PACK DESIGN

"In motorsport there is always something different, because of the duty cycle, the temperatures involved and the vibrations," outlines Basso. This was the challenge that awaited the triumvirate as Atieva set about the design of the battery pack.

Rawlinson is keen to bust one of the myths surrounding the jump in performance of the Gen2 battery over its predecessor. It's widely misreported that the doubling of energy storage was a result of advancing cell technology within the battery industry over the first four years of the electric series. Atieva's assessment of the Murata cell in the Gen2 pack may therefore come as a surprise. "Cells *are* advancing, but not at the rate they are perceived to be," suggests Rawlinson. "These cells were in production for a few years before the pack was conceived: we could have produced Gen2 packs a few years before!"

The exact cell specification is still a sensitive subject for all those involved. However, it is no secret that the cell is a small format cylindrical unit, around the size of a 'AA' battery, hence the significant number – +5,000 – of cells inside.

So, if it's not the cells, then what are the advances made to the battery pack to effectively double its life? "There's a world of cell technology and there's a separate discipline of battery pack integration," says Rawlinson.

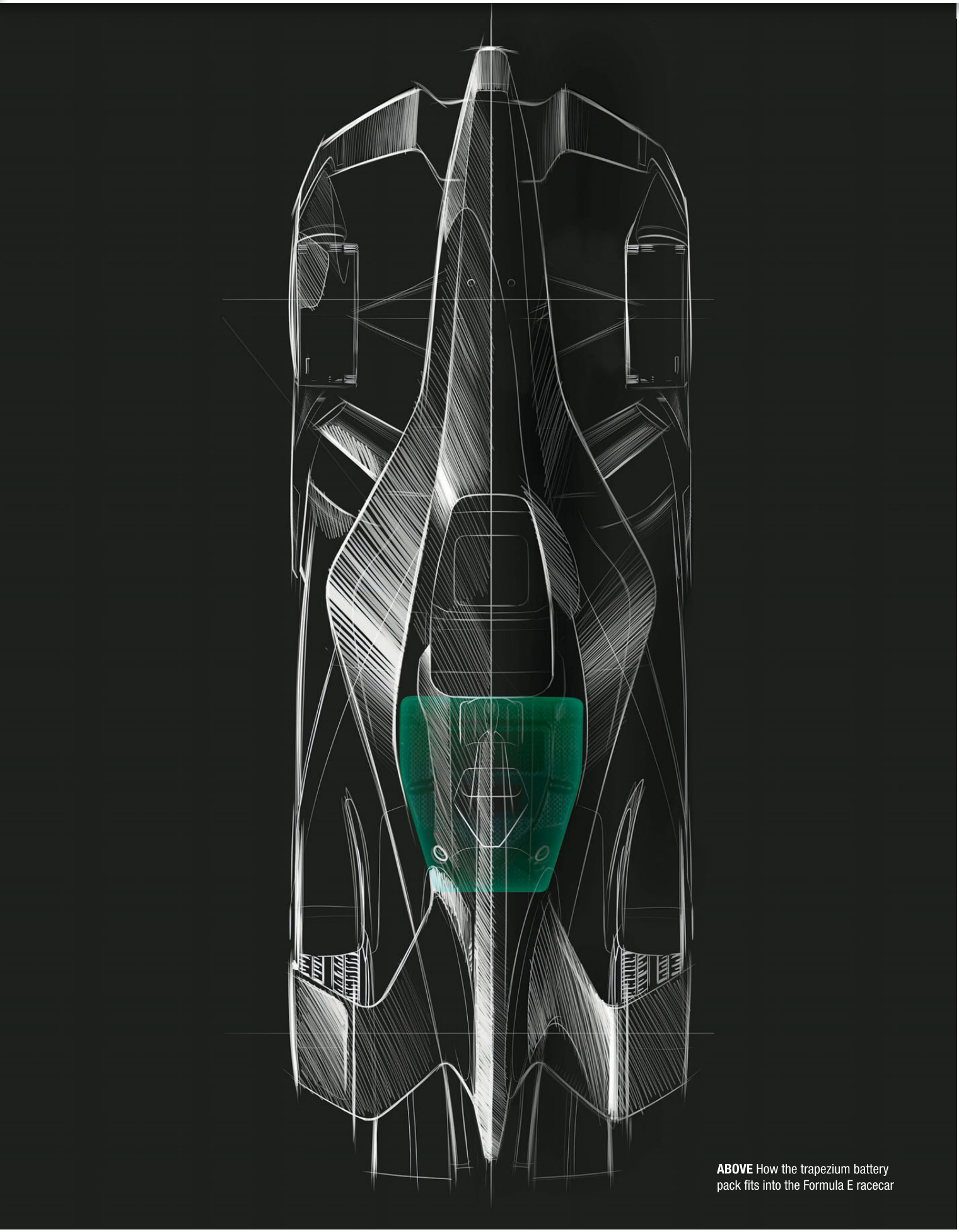
"Murata manufacture and supply these world-class cells, with the DNA that Atieva identified and matched to the race requirements. Atieva conceptualised and designed the whole pack with its technology, a lot of which its patented and is from our road car programme. Then it was tested and manufactured here in our headquarters in Silicon Valley, California."

This resulted in the 54 kWh 880v battery pack that will sit at the heart of all 24 cars for the Season6 curtain-raising double-header in Saudi Arabia later this month. As a semi-homologated series, the battery is a sealed unit which teams cannot open or modify. To them, it's very much just a large, black carbon fibre box with connectors for DC power, cooling and CAN output. Inside, it's far more complicated than merely a large number of individual cells wired up to each other. It's this integration of the cells into a working solution that raises the Gen2 battery up from its humble cell chemistry and format.

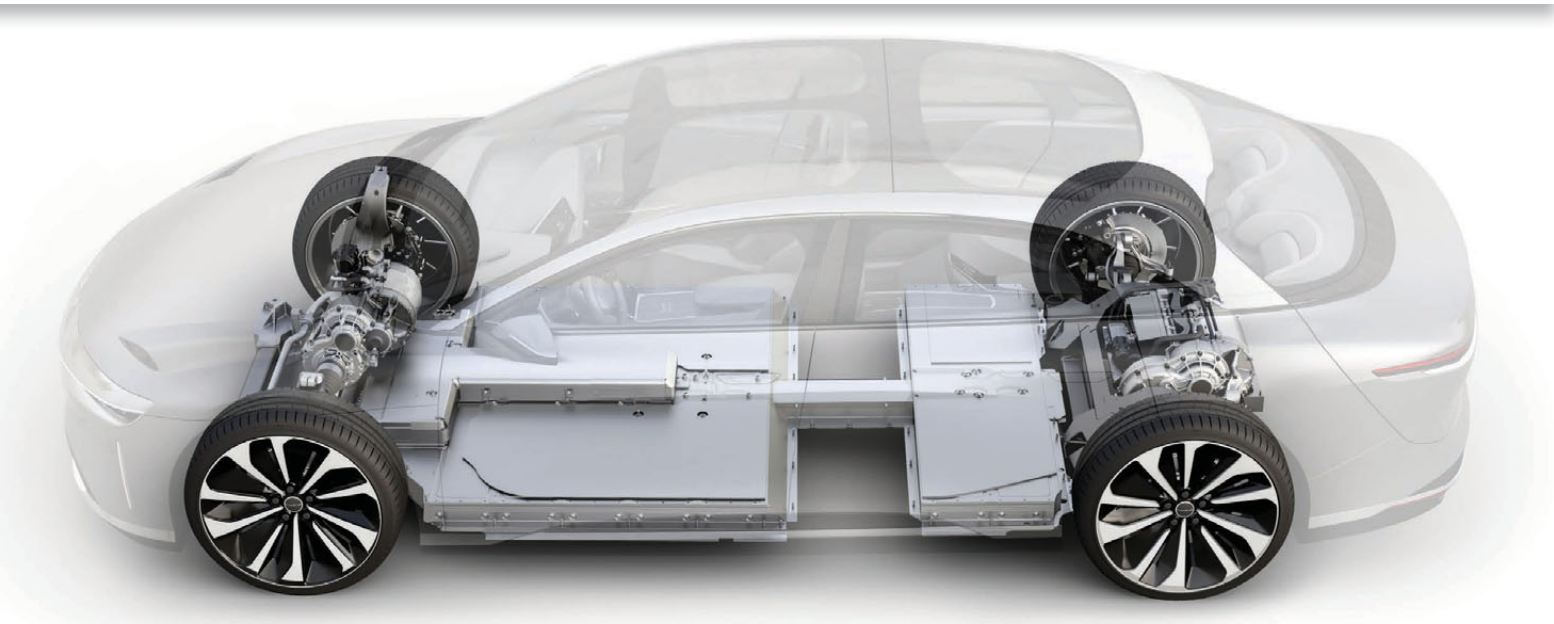
Another myth Rawlinson shoots down is that one secret aspect of the battery is the electrical design. "A large part of the battery pack is the science of integration," he insists. "You'd think it's mainly an electrical engineering discipline; actually, 80% of it is mechanical engineering!"

Vibration, heat and degradation are perhaps the biggest obstacles to overcome when designing a battery for use in motorsport. "The way you put these cells together ▶

BELOW The McLaren Applied Technologies battery at the heart of each car raised the amount of usable energy to 54 kW/h



ABOVE How the trapezium battery pack fits into the Formula E racecar



ABOVE The Formula E project piggybacked some of the expertise invested in the Lucid Air, the California company's all-electric prototype

to make sure it doesn't fall apart with the vibration, the modal analysis; that's structural engineering," notes Rawlinson, "holding those cells together to make them work as cohesive structural entities with kerb strikes, meeting durability and proof load cases. The ultimate example of that is a crash test: the car experiences up to 50g in a crash and the pack is reusable after that! We've done all that crash analysis here at Atieva."

Beyond the harder physical aspect, thermal issues also represent a huge challenge. "Keeping that pack cool is absolutely crucial to the life of the cells," he says. "There are over 5,000 cells within this pack, more than double the energy of the Gen1 pack. How we keep those thermally controlled is proprietary Atieva technology. We are able to do this with very intense computer thermal simulation with dielectric fluid and how that keeps all those cells in harmony. It's not just to do with the temperature of the pack, but the temperature distribution of all the cells as a group."

> *"The real secret sauce is the Battery Management System and the software behind that"*

Cooling could therefore be viewed as being as crucial to the cells inside the battery as it is to the internals of a combustion engine. There is a similar effect on the chassis performance, according to Rawlinson: "The more cooling you need, the bigger the radiator, the higher the pumping losses and the bigger the aero impact on the car."

The Gen2 car cools the battery with a Bosch electric pump and a radiator mounted in the right-hand sidepod. Circulating inside this cooling circuit is dielectric fluid, Novec. This is mandated by the FIA for safety reasons, as a water-based coolant would risk conducting electricity in the event of a crash.

Having a dielectric cooling medium brings challenges to the cooling system performance since its capacity to carry heat away is about half of that of water, and it's about 50% heavier. FIA Formula E tours the world and many races are held in far warmer climes than Europe. Atieva's work on cooling saw the battery well prepared for its worst-case scenario last season in South America. "We have seen some incredible local temperatures," observes Rawlinson. "we saw in Chile a record temperature, off the scale at over 40 degrees C. This is a different case to that we are used to with road car development. Here we don't have a refrigerant loop; we do on a road car. We modelled all of this and designed the pack for a full season of racing, the aim being for the pack to be as good in the last race as it was at the first."

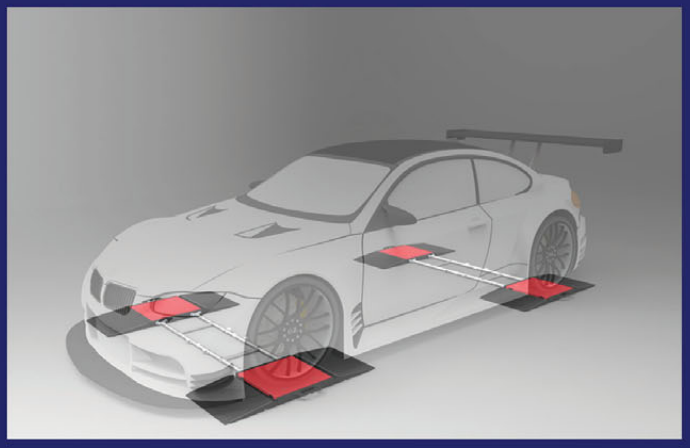
Audi team principal Allan McNish was one of those impressed with the progress. "If you think back to Santiago the previous season, it was 43 degrees C outside air temperature and it was a long race," he says. "Regen was a factor with the majority of the races in the previous campaign, with the old battery. Now that problem's disappeared."

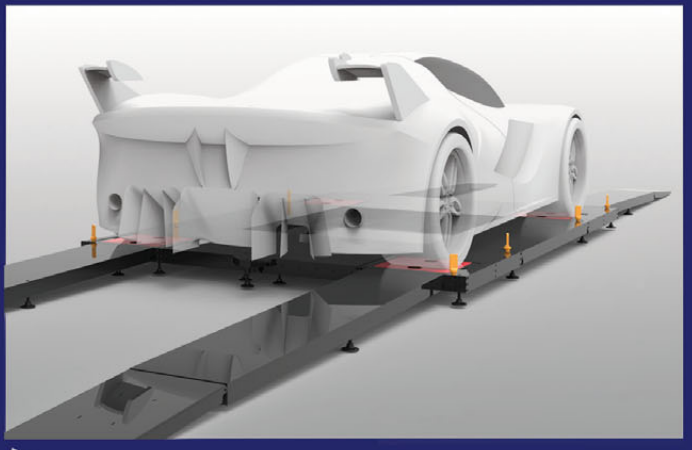
There is even a mechanical aspect to the electrical handling inside the battery. "With the electrical architecture, what we seek to reduce are the I^2R losses, the internal energy losses due to current heating," explains Rawlinson. "We use a bus bar system, which is an Atieva patent. We've used it in our road car and it's very innovative."

BUS BAR SYSTEM

For Rawlinson, the key to a battery lasting the full season without significant degradation goes beyond the cooling and more into the software. This appears to be at the core of the company's competencies. Proud of this area, he reveals: "The real secret sauce is the Battery Management System (BMS) and the software behind that. All this coding is really the veins and arteries of the system. We do all of that in-house with our software team. That's what is great about being in Silicon Valley: we have a rich vein of software engineers we can tap into."

With the BMS and the layout of the cell groups, the battery can adapt how it outputs the power, to suit both the tactical requirements of the current use-case but also with an eye to season-long performance with minimal degradation. "We group the cells into groups in series and parallel," he says. "I can't go into the precise numbers. How you balance each group in terms of the voltage and balancing the level of charge each of the ▶





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ABOVE The integration of the battery is very much part of the Gen2's structural package, helping make a 'coke bottle' shape

cells receives, makes sure there's almost a step ladder of voltage. Within the pack you go from group to group in series, as you step up through the voltage. One of the key attributes of our BMS is to ensure that each of those cells, in each parallel group, has the same voltage and same voltage delta. That's important, so they all work in harmony and individually contribute the same amount."

This approach becomes particularly important as the season wears on. The ability to group the cells together, balancing out dead voltage and current as a consequence, evens out the degradation across the season.

It might be argued that with a battery that withstands vibration, heat and degradation better than ever before, teams will be tempted to push the pack harder for greater on-track performance, something they feel they are ready for. "Yes, that'd be great, we'd welcome it," responds Rawlinson. "We want to support the teams to get the absolute maximum from the battery!"

PACKAGING INNOVATION

Beyond the battery internals, the whole package needs to fit into the back of the racecar. This is still a relatively new area for motorsport, packaging large, heavy battery packs that ideally cannot encroach into the other packaging aspects of the car and still need to be removeable.

Now the 'black box' battery pack sits inside the Spark Racing monocoque in a position not unlike that of a fuel tank in an ICE racecar. When the car is raised up on hydraulic lifts, the battery unit can be dropped out from below. The rear of the monocoque, built by Dallara, is slim and narrows towards the carbon rear casing which houses the electric motor, inverter and geared differential. Fitting the battery into this space was no easy task and demonstrated the tight loop back of ideas between Atieva, McLaren Applied Technologies, Spark Racing, Dallara and the FIA.

Ultimately, it relied upon a solution put forward by Atieva. "It's not just a rectangular box," stresses Rawlinson. "it was an innovation that we came up with. I personally assisted on it, actually. I believe that the battery pack is more than just a source for energy. The way we integrate the pack into the car it's very much part of the structural package, the envelope for the occupants: it has to fit harmoniously and contribute to the aero of the car.

"The first thing I did was to look at how we could benefit the sport with a battery pack that was sculpted to best suit the racecar package. I conceived this trapezium shape, as I wanted it to fit the aero and structure of the monocoque, to make a 'coke bottle' shape."

That shape wasn't immediately suited to the large cell installation, however. "Everyone thought I was nuts," he recalls with a grin. "They pushed back, 'Oh no, this is never going to work', and we looked at how we were going to configure the battery. Then we had a breakthrough in our thinking: a way to create a modular design for the packs inside, yet use the space in an imaginative way to create this trapezium shape."

While the actual layout of the cells inside the packs, then how the packs are arranged within the outer casing, is still secret, relatively accurate renders have appeared on the FIA Formula E YouTube page. They suggest that the packs are arranged transversely and longitudinally inside the case, surrounded by the bus bar system and cooling pipework, yet still fit into the narrow outer casing. The latter is likened to "a Fabergé egg inside" by Rawlinson.

With all the rig testing, on-track testing and the full season of races, the Gen2 acquitted itself well. There were no race failures, teams were able to run without thermal issues and there was little degradation of the battery over the course of the season. Overall, Rawlinson is pleased: "We were really delighted to complete our first season with a 100 per cent reliability record."

This specification of battery goes on to race in Season6 of the championship, starting later this month in Saudi Arabia. There will be a Gen3 battery in due course, as all areas of cell and integration improve. This will certainly affect the energy density, leading to lighter batteries, beyond the capabilities of the current version.

> *"The level of risk we were undertaking was exciting and quite frightening at times!"*

Despite the leap with the Gen2 battery, Rawlinson prophetically points out: "This technology is still in its relative infancy today, so the 'dinosaurs' of today will evolve massively in future generations."

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COSWORTH

SMART CELLS FOR A SMARTER FUTURE

William Kimberley talks to principal engineer Paul Freeland about Cosworth's re-assertion of itself as one of the leading engineering technology companies in this changing world

To many of a certain age, the name Cosworth evokes the glory years of the DFV V8 in Formula 1 in the 1970s and early '80s when it was the engine to have bolted at the back of your car. For others, it is the sublime high-performance Ford Sierra Cosworth that hit the public roads in the late '80s.

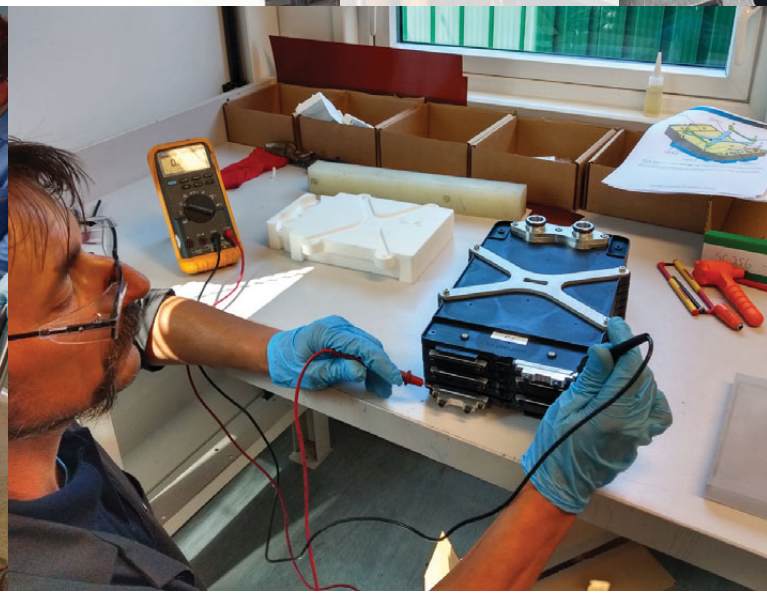
It would have been easy to let such a great name sail into the sunset, glorying in the past. But Cosworth is one of those motorsport engineering companies that refuses to let the past overtake its mission – and that today is to be as energetic, proactive, relevant and at the cutting edge of technology as it was back in the day when it was owned and run by Mike Costin and Keith Duckworth.

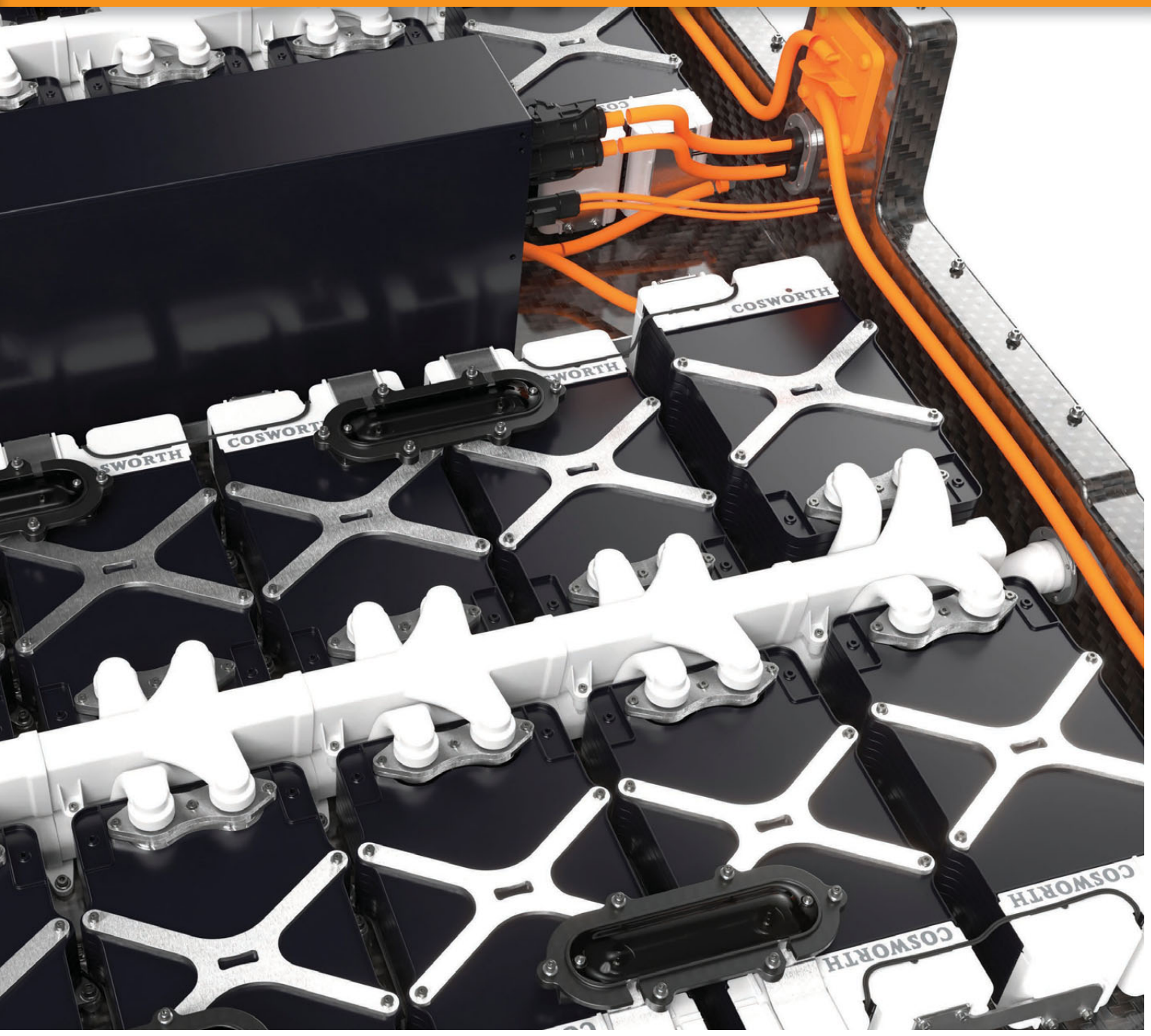
The company continues to use the ingenuity and creativeness instilled by its founders, ensuring its relevance and pertinency in a world where the rate of change of technology is accelerating. High-performance hybrid and electric vehicle systems are featuring increasingly in the major motorsport series, and are a key technology for the next generation of sportscars. Cosworth is very active in this arena, developing a concept demonstrator smart cell battery pack and optimising battery thermal management systems. Nor has it overlooked evolving IC engine technology, having recently developed a mass-production petrol engine with the efficiency to rival a modern diesel combustion engine.

"We are continuously exploring ways in which we can use our experience and state-of-the-art technology to evolve the internal combustion engine to reduce its impact on the world and help meet global targets to reduce emissions," says Paul Freeland, principal engineer at Cosworth. "We believe we can find a responsible solution to provide for future mobility needs in the technologies that currently exist by evolving and combining them to make best use of each set of attributes."

He says that motorsport provides a very good development platform where there's

ABOVE & BELOW Cosworth, in collaboration with its partners, recently completed the design, assembly and first trials of a prototype battery pack to demonstrate and explore the benefits of smart cell technology





a well-controlled environment in which to pioneer new technologies. "It gives us a great opportunity to trial new concepts, and we can gather a lot of very useful information, very quickly. However, there still remains a lot of development work needed for validation before it can be released to the market."

Referring to hybrid and e-mobility vehicles, Freeland says that their ultimate viability lies in battery development, and that energy storage is currently one of the greatest limitations facing this approach. The fundamental problem is that the deliverable energy density of a battery pack works out in the end to be about a third of what can be got from liquid hydrocarbon fuels. "It means that you're already starting with a system that can't offer the same range that customers are kind of used to," says Freeland.

Cosworth recently joined forces with a number of British companies to form the UK Automotive Battery Supply Chain consortium, in conjunction with the UK's Advanced Propulsion Centre, to develop a new approach to battery construction and control. The smart cell technology chosen for this project employs a bespoke silicon chip developed by Dukosi in Edinburgh, mounted on each of the 13Ah pouch cells specifically developed by AGM Batteries in Thurso, Scotland to create a new type of cell-based battery management system. The smart cell approach enables detailed information about the cell temperatures and voltages, and the state of charge and state of health of each cell to be determined and recorded throughout the whole life of each of the cells. During use, this information is transmitted to the main Battery Management System (BMS) via radio antennae using Dukosi's proprietary near-field RF communications. This eliminates significant weight and the packaging constraints of conventional wiring, as well as the need for hundreds of connectors and the risks of high-voltage leakage and long-term robustness.

"The Smart-cell battery concept is basically one of spitting out the BMS in a different way," he says. "A conventional BMS will have a master battery management unit which looks after the ▶

whole pack, to which slave units arranged in modules report. With the new system, the master unit will receive information directly from each of the smart cells. By integrating cell monitoring technology into each battery cell in this way, more information can be monitored with less wiring and connections, and this provides the opportunity to increase battery life, reliability, safety and ultimately the performance of electrified vehicles. This approach also helps reduce the costs of recycling at the end of the battery's life."

CREATIVE SOLUTIONS

Freeland says that with a lot less wiring and no connectors there is around three to five kilos saving in weight. "At the design stage, it's also very simple just to add another cell or two into each pack," he says. "All that's needed is to inform the software. This gives us far greater freedom in fine tuning the voltage, the capacity and the performance characteristics to match the requirements of each application."

To maximise the opportunities this system offers, Cosworth designed and built a bespoke technology demonstrator pack to explore the benefits in a realistic way. Typical to Cosworth, creative solutions were sought at every level for this new battery pack, which incorporates an innovative cell carrier and thermal management arrangement to make best use of the flexibility and freedom of design that the smart-cell approach offers, enabling all of the energy available within the cells to be used to the greatest effect.

> *"A new approach to battery construction and control"*

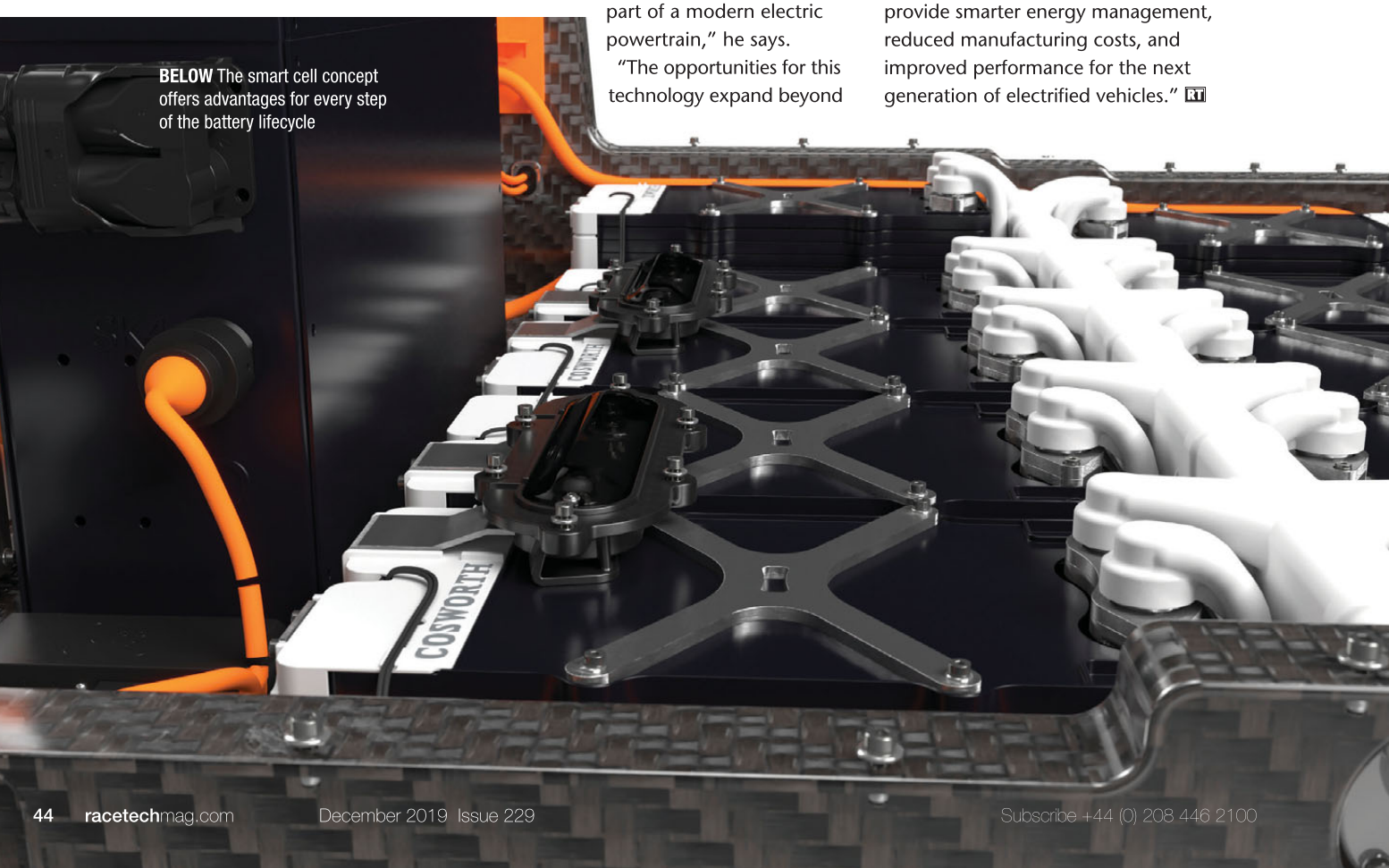
"At the same time, there's much better information coming through," notes Freeland. "At the moment we've got cell voltage, the current coming into the cell, and three temperatures, but with this concept we can easily expand that to cover more temperatures, and other instrumentation indicating directly the state of charge, electrolyte condition and things like that."

The smart cell pack is being tested in Cosworth's facilities at Northampton to prove its functionality and energy delivery characteristics. "Using advanced instrumentation and energy management algorithms woven into our bespoke testing programme, we'll study how the battery pack performs as an integral part of a modern electric powertrain," he says.

"The opportunities for this technology expand beyond the automotive to energy storage, marine, and aerospace applications. With the integration of cell monitoring capabilities, repurposing battery systems will become more efficient and reliable than ever before. With better instrumentation and temperature control, we can improve the ageing process within the battery cells to make a significant impact on the cost-effectiveness of this process."

He says that the target for battery pack life is currently 150,000 miles or 10 years, but as he maintains, "Over time there is a gradual reduction in capacity, and typically it's accepted at the moment that the pack will only retain 80% of its capacity in that period of time. Everything we can do to reduce this capacity degradation allows us to buy back maybe 10% surplus capacity that we don't need anymore.

"Our collective mission is to produce a leading-edge smart cell battery management system that will power the next generation of hybrid and fully electric vehicles. As a result, we will showcase the benefits of advanced battery systems that provide smarter energy management, reduced manufacturing costs, and improved performance for the next generation of electrified vehicles." RT



BELOW The smart cell concept offers advantages for every step of the battery lifecycle

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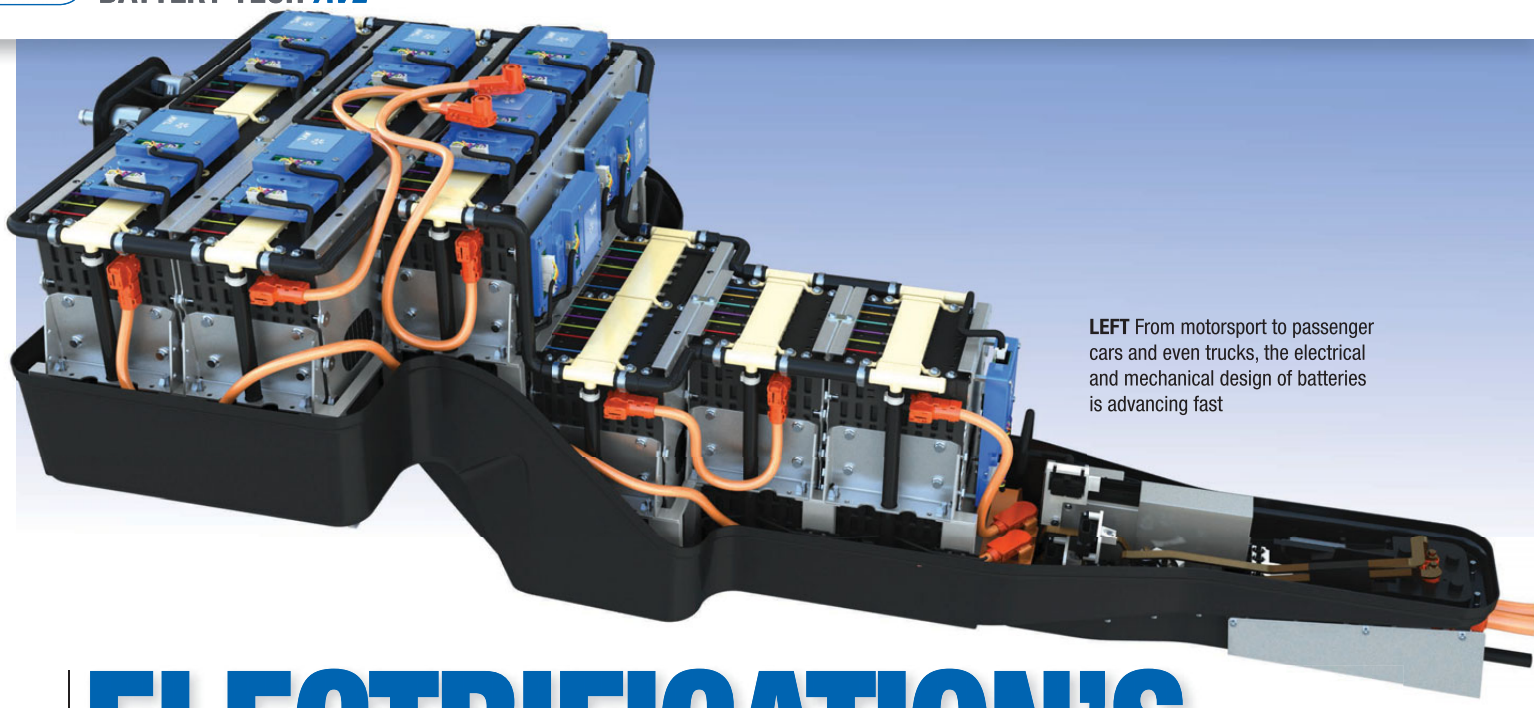

LEFT From motorsport to passenger cars and even trucks, the electrical and mechanical design of batteries is advancing fast

ELECTRIFICATION'S GREATEST CHALLENGE

What industry trends can we expect to result from motorsport's conflicting demands for greater performance, yet lighter weight? **Sara Kimberley** quizzes one of the market leaders

BATTERY technology in its current form faces many challenges in the racing and automotive market, from durability, weight, heat, safety, recyclability and cost to, of course, performance. Increasing the energy and power density of batteries is regarded by many as electrification's greatest challenge with manufacturers faced with a compromise between energy and power density as they try to minimise the size and weight of battery packs.

One of the main independent market leaders in battery technology is AVL, which finds battery solutions for clients using its own testbeds and extensive research and development programme, in which it invests 10% of its turnover.

€50 MILLION BATTERY TURNOVER

Currently 98% of its designed batteries are lithium-ion and Dr Wenzel Prochazka, AVL's senior product manager Battery Systems, Business Field Electrification, says the key to getting battery technology right is understanding precisely how the cells work. He comments: "Our technology is that we know exactly how those cells work – we work with cells from more than 10 different suppliers and know how to integrate them perfectly into a battery."

With a €50 million turnover of battery services alone, 300 battery specialists worldwide, eight testbeds in the headquarters, six across Shanghai in China and in two locations in the US, AVL has reinvested over €13 million in its battery test capabilities in the last year extending its testbeds, and it is continuing to invest in a new facility for new processes. One will be for developing the first modules and battery packs using all solid-state lithium batteries for sportscars, as well as looking at some technologies using alternative ions, such as magnesium and aluminium, that testing results have proven to be very successful replacements. Its battery technology can be seen in cars as diverse as the Jaguar I-Pace, Volvo Polestar 1 and the new Audi E Tron.

While energy density remains one of the top challenges for battery engineers, other issues include solutions for peak and continuous power, which has enabled AVL to develop highly efficient cooling systems, as well as lightweight issues that involve integrating battery cells into a pack that are as light and as rigid as possible for the vehicle driving performance. "That's why we are investing in a facility to develop never-there-before processes for battery building in the future," says Prochazka.

> *"The key to getting battery technology right is understanding precisely how the cells work"*

AVL has also invested a great deal in designing batteries that are easy to recycle. Currently the target is environmentally safe destruction and re-use of the materials that can be recycled with today's processes such as aluminium, copper and plastics. ▶

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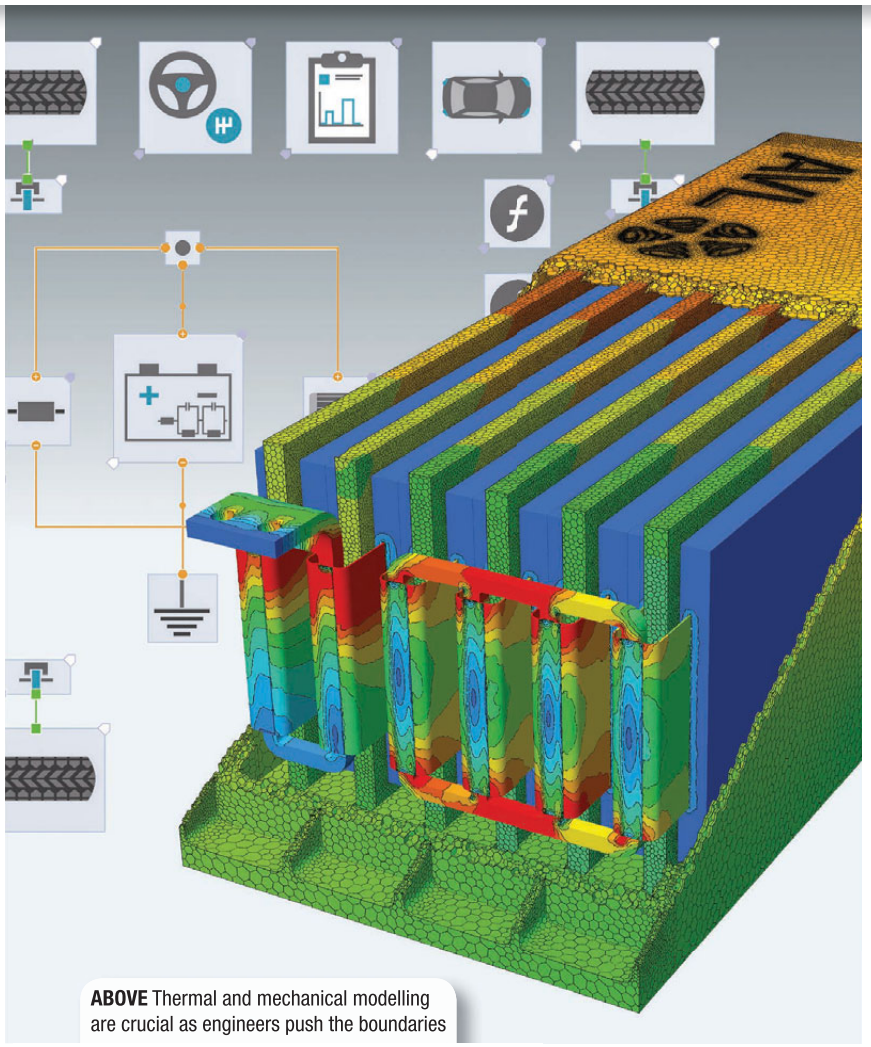
> *"Solid-state will not be going into a large race series until 2028/2030, he predicts"*

Prochazka also says AVL targets the re-use of cathode materials and electrolyte.

"We are especially known for our module developments for pouch and cylindrical cells and here we achieve the best performance in energy density gravimetric and volumetric currently on the market. The highest we have achieved in power is a bit lower than 5 kW per kg for a hybrid racecar series with the packs withstanding whole seasons. These developments actually came from concepts we did for racing batteries for an EV-series – industrialised for large series with five million battery modules per year."

COMING OUT OF THE LABS

However, much has been made over solid-state-batteries over the past few years as they replace the wet electrolyte in today's lithium-ion batteries with a solid and can be considered to be cheaper, lighter and may not need liquid cooling. Solid-state, though, is still in its infancy and is only now coming out of the labs and going into industrialisation for the first time.



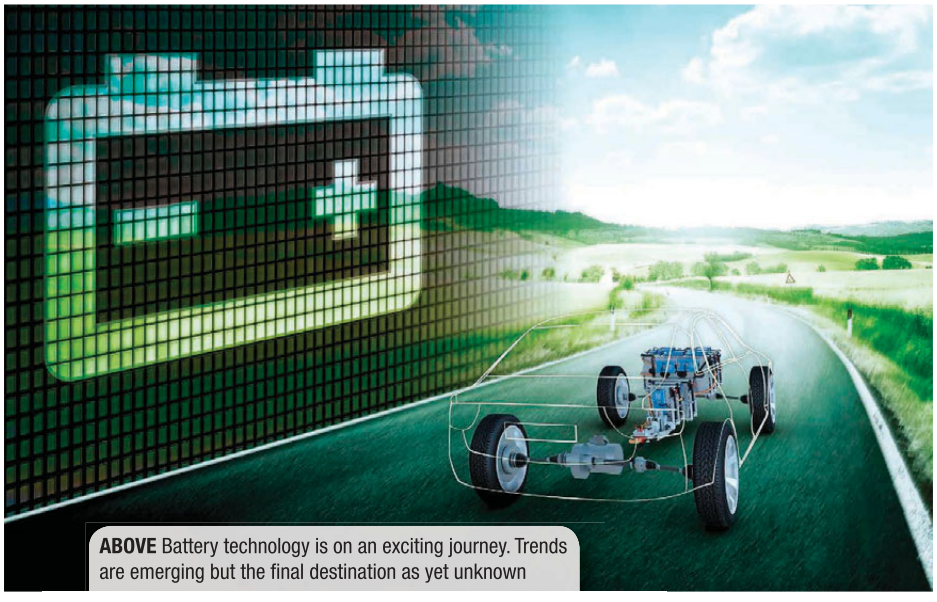
ABOVE Thermal and mechanical modelling are crucial as engineers push the boundaries

The benefits of solid-state are that they can operate at higher temperatures, says Prochazka. "Whereas liquid lithium-ion cells are built for usage at temperatures around 25°C, there are some cells that are able to run at 80°C. Solid-state will make another temperature move higher up which allows charging to become much faster and you will get more performance out of it.

"It is also making its first journey into small race series and sportscars," he says. "We are currently looking at solid-state for sportscars as with a conventional battery you can drive maybe two or three laps before recharging for 20 minutes. However, with solid-state you might go four or five laps and recharge for 10 minutes. You will see Toyota come out with the first solid-state series next year probably followed by some other manufacturers, but solid-state will not be going into a large race series until 2028/2030," he predicts.

When it comes to batteries in motorsport, though, being green is not really first priority. "A battery in motorsport is there for performance improvement," says Prochazka.

"There is a real deal of effort being made to make sure the battery is becoming genuinely green and there are also a lot of people trying to protect their old technology. We will get there in making batteries green, we just need a couple more years to actually be there," concludes Prochazka. RT



ABOVE Battery technology is on an exciting journey. Trends are emerging but the final destination as yet unknown

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HYDROGEN DREAM EDGING CLOSER TO REALITY

Chris Pickering talks to the man behind the machine blazing the trail for hydrogen racecars at the Le Mans 24 Hours

HYDROGEN has long been touted as the fuel of the future. To its advocates, it's clean, abundant and easy to refuel. And yet the fuel cell technology required to harness these benefits has been something of a scientific mirage – seemingly always on the horizon, but never quite within grasp.

There are signs that things are changing, though. Last year, the GreenGT team from Switzerland carried out demonstration runs at the Spa round of the European Le Mans Series using its LMPH2G prototype. This year it returned, logging another 20 laps during the free practice session for the event's Michelin Le Mans Cup support event, running alongside conventional GT3 and LMP3 cars.

The LMPH2G's most recent public outing also represented another milestone. For the first time, the car came in for refuelling during a live session. Four successful stops were completed using a specially-developed refuelling rig from the team's official partner Total. Admittedly, these were a somewhat convoluted affair that required the car to leave the pit lane and drive to the paddock, but they proved the validity of the basic concept.

Refuelling is central to the logic of using hydrogen. Batteries are almost certainly a more efficient solution if you want to drive a road car around a city or perhaps race a Formula E car around a street circuit for 45 minutes. But as soon as you want to go further than that you run into the problem of recharging, which can take hours. In contrast, you can theoretically fill a tank up with hydrogen in a matter of seconds.

"Refuelling a hydrogen racecar will ultimately take more or less the same time as it does with a gasoline or diesel car – under one minute, for sure," comments GreenGT's founder and head of R&D Jean-François Weber.

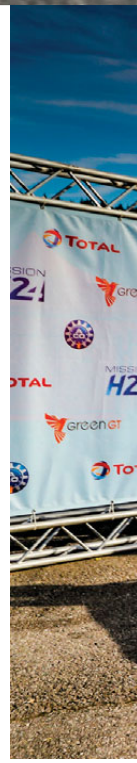
It's not there quite yet. The refuelling stops at Spa took around six minutes, but that was partly due to the location of the filling station in the paddock and the limitations of the current refuelling rig, both of which he believes should be fairly easy to rectify.

The biggest challenge with handling gaseous fuels is the temperature. As the hydrogen is consumed by the fuel cell, the pressure of the remaining gas in the tanks reduces, which causes it to cool. Conversely, as the tank is re-pressurised with fresh hydrogen, the temperature goes back up. The fuel system in the LMPH2G is designed to operate between -40 and +80 deg C and the test at Spa proved that the GreenGT engineers were almost spot on with their thermal management. Freshly refuelled, at the start of the stint, the temperature was said to be between +50 and +70 deg C, which dropped to around -30 deg C once the tanks were empty.

This wide range of temperature conditions might sound problematic, but from a thermodynamics perspective it works quite well: the colder the fuel system is when the car arrives in the pits, the faster the hydrogen can be pumped in without hitting the upper end of the temperature range.

"If the temperature was low enough we could refuel in about one to one and a half minutes [with the current equipment]," explains Weber. "The challenge at Spa was that we had to leave the pit lane and go to the station in the paddock, during which time the temperature of the tank started to increase [due to heat soak from elsewhere in the car]. It was 10 deg C warmer by the time we got to the hydrogen station, which meant we had to slow down the refuelling."

Weber and his colleagues have looked into whether the unique thermal characteristics of a hydrogen fuel system could be useful for cooling other parts of the car, but so far the answer appears to be no. "The period of time is very short. We go from 100 bars to 10 bars in maybe five minutes at the end of the stint, so it's very difficult to capitalise on this effect for anything other than refuelling," he notes.

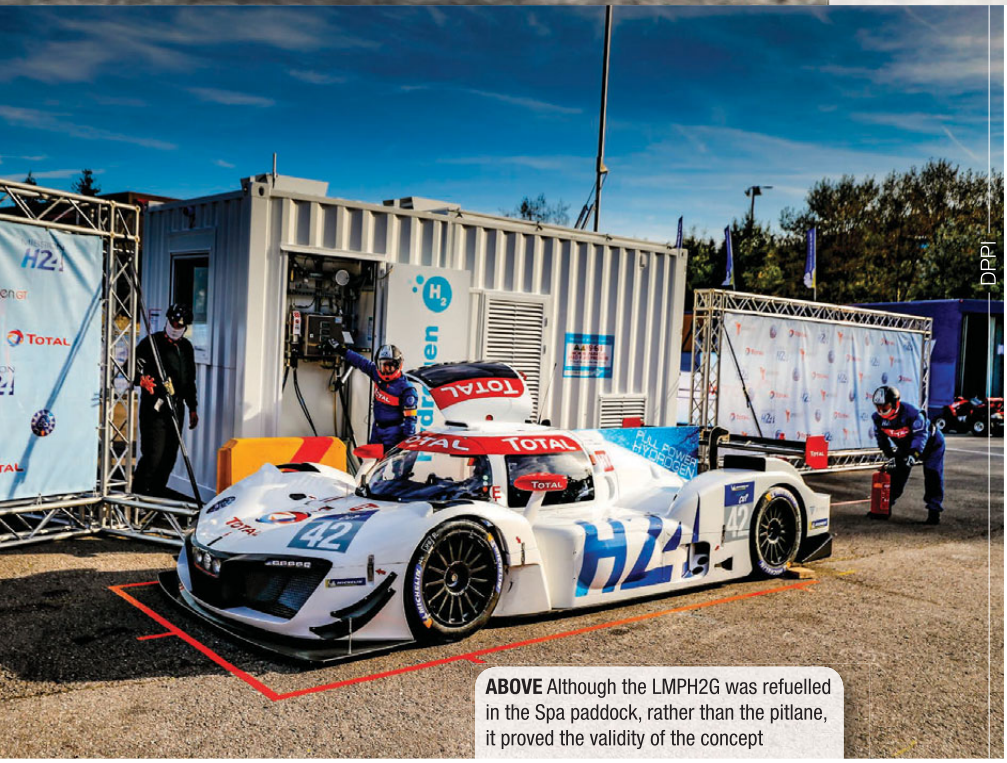


FILLING STATION

The refuelling rig developed by Total is effectively a self-contained mini filling station. It's comprised of a multi-stage compressor and a 450 bar high pressure tank that's around three times the volume of the hydrogen storage onboard the car. The whole thing fits inside a 6 x 2.5-metre shipping container that can be

DPPI

ABOVE A stalking horse for the hydrogen racecars expected to enter the Le Mans 24 Hours in 2024, the LMPH2G shared the track with other cars at Spa without issues



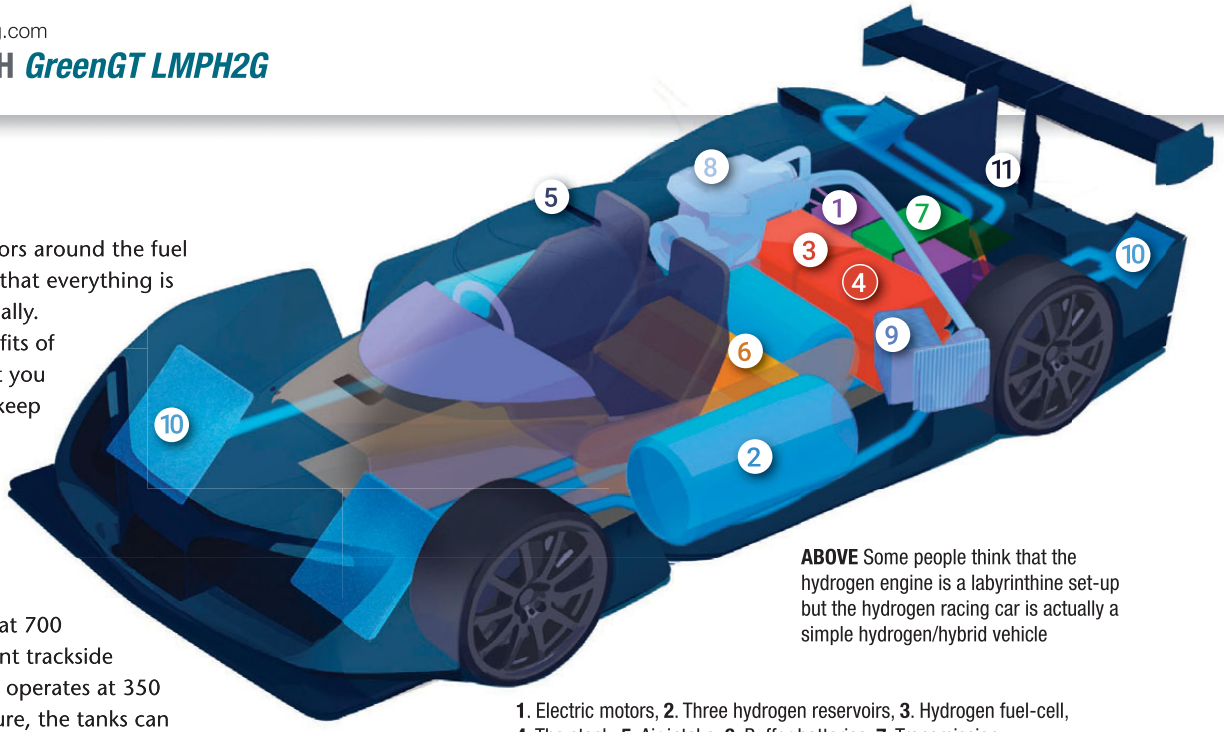
DPPI

ABOVE Although the LMPH2G was refuelled in the Spa paddock, rather than the pitlane, it proved the validity of the concept

transported to circuits around the world.

The physics of hydrogen refuelling is simple in theory. When the car comes into the pits, the pressure inside its fuel tanks is down to about 10 bar, so essentially all you need to do is open the valve from the high pressure tank and the hydrogen will then flow into the car on its own accord. The reality is slightly more complex as the flow rate needs to be regulated to ensure that temperatures and pressures on both sides of the system remain within a safe range. In order to do this, there's an infrared communications interface built into the nozzle, as is the case on some road cars, which allows the two halves of the system to talk to each other.

On the car side, there are two temperature sensors on each of the three tanks – one on the valve and one at the opposite end of the tank. There are also leak detectors and additional ▶



ABOVE Some people think that the hydrogen engine is a labyrinthine set-up but the hydrogen racing car is actually a simple hydrogen/hybrid vehicle

1. Electric motors, **2**. Three hydrogen reservoirs, **3**. Hydrogen fuel-cell, **4**. The stack, **5**. Air intake, **6**. Buffer batteries, **7**. Transmission, **8**. Compressor, **9**. Humidifier, **10**. Radiators and cooling system, **11**. Exhaust

temperature sensors around the fuel system to ensure that everything is functioning normally.

One of the benefits of using a gas is that you can theoretically keep squeezing more and more fuel into the tank by increasing the pressure. The fuel system in the LMPH2G is rated at 700 bar, but the current trackside refuelling rig only operates at 350 bar. At that pressure, the tanks can hold approximately 4.3 kg of hydrogen, but next year the plan is to increase the refuelling rig's pressure to 700 bar and add a pre-cooling system. "At 350 bar we can store 4.3 kg of hydrogen, which gives us about 25 minutes of track time. We've done tests at 700 bar – with 8.6 kg of hydrogen – and it will run for between 50 and 55 minutes," notes Weber.

GreenGT's shipping container solution was designed by Total to be easily portable and set up without any particularly specialist facilities. For testing, Weber and his colleagues have also used standard 200 bar gas bottles from the Linde Group, which provide enough range for development work. They also have a small compressor that's capable of charging the tanks to the full 700 bar, but that's not designed for trackside use and it can take several hours to fill.

INFRASTRUCTURE

The environmental case for using hydrogen hinges to a certain extent on how it's processed. The most common technique at present is natural gas reforming, which reacts steam and methane in the presence of a nickel catalyst to produce carbon monoxide and hydrogen. A second process is often then used to react the carbon monoxide with water to produce further hydrogen, along with CO2. According to the US Office of Energy Efficiency and Renewable Energy, the total greenhouse gas emissions of running a fuel cell vehicle supplied by this process are around half that of the equivalent combustion engine. Nonetheless, it does still consume fossil fuels and emit greenhouse gases, which some would argue rather defeats the point.

A greener option is to split water into hydrogen and oxygen using electrolysis. This is the technique used by GreenGT's fuel partners and it can theoretically be totally carbon free if the electricity is taken from a renewable source.

"Clearly, using electrolysis is not as efficient as taking the electricity and putting it straight into a battery, but it's a question of storage," explains Weber. "With this technique you can use the electricity when it's not required for the rest of the grid and you can store the hydrogen as long as you want."

He points out that a lot of the infrastructure needed to do this already exists (at least on the scale required for motorsport): "At Le Mans they have a solar farm to create electricity. If you have a renewable energy source like that and an electrolyser you can take as much time as you need to produce the hydrogen, compress it and store it. You don't have a 24 hour race every day, so if for the sake of argument, it takes one month to create the hydrogen for maybe 10 or 20 cars that's not a problem."

Weber estimates that it would take around 350 kg of hydrogen per car to complete the Le Mans 24 Hours. A field of 10 cars would therefore require 3.5 tonnes of hydrogen, which could be carried to the circuit in liquid form by a single tanker truck. This is already a proven technique for transportation, although long-term storage of liquid hydrogen (which has to be kept at a temperature of less than -253 deg C) is very much a cutting edge science at the moment. ▶

BELOW An infrared communications interface built into the nozzle ensures that temperatures and pressures on both sides of the refuelling system remain within a safe range

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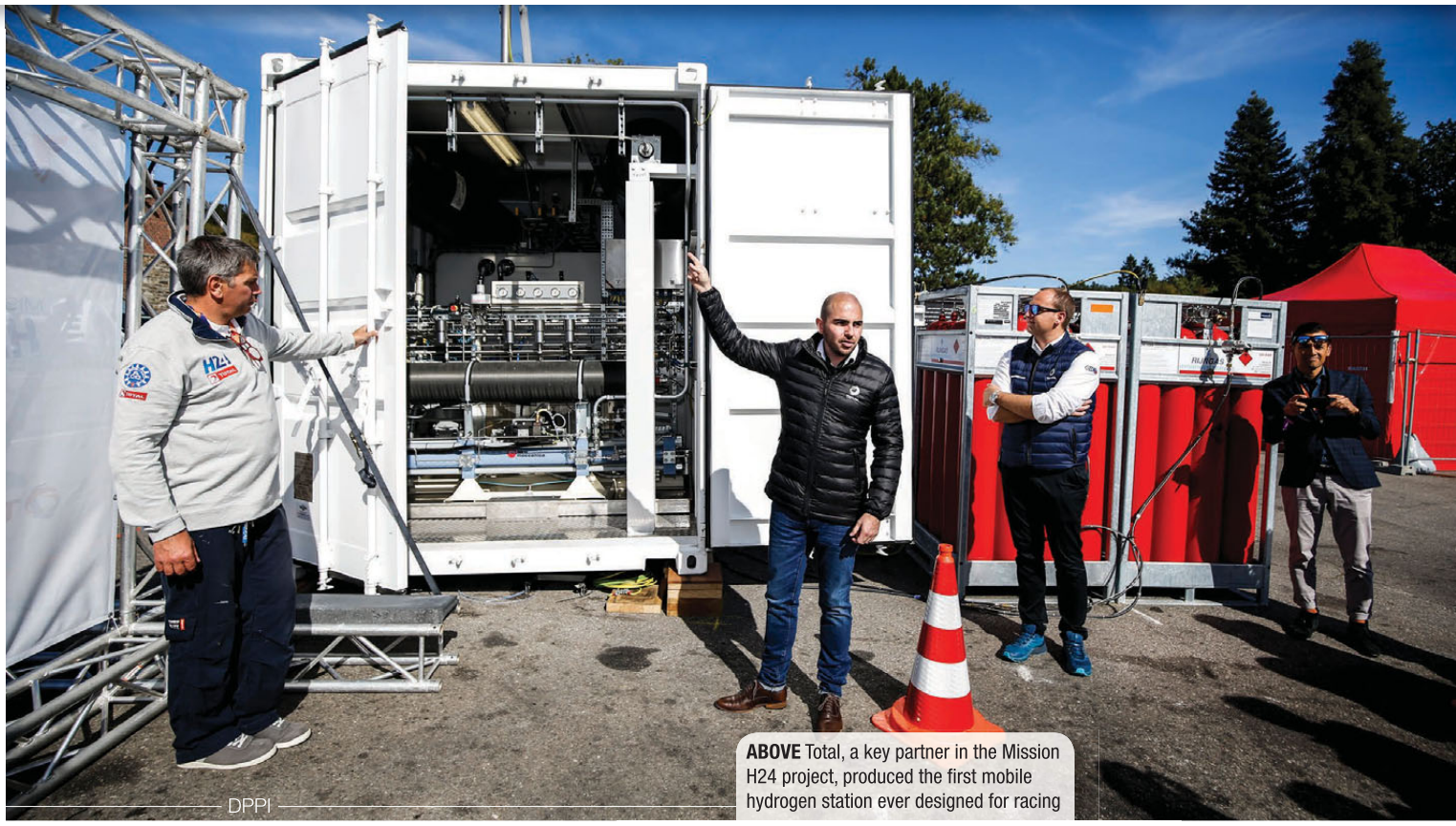

DPPI

ABOVE Total, a key partner in the Mission H24 project, produced the first mobile hydrogen station ever designed for racing

SAFETY

All this talk of compressed hydrogen tends to raise questions about safety, but Weber maintains that the risks are no higher than they are with gasoline – and potentially lower in some cases: "If any of the sensors detects a leak during the refuelling process it will immediately close the valves on the car and tell the filling station to stop [via the infrared link]. Once it's onboard the car, the hydrogen is carried in metal tubes and they're not very big. You have maybe the equivalent of a quarter of a litre of gasoline energy in each tube once you shut the valves off."

The carbon fibre fuel tanks are road-going designs that have gone through the full range of tests required for homologation. There's yet to be any report of a serious incident involving a ruptured or leaking tank on a hydrogen road car – thousands of which are already on the roads. That's partly thanks to the fact that hydrogen tanks are immensely strong. Toyota famously fired bullets at the tanks used in its Mirai road car and found that regular rounds simply bounced off; the engineers switched to high-calibre armour-piercing rounds and found that they still needed to shoot the same spot twice to break through. Weber also points to the fact that when the Skylab space station crashed to earth in 1979 its oxygen tank – similar in concept – was one of the few components to survive re-entry and a 300 mph (480 kph) impact largely intact.

"Hydrogen cars and hydrogen refuelling stations are fundamentally safe," he says. "The most critical aspect is the hose from the station to the car, but the response times [from the safety systems on the car and the rig] are so rapid if a leak is detected that very little energy actually leaves the system."

> *"Refuelling a hydrogen racecar will ultimately take more or less the same time as it does with a gasoline or diesel car – under one minute, for sure"*

Even if a leak does occur, the consequences are a lot more manageable than you might expect. The explosive power of a tank is fundamentally proportional to the amount of energy stored in it, so the risk posed by a ruptured hydrogen tank is no worse than its calorific equivalent in gasoline or diesel. It is highly flammable, but because it's so light, escaped hydrogen tends to dissipate quickly (even if it's on fire) rather than forming a pool like a conventional liquid fuel. "If you speak to firefighters they'll tell you they'd rather deal with a hydrogen fire than a gasoline one," comments Weber.

THE CAR

So far, GreenGT has stuck with the same chassis and powertrain that debuted in the LMPH2G last year. It uses a lightly modified Adess LMP3 tub, with off-the-shelf brakes and dampers from Brembo and PKM respectively.

The fuel cell is a proton exchange membrane (PEM) design from Symbio FCell with 230 individual cells arranged in four stacks. It operates at a virtually constant 250 kW (330 bhp), even when the driver is off the throttle, supplying charge to a 2.4 kWh lithium ion battery system. This also acts as a KERS system, capable of harvesting energy under braking and deploying up to 250 kW for as long as 20 seconds.

Oxford-based YASA has supplied the electric motors, with two on each rear-wheel providing a combined maximum output of 480 kW (634 bhp). There is no mechanical link between the rear ▶

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wheels; instead each pair of motors drives through a single-speed 6.3:1 transmission, made in-house with driveshafts from Sadev. The car's control software provides a 'virtual differential' between the two wheels with a torque vectoring capability. Four IGBT inverters are used to convert the DC output of the battery and the fuel cell to an AC signal for the motors.

Work is continuing to analyse the performance of this setup – in particular the long term durability of the fuel cell – but the plan is to upgrade it over the winter. "We first defined the powertrain for the LMPH2G around three years ago, but this technology is moving quite quickly, so quite a lot has changed in that time," comments Weber. "We'd like to go from four motors to two [still driving the rear wheels independently] and we also plan to go from the present IGBT inverters to SiC [silicon carbide]."

The thinking behind this is mostly weight reduction, he explains: "Weight is always the first priority for racing. Switching to two motors obviously reduces the weight of the motors, but it also means that we will be using two inverters rather than four, so you get twice the benefit. Overall, we think we can shed nearly 100 kg from the weight of the powertrain."

THE MISSION

GreenGT is one of the founding members of the Mission H24 project, which aims to introduce hydrogen-fuelled cars to the Le Mans 24 Hours in 2024. The plan is to have an additional prototype class for these vehicles, which will race alongside the combustion-engined cars in the main 24-hour event.

It's understood that multiple manufacturers are in discussion with the FIA and the ACO about the entering the category. None have yet been named, although there are some intriguing possibilities. Toyota, which has been a huge supporter of Le Mans in recent years, is one of the recognised leaders in fuel cell technology, which would make it an obvious candidate. Likewise, long-time LMP competitor Audi has dropped hints that hydrogen racing is on its radar, as has BMW, which has recently announced its plans to begin offering its own fuel cell-powered road car.

It's likely that we'll hear more about the technical framework for Mission H24 at next year's Le Mans 24 Hours in June. By that point, any manufacturers looking to sign up would have around three and a half years to commit to the project, develop a car and begin testing. That's a relatively short timescale in the context of such an ambitious undertaking, but Weber says he's confident: "If you look at what we've done with GreenGT in the past, we've changed the car every three years. And don't forget they wouldn't be starting from zero – most of the major automotive manufacturers have already done work on fuel cells."

Jakob Ebrey/JEP/Le Mans Cup

BELOW The running at Spa indicated that the GreenGT engineers were almost spot on with their thermal management

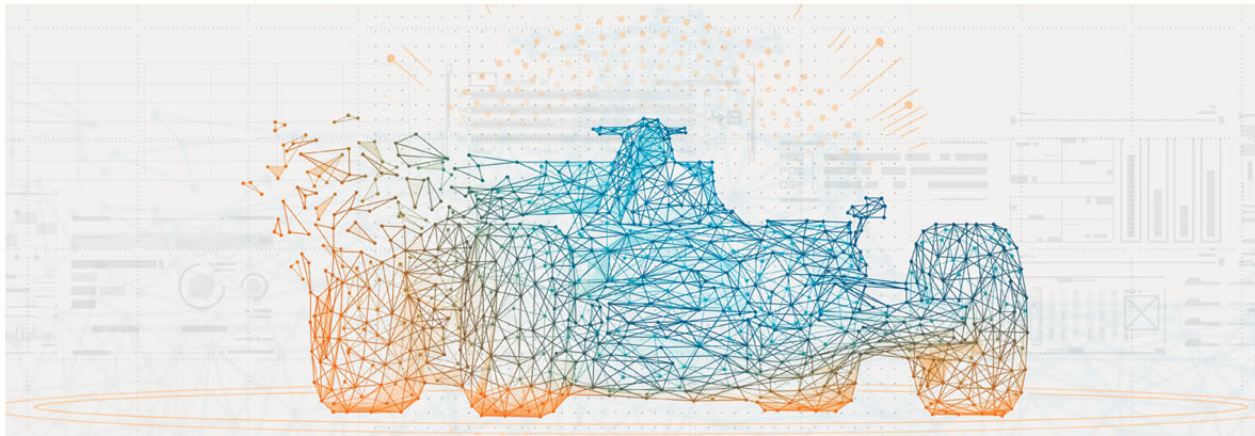
One thing that could help is the use of standardised parts, but Weber says he doesn't see it as a Formula E-style spec series: "I don't think the model of Formula E would work for endurance racing. Mission H24 is an opportunity for manufacturers to prove their hydrogen technology. We have a working group with the ACO looking at whether they could share some components – maybe a universal body shell or fuel tank design – with their own fuel cell."

PERFORMANCE

Another aspect of the discussion is where exactly the hydrogen cars might fall in terms of target performance. GreenGT's best lap time during the recent test at Spa was a 2:33.149, which was around 10 seconds off a GT3 race lap and 15 to 20 seconds off a GTE lap. It's fair to assume that the hydrogen cars will have to be at least as quick as a GTE Am entry to maintain safety on the track. Weber says it's too early to give a specific target, but confirms that they would have to be "up to the GTs for sure and closer to the LMPs" at Le Mans.

Closing that gap isn't so much a question of refining the fuel cell and the electric drivetrain, but rather optimising the package as a whole, he explains. At present, the LMPH2G weighs a not-inconsiderable 1,460 kg and uses a relatively conservative aerodynamic package. Work is planned to address both these aspects with the next iteration of the car, which is likely to move away from the LMP3 chassis. "As we go forward we will look to re-think the design of the chassis to optimise the layout and the storage space for hydrogen," comments Weber. "Optimising the weight and the aerodynamics should put us on a similar performance level to the GT cars. After that we will wait for the results of the ACO working group to see what the targets are for the next stage of the project."

All this means that the prospect of seeing hydrogen-powered cars competing at a major international event like Le Mans is gradually edging closer. There may still be some way to go, but crucially there is now a roadmap in place and some genuine progress being made by organisations like GreenGT. Perhaps soon the hydrogen future will become a reality. RT



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Most Innovative New Motorsport Products of the Year

They might have flown beneath the radar when it came to grabbing the headlines but, behind the scenes, these are some of the products that helped shape motorsport this season. **William Kimberley** reports

MOTORSPORT is at the vanguard of product development. Some of it will never see the light of day beyond being featured in a racecar, but some is extremely useful in other industries having been through the rugged testing time of being in a competition car.

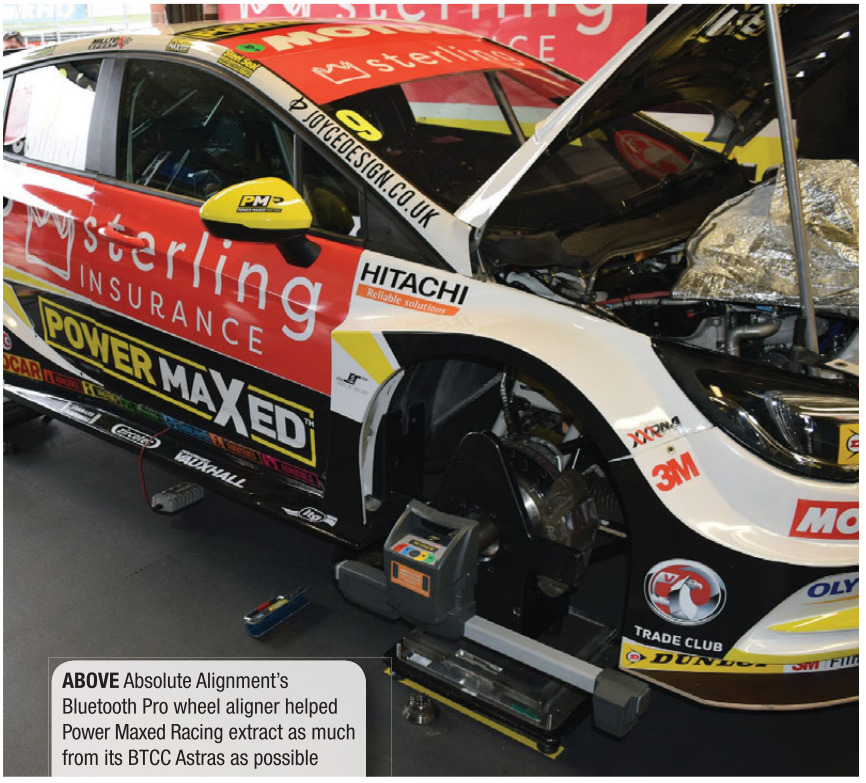
We have created a shortlist of those products that have caught the editorial eye in the last year that we present as worthy nominees to receive the prestigious Most Innovative New Motorsport Product of the year award at the World Motorsport Symposium.

Absolute Alignment
Nominated for its Bluetooth Pro wheel aligner

In the 2018 season Absolute Alignment supported Power Maxed Racing in securing nine podium finishes including three race wins. Martin Broadhurst, technical director for PMR, said, "Within elite level motorsport, we are fighting to extract the last 1/1000ths of a second from the cars, and so our steering and suspension setup has to be the best it can possibly be. The support provided by Chris and the team has been absolutely second to none."

Power Maxed Racing uses the same Bluetooth Pro wheel aligner that is the mainstay of Absolute Alignment's range. PMR has continued working with Absolute Alignment throughout the 2019 season.

Absolute Alignment's Bluetooth equipment is compatible with two and four-post ramps, plus scissor lifts and even inspection pits, as well as being pit lane friendly. The base unit sits in its own self-contained cabinet with a dedicated monitor and printer, and alignment setup checks take a matter of minutes.



ABOVE Absolute Alignment's Bluetooth Pro wheel aligner helped Power Maxed Racing extract as much from its BTCC Astras as possible

Alcon
Nominated for its AAC01 BBW system

Alcon has been developing fully active braking systems to meet advances in electric and autonomous vehicle technology. It has engaged with top-flight motorsport suppliers and specialist contractors to enter the market with its AAC01 BBW system that it claims offers cutting-edge technology and class-leading performance. This is a lightweight, off-the-shelf, high-performance black box BBW system that features a failsafe design for passive braking in the event of power loss; dual-channel pedal and calliper pressure measurement, and a Pedal Compliance Chamber Port for customer pedal-feel tuning.

The system offers the highest brake pressure delivery capability and fastest pressure response along with the best thermal and performance endurance available to electric racing cars.

Despite being Alcon's first ever venture into motorsport mechatronic systems and entering the market in the pinnacle of electric racing, the AAC01's performance was reflected in its immediate success in the FIA Formula E Championship. It achieved excellent results with its customer ▶

ABOVE Alcon is meeting the need for fully active braking systems in electric and autonomous vehicles with its AAC01 BBW package

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team including a podium finish in its first competitive event and a win in its second. It went on to achieve another podium finish, two fastest laps and a pole position over the remainder of the Formula E season.

Ansible Motion
Nominated for its Theta C driving simulator

Ansible Motion has developed a compact simulator that is powerful enough to create an immersive test environment yet compact and self-contained enough to be housed anywhere.

Thanks to its compact footprint and sophisticated computational architecture, Ansible claims that its new Theta C driving simulator offers a more immersive and car-like environment than is currently available from other compact simulators. It also avoids the complexity and facility challenges typically associated with test equipment of this accuracy and calibre. This makes it easier to deploy or move.

It incorporates a panoramic projection system, detailed vehicle interior, Ansible Motion's immersion technologies for driver touch points, active steering torque and seat loading systems, foot pedal and gear select emulation, along with a surround-sound audio system. Its integrated form and internal sound isolation mean it can be used in standard office spaces.

Chell Instruments
Nominated for its nanoDaq-LTR-64 pressure scanner

Chell Instruments has updated its range of MicroDaq pressure scanners with the innovative nanoDaq-LTR-64, specifically for motorsport. It has been supplying high-end pressure scanners to Formula 1 teams for over 30 years. Until now, the precision required has made the hardware prohibitive for others in motorsport, but with the launch of the nanoDaq-LT, Chell has created an accessible scanner with the same essential features for just one third the cost. The nanoDaq-LT-64 is the most recent development in this range and gives unparalleled measurement density for the aerodynamicist.

By utilising the latest technology in digital transducers, Chell has created a slim-line and cost-effective scanner which helps all levels of motorsport deliver gamechanging aerodynamic developments.

"Pressure scanning applications are an area we've been heavily focused on, in particular the aerodynamic testing of Formula 1 cars," says Jamie Shanahan, Chell's sales director. "With the nanoDaq-LT we've developed a scanner that is not only affordable to many more customers but its size and construction mean it's ideal for many motorsport and automotive applications."

Cosworth
Nominated for its Motion Controller (CMC)

The Cosworth CMC which is designed to enhance productivity and repeatability in the windtunnel environment, provides dynamic and precise attitude control of vehicles, leveraging the speed and accurate timing of EtherCAT. The solution uses real-time, closed-loop control, based on measured axis feedback, to compensate for vehicle or motion system deflections. The result, claims Cosworth, is optimised repeatability.

In this latest commission, the CMC allows the manufacturer to control full-size vehicles that sit on a moving belt on standard, flexible tyres. The size and mass of the cars, plus their elastic link to the road create unique challenges for accurate, fast positioning as oscillations may set in. It has been tuned to prevent such oscillations from occurring. Modifications allow for the large, undamped mass of a car on flexible tyres, with a non-linear suspension. Out of the box, the CMC has provided a significant improvement in positioning accuracy, 0.1m vs. 0.4mm, as well as a 40 per cent reduction in test time.

More importantly, the CMC introduced continuous motion playback to full-size car testing, which allows for even greater efficiency and gathering of richer data. In this mode, a long motion profile is predefined, through which the vehicle moves continuously with concurrent data acquisition. It also greatly reduces vehicle set-up time by removing the need to conduct a time-consuming motion calibration prior to running.

EEC Performance Systems
Nominated for its f-POD Max-i

This is a version of EEC Performance Systems' existing f-POD Max Intelligent Race Fuel Bowser but with the following innovations which it believes are the first in the field.

1. The first, purpose-built fuel bowser to be specifically designed to integrate into a team's garage walling, featuring a 'slide out' control panel, which is slid out from behind the wall when required to fuel the cars, and slides back behind the wall when not in use.

2. The first fuel bowsers to be built with left-handed and right-handed versions for each side of an F1 pit garage improving connectivity between the bowsers and the cars.

3. The first bowsers to feature a built-in web browser enabling such features as a 'chat' system where the bowsers are connected directly or WiFi to the team's own private network so instructions can be sent from the engineer directly to the fueller to say how much fuel must be added or taken out, and the fueller can send his responses ▶

BELOW The f-POD Max-I from EEC Performance Systems integrates neatly into a garage wall yet offers smart features to ensure refuelling is as seamless as possible

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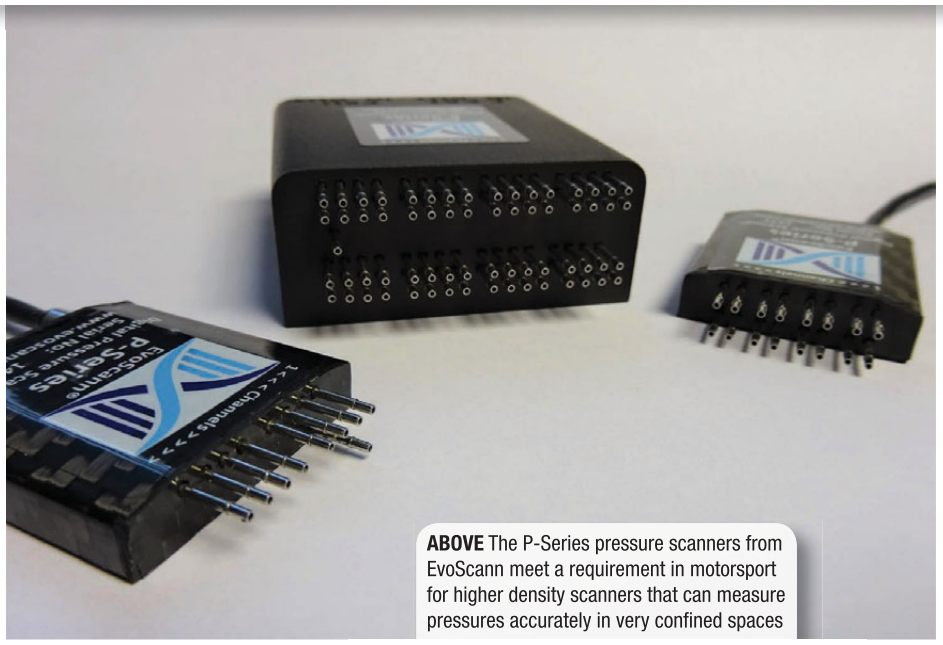

ABOVE The P-Series pressure scanners from EvoScann meet a requirement in motorsport for higher density scanners that can measure pressures accurately in very confined spaces

back. The engineer also can view and download all fuelling transaction histories. The web access is limited to prevent unauthorised browsing of non-relevant sites.

4: Remote access to the machine enabling easy software updates and remote support from EEC Performance Systems.

Evolution Measurement
Nominated for its EvoScann P-Series miniature pressure scanners

Evolution Measurement's EvoScann P64-D provides 64-channel high-performance MEMS pressure sensors to ensure high density, high accuracy and measurement of complete aero sections in one compact device. Supplied in true-differential mode across a selection of pressure ranges, including custom ranges, integrated temperature sensors provide observation data and apply digital temperature correction to each of the pressure sensors to ensure optimal performance and correct for ambient effects. For optimal accuracy, a reference tubulation is provided to connect to a stable static source.

In consultation with many customers in the motorsport world, the need was identified for a higher density scanner that could measure pressures accurately and quickly in very confined spaces, that are also often subjected to high temperatures and much vibration. EvoScann P-Series is ideal for a wide range of applications, often being inserted directly inside an aerofoil section where it provides no disturbance to the airflow.

Weighing-in at less than 110g and encapsulated in a carbon fibre reinforced shell, the EvoScann P64-D transmits accurate, fast data, in engineering units, directly to the test article's central processing unit over CANbus.

The EvoScann P-Series has been a significant success since its release in 2017. Its unique, compact dimensions have enabled users to make the measurements as close as possible to the desired test locations. With an ultra-low profile and restricted height, they can be placed in very narrow sections to gather data as quickly and accurately as possible with negligible frequency response effects.

LSP
Nominated for its IBSe active brake system ready for Formula E racing cars

The special feature of LSP's IBSe is that it fully supports regenerative braking. Energy recuperation has immense advantages over conventional brake systems because it recovers kinetic energy. This directly increases the vehicle's range. The motorsport brake system also offers drivers a further highlight – the optimal pedal feeling. Even during the recuperation phase, the pedal characteristics remain reproducible and precise. The brake balance remains constant in all situations.

The heart of this braking system is LSP's patented Double Air Gap motor. Combined with a friction-optimised ball screw drive and an integrated master brake cylinder, the system displays impressive pressure build-up dynamics. LSP's specially developed high-performance control valves precisely control the volume flows in the valve block. Low-noise, intelligent sensors and a controller tailored to the vehicle provide rapid and targeted pressure build-up in the brake circuits. Depending on a customer's needs, the brake pressure can be controlled either axle by axle, or on each wheel.

Making the system work seamlessly is a combination of precision hardware and elegant software integration. The hardware, despite being so small and light, means the system offers a maximum possible pressure of 110 bar. While the software means that both drivers and engineers can have precise control over the braking forces that are deployed.

Oerlikon Balzers
Nominated for its BALIQ CARBOS coatings

Oerlikon Balzers has developed new amorphous hydrogen-free carbon (a-C) coatings, BALIQ CARBOS and BALIQ CARBOS STAR6 They are very versatile and best utilised in applications with high contact pressure combined with sliding velocities, such as in high-performance ▶

BELOW LSP's IBSe brake by wire system allows nuanced control of recuperation, critical in series like Formula E

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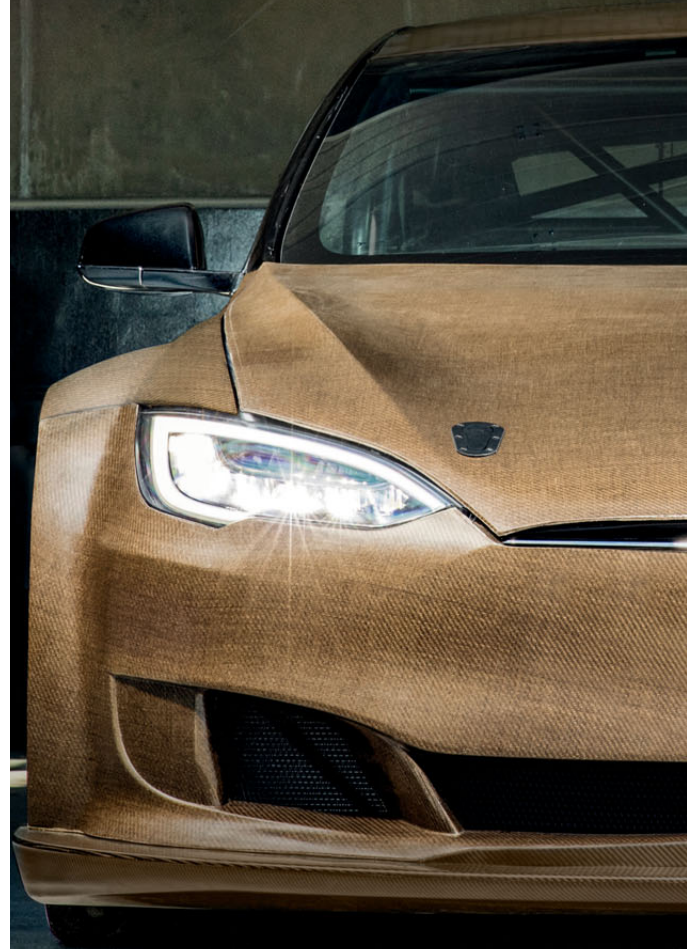

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In a proprietary process developed by the company, the coatings are applied utilising Scalable Pulsed Power Plasma (S3p), which combines the advantages of the arc evaporation and sputtering methods. Arc evaporation is known for producing dense coatings with high adhesion. Sputtering, a conventional coating technology where atoms are ejected from a target or source material to be deposited on a substrate, is known for high levels of smoothness.

The result is a hydrogen-free DLC coating that delivers the benefits of low friction carbon coatings with the smoothness achieved by sputter- or PACVD-applied coatings without additional polishing treatments.

ABOVE Developed by Pipo Moteurs and Poly-Shape, the PMPS ball joint can handle the crashing impacts of Rallies, while still sealing tight to avoid leaking under high pressure

Online Resources
Nominated for its MetraScan 3D scanning system

Online Resources provides accurate laser and white light scanners for components and surfaces of any size or shape – everything from tiny parts requiring sub-thousandths accuracies to entire vehicles. Motorsport uses include design and manufacturing, rapid prototyping, reverse engineering, quality control inspection, and more.

The company's new MetraScan 3D scanning system is free of any rigid measurement setup, providing shop floor measurement accuracy that is insensitive to the instabilities of the environment. Online Resources says that it represents the most complete metrology grade 3D scanner on the market and a practical alternative to traditional portable CMMs.

Pipo-Moteurs and Poly-Shape
Nominated for the PSPM ball joint concept

Searching for a solution to tackle mechanical failures of the exhaust system in extreme Rally and Rallycross competitions last year, Pipo-Moteurs designed and developed a brand new ball joint exhaust system. It took into consideration the different heat expansion between the three layers of the ball joint to keep it free and sealing when hot during the race.

It worked with Poly-Shape, another French company and also European leader in metal A3D printing, which was challenged to find the right process to produce the parts with thin clearance between the layers, in only one print. Numerous design and manufacturing processes were explored before having the right set up. It led to the development of a ball joint exhaust system link which offers a +/-10° rotation on any axis to give freedom of motion for any given exhaust system installation.

This new PSPM ball joint concept is simple with the two layers sliding, one inside the other, and the sealing is ensured by the differential expansion phenomenon created between the two parts. The innovative system has been tested extensively on Pipo Moteurs' engine since the start of 2018 and it has produced excellent results, without leaking under the high exhaust pressure of the rally engine. Also, one system has been used on one of Pipo Moteurs' customer cars competing in the WorldRX Championship since the middle of the 2018 season, without any failure.

Racelogic
Nominated for its VBOX 3iS

The Racelogic VBOX 3iS (RLVB3iS) is a compact GPS/Inertial sensor which offers extraordinary precision and accuracy, by combining wheel speed data with a high-grade Inertial Measurement Unit and 100 Hz RTK GNSS receiver.

Due to the 100 Hz multi-constellation GNSS engine and the tracking of both the GPS and GLONASS networks of satellites, the VBOX 3iS ensures the accuracy of the data being captured even in restricted sky view conditions. In areas with limited or no satellite signal (such as tunnels or test tracks surrounded by trees), the VBOX 3iS can fill in the gaps for prolonged periods of time – allowing you to continue testing without having to worry about erroneous data.

Designed to be used with a customer's existing control system or data logger, the VBOX 3iS offers accurate acceleration, speed, position and attitude data. It is designed for conducting tests such as performance, braking, ADAS and benchmarking.

Texense
Nominated for its Micro-Bolometer

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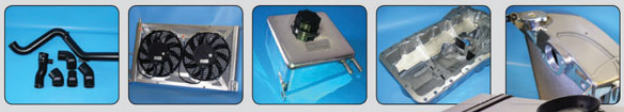

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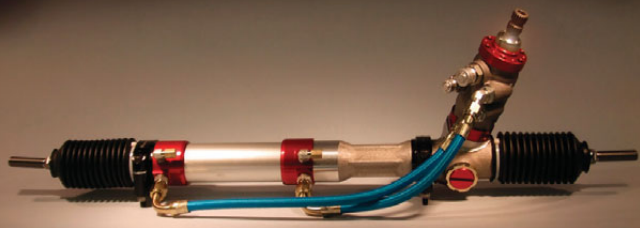

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Total

Nominated for its Mobile Hydrogen Refilling Station

Total has been working alongside the ACO since 2018 as fuel supplier to the World Endurance Championship, and the European and Asian Le Mans Series. It was therefore only natural for the energy supplier to get involved in MissionH24.

The technological and sporting aims of the programme are perfectly aligned with Total's strategy and commitment to a sustainable future and responsible energy. This partnership has also given Total the opportunity to break new ground in designing and developing safe, efficient modular hydrogen filling systems. To meet the needs of the MissionH24 programme and the LMPH2G's introduction into a race environment, Total has developed the world's first mobile hydrogen station.

This station can refuel the prototype with hydrogen, safely and reliably. The H24Racing team is able to transport it from circuit to circuit, whenever the car undergoes private testing or races at tracks that are yet to install hydrogen refuelling facilities. Like all hydrogen filling stations, the mobile system developed by Total consists of three main components: a compressor, two intermediate reservoirs and a distribution device connected to the vehicle.

ZF Group

Nominated for its e-drive

ZF Group has developed the e-drive with a maximum performance of 250 kW for the Monaco-based Venturi team. The e-drive has been in use since the start of the current 2018/2019 season, and Venturi driver Edoardo Mortara clinched the first-ever Formula E victory with it during the race in Hong Kong at the beginning of March 2019.

The development phase was extremely dynamic, combining materials knowledge, experience in gearing technology, and the newest trends for power electronics which allowed the development an optimal total package. With numerous variables, short-term modifications, and various design phases, it was fundamentally different from a series project.

The result is an e-drive with extremely low weight and very high efficiency. Among the numerous new paths followed by the ZF team, the use of silicon carbide for power electronics proved to be particularly promising. Silicon-carbide chipsets can be designed 10 times thinner than current silicon types, so there is a lower internal resistance. The results are increased efficiency and range. Alternatively, smaller batteries would be possible with the same range, which could save weight and overall costs.

The five finalists and the winner will be announced at the World Motorsport Symposium Awards dinner that will take place on the evening of Tuesday 3rd December at the Millennium Gloucester Hotel, London Kensington. Tickets are available at **www.worldmotorsportsymposium.com**

ABOVE Total's Mobile Refilling Station, developed alongside the MissionH24 project, is the first of its kind anywhere in the world

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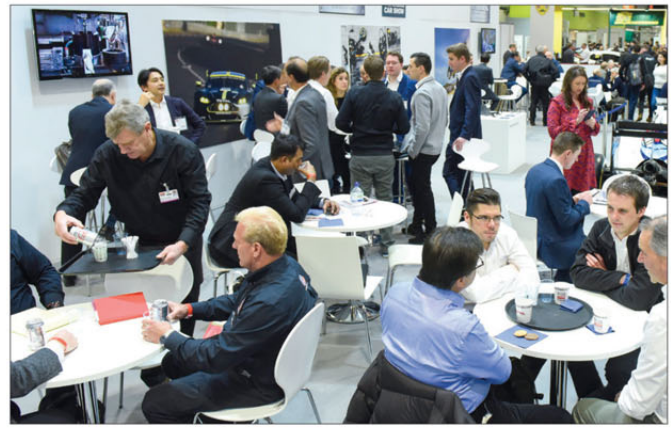

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ABOVE Drivers spend hours in simulators, but ensuring they are accurate enough to be realistic presents a multitude of challenges

TESTING WITHOUT A TRACK

Virtual track testing is vital for the success of any top-flight team, but as **Alan Stoddart** discovers, FE's temporary circuits mean that this process is anything but straightforward

THE benefits of simulation are well known in the world of motorsport, with constraints on time, budget, and testing all making it ever more critical to refine ideas and set ups ahead of a race weekend in order to give a driver the best shot of victory when the lights go out. What's more, with the increasing complexity of motorsport powertrains, the growing importance of efficiency and the endless corner to corner customisability of everything from engine modes to differential ramp angles, experimenting with strategies for weeks before a race has also become crucial.

There is nowhere that this is truer than in Formula E. Not only is the young single-seater category the one in which energy is arguably at the highest premium, with the entire concept of the series formed around energy efficiency and power management, but there are hurdles unique to the whistlestop format of the races.

Whereas Monza, Daytona's Roval and Monaco don't change much, if at all year to year, Formula E follows a far more volatile calendar. Locations are added and dropped season to season, while even the cities that remain on the calendar often have tracks moved into different districts and are given new layouts. In addition, unlike permanent, purpose-built circuits, Formula E's street tracks only exist for a day or two each year. Because of this, practice time is very limited, which increases the importance of simulation. Time constraints don't just impact the teams however, the temporality of the tracks also means creating the simulated tracks is a challenge in itself. Aside from these hurdles, the simulation in Formula E adheres to a completely different model to any other form of racing. All of these challenges are faced by Cruden, along with its scanning partner 6T3.

UNIQUE SCANNING SERVICE

"The way we got involved is entirely different to any other series," explains the Dutch firm's commercial manager Dennis Marcus. "As of Season 5, we have actually provided the Formula E organisation itself with a LiDAR scanning and post-processing service, which Formula E then sells on to the teams enabling them to prepare for the events.

"It is a service that is unique for us as a company, but it is also one that is unique in motorsport because Formula E took the initiative to reduce costs. In other series, teams do all the scanning themselves, but when you have circuits all over the world it gets very expensive, and FE sees a lot of value in ensuring that the cost of participating and being competitive in the sport does not go overboard.

"So, this way all the teams get proper LiDAR scanned data and not just the top teams who can afford it."

Getting the data from these temporal tracks presents a significant challenge. Given that the street circuits are, for almost the entire year, just streets, 6T3 has to go out and scan the tracks while they are still being used by commuters, cyclists, pedestrians and all the other paraphernalia of city life. In fact, the best Cruden can do is wait for an "evening when there isn't too much traffic" and get on with it.

Although this isn't an ideal way to gather data, it does at least work, and allows the company to gather hugely detailed information about the road and its surface, the bumps, crests and dips, elevation changes and the various cambers.

This data is only half the story, however, ▶

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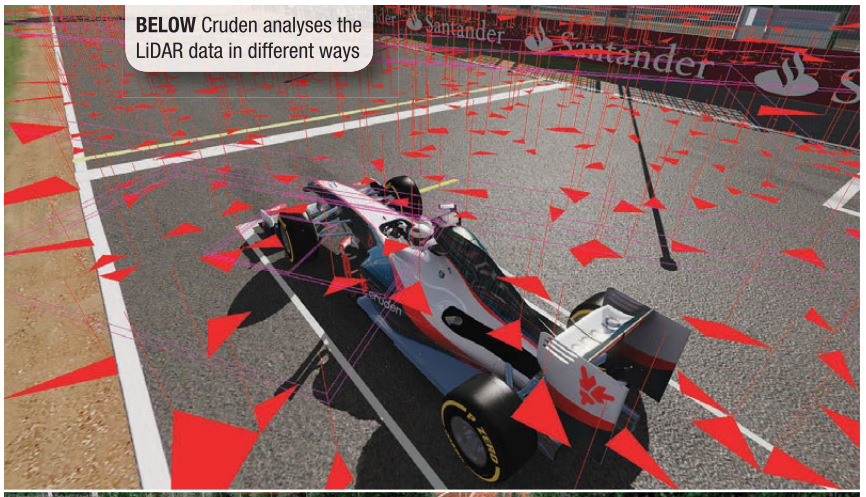


BELOW Cruden analyses the LiDAR data in different ways

ABOVE The LiDAR data is brought to life by Cruden's artists

as the LiDAR data will just create a point cloud. This will then need to be processed by Cruden before it can be used in each team's simulators. To achieve this the team uses the CAD drawings for the planned circuit, which are provided by Formula E. This allows it to build up a digital version of the track and accurately place all of the additional trappings of a world class motor circuit into the virtual model. This includes placing things like barriers, walls and kerbs, transforming a model of a busy city street into a high-resolution model of a completed racing circuit.

The information in these simulations is crucial for the teams, with it all having an impact on the ideal line for both setting the fastest lap times, but also for efficiency-focused calculations such as calculating the overall energy requirement for completing a lap, and how best to map deployment and regeneration in different parts of the circuit.

Information about bumps and holes in the road surface is also key and allows drivers to know which parts of the track can be driven over, and which need to be driven around to avoid unsettling the car. Key knowledge come race day, when there are mere inches between the machines.

From the LiDAR data (measurements that provide an accurate 3D model of the road) comes the 3D track model and graphics built by the Cruden artists.

On top of this, another critical component of Cruden's simulated tracks is the visual cues that the driver relies on to practice things like braking points and turn-in points. With time on the real-world track being so precious, the drivers have very limited opportunity to carry out laps to acclimatise themselves to a circuit. This all needs to be done beforehand, allowing the track time to be spent on more useful endeavours like honing the setup.

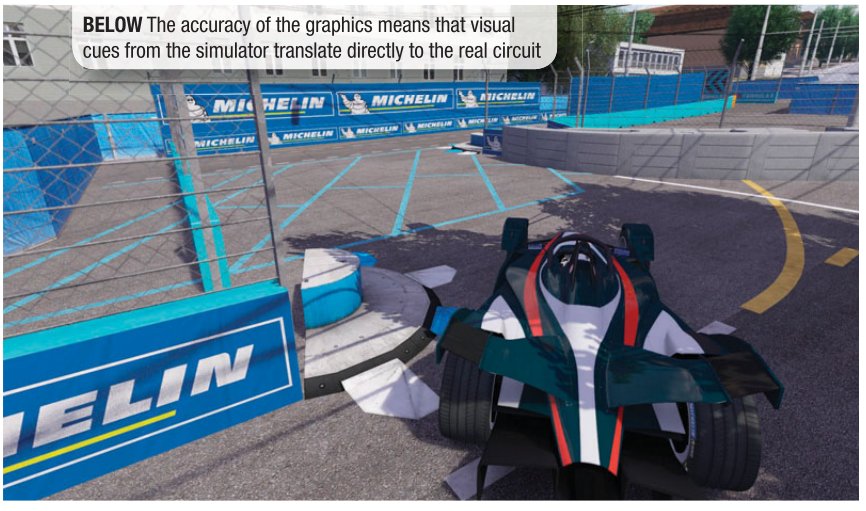
What's more, because drivers are expected to hit the ground running from their very first practice session, the visual cues in the virtual tracks made by Cruden have to be spot on. After all, it could be very disorientating to have done hundreds or even thousands of laps of a circuit in a simulator, only to come to the real track and find that the details that had been relied on to perfect the exit of a complicated series of turns were slightly off.

DETAILED 3D MODELS

These detailed 3D models are usually finished about five weeks before a race. The 3D track model builders can also help the actual track designers by pointing out where and why their design cannot be built, due to information they got from the LiDAR.

Interestingly, the simulation's accuracy relies on the precision of the track builders themselves, and their ability to perfectly match the plans for the track, as well as any comments from an FIA safety delegate when the track is actually built. Because of this, the final layout isn't always exactly as was planned, and so isn't exactly the same as the track model used in the teams' simulators.

"To deal with this we offer the teams a ▶



BELOW The accuracy of the graphics means that visual cues from the simulator translate directly to the real circuit

Giorgio Piola

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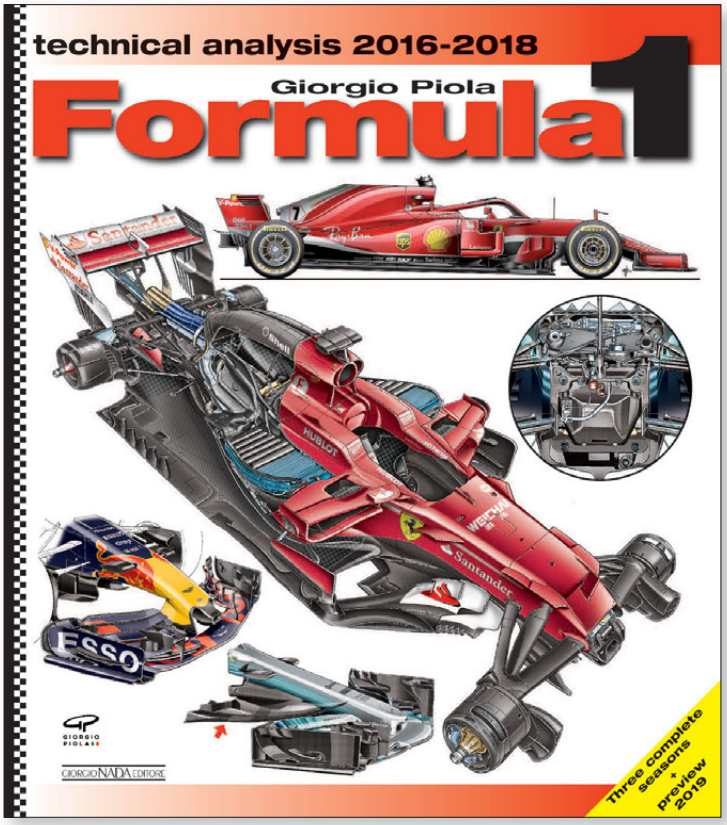

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THE last edition of an automotive literary classic: the technical analysis of Formula 1 penned by Giorgio Piola. After 25 years of publication, the historic draughtsman brings the curtain down on this experience with a volume that examines the last three seasons, from 2016 to 2018, as always reviewing the principal technical innovations in the spheres of chassis and engine design. This three-year analysis is appropriately completed with a retrospective of some of Piola's most important drawings from a 50-year career that began back in 1969.

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touch up service, which we do based on a trackwalk," says Marcus.

"So, the drivers and engineers walk the track on the Friday before a race, when the track is finished. They take pictures and notes of anything that they notice, and send those details to us.

"We then modify the 3D model of the track including the kerbs, the walls and the fences, and send that back to teams so they can run the simulator again based on the modified track to see if there is any optimisation that can be done based on those changes.

"We agreed to spend five hours on the touch up to leave the teams enough time to run the modified track in the simulator before the first session on the real track."

There are several key abilities that Cruden rely on to turn the raw data from a LiDAR scan into something that interacts correctly with the tyre models that the teams use. There is a significant post-processing workload, which involves managing the data and refining it to get it to a stage which is usable. One of the main jobs at this stage is doing subsampling, and carefully inserting points in areas where there are holes in the LiDAR, as a result of obstacles like parked cars that were present at the time of the scanning.

There is also graphical expertise at the company. As mentioned the drivers rely on visual cues, but time is very limited, so creating the most useful models relies on Cruden being very canny, and closely focusing on what the driver would need for him to perform at his best, and not waste time on superfluous detail that will add nothing to the driver's experience.

Above all though, Cruden thoroughly understands the intricacies of vehicle models, and is able to successfully integrate them with driving simulators.

ECU INTEGRATION

"There are different software tools, and different real time systems that engineers use to run the models on. We also integrate a car's actual ECU into the simulator so both the simulator and the car are using the exact same ECU," says Marcus.

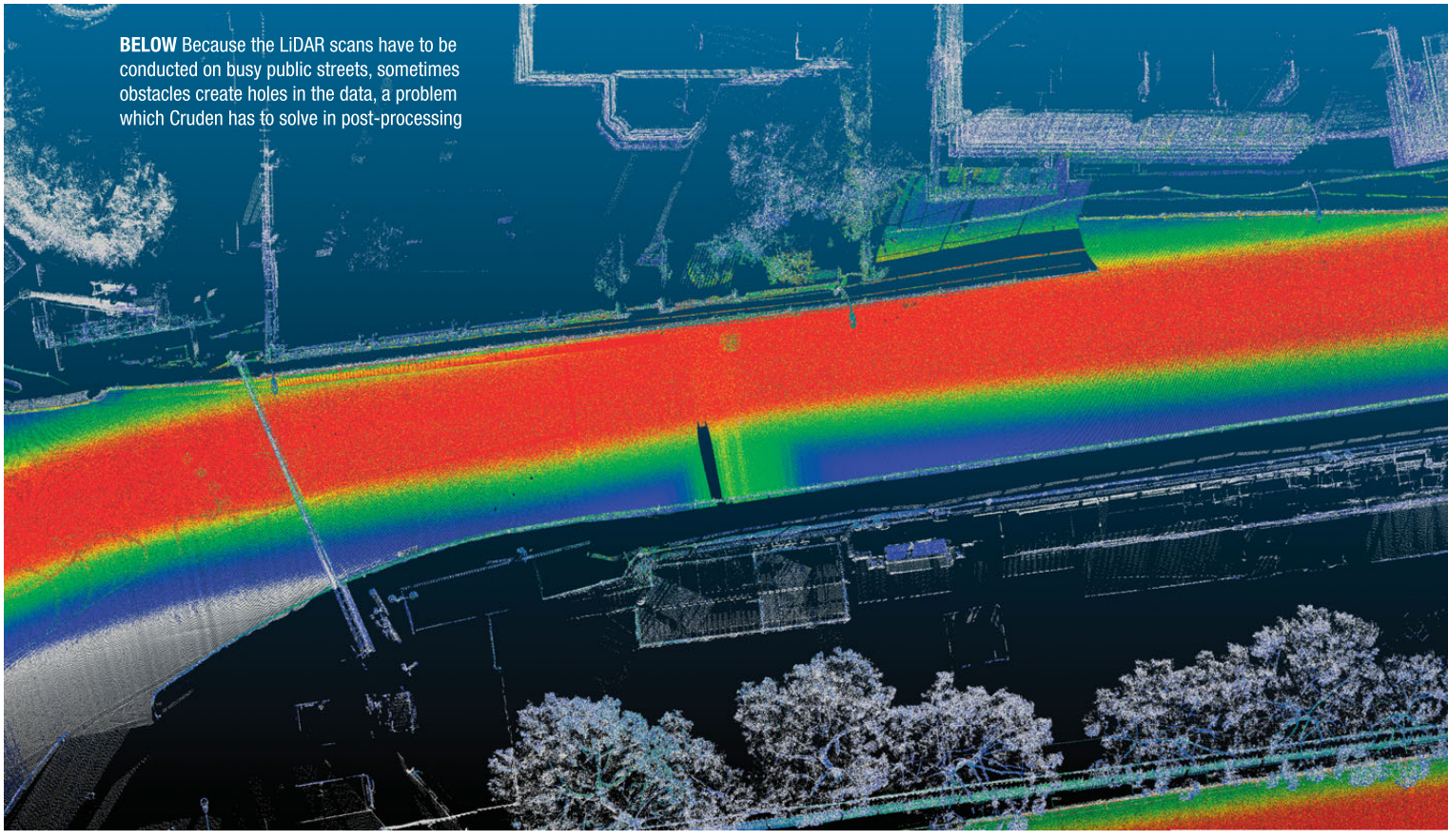
"The experience we have in that field is essential in order to be successful with a driving simulator. In fact, through integration with the actual ECU in the simulator, the simulator can be used to develop the software on the ECU and validate it before connecting it into the race car."

All of this means that despite the obvious problems involved in creating, from nothing, a digital reproduction of something that doesn't yet exist physically, from negotiating hectic schedules in order to scan New York's usually closed harbour area, to dealing with the diversions and impediments of any city's streets, Cruden's models are as accurate as those used in any other series.

"It is exactly the same," confirms Marcus. "That was one of the requirements from the Formula E teams, because there are a lot of simulation engineers and power engineers in Formula E who have a background in F1, so their requirements were the same as what they required for Formula 1 simulation.

"So, from that perspective, the simulation tools are at a similar level to those used by a Formula 1 team, but, if anything being able to prepare for an event is even more important than F1 because Formula E events are only one day.

"There is such a small amount of time it's crucial that you can complete as much set up work as possible in the simulator beforehand. The accuracy is very important," he concludes. RT



BELOW Because the LiDAR scans have to be conducted on busy public streets, sometimes obstacles create holes in the data, a problem which Cruden has to solve in post-processing

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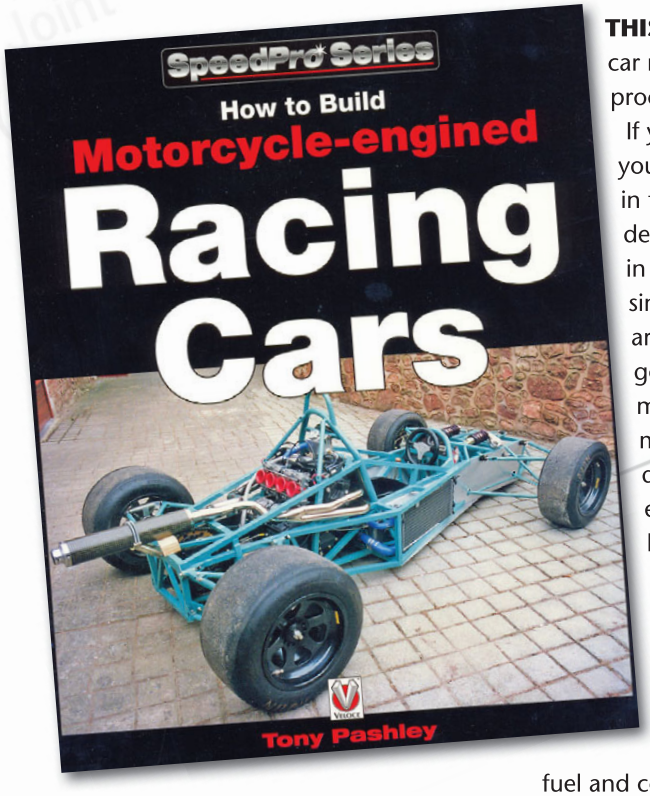

THIS book takes the reader from the conception of a budget racing car right through to its appearance on the racetrack, with the whole process described in easy to understand steps. By Tony Pashley

If you are aspiring to build a racing car this could be the book that you've been waiting for! Tony Pashley revisits the path that he took in the Pashley Project articles in Race Tech magazine during the design and construction of two successful hillclimb cars. This time in great detail with a view to enabling the reader to carryout a similar exercise for themselves. Although hillclimb and sprint cars are the focal topic, a lot of the book is applicable to race cars in general. The cars under discussion in the book are powered by motor cycle engines which, in the smaller racing car classes are meeting with great success. The total process of building a car is described beginning with the selection and procurement of the engine. Chassis and suspension design is covered in a simplistic but adequate manner as the author's aim is to minimise the inclusion of involved calculations. Two recipes for chassis construction are illustrated in detail along with guidance on the processes of construction and a description of the required equipment. Following on from this the fabrication of the suspension is explained. Further chapters are dedicated to the remaining aspects of the vehicle covering; transmission, brakes, fuel and coolant systems and electrics. The book is heavily illustrated with 200 photographs and extensive explanatory diagrams and tables. This book is a vital addition to any would be kit car builders library.

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SHOW SEASON PREVIEW

ABOVE Racetech's new RT4100 seats are able to safely accommodate broader drivers, while remaining narrow enough for most cockpits

It's coming to that time of the year when new products appear for the various trade shows, the PMW Expo starting proceedings. **William Kimberley** takes a sneak peek at those products that have caught his eye

RACE SEATS continue to evolve. This is partially to do with the FIA's safety standards that continue to be updated. For example, the list of race seat manufacturers that have homologated their range of seats with the FIA 8855-1999 standard has dramatically decreased as many have not opted to update their products to comply. However, not **Racetech**, which has implemented the required development to ensure its new RT4100 family of seats, weighing in at a lean 8.9 kg (total) and homologated to FIA 8855-1999 standards, comply with the two-year extension at the end of their initial five-year life.

Racetech has focused on achieving a lightweight, standard-sized fibreglass seat shell with optimised geometry, straddling that line between designing the seat to be wide enough in the shoulders to suit the athletic build, but narrow enough to fit in most cockpits. Its patented back-mounted technology has trickled down from the 119 and 129 Series, giving the option of fixing the seat to the roll cage at shoulder level, while large harness guides and a removable moulded base cushion allow a range of drivers of varying heights to fit.

Breathable spacer fabric, parallel sides and pronounced thigh support round off the features of this accomplished motorsport seat. For the larger driver, the RT4100WT is 60 mm taller and 40 mm wider and for those wanting a seat with head restraints, Racetech's RT4100HR and RT4100WTHR complete the 4100 Series. The 4100 Series seats use Racetech RTB1009M alloy side mounting brackets.

Motordrive is showcasing its 6-point mounted FIA 8862 seat, claiming its MD20 is the industry's lightest 6-point mounted FIA 8862-2009 seat due to the ultra-lightweight 7.5 kg carbon shell. It also scores with energy-absorbing foam and the option of personal branding, making it appeal to teams and drivers alike. Uniquely, the seat is available in both 6-point and ▶

ABOVE The MD20 from Motordrive offers great comfort and safety to drivers, with improved protection for the head, neck and spine all present in the new model

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4-point mounted versions and all meet the FIA homologations for race and rally.

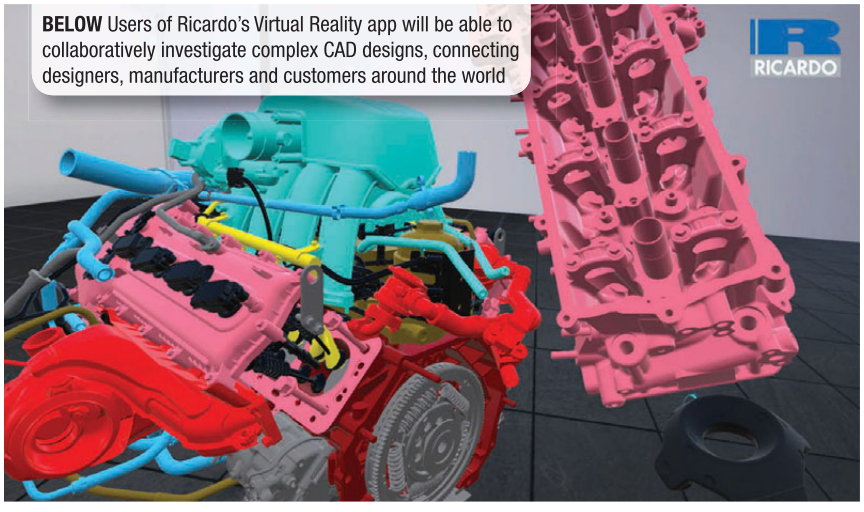
Motordrive is also exhibiting its new MD prototype concept seat that uses the company's advanced manufacturing infusion process. This allows it to produce a striking prototype design with a smooth inner and outer finished shell. This technology, along with the innovative design concept, offers an ultra-lightweight seat that can be individually tailored for all sizes of driver and co-driver by the use of adaptable cushion pads to ensure perfect fit. Enhancements include seat shell lumber support to protect the spine against high compression impact accidents, improved head and neck ergonomics to work in conjunction with Hans systems and a lower front base allowing for improved leg movement when used with Motordrive's custom fit base bolsters. While the safety and comfort of the competitor has been the primary focus for the MD Concept seat, Motordrive has also delivered a design that is optimal for fitting in the car as it understands that size and weight constraints are important.

Sabelt, meanwhile, will be exhibiting its new X-Pad seat that is a very close to a custom seat with off-the-shell availability. There are three versions: fibreglass shell; carbon fibre shell and the fibreglass/ rallycross with full washable neoprene padding. They have been specially developed to offer a light, comfortable and versatile product homologated according to the FIA Standard 8855-1999. All the seats feature the arrow head protection, which is only 400 mm wide, to ensure fitting in every cockpit.

ABOVE Combining the fit and comfort of a custom seat with off-the-shelf availability is Sabelt's versatile X-Pad seat

The new seat gets its name from the cover, which is made up of individual pads that are rugged and can be applied to the shell in different positions to accommodate different driver body types and preferences. In addition to being adaptable, the pad construction is also lighter than a traditional cover by around 1 kg.

The carbon fibre version is already seeing service with Hyundai in the WTCR championship, and with McLaren on the Senna GTR. Renault Sport's upcoming Clio Cup car will feature the GRP version of the X-Pad.



BELOW Users of Ricardo's Virtual Reality app will be able to collaboratively investigate complex CAD designs, connecting designers, manufacturers and customers around the world

PUTTING A BRAKE ON IT

On the shared booth of brake manufacturer **920E** and control systems developer **Shiftec** will be a number of new technologies, including a brand-new range of GT3 braking components due for release as a complete brake system package at the end of 2019. 920E promises never-seen-before technology that is patent pending.

Another focus of the two companies will be data analysis. The integration of sensors into products at the design stage brings real advantages, including improved packaging and cost savings. The patent-pending technology used in the new callipers gives teams access to real-time data during a race to optimise performance and identify issues before they develop into a bigger problem.

Finally, Shiftec will present a compact hydraulic power pack and control unit capable of controlling several hydraulic systems. One application for this is a complete brake-by-wire system as used on the Roborace car which uses a brake control system that equals the response times and braking performance of a traditional racing car and driver. Specifying these requirements early on in the design phase resulted in an integrated solution that provides a much better platform to gather the required data.

While **Ricardo's** booth will feature plenty of exciting high-performance, competition-ready transmission systems for both conventional and electrified vehicles, the company will also showcase something that is slightly different. It has come up with an advanced immersive virtual reality app that enables collaborative, simultaneous design reviews to be carried out by multiple users. As high-performance transmission systems become increasingly more complex, greater levels of virtual toolchains are required to meet tight timescales. This new technology enables users to investigate complex CAD designs, at full scale, in a shared VR session. This way, it connects interdisciplinary teams, customers and suppliers around the world.

Through the VR Engineering Design Review app, users will be able to manipulate and examine individual components as well as show, hide and isolate subassemblies. The dynamic cross-sectioning tool allows users to visualise the innermost components, something that is not even possible with physical prototypes, while also assessing ▶

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Essential BOOKS for the motorsport engineer's library:

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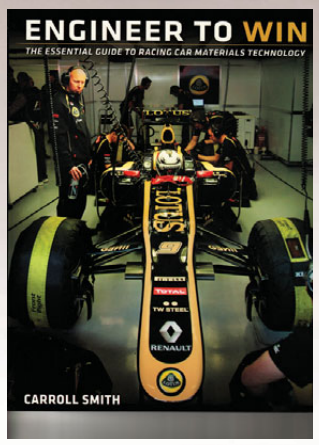

Current state of the art in racing technology by a foremost expert in the field. Covers all forms of racing cars and includes a thorough analysis of metallurgy, metal fatigue and general materials technology. Details specific components and specific activities such as heat treatments, stress relieving, etc. Plus aerodynamics, ground effects, brakes, tools, and more.

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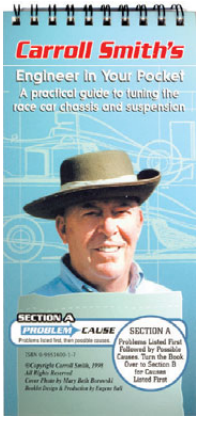
Engineer in Your Pocket: £15



Store all the answers in your hip pocket! This handy pocket guide written by racing professional Carroll Smith suggests realistic solutions to common race car handling problems. Formatted listing causes and possible effects, and problems and possible causes. Spiralbound, 3 1/2"x 7 3/4," 32 pgs.'

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manufacturability and ease of assembly, as well as the potential for component clashes. In manipulating the model, users can also take measurements, add 3D annotations, and record screenshots and voice memos.

Elsewhere, **Thermisol** is exhibiting its high-temperature insulation solutions – integral insulation, blankets, shielding, claddings – contribute to enhance the performance and safety of racing vehicles. Its insulations provide maximum efficiency at minimum weight. The different possible combinations of foil – the outer shell – and insulation materials offer numerous possibilities, depending on the requirements.

The insulation system's outer shell has outstanding characteristics, claims Thermisol. If gold-coated, it provides very high reflective qualities enhancing its insulation performance. With a thickness of just 0.05 mm, it is ultrathin and 50 per cent lighter than conventional foils and is made out of titanium, the foil is extremely hard and enduring. As far as the insulation material is concerned, due to the use of new methodology, the material can be shaped into almost any conceivable form, adapting to the smallest of profiles and spaces. Where most efficient insulation in the smallest of spaces is required, a microporous material, due to its extremely low thermal conductivity, is the best fit, says Thermisol.

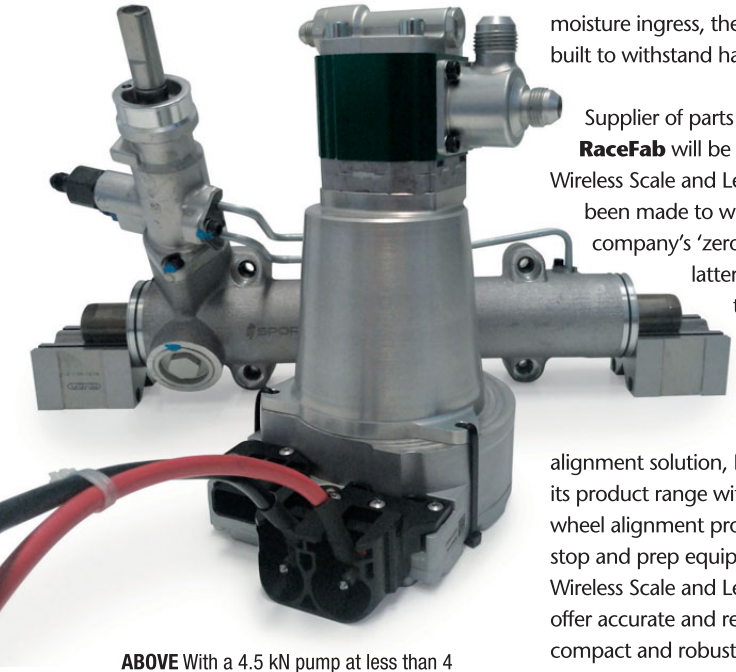
ABOVE As well as contributing to a car's safety and performance, Thermisol's high-temperature insulation solutions provide maximum efficiency at minimum weight

It is also presenting the Integral-F, a very flexible integral insulation that, due to an ultra-thin stainless-steel mesh, enables the insulated component to remain stable where necessary while allowing it to remain highly flexible elsewhere.

Deutsch is showing its ASDD series connectors offering high-density and high-performance that it claims is a revolution in connector design. They are lightweight with almost double the number of contacts compared with the regular autosport range equivalent shell size. With its conductive black zinc nickel, its interfacial wire sealing, and its bonded and sealed insert preventing moisture ingress, these connectors have been built to withstand harsh environments.

Supplier of parts and set-up equipment **RaceFab** will be launching its TDAC Wireless Scale and Levelling platform that has been made to work seamlessly with the company's 'zero flex' setup wheels. The latter were launched earlier this year and following positive feedback about the accuracy, functionality and versatility of the wheel alignment solution, RaceFab is expanding its product range with further setup and wheel alignment products, as well as pit stop and prep equipment. The new TDAC Wireless Scale and Levelling platform will offer accurate and repeatable weighing in a compact and robust package.

RaceFab will also display its range of billet CNC-machined air jack stands and skates, both of which have become a common sight in the British GT Paddock. To complement the pit stop and prep equipment, the company will also debut its GT-spec tyre scraper which features adjustable temperature settings ranging from 100°C-600°C and variable fan speeds. As a result, it will effortlessly remove debris and rubber build-up from worn tyres to prolong their lifespan.



ABOVE With a 4.5 kN pump at less than 4 kg, Sportech's offering has a power/weight ratio four times higher than the benchmark

Sportech Engineering, a supplier of motorsport and high-performance vehicle power steering systems, will exhibit a new compact electrohydraulic unit featuring what it claims is unmatched performances: 4.5 kN electrohydraulic pump weighing less than 4 kg, meaning a four times higher power/weight ratio than the benchmark.

Due to a standalone or CAN driven, four quadrant 48V DC electric motor with fully integrated control electronics, a scalable pump range and specific hydraulics features, this assembly overcomes the power assistance requirements of the most demanding applications such as rough gravel WRC rallies, cross-country rallies, World Rallycross and other extreme usage. A user-friendly interface allows the users to map the motor control to any specific condition. Due to the CAN communication, all internal parameters and status information can be logged and integration to the car system is complete.

Sportech Engineering says that the system is ideal for high-performance and extreme electric vehicles requiring automotive industry quality standards, a high level of boost and the unmatched feedback of hydraulic assistance. RT

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WHY SPEC RACING WAS THE BEGINNING OF THE END!

Sergio Rinland shoots from the hip as F1 dithers over spec components, open-source and gimmicks to spice up the show

SOME time ago, we debated in this column the fact that well into the 21st century, motorsport was, and still is, having an identity crisis. We suggested: 'Motorsport has to understand who or what it is, where it belongs and where it wants to go'.

The latest debates in Formula 1 – over standard parts, reverse grids and open-source methodology – reminded me of that phrase.

The first two have been tried without much success. Standard parts mean control/single-make formulas in all but name. In 1988 Dan Partel, from EFDA (European Formula Drivers' Association), created the first single-make controlled formula: Opel/Vauxhall Lotus. Even Dan regrets having done that! In my opinion, it was the beginning of the end.

Today, except for F1, LMP1 and Formula Student/SAE, the rest of single-seaters and sportscar racing are with single-make cars that are so controlled that if a competitor makes its own Gurney lip, it is disqualified!

The concept of controlled series did not achieve any of the intended goals: they didn't reduce costs – none of the single-make formulas is cheaper by a big margin than when it was open to competition! – and did not open opportunities for the 'also-rans' to become competitive. Yes, everybody runs the same car, but the best teams still win. Those teams attract the most talented drivers; hence nothing has changed.

If the notion of single-make racing achieved one thing, it was to kill the huge and diverse racing car manufacturing industry we had in Europe, particularly in the UK. It also killed the 'need to win' for the few who remained: now a manufacturer produces a car in the cheapest possible way to win the dreadful 'tender' process and secures a cash cow for three years without competition, the antithesis of what motor racing stands for.

> *"To save costs in any business, you don't start by buying the cheapest toilet paper; you start with the biggest expenses"*

I have always been against controlled formulas and now I have to read that, to save costs, FOM and the FIA are proposing single common parts for the F1 teams because "the fans don't see them"! Who are they kidding? Save costs? It did not work before in other disciplines; what makes them believe that it will work this time around?

How much cheaper will brake discs and callipers, wheel rims, steering racks or gearboxes be than now? The millions F1 teams spend are not there: the money spent in developing those components is peanuts compared with the cost of aero and engine research. We have already proposed how to regulate those areas to reduce costs and the ACO is applying it in the new LMP1 regulations.

To save costs in any business, you don't start with cutting overheads on tea bags or buying the cheapest toilet paper. Instead you list where you spend the money, from top to bottom, and start with the biggest expenses, where a small percentage saving will be an order of magnitude more than the cost of tea bags.

Regulating aero and engine development will *really* save money. The answer isn't to make it mandatory for everyone to buy the same brake calliper – which they may do already. Because it is an open market, the company selling those brakes cannot name ▶

Dunbar/LAT

ABOVE Only when the regulations enable cars to run wheel-to-wheel will we regain the 'Wow Factor' we crave

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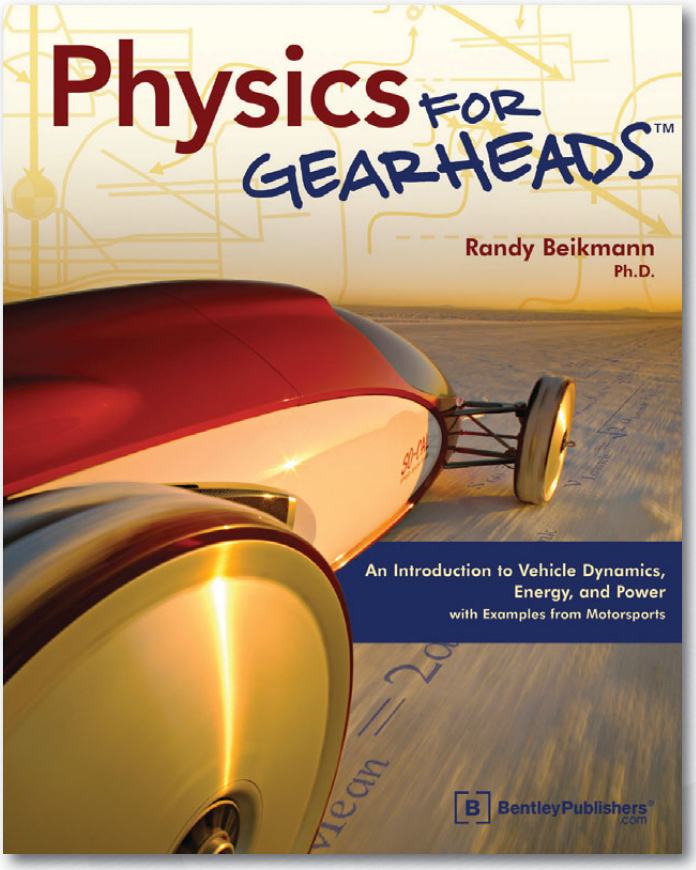
Essential BOOK for the motorsport engineer's library:

Physics for Gearheads: £50



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BELOW The drive towards every team using the same components has cooled, with suggestions of going 'open-source' finding some support

its price: it has to improve its product to a cost to make sure a competitor does not produce something better and/or cheaper.

It is the same for the other components. The moment you name a sole supplier, you damage the industry and achieve nothing other than to reduce quality at the same price. It does not work. It has been proven time and time again. So, I hope F1 does not go down that route.

A reverse grid proposal to spice up the race? That is done in F3 and F2 and I am still trying to understand what purpose it serves, other than getting some drivers that otherwise would not have a chance, to do a few laps at the front. Spicing up the show? I don't think so. Formula 1 will improve the day that drivers can race wheel-to-wheel again with cars that are over-powered and have less downforce. Then we will get the 'Wow Factor' we are all looking for. Reversing the grid and DRS will not do that.

OPEN-SOURCE

The other proposal doing the rounds is 'open-source'. Here we have something which has not been tried before on this side of the Atlantic. For years NASCAR had the rule that cars will be chosen at random to be completely disassembled in front of the whole paddock; that is a sort of open-source. Does it save costs? I am not too sure, but it does not hurt. If the fans are also privy to drawings and specifications, then it will really become an attractive proposition.

Formula 1 fans are well known for their technical knowledge and are attracted to F1 because of technology, not in spite of it. The comment that 'fans are not interested in what brakes drivers are using', is untrue: they are. They want to see telemetry on the TV screen and if on top of that you show them drawings and specifications, the young generation will start becoming interested again. So, I am all for open-source, although it will take some time to percolate.

What is Formula 1's identity? It is a sport which will give a good show if the highest technology is used in the right direction. Do not dumb the technology down with policies that have already been proven wrong; guide the technology towards spending money wisely. RT

Red Bull

ABOVE The big-ticket items on the teams' list of expenditure are aero and engine development

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