SUPERCARS We join Matt Stone Racing at the legendary Bathurst 1000

9 770961 109111 02
UK £6.95 / US $16.25
February 2024 / Vol 34 No 02

Inside the world of modern motorsport technology

Racecar engineering™

Red Bull RB19

Formula 1 world champion team on its eternal quest for perfection

Performance balancing

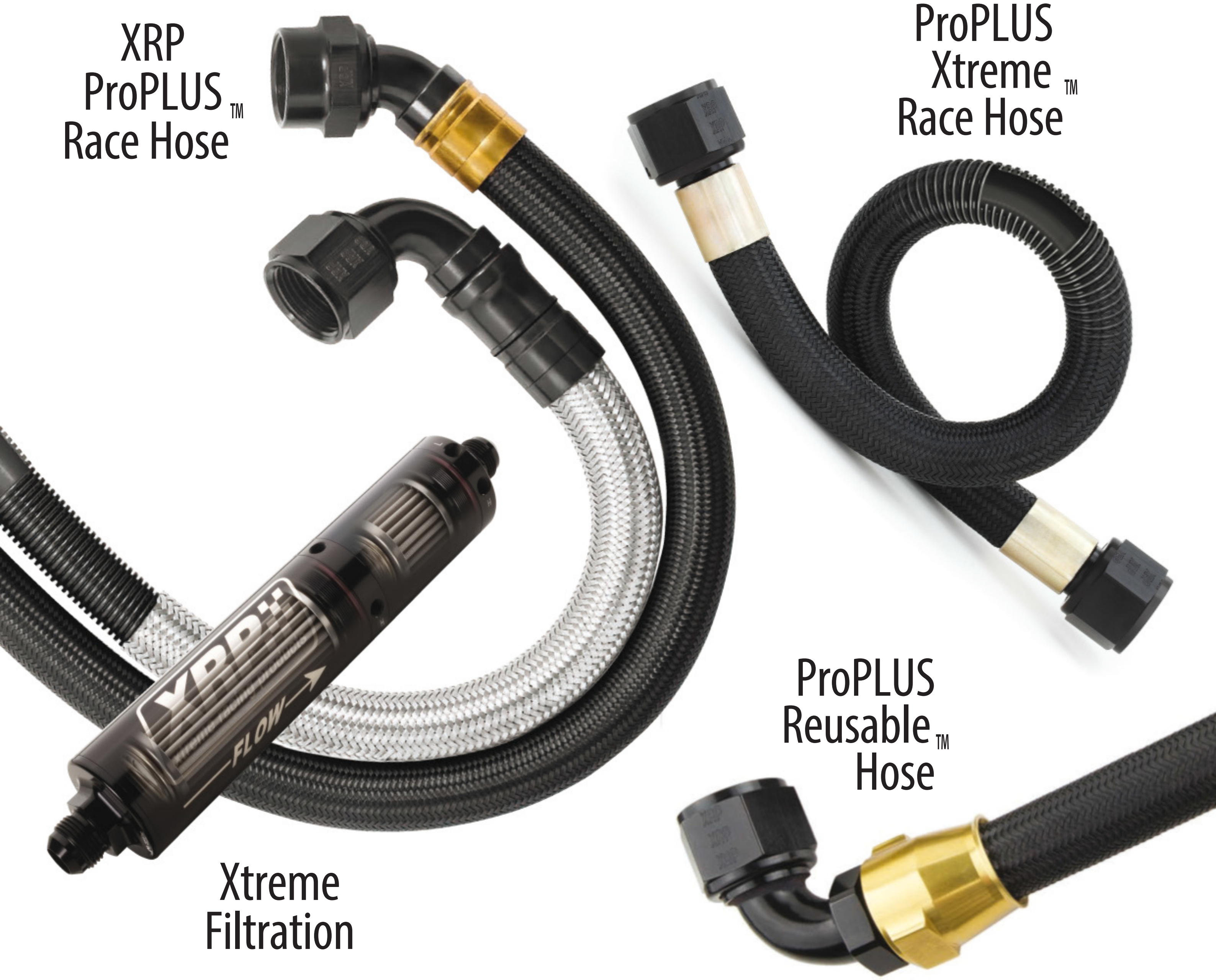
All-new system for GT3 at the Daytona 24 Hours

Team Brit

How one race programme has embraced adaptive racing

The evolution in FLUID HORSEPOWER

Xtraordinary Hoses, Fittings & Filters



Log on to
www.xrp.com
anytime for
catalog downloads,
new product updates
and tech tips.

XRP®

THE XTREME IN RACECAR PLUMBING

Like us on Facebook /XRPinc

Follow us on Instagram @XRPracing

UNITED STATES XRP, Inc. 5630 Imperial Highway South Gate, CA 90280 sales@xrp.com tel 562 861 4765 fax 562 861 5503

IN EUROPE AND THE UK Protec Fuel Systems Ltd. info@protecfuelpumps.com tel +44 (0) 121 572 6533

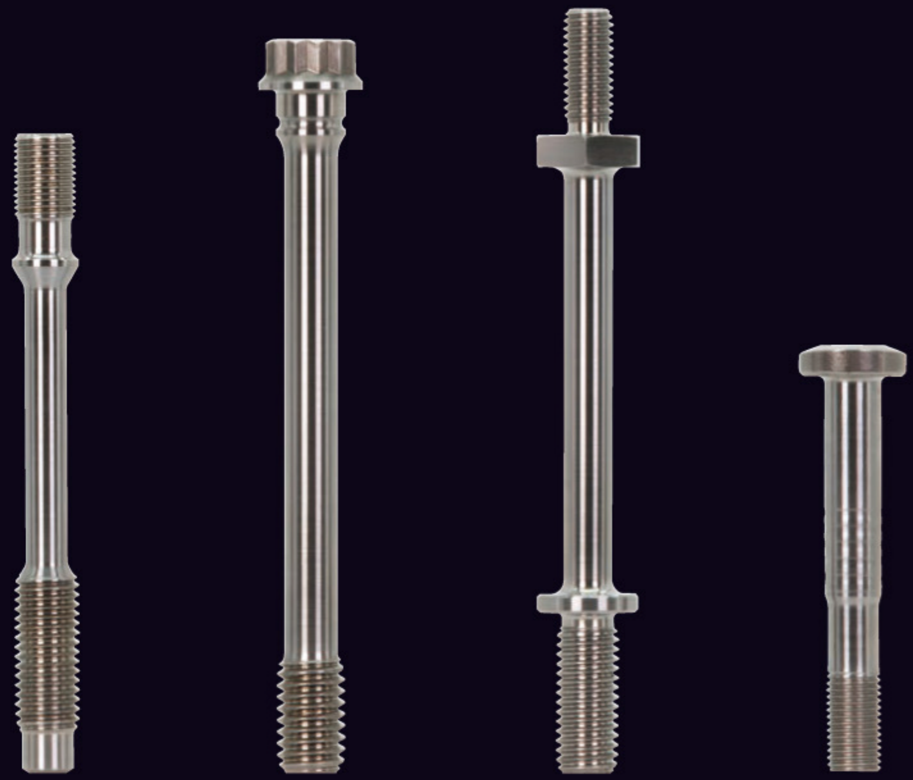
Ford's GT3 Mustang will make its competition debut at the Rolex 24 at Daytona at the end of January, having taken part in BoP testing in December

Richard Dole

Subscribe to *Racecar Engineering* – find the best offers online
https://shop.chelseamagazines.com/collections/racecar-engineering
Contact us with your comments and views on Facebook.com/RacecarEngineering or @RacecarEngineer

ARP®
automotive Racing products

CUSTOM FASTENERS



ARP has available stocks of all high strength materials, including Custom Age 625+, and our custom fastener manufacturing turnaround times are continuing to drop. Call us to discuss your custom fastener project.

ARP Fasteners are tested and proven in the most demanding environments on Earth...and beyond.

ARP fasteners are used in racing all around the globe and applications from space to below the earth's surface.

Made In USA

All ARP fasteners are manufactured entirely in our own facilities in Southern California and raced all over the world.

5,000 catalog items and specials by request

Special Orders +1.805.525.1497 • Outside the U.S.A. +1.805.339.2200

1.800.826.3045 • arp-bolts.com

That's entertainment

After an eclectic year of motorsport viewing, our club and national contributor asks what mainstream racing might learn from other disciplines

There was an almighty clang, sparks flew off the barrier and the Ford Focus rebounded back into the path of the pack, where it was t-boned and then spun around, before coming to rest in the middle of the track, steam pluming from its radiator and a door skin peeled back. And the race continued…

This was banger racing. I had not planned to watch these much-maligned machines, but was at Foxhall Stadium, Ipswich for the National Hot Rods on the same bill. I'm glad I did though because, while there was plenty of crashing, this was not just the demolition derby I had expected. This was real racing, with some of the best car control I witnessed all year, as drivers tried to avoid the wrecks. And I watched a lot of motorsport in 2023.

It started at Brands Hatch in January, which was hosting the Circuit Rally Championship. The thinking behind this series is to use a venue already set up for motorsport, with all the amenities available, rather than a remote forest or disused airfield. But it's certainly not just driving around the track. Rather, it's a series of stages using the pit road, paddock, the rally school – naturally – and a portion of the circuit in both directions.

The cars ranged from standard 1.4s to old Ford Escorts, right up to modern R2 machinery. It's a brilliant way to introduce people to rallying without them having to get their boots muddy, and with a hot coffee in the Kentagon never more than a short walk away.

Instant thrills

Muddy boots were definitely a feature of my visit to an Autograss event later in the year (see *RE* V33N5). This niche discipline seems designed to encourage rapid, sideways motoring and did not disappoint in terms of spectacle. The races are short and sharp, and just right for the instant thrill age in which we now seem to live.

More mainstream was the British Hillclimb Championship (*RE* V33N7 and N8), which takes some beating when it comes to high-speed thrills. Bearing in mind I also watched Formula 1 through Maggotts-Becketts at Silverstone – often said to be the best place to witness F1 – I'd have to say that seeing the top cars going up the hill at Prescott was just as spectacular. The paddock was more friendly, too. As was the paddock at the Time Attack event in June (see *RE* V33N10), at least when any conversation could be heard over the thumping backing track.

Actually, without exception, *every* paddock I visited this year was friendly. This is because people who race cars like to talk about them, even the shy types with absolutely no interest in appearing in the pages of *Racecar Engineering* who come alive when you start asking them about their machines. The language is always the same, too: understeer, weight transfer, cooling. If you speak 'paddock', you can use the lingo at any motorsport event in the world.

A classic Mk2 Ford Escort at the Circuit Rally Championship round at Brands Hatch, just one of many very different motorsport events Mike attended in 2023

That said, one place where the language was a little different was at the club motorcycling event I attended at Brands Hatch. The racing was fantastic, even if it was sometimes difficult for me, a newcomer to bike racing, to pick out the different machines.

Of course, in this era of likes, swipes and instant judgement, the first question everyone asks is: which was best? The rather unsatisfactory answer is they are all different. That said, there are some disciplines that are definitely better than others in particular respects. And some might certainly learn from others.

For instance, I remain a dyed-in-the-wool club racing fan. Always have been, always will be. But something happened while I was perched in the stands at one meeting, interviews in the bag and hot dog in hand, that made me think. Sitting in front of me were a couple who seemed new to racing. There was a delay in proceedings, one of many hold ups on this particular day, and, although it was obvious it was because someone had gone into the gravel, it wasn't clear why it was taking so long to get the race going again. Then, just one lap after it did restart, a red flag flew because someone else had spun off. This was too much for our new-to-club-racing pair.

Flipping pointless

'This is flipping pointless,' said the guy, or words to that effect, and his girlfriend looked up from her phone and agreed. That was the last I saw of them, and probably the last they will see of club racing.

Now, there's not much racing can do about red flags and safety cars. It's impossible to roll back on any procedure to do with safety, but there still seems to be an awful lot of dead time at club meetings.

Conversely, at the motorcycle racing, the programme was slick and I witnessed race after race after race with hardly a pause. There were red flags, sure, but it was wholly clear why – big bike accidents tend to be scary – and there were certainly not as many stoppages as with the cars.

More importantly, at least from a spectator point of view, the action always restarted quickly and without undue fuss. The same goes for some of the other disciplines mentioned earlier.

Perhaps these delays are one of the reasons there seem to be so few spectators at club race meetings these days? Though to be fair, clubs are trying very hard to deal with this. For instance, some races for cars with road tyres now just employ a formation lap, with no warm-up lap, which makes sense.

There certainly wasn't a lack of punters at Ipswich on a cold November's day. Admittedly, the gate was undoubtedly boosted by a fireworks display, but the stands were absolutely crammed with fans. It was a great show too, one I'm sure any club race regular would have enjoyed, and then gone back for more. I'm not convinced the same can be said for short oval fans going to club race meetings these days.

It's impossible to roll back on any procedure to do with safety, but there still seems to be an awful lot of dead time at club meetings

Raising the bar

Red Bull continued to set the standard in the second year of Formula 1's ground effect rules with a car that managed to surpass its dominant predecessor

By DANIEL LLOYD

No Formula 1 team adapted to the championship's 2022 regulations overhaul better than Red Bull Racing, which swept the Drivers' and Constructors' titles with the dominant Red Bull RB18.

The team won 17 out of 22 races, topping the table by 205 points ahead of Ferrari, leaving its rivals wondering how on earth they could close the gap that had opened up. By the end of the second year of ground effect racing, the gap was even bigger.

The RB18 was Red Bull's answer to the regulations in its first form, but the RB19 built on that strong foundation and went on to statistically surpass its predecessor in 2023. The difference between Red Bull and the second best team, this time Mercedes, more than doubled, to 451 points. The team won all but one race, and wrapped up the Constructors' crown with six rounds to go.

The fact Red Bull achieved those impressive numbers, despite a penalty for its breach of the cost cap rules that reduced its already restricted aerodynamic testing allowance (for being last year's champion) by 10 per cent, was even more remarkable.

According to Red Bull's head of performance engineering, Ben Waterhouse, the first season of the ground effect rules gave the Milton Keynes-based team a 'clearer vision' for how to approach its design of the Honda-powered RB19, which will go down as one of the most successful F1 cars in history.

Rolling back the years

'If you roll back nearly two years, it was all about how do we understand these new regulations, how do we optimise all the different parameters?' says Waterhouse. 'But there's still a huge number of unknowns. Yes, you know something about the tyre.

Photos: XPB

Red Bull's crew have every right to look happy in their work as the RB19 has been an exemplary performer this year

‘Having had the whole season with RB18, we knew it was a very good car [but] also had plenty of limitations. It therefore meant we had a very clear focus of what we wanted to do to improve it and make it a better car’

Ben Waterhouse, head of performance engineering at Red Bull Racing

After winning 17 out of 22 races in the the 2022 season, Red Bull underlined its dominance by taking the chequered flag at all but one race in 2023, collecting the Constructor’s Championship with six races still left on the calendar

Yes, you have an idea of what the aero maps are going to be but, until you actually see it for real, you're never really certain.

'Having had the whole season with RB18, we knew it was a very good car [but] also had plenty of limitations. It therefore meant we had a very clear focus of what we wanted to do to improve it and make it a better car.'

Waterhouse points out that the RB18 suffered from some 'balance limitations' related to its weight saving programme during the 2022 season. The weight reduction of around 20kg was an unintended consequence of F1's cost cap, introduced in 2021, that prompted Red Bull to use heavier parts with increased lifespan on the RB18.

'The RB19 started in a much better position,' reflects Waterhouse. 'It's no secret that RB18 started overweight, and it remained to some degree overweight throughout the season. So there was free lap time in RB18 anyway, which we then realised in RB19.'

On the limit

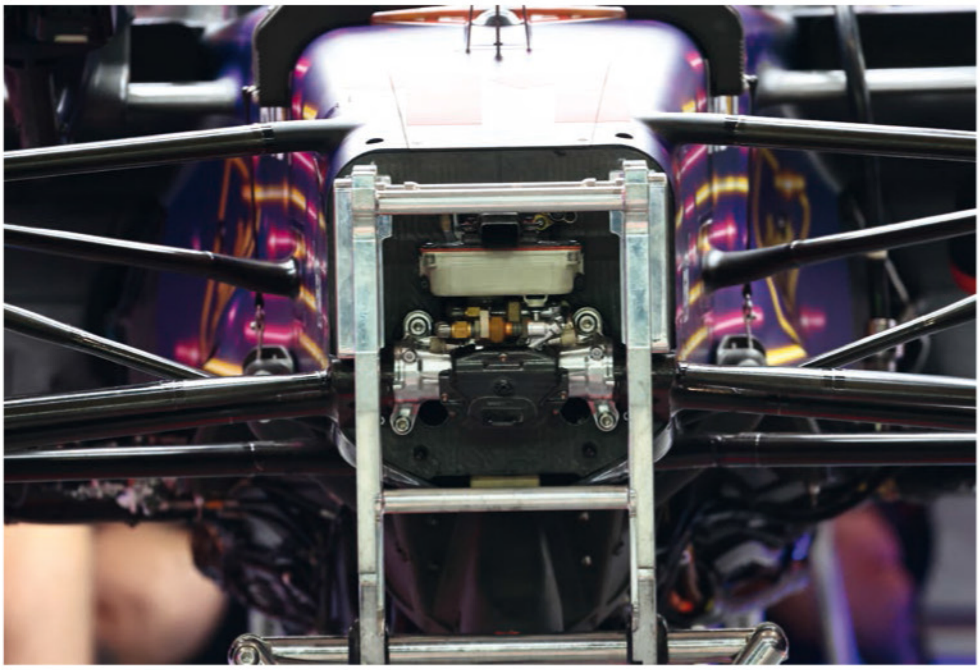
Being on the regulation 796kg minimum weight from the start gave Red Bull one less thing to worry about when rolling out the RB19. Although Waterhouse describes the newer car as a 'descendant' and an 'evolution' of its precursor, the 2023 machine featured a number of important changes.

The chassis was re-worked to make a v-shape when observed from the front, increasing the amount of air that could dive into the further improved low-pressure ground effect tunnels sculpted into the underfloor. The undercut beneath the sidepods was made even more extreme to amplify the airflow down the side of the car, and the pushrod rear suspension was adjusted, with one of the arms being raised to increase anti-squat under acceleration.

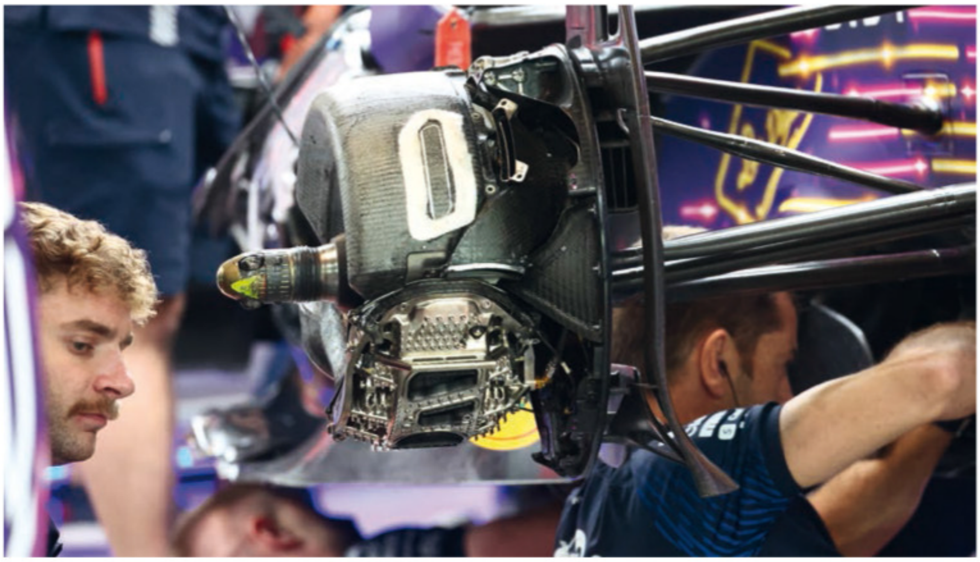
A big reason for the RB18's handling consistency was its superior platform control compared to the rest of the field. The extreme anti-dive and anti-squat suspension – with pull rod on the front and pushrod on the rear – meant it could run lower to the ground without the unwanted bouncing.

'In the RB18 there were issues with, for example, floor edges touching the ground regularly,' notes Waterhouse. 'There was damage, which was occurring to strakes and components of the floor. So I think from our side, it was not a disaster to have to them raise the floor edge to prevent those sorts of details. And then, of course, you move into a less sensitive area from an aerodynamic perspective when you're not interacting with the ground quite so closely.

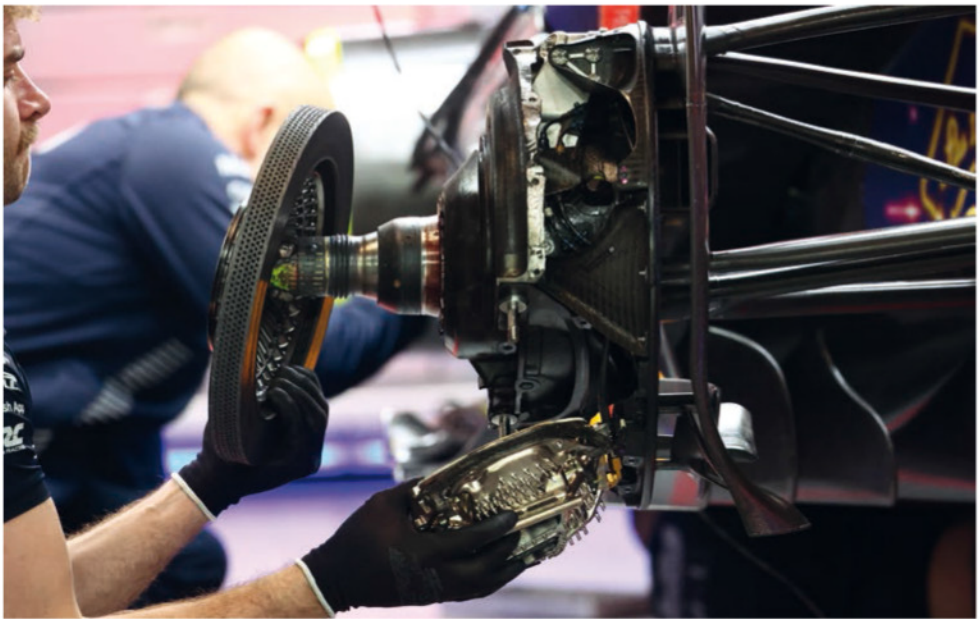
'From our perspective, we didn't feel that we were the worst in terms of bouncing, but we perhaps didn't exploit ground contact of the floor as much. So I think for us, it was not such a bad detail.'



New chassis design to a v-shape was one of the key noticeable differences to the RB18, while the front axle was brought forward



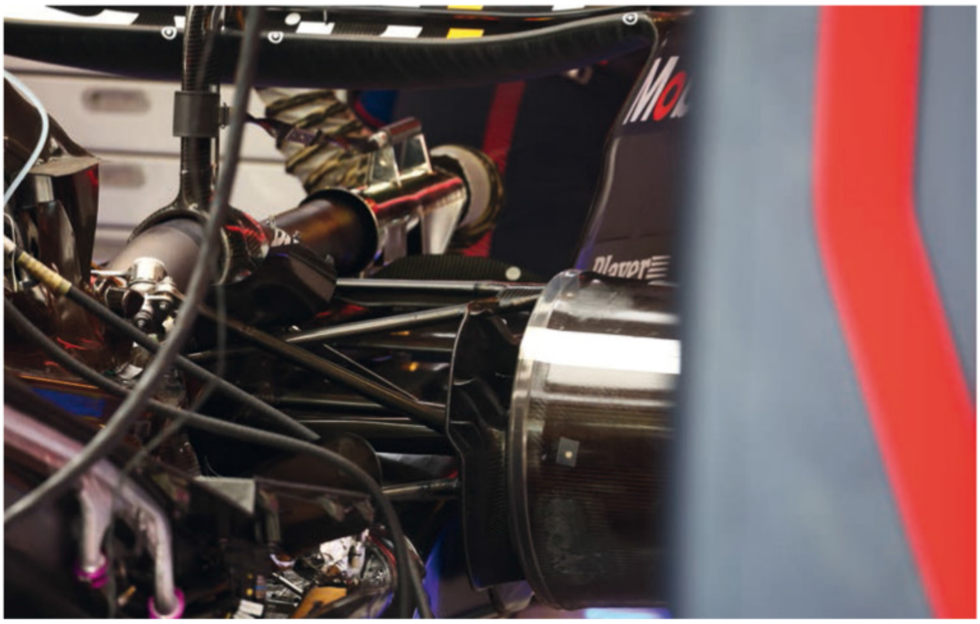
Brake calipers, seen here on the RB19 with its cheesegrater-style cooling inlets, are mounted under the disc in order to lower c of g



Using brake temperature to heat tyres is a well-worn path, but that doesn't mean teams take any element of the design for granted

Reducing the minimum weight of the car for the 2023 season was a key focus for the development team during its season with RB18

Having experienced failures in 2022, Red Bull's revised DRS was one of the best in the field, reflective of the team's efforts for 2023


Rear suspension was re-designed on the RB19, with one of the links raised to increase anti-squat under acceleration

'Without wanting to give too much away, we made some reasonable changes, which were small kinematic changes and subtle compliance improvements'

Ben Waterhouse

Many parts of the RB19 were indeed evolutions of the RB18 design philosophy.

Sergio Pérez's accident in qualifying at Monaco – where cranes hoist the cars into the air for recovery – displayed the continuation of the complex, high-roof underfloor that generated so much downforce in 2022.

'Without wanting to give too much away, we made some reasonable changes, which were small kinematic changes and subtle compliance improvements,' adds Waterhouse. 'From an aero [department] perspective, they were comfortable with the directions we wanted to go from a vehicle dynamics side, so it was an all-encompassing change, which was beneficial for all parties.

'It wasn't that this was a big negotiation to say, well, it's a gain from the vehicle dynamics perspective, but a loss from the aero side.'

Bump in the road

Many years from now, people will open a Formula 1 history book and peruse the 2023 season's results to find one race that stands out: the Singapore Grand Prix. It was on the streets around Marina Bay where Red Bull experienced its only defeat of the year, and the only race in which neither of its drivers stood on the podium.

Verstappen finished fifth and Pérez eighth, with Ferrari's Carlos Sainz jnr taking victory as part of a second half awakening for the Italian outfit and its SF-23.

Singapore was interesting not just because of the result, but because of how far away Red Bull was throughout. Neither of the team's cars made the final qualifying session, for the first time since 2018, and both were out of the podium fight on race day.

The normally mercurial Verstappen had turned sub-par qualifying results around earlier in the season, such as his advance from 15th on the grid to second at the chequered flag in Saudi Arabia after encountering driveshaft issues during the build up. Yet in Singapore, the Dutchman's progress from finishing 11th in qualifying only went so far.

'It was a painful experience to get through, but I think in some ways it served as a big positive for the rest of the year,' reflects Waterhouse. 'It meant we had to really take stock and understand what had happened.

It's on those bad days you learn the most, and then you can apply it going forward.'

Red Bull chopped and changed its set up direction in Singapore. It arrived with an updated floor featuring more camber in the forward section of the floor edge wing, but dropped the concept after opening practice.

'I think we suffered with instability, low-speed understeer and poor traction,' admits Waterhouse. 'As soon as you're in that situation, you're then struggling with tyre temperatures, and then any disturbance, whether it's a gear shift, a bump… all these problems are compounded. And they are exacerbated by the fact the car's not in the window where it needs to be.

'We didn't do a good enough job in being prepared and getting the car in the right window quickly enough. And then I don't think we reacted strongly enough at the time to be able to understand the problems.

'There were various reasons why we didn't, but it's what we've been through and have since debriefed in detail. So now we understand largely what happened, and I think we know what we would do differently.'

Return to form

From the relative low of Singapore came one of Red Bull's best races of the season, in Waterhouse's opinion. The Japanese Grand Prix saw a blistering return to form as Verstappen shrugged off McLaren's early challenge to win by 19.3 seconds.

That result washed away any remaining insinuations that an FIA Technical Directive issued before Singapore had any correlation with the RB19's performance. The Directive told the teams that the FIA would be keeping a close eye on wing flexibility and ask for details of components going forward.

'I think it's safe to say that didn't impact us at all,' says Waterhouse. 'It was an FIA Directive, which was certainly not aimed at us. There were other teams that were exploiting, shall we say, some of the vagaries of the regulations far more than ourselves. So we didn't have to make any changes to the car because of that.

'I think the best one [race] from a pure car performance point of view, for me was Suzuka. Coming off the back of Singapore, where there was a lot of soul searching done, we spent a huge amount of time that following week going through data to make sure we understood what happened.

'There were inevitably some doubts within the team, but literally from that first lap that Max rolled out the box, it was very clear all the issues had been resolved.'

While Verstappen romped to his third world title, Pérez endured a tough campaign, despite finishing second in the standings. The two drivers were closely matched in the early rounds, but the gap widened over the season.

Sidepod intakes changed through the season, according to the cooling requirements of tracks, and lessons will feed into the RB20


Controlling wake and brake temperature has been a constant factor

'[In Singapore] we didn't do a good enough job in being prepared and getting the car in the right window quickly enough. And then I don't think we reacted strongly enough at the time to be able to understand the problems'
Ben Waterhouse

The mandated raising of the floor to avoid porpoising actually helped Red Bull, even though the team avoided the phenomenon in '22

It takes a particular company in motorsport to stay ahead of the game for this amount of time. But it takes a very special type of company in motorsport to keep their customers ahead of the game, too.

The success rate of our transmissions in all forms of motorsport is bordering on the legendary and this success is now dominating hypercars and electrification in both motorsport and high performance automotive.

As we enter our 5th decade of transmission excellence, employing state of the art technology and a diverse workforce, we are leading the transition from ICE, through hybrid to EV, a once in a generation technology change.

This change is for our customers and our employees; this change is for the future.

A NEW DIMENSION IN TRANSMISSION TECHNOLOGY

XTRAC
TRANSMISSION TECHNOLOGY

THATCHAM, UK • INDIANAPOLIS AND MOORESVILLE, USA
www.xtrac.com

According to Waterhouse, Pérez struggled more with the set-up direction his crew took, whereas Verstappen only grew more comfortable, especially from the fourth round in Azerbaijan onwards.

'I think where we started, both drivers were really quite happy,' notes Waterhouse. 'You certainly saw in those first four events, it was nip and tuck between them. But I think that two things happened. One is that Max had made some quite big steps during the Baku race weekend, where he perhaps understood how to use the tools a little bit differently. That gave him another advantage.

'When we look back across the course of the season, there were some things on the set-up from Checo's [Pérez's] side. We went down a direction that certainly at the time we felt was the right thing to do… but that meant Checo was not quite as comfortable with the car [as Verstappen].

'I guess those things sort of snowballed and required a reset towards the end of the year. But we did have that reset, and Checo's performance at the end of the season was back to more where we expected it to be.'

Upgrade point

Azerbaijan marked an early-season upgrade point for Red Bull, including the first revision of the sidepod inlets. The RB19s arrived on the streets of Baku with inlets lower and wider than before, designed to exploit the flow of high-pressure air entering them, aiding cooling efficiency as a result.

A similar change was made ahead of the Hungarian Grand Prix seven rounds later.

'There wasn't any specific failure or issue with the inlet,' says Waterhouse. 'It was more a vein of development that was proving positive. As is often the case with the aerodynamics guys, once they find a thread to pull on, they keep going and they'll take it to its extremities. That's exactly what they did.'

By the time Red Bull had secured both titles, development of next year's RB20 was well under way. In the background, the team is also looking ahead to 2026 when the technical regulations are again refreshed with new powertrain requirements.

The next step

'RB20 is, in our world, largely complete from a design aspect,' reports Waterhouse when we speak in December. 'All the surfaces and kinematics are defined. It is into the final design process, and then into the manufacturing process now. RB20 is a car that is at least six months old, and we're already starting to turn our attention to RB21 yet the [2024] season has not even started.'

Despite two dominant seasons, Red Bull's philosophy is to never declare the job done. Some other teams showed flashes of form in 2023 that offered signs of being potential future challengers. Aston Martin, for example, had an excellent start, taking six podiums in eight races before tailing off, while Ferrari and McLaren came on strong later in the year.

'When you look at the progress teams like McLaren made this year, it was quite remarkable,' says Waterhouse. 'I have no doubt they've got a good handle on what they need to do now. Same for Mercedes and Ferrari.

'We defined some reasonably clear objectives quite a long way back in the RB19 development process for RB20… I won't say they're all done and dusted, as there's still plenty of work for us to do to try and improve on RB19'

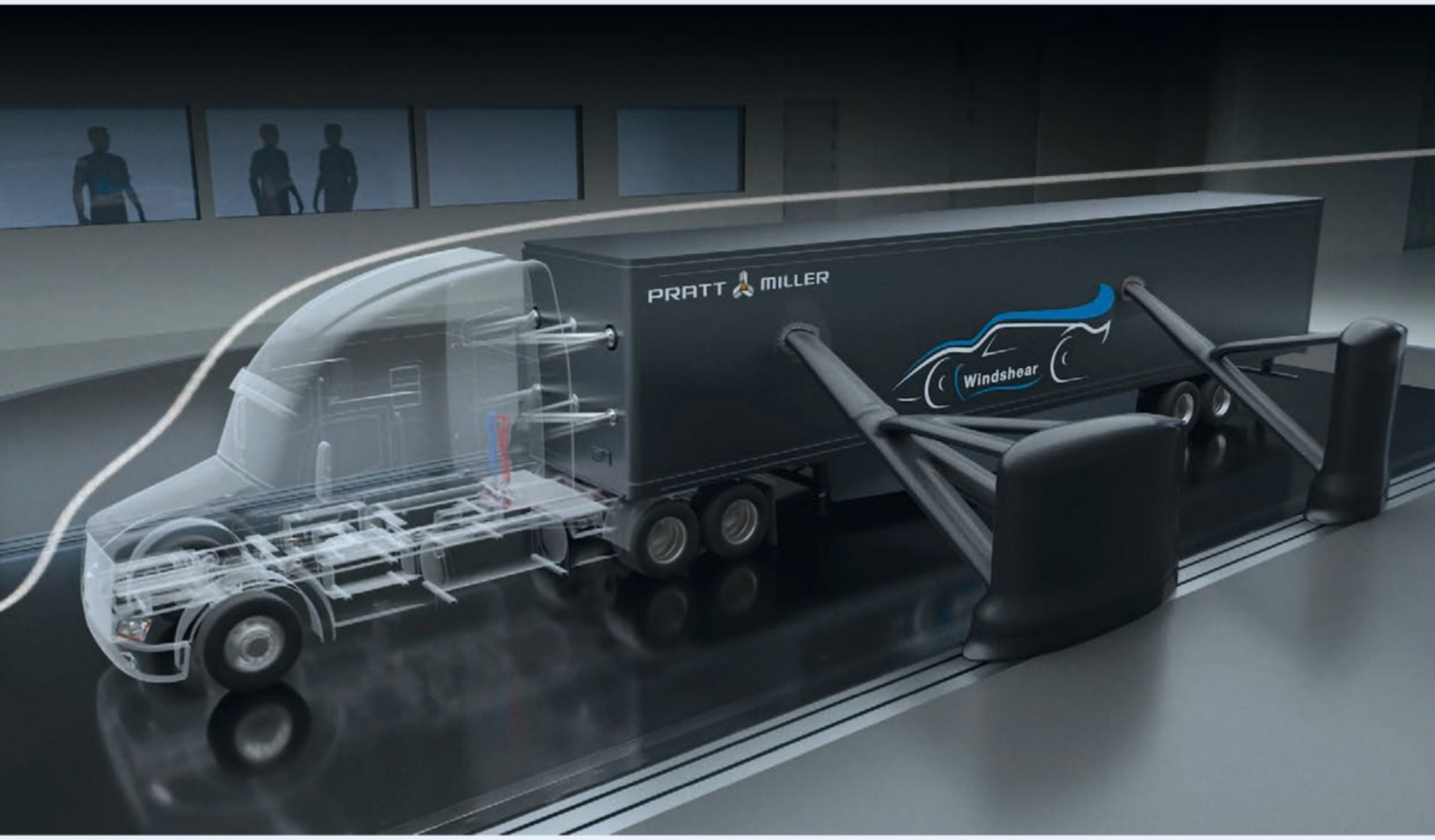
Ben Waterhouse

'We know RB19 still has some reasonable limitations. If you look at Singapore, that was certainly a weakness, so there are areas, whether it's high or low-speed performance, where we want to improve it.

'While it had some clear strengths, you want to build on those and address your weaknesses at the same time. So we defined some reasonably clear objectives quite a long way back in the RB19 development process for RB20. So far, we've managed to address most of them. I won't say they're all done and dusted, as there's still plenty of work for us to do to try and improve on RB19.'

The way F1 dishes out wind tunnel and CFD testing allowances – with teams that finish lower in the standings receiving more runs – is designed to close the gap between teams, but Red Bull's competitors will start the 2024 season playing catch up with a squad that nailed its concept from the outset. The question now is whether the team can raise the bar even higher than it did in 2023.

Despite incurring penalties for breaching the cost cap, Red Bull's RB19 was the standout car of the 2023 F1 season, and learnings from it will be fed into the RB20 for 2024 and other cars beyond



Take cutting-edge wind tunnel technology. Add a 180 mph rolling road. And build in the best in precision data acquisition capabilities. When we created the world's first and finest commercially available full-scale testing environment of its kind, we did much more than create a new wind tunnel. We created a new standard in aerodynamics.

Windshear

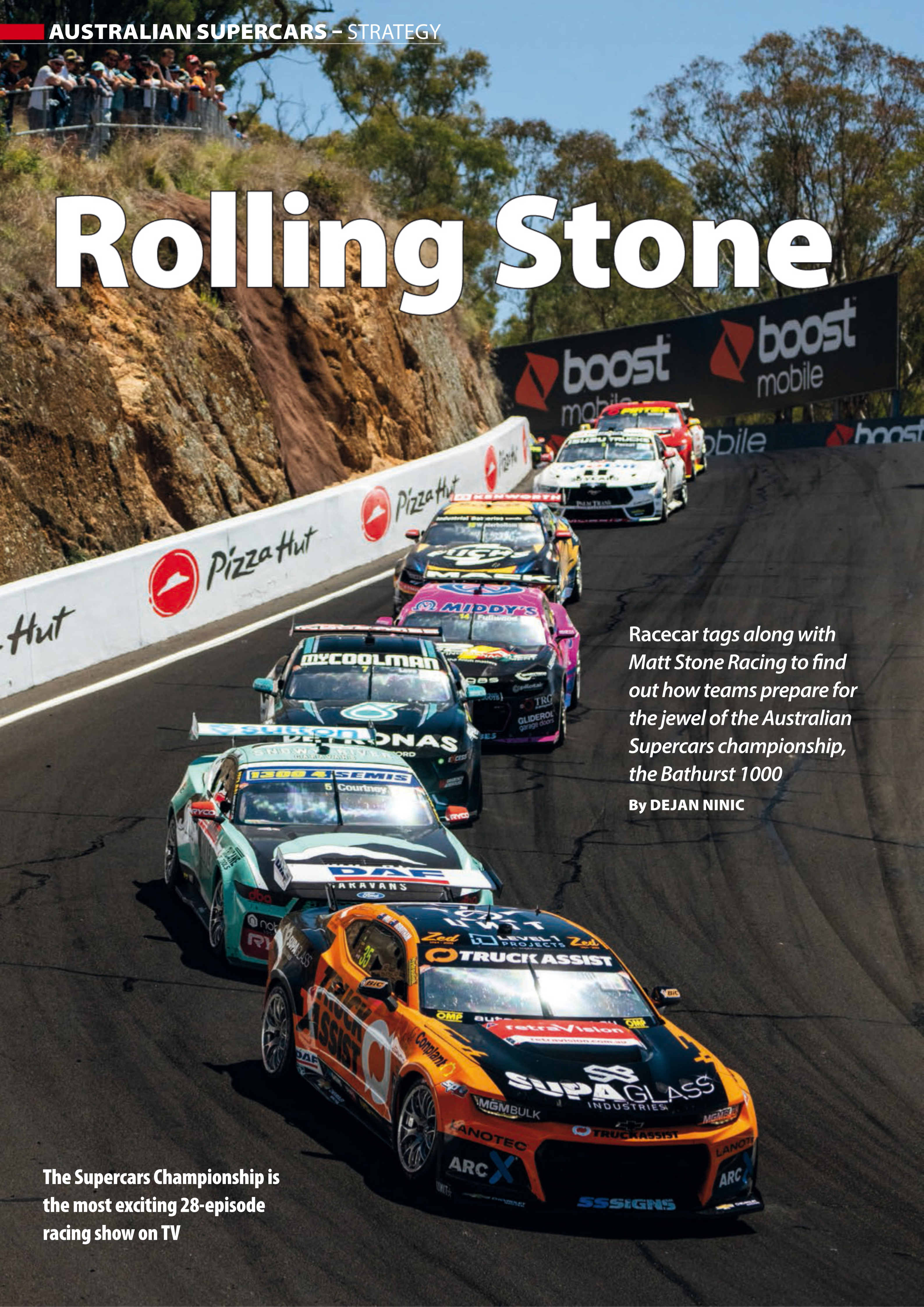
704-788-9463 INFO@WINDSHEARINC.COM WINDSHEARINC.COM

WSI-28

Rolling Stone

Racecar tags along with Matt Stone Racing to find out how teams prepare for the jewel of the Australian Supercars championship, the Bathurst 1000

By DEJAN NINIC



The Supercars Championship is the most exciting 28-episode racing show on TV

The Bathurst 1000 celebrated its 60th running in 2023. The 161-lap endurance race around the 6.2km Mount Panorama circuit in southeastern Australia is the jewel of the Supercars championship, in much the same way that the Indianapolis 500 is the highlight of IndyCar. Winning the '1000', as it is known, is as prestigious to many competitors as winning the championship itself.

So, what makes winning the 1000 so special? How do the teams prepare? Could a genius strategy give any team a chance to win? We joined Matt Stone Racing to uncover what happens within the team during the 1000 and gleaned insight into the challenges that make the effort worthwhile.

Mount Panorama Circuit draws the attention of the world, thanks to the annual Bathurst 12 Hour GT race in February, as well as the Bathurst 1000 in October. It attracts the best drivers from all over the world to tempt their fate between the walls 'across the top', 'over Skyline, 'down the hill' and 'through the Chase'. Any small driving error at any of these sections is punished, often with a hefty crash.

Consequently, leading an endurance race at Mount Panorama for any number of laps is no guarantee of a win. Traffic, fatigue and pride can all lure drivers into lapses of awareness, and a brush with the walls that line the entirety of the circuit can be the result.

True life drama

With such high risk, motorsport becomes one of life's true sources of drama, and the Repco Supercars Championship is the most exciting 28-episode racing show on TV.

Many viewers see the track action as the whole story, but the true fans, and those involved, know the plot is interwoven with multiple challenges faced by the team technicians by the demanding pit regulations, the diverse strategy options offered by the sporting regulations, parity adjustments mid-season, unexpected early announcements of driver team changes for the next campaign and, of course, the behind-the-scenes story of the Ford vs Chevrolet battle.

Indeed, the intention of the Gen 3 Supercar for 2023 was to deliver greater parity between the cars and make the race results more a factor of driver skill and daring, rather than the competitive advantage of any particular car or team.

Whilst the 2023 season did offer high drama through a range of penalties, close race finishes and diverse pole winners, that didn't stop the teams from lobbying for upgrades on the eve of this year's 1000 to grab any advantage for the big event. Being the first 1000 for the Gen 3 Supercar also opened the opportunity to a greater number of teams hopeful of sneaking a win through luck, strategy or sheer pace.

Photos: Christian Hartung

Queensland team Matt Stone Racing ran two Chevrolet Camaro ZL1-1LEs in 2023 for Jack Le Brocq and Cameron Hill

An increased factor for strategy for both Sandown and Bathurst this year was the decision by the regulatory body to use tyre compounds one step softer than the previous years

One key to winning the Bathurst 1000 is an experienced and willing driver pairing. The Bathurst 1000 is only open to professional drivers, so usually every driver on the grid is a prior race winner in a national category or series. The co-driver is either a young gun with a proven history in the junior ranks, a seasoned Supercars professional or a hotshot import from an overseas category.

Two-driver dynamic

The principal role of the guest co-driver is to complete their minimum of 54 racing laps and deliver the car to the main driver for the final stint to the chequered flag, hopefully either on the lead lap or within striking distance of it. However, to achieve the best car pace, a handy co-driver can use their dedicated track sessions to work on car set-up or gathering reliable data for strategy calculations, rather than using those sessions to become familiar with the car.

An experienced co-driver can test a car at controlled pace to compare set-up changes, or push hard consistently for multiple laps to give a quantitative assessment on tyre degradation. So, if the co-driver can make a difference regarding car speed and race strategy, how can less experienced driver pairings raise their standard?

To assist in the preparation for this event, Supercars holds a 500km 'Enduro' three weeks prior at Sandown Raceway. This allows the co-drivers to become better acquainted with the car and their team, and allows teams to fine-tune pit stops and race strategy.

An increased factor for strategy for both Sandown and Bathurst last year was the decision by the regulatory body to use tyre compounds one step softer than the previous years, based on the Gen 3 being lighter and having less downforce than its predecessor. This meant tyre degradation could be more significant, reducing the number of laps over which a set of tyres could perform well.

With the softer compounds, drivers were required to be gentle with their delivery of torque to the rear wheels, and be especially cautious not to push too hard during the first five laps on the next set of tyres. Tyre management meant resisting the temptation to forge out of the pits to create the overcut, instead requiring the driver to 'bring the tyres on' at 90 per cent pace, and then make hay at the end of the stint when those competitors ahead preferred the immediate gratification of new tyres at the cost of slow laps later. The average speed of a stint may therefore prove to be more important than the peak speed possible over a handful of laps.

The regulations allowed for 15 sets of tyres for the entire Bathurst 1000 event so, with care taken on the number of tyres used in practice sessions, a team could have enough near-new sets for up to 10 stints. The option to push hard and fast and use up tyres for shorter stints could therefore prove a faster strategy than choosing to more carefully manage tyre wear and stop fewer times.

Number crunching

To shed more light on this, we must consider the fuel situation. Refuelling is permitted in Supercars and is a method used by the series to mandate pit stops during the races.

Typical fuel consumption at Bathurst for a Supercar on E75 fuel is predicted to be around 3.5kg per lap at race pace.

At that rate, the range of the 130L (103kg) tank would be 29 laps, with a 1kg margin at the end of that stretch. That suggests five long stints of 29 laps with a shorter, 16-lap stint within, so stopping five times to refuel. Or, say, six even stints of 27 laps apiece, again stopping a total of five times.

The minimum number of stops with the given tank capacity and fuel consumption would be five stops over six stints. Now, the total fuel requirement for the race is 570.5kg, including formation laps. If a car starts lap one of the race with 102kg in the tank, then 470.5kg of fuel needs to be added during the race (with a slim margin of 2kg at the end).

There are several options for the refuelling strategy but, for simplicity's sake, let's compare the three scenarios with the least number of refuelling stops: five even stops with 94kg of fuel added at each stop (requiring 50.9 seconds of refuelling time); six stops of 78.4kg each (41.3 seconds of refuelling time); or seven stops of 67.1kg each (34.5 seconds of refuelling time).

A phenomenon of the design of the refuel couplers and refuelling tower is that the tank fills fastest when the tower is full and the tank is empty. The fill rate then slows significantly when the tank is near full and the tower is depleted of a tank's worth of fuel. At best, the fill rate is 2kg/s, and at worst can be as low as 1.7kg/s. However, the refuelling tower is allowed to be refilled to maximum capacity between pit stops. This means that two separate fills of, say, 40kg each takes less cumulative time to flow than one of 80kg.

Using some estimated refuelling flow rates, seven stops for fuel would be 16.4 seconds quicker than five stops, but at the cost of two extra pit lane transits, each worth about 38 seconds. If we include the total pit loss, the seven-stop strategy is 59.6s slower than the five-stop. However, if tyre degradation is significant, the additional seven laps covered per stint in the five-stop strategy could prove sufficiently detrimental to race pace, especially if the tyres are grained, or fall of a cliff.

Conversely, if a driver on a five-stop strategy is too cautious in managing the tyres, they may not have used the full potential of the rubber having simply driven too slowly.

Practice sessions

Multiple such scenarios are considered before the cars hit the track. Information such as fuel consumption, tyre degradation, driver speed and other factors impacting effective lap time are considered unknowns that need to be determined during the practice sessions.

For example, the critical information required from the practice sessions to compare the five or seven-stop strategy is the average lap time for a set of tyres over a 20-lap stint (seven stops) compared to a 27-lap stint (five stops). In this case, the average lap time for the former strategy must be 0.37s/lap faster to overcome the loss from stopping in the pit lane two additional times.

Considering a typical race lap is 2:09 minutes, some teams may believe that 0.37s/lap faster could be possible if the driver pushed a little bit more, without destroying the tyre.

In the race scenario, this specific control of lap pace may not be easy for the driver to judge alone, but could be managed with feedback such as lap times and sector times from the race engineer on a lap-by-lap basis. Furthermore, depending on driving style, the greater mass of fuel at the start of each longer stint could have an additional detriment to lap time, both directly in acceleration and indirectly with increased tyre temperature and wear due to the increased vertical load.

With just these three simple refuel scenarios in question, it becomes apparent that the information required to decide on the strategy must be gathered with a high level of accuracy before the race. Better teams might consider even more potential situations, perhaps with even shorter stints, or combinations of short and long stints to suit the live conditions such as safety cars, co-driver minimum laps, real-time tyre degradation and the desire to split a strategy.

Practice sessions are therefore finely orchestrated by each team to obtain data for the strategy, such that it is never obvious which driver is the fastest. That only starts to become apparent during qualifying.

Detailed run plans

To give us a better insight, experienced Queensland-based team Matt Stone Racing (MSR) kindly shared its preparation and run plans with *Racecar Engineering*.

'The Supercars regulations force teams into making errors. Our job is to be the best we can be with tyre management, pit stop operations and car preparation to minimise the errors,' says Matt Stone, owner of MSR.

Jack Bellotti is the race engineer for Truck Assist Racing car no.34, driven by full-season competitor, Jack Le Brocq and his endurance co-driver Jayden Ojeda.

'My focus shifts towards the Bathurst 1000 in the weeks prior to the Sandown endurance race,' says Bellotti. 'The team uses one of its three test days to focus on co-driver familiarity and endurance-style pit stops with brake changes. During the Sandown event, the team identifies any weaknesses and aims to improve these before Bathurst.'

Teams are given two weeks after Sandown to rebuild their cars and make improvements to pit equipment. They will also use this time to rehearse pit stop practice, including tyre changing, refuelling, brake changing, removing tear-offs, replacing drink bottles, driver changes and any simulated repairs.

The pit stop practice does not stop at the workshop either. On the Tuesday of the event, the trucks are unloaded and pit equipment is set up with priority. At 3pm, Truck Assist Racing was one of the first teams to practice pit stops in the Mount Panorama pit lane.

Pit stop practice

'You can never do enough pit stop practice,' says team manager, Peter Vale, who is also car controller for all pit stops throughout the championship season.

True to his word, Pete has the pit crew assembled at 7.30am the following morning. Already, diehard fans are sitting on the hill opposite to witness the practice first hand. The team performs seven rounds of practice, including a driver change and a simulation roll back into pit garage to diagnose a problem at the rear of the car.

Later that day, the track is closed to public driving so the engineers and drivers can walk the track. If the name doesn't give it away, Mount Panorama is a track built into a mountain, with an elevation change of 174m. For anyone walking the track, that's the same as climbing up a 65-storey building and back down again. Consequently, walking the track is a powerful reminder to the drivers that maintaining momentum through the uphill sectors is key to a good lap time.

In the meantime, there is more pit stop practice, this time simulating brake changes and fine-tuning of pit timing equipment.

'The Supercars regulations force teams into making errors. Our job is to be the best we can be with tyre management, pit stop operations and car preparation to minimise the errors'

Matt Stone, owner of Matt Stone Racing

A softer tyre was mandated at Bathurst in 2023, due to the Gen 3 cars being lighter and producing less downforce. Tyres, driver change and refuelling can all be performed at a Supercars pit stop

Ian Xu is responsible for the pit boom lighting and fuel timing equipment, and doubles up as data engineer for the no. 35 car. Each rattle gun has a button to activate a light the car controller can see when tyre changes are complete, and the car can be 'dropped' and released. Xu reflects: 'The pit equipment gets used hard and frequently at race meetings, test days and workshop practice. This equipment is critical to the pit stops so, if it breaks down, it's like the car breaking down.'

Practice session

Track action begins on Thursday, but fans who have chosen to stay at the campsite do not need to set alarm clocks as the pit lane is full of pit crews practicing at 6.30am.

Practice sessions are carefully planned to allow teams to gather vital data on tyre degradation, fuel consumption and driver style in order to plan a race strategy

Free Practice 1 then starts at 13.20 and lasts one hour. All drivers are involved. This first session is concerned with longer runs, giving each driver the chance to become comfortable with the difficult track.

'Confidence is a big thing,' confirms Bellotti. The cars usually start with a 'race set-up', which means low cambers, heavy fuel and used tyres. To assist drivers in gaining confidence, the set-up typically includes maximum wing and changes to make the car stable. Some tyre wear information can be gathered from FP1, and the session ends with race start practice on the front straight. For this, cars normally return to the pits to put on another set of tyres that are cold.

Rohan Kalish is the data engineer for car no.34. His role involves monitoring live data coming through the telemetry and then downloading and processing detailed data during and after the sessions.

'I also monitor track progression,' he adds. 'There are other categories on the track between the supercars session and they can make the track have more or less grip, based on which tyre they are using. We know that Supercars are generally faster for a few laps after the Porsche Carrera Cup cars have been on track. However, the track feels greasy after the Toyota 86 series have been on.

'High track temperatures can also make the track feel greasy, so I make sure to start monitoring this from the moment we arrive at the track.'

Come 16.50 on the Thursday, it's time for Free Practice 2, which lasts another hour, but this time is for co-drivers only.

In the MSR pit garage, Bellotti chooses previously marked used tyres for this session. Ojeda was tasked with running 20-lap stints to determine tyre degradation and to get a feel for the car's handling with light and heavy fuel loads.

Ojeda and Bellotti are Mount Panorama specialists. They have worked together for several years and, earlier this year, teamed up to win the Bathurst six-hour production car race, so in this respect have an element of advantage over the other entries.

The challenge faced by some less experienced Supercar teams is the need for the co-driver to use FP2 to prove their worth. So, rather than focusing on building a workable run plan to prepare for the race, a 'hired gun' with a point to prove might get caught up in trying to be the fastest co-driver in the session, and destroy a set of tyres in the process, leaving the team with little knowledge gained of tyre degradation in racing conditions.

Thankfully for MSR, Ojeda is reliable and regular on his laps, knowing that the overall race result is more important than his position on the leaderboard at the end of FP2.

Check off items

The work list for the cars has now increased with the knowledge gained from Thursday's running on track. The mechanics are busy setting down their cars, repairing and replacing any parts that need attention, and building up some suspension sub-assemblies, such as spring damper systems, for quick changes during Friday's running.

At sunrise on Friday, the pit crew for MSR are once again busy in the pit lane with pit stop practice. This time they are also getting ready for the first 'live pit lane' session, which allows for refuelling.

At 10am, Free Practice 3 begins. All drivers are in the session, with the main objective being to successfully achieve two live pit stops with tyre changes, brake changes (this time with brakes at race temperatures), refuelling and driver changes. Whilst every team member is well prepared and experienced, there is still a feeling of tension in the air as this is as close to race conditions as possible.

LeBrocq is a seasoned competitor in Supercars, having competed in the series since 2018. Despite this experience, he still needs many laps to get up to speed. By the end of FP3, LeBrocq receives a set of new tyres to get comfortable with the race set-up with a high fuel load, and so Bellotti can get a read on tyre wear.

For the rest of the Friday, the focus is qualifying. LeBrocq is released for the last few minutes of the session with low fuel and new tyres to get a read on the set-up in preparation for qualifying.

Free Practice 4, on Friday at 13.05, again for one hour, is for all drivers. Two hours after that comes qualifying. This means it is common for only drivers who will qualify the car to participate in FP4 as they focus on tuning their cars for speed. Bellotti has planned for three new sets of tyres, each to do only three or four laps. Two of these sets will go on to be used in the race, so they need to be treated well and 'broken in' gently to avoid graining and ruining them as race tyres.

Bellotti's focus now becomes qualifying set-up. He makes changes to improve the turn-in response, such as raising the rear ride height, raising the rear roll centre, stiffening the rear anti-roll bar and restricting droop.

Time to qualify

Qualifying then takes place between 16.15 and 16.55, with one driver only allowed per car, and no refuelling allowed.

Bellotti has planned to use four sets of new tyres, so it is clear to everyone that the fastest run will be the last run when the car has the least amount of fuel onboard and the track has the most amount of rubber laid down on it. LeBrocq paces himself in the first two runs – each of which comprises an out lap, two flying laps and an in lap – with the second of the flying laps being the best for tyre preparation. All the while, Bellotti fine tunes the car set-up.

The fuel is calculated to such an extent that if a driver makes a mistake, or is held up on a flying lap, they cannot simply abort and try again on the next lap. Rather, they must return to the pits for another set of tyres.

On this occasion, two separate crashes brought out the red flag, stopping the session twice. For many drivers, the red flag came out during a fast lap that would be invalidated due to red flag procedures, so the pressure was really on those drivers to set a good time with their last set of tyres.

For MSR, LeBrocq struggled to achieve the promising speed he has shown in previous years at Bathurst and missed out on the top 10 shootout. Later that evening, the team discovered the front splitter mounting was damaged, possibly during an off-track excursion at the beginning of qualifying, causing the splitter to deflect and oscillate with detriment to the car's aerodynamic balance and downforce. By then, though, the damage had been done.

Experience counts

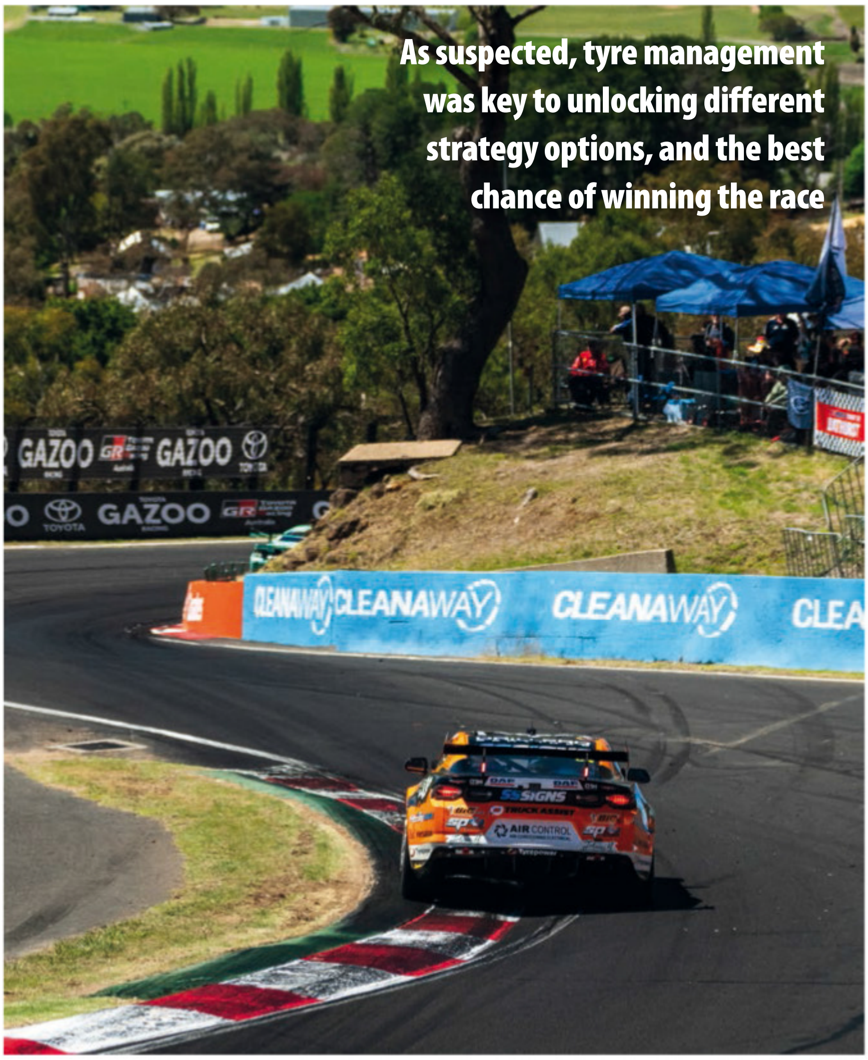
The MSR team's sister no.35 Chevrolet is driven by Cameron Hill and endurance guest Jaylyn Robotham, two competitors with very limited experience in Supercars machinery but with the benefit of both serving as co-drivers at the 2022 Bathurst 1000.
Hill, like Ojeda, is also very familiar with Mount Panorama. He won the Porsche Carrera Cup championship there in 2021 and the Bathurst six-hour production car race in 2022, with the author as his race engineer for each of those feats.

For the Supercars campaign, the engineer for car no.35 was Paul Forgie, a Supercars veteran of 20 years. Forgie's reputation is as a fierce competitor, and he has claimed plenty of wins in his career. Despite this, and Hill's speed, car no.35 was plagued with clutch issues, eventually causing it to start from the pit line. As a result, car no.34 was ahead on track and would have priority amongst the team cars for when to pit.

By Saturday morning, with the air full of smoke from the campfires that had been burning through the night, the MSR pit crew were in the lane again at 7am, hoping to improve their stop time.

Tyre changing in the pit lane in Supercars can be performed with one tyre changer on each corner. The changers are allowed to wait in their pit box as the car enters pit lane, and the car can be released without the need for them to return to the garage.

An efficient tyre change only stop takes about seven seconds, while a driver change would be applauded if completed within 20

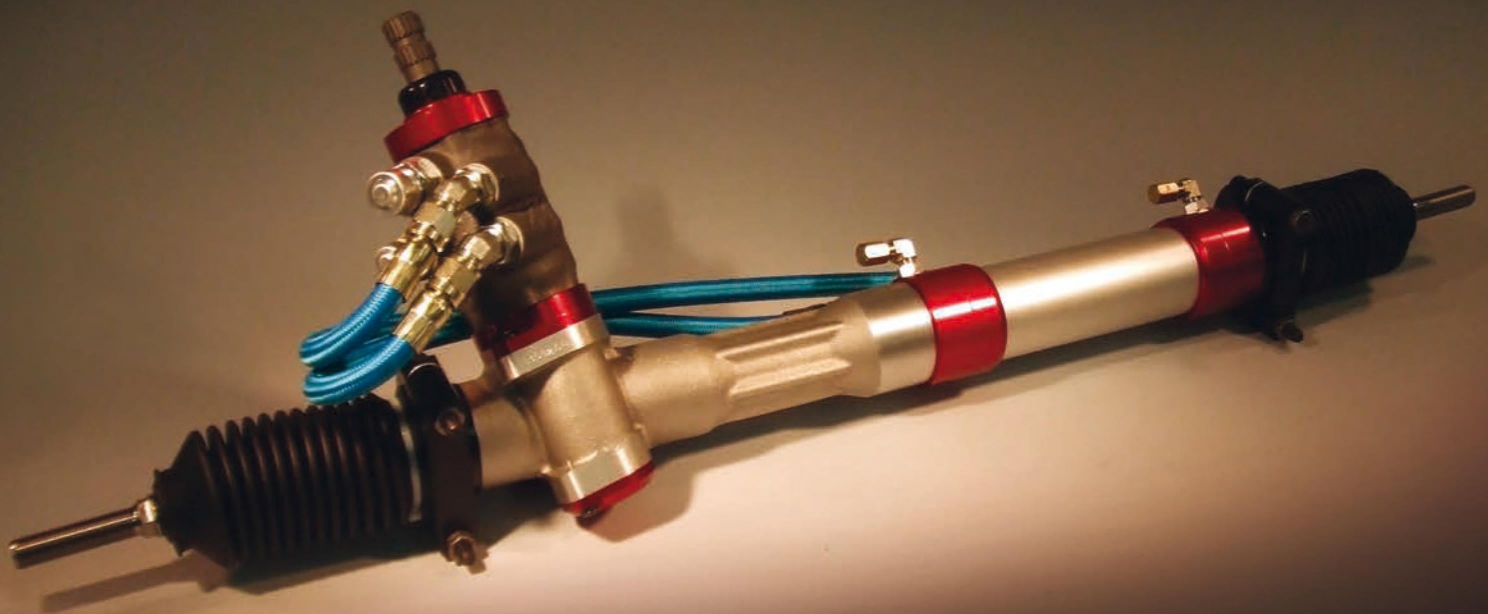


As suspected, tyre management was key to unlocking different strategy options, and the best chance of winning the race

Adding to the strategy variables, Mount Panorama offers a 174m elevation change over the course of a lap, making it vital drivers maintain momentum on the uphill sections and preserve brakes and tyres on the downhill segments

WOODWARD

Euros, pounds or dollars,
we give you more
engineering for your money.



Power steering racks

for left or right hand drive, front or rear steer,
with a choice of three pinion angles,
three piston sizes, seven gear ratios,
forty valve combinations
and an almost infinite variety of dimensions,
built for the most demanding racing
applications in the world.

USA
WOODWARD PRECISION POWER STEERING
www.woodwardsteering.com

Europe
HYDROLINE PRECISION POWER STEERING
www.hydroline.eu

Pacific Rim
RACER PRODUCTS
www.racerproducts.co.nz

Download a Type CF design worksheet at woodwardsteering.com

seconds. Tyres, driver and refuelling can all be performed in parallel during a pit stop.

After another Saturday practice session (FP5) between 10 and 11am, for co-drivers only, the cars are returned to race set-up for long runs. By now, Bellotti has two tyre sets from the qualifying simulations in FP4 that he intends for Ojeda to drive on 'until they have nothing left to offer.'

A careful assessment of the lap time data from this session is the key to every team's race strategy decision. So much so, most teams will also be reviewing the lap times from other teams as well as their own.

Unsurprisingly, the two teams fighting for the 2023 driver's championship, Triple 8 and Erebus, show very little lap time increase over a long stint. The experienced eye would recognise that the lap speed of the last five laps is closely related to that of the first five, meaning a driver that was careful on the tyres at the start would have good grip towards the end.

The final practice session (FP6), between 13.00 and 14.00, is a live session for all drivers, with refuelling allowed in pit lane. All competitors now focus on practising pit stops, with additional service protocols on the run plan such as cleaning front radiators, replacing drink bottles, assisting driver changes and cleaning windscreens (rather than using tear-offs).

Bathurst 1000 rules

- 161 laps. No time certain limitation
- Two drivers per car. The main driver is registered for the Supercars season; the co-driver must be a professional racer
- Each co-driver must complete at least 54 laps during the race
- Maximum continuous driving time of any driver is 3.5hrs
- Each two-car team has one pit box (so double stacking is a regular occurrence)
- Refuelling tower has 150L capacity and 2m maximum height from ground
- Car fuel tank capacity is 133L, holding approximately 103kg of E75 fuel
- All cars use tyres supplied by Dunlop
- Each car limited to 15 sets of soft tyre for the entire event. Two of these sets must be 'marked' from a previous event of that year's Supercars Championship; the soft tyre is one step softer than previous years to create tyre degradation effect
- Compulsory front brake pad change between lap 55 and lap 120
- Teams can perform tyres, fuel, brake and driver change at the same time
- Safety car wave-by rule, also known as "Lucky Dog", keeps more cars on lead lap

Sunday starts with a live, all-driver, warm-up session between 8am and 8.20. This is the last chance to shakedown any final changes made overnight, and another opportunity to practice a pit stop before the race starts promptly at 11.15am.

The main show

The strategy Bellotti settled on for car no.34 was six stops, running seven even stints of 23 laps each, arrived at after judging the lap-by-lap loss of stretching the tyres out to 27 laps too significant. However, it became apparent early in the race that the tyres were not going to remain effective even for the proposed 23-lap stints, so Bellotti pitted his car early and considered the option of a seven-stop strategy.

Car no.34 took the team advantage in the double stack when the safety car came out on lap 41. From then on, Le Brocq and Ojeda worked their way up to ninth position by the end of the race by overcoming their tyre degradation concerns.

Reflecting after the chequered flag, Bellotti confirmed that, as suspected, tyre management was key to unlocking different strategy options, and the best chance of winning the race. It did not slip his attention that several other competitors showed very little drop in performance over long stints while still managing to circulate at a comparable pace. He knows the team still has some work to do.

Having started from pit lane, car no.35 stopped on lap 24, as scheduled. However, the delay from double stacking forced it to the rear of the grid when it re-joined the circuit. The same outcome befell several other cars whose team had decided the loss of a double stack would be less than the loss incurred through pitting later under race conditions.

Forgie did attempt an alternative strategy by not stopping under the subsequent safety car on lap 71 (when many others did), with the aim of putting his car ahead of car no.34 in the running order, thus gaining the lead car advantage in subsequent pit stops if both team cars decided to stop at the same time. However, as there were no further safety cars, car no.35 had to make its final pit stop under racing conditions, eventually finishing 15th but still on the lead lap.

Conclusion

So, was there one strategy that was clearly the fastest? Reviewing the results showed 13 cars, including the eventual winner, stopped seven times (two more would have joined the seven-stop group had they made final-lap stops for fuel). Five cars stopped six times, including car no.99, which finished second. Only one car, no.26, completed the race on five stops, and came home in fifth.

What to consider when tackling the event

- Fuel tank range under race conditions is approximately 29 laps
- Strict regulations around refuelling tower design result in a typical flow rate of between 2.0kg/s (full tower, empty car tank) and 1.7kg/s (almost full car, a tank less fuel in the tower)
- Soft tyre grip degradation could deter teams from running full tank stint lengths
- A driver change in the pits can normally be completed in 20-25 seconds
- Bathurst has two long straights, so a low drag aerodynamic set-up can result in increased chance of passing cars on track and reduce fuel consumption
- The climbing and descending nature of the circuit could benefit cars running lighter on fuel
- Softer tyre compounds may demand softer spring and damper arrangements to improve mechanical grip

The most interesting one to look at is the no.26 Grove Racing Ford Mustang S650. Having started seventh, it was forced to serve a drive-through penalty early in the race, relegating it to 26th place. The safety car episode then gave it the opportunity to catch the train of cars and it came back into pit sequence with the field, albeit still a fair way down the grid in 21st. From then on, though, it forged its way up to first place within 21 laps, and maintained that fast pace in subsequent stints, making one fewer stop than other teams in the process.

The speed that the Grove Mustang carried through traffic, while still managing to make its tyres last the longer stints, is a strong indicator to Bellotti that there may be more to be done in terms of car set-up to make the tyres last longer.

So, while there is no obvious advantage in any one strategy, common opinion still stands that ensuring your car has fresh tyres for the last stint is critical. By stretching the middle stints and reducing the last stint by being late to pit, a driver can fight and defend for positions late in the race.

The Gen 3 Supercar and the introduction of a softer tyre compound certainly created a novelty for 2023. There was drama, with a leading car breaking down; suspense from potential winners holding back, managing their tyres and waiting for the ideal time to push; disruption with many cars being forced to double stack, and heartbreak for the few that needed to make last-lap pit stops for fuel out of fear they would not make it to the end.

Ultimately, the winners were the popular New Zealand duo of Shane Van Gisbergen and Richie Stanaway from Triple 8 Race Engineering, giving van Gisbergen a third Bathurst 1000 jewel in his crown.

LifeRacing

12, 24 and 48V Power Distribution Units

PDUX range

12V, 24V and 48V Vehicle Control System solutions for a wide range of applications: Automotive, Commercial, Defence, Motorsport, Marine, Mass Transportation. Advanced networked systems for Power Distribution, Display Technology, Engine and Vehicle controllers.

www.liferacing.com | +44 (0) 1268 904124 | info@liferacing.com
6 Repton Close | Basildon | Essex | SS13 1LE | United Kingdom

New age thinking

The battle for a perfect Balance of Performance continues as IMSA takes a new approach to its own category for GT3 cars

By ANDREW COTTON

The thorny issue of performance balancing continues to evolve in 2024 as the IMSA organisation, which runs the IMSA Sportscar Championship in the US, has taken a completely new approach to balancing its GTD category cars.

GTD is the name IMSA gives to its arena for GT3 vehicles and is split into two classes: GTD Pro for all-professional driver lineups and GTD for pro-am crews.

GT3 cars race in various series around the world, and all have to fit within performance windows set by the FIA, which owns the intellectual property for the category. These performance windows balance lift, drag and power, and the combination of these elements brings the cars to a reasonable level of competition with each other.

Given that the racecars come from production models, there are vast differences between them in terms of concept, which then leads to different behaviour on track, and so a system is needed to balance the cars within these performance windows.

Fortunately, with so many cars out on track, there is a mountain of data from which to work, but subtle differences between the various championships makes life more complicated, and the sanctioning bodies have each had to adopt their own method of working.

Model behaviour

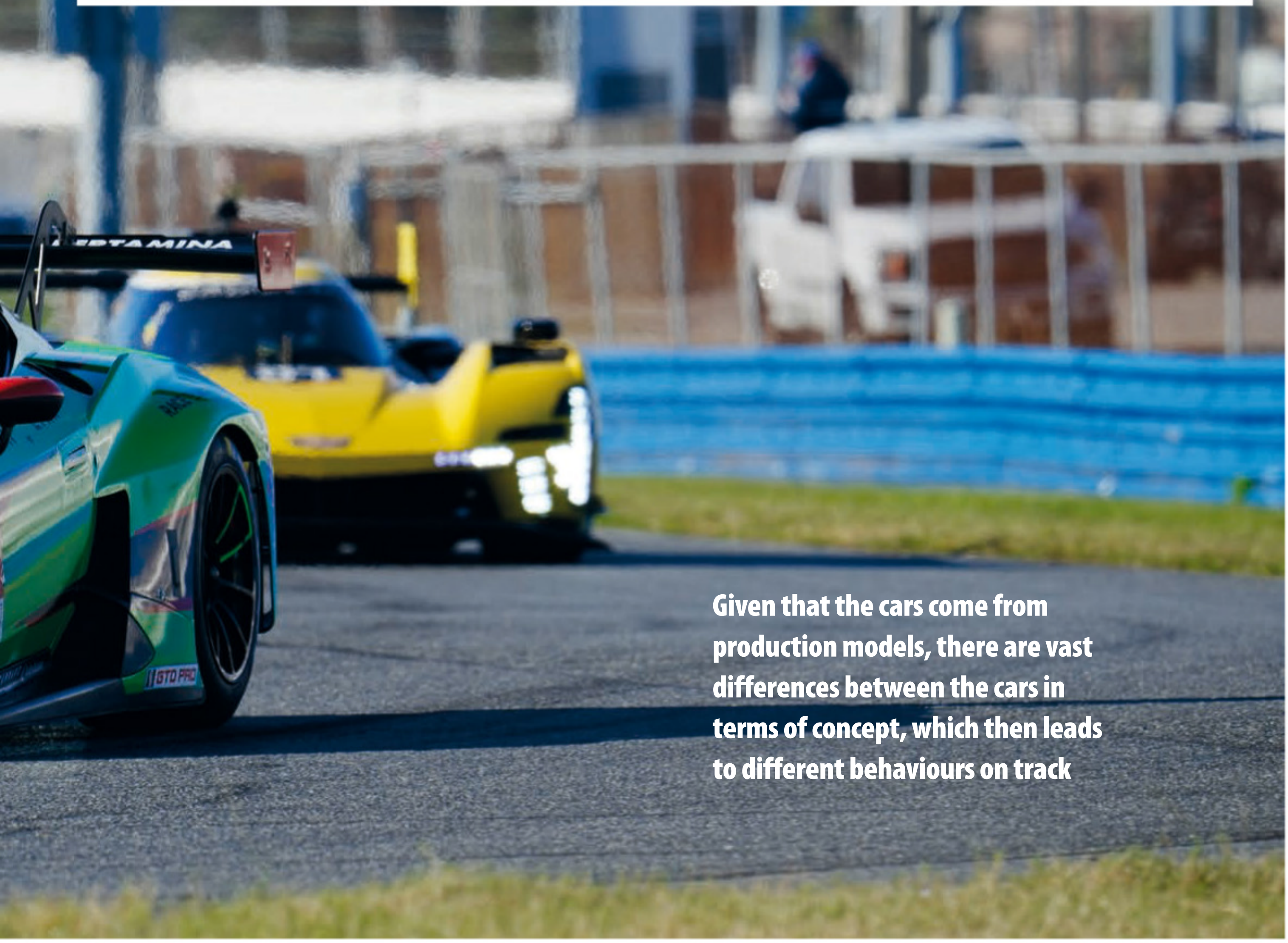
IMSA's model is developed in conjunction with the FIA, which governs the GT World Cup in Macau, and the World Endurance Championship (WEC) with the ACO, which runs the 24 Hours of Le Mans. Although the three bodies share information and processes, even between these partners there are differences in the specification of the cars, which means the performance balancing cannot carry over directly.

Unlike the prototypes that run in the WEC and IMSA, the American body does not test the GT cars in its Windshear wind tunnel in North Carolina. Instead, it relies on data supplied by the FIA from its aerodynamic testing at the Sauber wind tunnel near Zürich.

This means manufacturers do not need to run different aero kits in IMSA and the WEC, which saves money, but this is where the similarities end.

IMSA elected not to run torque sensors on the GT cars for 2024, unlike the WEC, which means the engine maps are different for the cars in the US compared to those in the world championship. With the torque sensors, power at the wheels is measured and balanced, while IMSA still relies on air restrictors, which do not take into account losses incurred before the power reaches the track. The reason for that decision is the sensors are expensive to fit, being housed in the driveshafts, which have to be shipped to MagCanica in California, and then the information that comes back from them has to be monitored.

Further differences between the two series that are relevant to the performance balancing are found in the fuel and tyres. The former is provided by different manufacturers, with TotalEnergies supplying the WEC and VP Racing Fuels



Given that the cars come from production models, there are vast differences between the cars in terms of concept, which then leads to different behaviours on track

New cars such as the Aston Martin evo (pictured), McLaren, Ford and Corvette all throw a little uncertainty into the mix for the balance of performance team as they prepare for 2024

covering IMSA, albeit with products said to share largely similar properties. IMSA competitors, meanwhile, run on Michelin tyres, while WEC GT3 cars use Goodyears.

Each of the sanctioning bodies uses a combination of simulated and real-world data to help understand the performance potential of the cars and then makes adjustments accordingly. IMSA is unique among the three as it runs its December test to establish the data, and then has a further pre-season test, again at Daytona, to validate its findings a week before the 24-hour race.

The FIA, on the other hand, runs only the pre-season test day, this year in Qatar, while the ACO holds a pre-season test day for its European and Asian series, and a further test at Le Mans ahead of the 24-hour race.

IMSA is the only one to have set aside time to run a programme for the manufacturer cars.

Shared data

Despite these differences, it is hoped the on-track data shared will mean the cars will be better balanced in 2024 in both series.

For the WEC, this year will be its first experience of GT3 racing, so the series will need IMSA's data to ensure its figures are right from the start. However, it can also draw upon data from the FIA which produces the BoP table for the GT World Cup at Macau, while the ACO has balanced GT3 cars before in the European Le Mans Series.

The 2023 edition of the Daytona 24 Hours saw the introduction of new cars from Ferrari, Porsche and Lamborghini. For the 2024 edition, IMSA also has to contend with new cars from Corvette and Ford, so desperately needs reliable information from the outset.

The governing body is hoping its new, robust test programme will prevent manufacturers trying to deliberately skew the numbers, as they appeared to do in 2023.

Following a sternly worded email sent to all manufacturers at the Daytona 24 Hours in January of last year, warning them against trying to 'game' the system, IMSA has taken more control of the situation for the 2024 event.

'It is highly disappointing that the on-track demonstrated performance data from the 2023 Roar [the Daytona pre-race test event] continues to be inconsistent and unreliable,' wrote IMSA's technical team to its manufacturer group ahead of the race in 2023. 'Validated scrutineering data is representative of this, (examples include vehicles being overweight, excess fuel 'left on board' after qualifying, wing angles not representative of what may be raced, unrepresentative ride heights, etc).'

Such gamesmanship is nothing new in the world of performance balancing. In the past, it was not uncommon for manufacturers to build cars specifically for the test sessions with as much inefficiency as possible to get a good starting point from these controlled tests. While the system has been tightened up, clearly there is still room for improvement.

To combat this problem, at the December test at Daytona, IMSA demanded control of one car from each manufacturer, with a professional driver, at a given point in the two-day session. The organisation put together the run plan, and closely monitored the results with a view to then sharing all available data with competitors post-test, and before it set the BoP for the race.

The governing body is hoping its new, robust test programme will prevent manufacturers trying to deliberately skew the numbers, as they appeared to do in 2023

This plan was negotiated and agreed upon with the manufacturers and the process started in August last year.

'[In 2022], we performed December tests just for those new cars, but it was not a BoP test' says IMSA's technical director, Matt Kurdock. 'We basically let the cars run their own test plans, and essentially used it as a systems check of a variety of things that IMSA was doing.

'We recognise that with the introduction of new cars, we were missing some reference data that we could use to make that introductory BoP a little closer.'

Controlled test

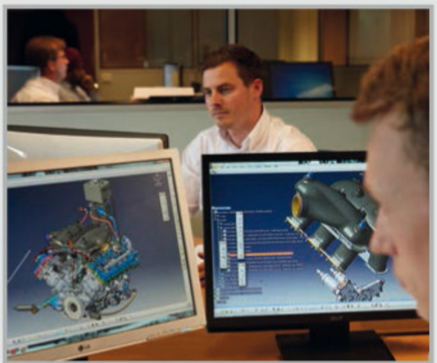
There was certainly no shortage of cars around to complete the BoP test in 2023, with 11 OEMs and a total of 27 cars running in one or other of the GTD classes over the course of the two days. IMSA completed its runs on the second of two days allocated for the GT cars.

'We focused on 14 of those cars to run essentially an IMSA-mandated test plan,' says Kurdock. 'We controlled not only the BoP the cars were running, but also the fuel loads, the tyres and essentially put the cars through a full tech process, then kept them under parc fermé throughout the test blocks.

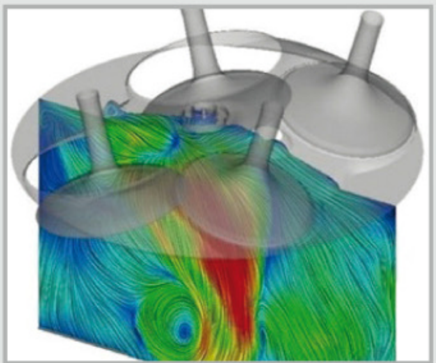
Advanced Engine Research

High Performance Engine Solutions

Advanced Engine Research provides expertise in the consultation, development and production of high performance engine technology.



DESIGN & ANALYSIS



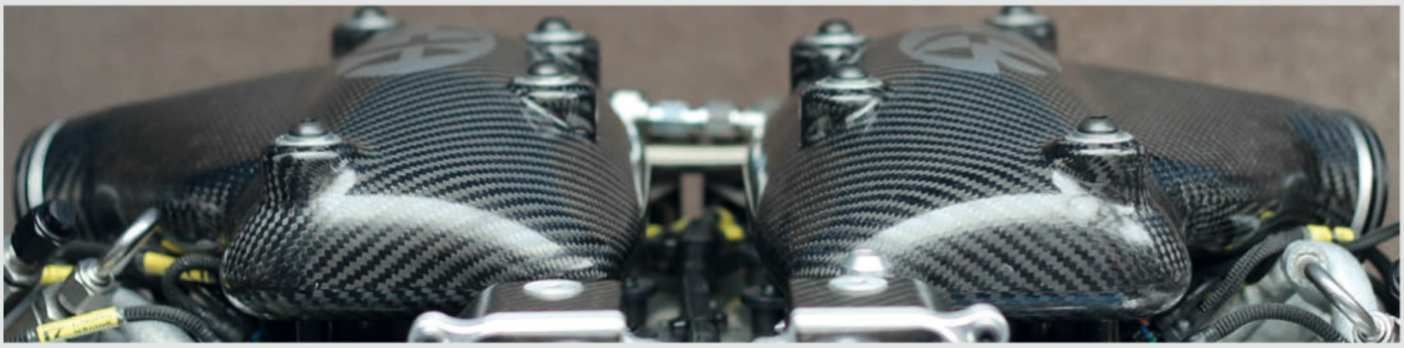
PERFORMANCE & SIMULATION

ENGINE TESTING & DEVELOPMENT

PRECISION MANUFACTURING

ENGINE ASSEMBLY

RACE TRACK SUPPORT



ADVANCED ENGINE RESEARCH LTD – BURNT MILLS INDUSTRIAL ESTATE – BASILDON, ESSEX SS13 1LE

Tel: **+44 (0)1268 274421** • Email: **Info@aerltd.com**

www.aerltd.com

Adding further to the balancing task is the introduction of a new Michelin tyre for 2024, so the BoP team needs to build data on its performance under different conditions

'We had an insert technical official embedded with each one of the teams, overseeing what they were doing and making sure only adjustments permitted by IMSA were being performed on the cars. That way, we could make sure the test data was as free of variables as possible, which is often very difficult to do.'

Complicating matters further was the new 2024 tyre from Michelin, designed to operate without tyre warmers, which added a further focus of attention for IMSA during the test.

'In 2024, we will introduce the new Michelin Pilot Sport Pro tyre in GTD and GTD Pro. Historically, the introduction of any new tyre, even just changing the compound, can destabilise the BoP,' adds Kurdock.

Demanding subject

One of the issues surrounding the BoP process is the targets the governing body sets itself. For IMSA, it runs races of different lengths, from 100-minute sprints to 24-hour enduros, and balancing for these can be very different. Conditions vary dramatically over the course of 24 hours, and some cars may perform better at night than during the heat of the day. Or does it focus on balancing in a sprint format, in the event of there being a final run to the flag after a late yellow?

The December test won't provide the answers to all those scenarios, but it does give IMSA enough data to take them into account on a race-by-race basis.

'We recognise that in our racing, particularly when we have full course yellow restarts, that people are on various different configurations,' admits Kurdock. 'We just wanted to sample both ends of the spectrum.

'I think with the new tyre, we're trying to build our notebook, working with our partners at Michelin to understand the tyre performance over more than just a full fuel run. Adding some essentially simulated qualifying to that gives us a more realistic condition of what we would see at the beginning of a race where you are starting on your qualifying tyres.'

Real-world data is crucial to the BoP team as it cannot only rely on simulation. Simulation will only take the figures so far, as the manufacturers themselves have seen this year. Notably Porsche, which ran a detailed track testing programme in May with its 963 prototype and found the correlation between track and simulator data far from perfect.

'It's very difficult,' says Kurdock. 'You could have a team of engineers spending years trying to correlate your own simulation on your own car. We recognise that simulation is a very difficult task to undertake on one car, let alone trying to do it on 11.

'However, there are definitely aspects that can feed into a BoP process to make sure the data we're analysing, and the adjustments we're making, are within an order of magnitude of being realistic for that car.

Real world data is crucial to the BoP team as it cannot only rely on simulation. Simulation will only take the figures so far, as the manufacturers themselves have seen this year

Or whether we're reacting to a potential problem on a car, or a potential problem with set-up, or how the car was being driven.

'So, I think using it as a filter, so to speak, in the BoP processes is where we see its initial benefits in the GTD category.'

Data mountain

The test at Daytona means the tech team has a mountain of data to sift through before mid-January, when the tables for the cars will be set for the opening round of the '24 season. Even then the job is not yet done, though, as the Florida track is an outlier. The second race is on the bumpy airfield circuit of Sebring, while other events are held on closed courses such as Watkins Glen, and street tracks such as Long Beach.

However, it is the first round, and one of the highlights of the season in terms of prestige and points available for the championship, and therefore the BoP must be right. To achieve that, IMSA will use all the data it can from the tests and the race, before deciding what to do for the rest of the year.

'Daytona is a unique circuit on our calendar,' notes Kurdock. 'It's a very drag sensitive racetrack, but you can't lose sight of the performance on the infield, particularly with a new tyre. That infield performance is going to be one of the critical areas where we'll be able to see the performance differences of the new tyre.

'We don't expect a new tyre to have the same performance offset on the cars that are returning from last year. And we recognise that after only a handful of days testing on Daytona with the new tyre, not everyone is going to come to grips with it.

FORGELINE

#NeverCompromise

When Pratt and Miller created the all new 2024 Z06 GT3.R to race globally in IMSA,WEC and SRO they chose Forgeline as their wheel partner. For a decade Forgeline has manufactured the wheels for their highly successful championship winning Camaro GT4 and GXPR race cars. At this level you must have confidence and trust with your wheel manufacturer... Do you?

After 30 years of involvement with teams of virtually every sports car racing organization in the world, we have learned what it takes to produce a racing wheel that can with stand the fierce conditions of the sport.

We put that level of commitment into every wheel we make.

NW105

SL3

VV1R

AMERICAN DESIGNED AMERICAN MADE

800-886-0093 WWW.FORGELINE.COM

'We expect there will still be learnings to be had until teams and manufacturers have had the opportunity to run the new tyre on the bulk of IMSA's race calendar. Until then, there will still be evolution of set-ups and approaches to try to extract the performance out of the tyre.'

Further skewing the BoP for the 24-hour race is the performance of the new rubber over a double stint. Michelin has dramatically reduced its allocation of tyres for Daytona to just 25 sets per car for the event and, in order to protect the tyres, teams are not allowed to double stint the right-side rubber. That means the lefts will have to complete multiple stints, and there's no doubt some cars are kinder to their tyres than others.

The flip side of this is that the ultimate performance of the car is not likely to be a race-defining issue. 'Right now, we're just really focused on Daytona, and setting a BoP for the Rolex 24,' says Kurdock. 'We will assess the quality of that BoP when we come out of the event, and then make decisions on how we treat Sebring and beyond.'

Aero restrictions

'The thing that makes it a little more difficult is that at Daytona we run aerodynamic restrictions,' continues Kurdock. 'We've essentially run minimum wing angles to try to balance the drag across the cars, but for Sebring we will have to abandon that methodology and just accept the homologated range of the rear wings.

'That makes it a little difficult to take a BoP from Daytona and apply it to Sebring. But it is something we're looking at, particularly with the new tyre. That may prove to be a better starting point for us than taking historical data and carrying that forward.'

The goal is to avoid having to make any big adjustments mid-season.

'We are looking for very small magnitude changes throughout the season that are ultimately driven just from simulation, not from on-track performance,' confirms Kurdock. 'I think you can see that over the course of this season, we had variability in performance, with a very narrow range of adjustments, and that all manufacturers had the opportunity to compete and win with that.'

For the future, IMSA will look at the possibility of introducing the torque sensors to bring the cars into line with the WEC, and will also look at testing the cars with its own wind tunnel programme at Windshear, which will give IMSA its own picture of the aero potential of a car. 'It's always going to be difficult because the GT3 regulations are not as restrictive as an LMDh set of regulations,' concludes Kurdock, 'but we believe that applying those core engineering fundamentals, like we did, shows promise for further condensing GTD performance.'

Corvette's GT3 chapter about to begin

Corvette Racing had a tough task on its hands to turn the Z06 into both a competitive GT3 car and an accessible customer racer

Corvette's Z06 GT3.R machine will make its competition debut at the 24 Hours of Daytona in January and, while the team has focused its attention on making it a true customer car for racing on both sides of the Atlantic, there's a lot of carry over from the outgoing modified GTE model that IMSA allowed in GTD Pro for two years.

The team has worked with the FIA to ensure the car meets not only the technical regulations, but also the intent of the regulations as a customer car. That entailed dialling down a lot of the componentry to reduce the cost of running, as well as increasing reliability.

'You don't have to worry about differential efficiency, for example,' says Ben Johnson, motorsports technical director at Corvette Racing. 'The work is there upfront to make sure it's reliable and the efficiency is still high enough that you don't have such heat rejection issues, or have to worry about how much oil is in there, or its running viscosity.'

> The team has worked with the FIA to ensure the car meets not only the technical regulations, but also the intent of the regulations as a customer car

The cockpit is almost the same as the previous model, and GM says it has carried over as much as it can to save development costs, but this is still a very different animal compared to the previous Corvette C8.R.

The engine is designed to work to a prescribed power curve rather than through sonic restrictors. The Z06 GT3.R will also run in the US without torque sensors in the driveshafts, although it will run them in the WEC. 'The engine team has done good work, so there aren't two completely different philosophies of engine control between a torque sensor car and a non-torque sensor car,' says Johnson. 'There's a feedback loop on the torque sensor car and it's open loop on the standard axle car, but the way the engine control is done is similar, so we don't have to learn one car in one championship that's completely separate from another one.'

Regulation differences mean the rear diffuser of the car can start further forward compared to the GTE car, which led to a re-design of the rear suspension and its mounting to the gearbox.

'There's a lot more performance extracted from the bottom of a GT3 car,' says Johnson. 'You can make some pretty extreme bodywork and aerodynamic choices on GT3 cars, which was a good exercise for the aerodynamicists and the programme as a whole.'

Attention was also paid to improving the stability of the car on the brakes and turn-in to make it less edgy than the GTE model.

'We re-set all of our targets for the aerodynamic performance, not just for the overall downforce, but also how the car operates.'

There are also big differences to the underfloor aerodynamics. While the top body looks similar to last year's car, the Z06 GT3.R generates much of its downforce from the floor.

'We had to retain the GTE bodywork, so our main goal with aerodynamic performance on this car is to make it as simple as possible,' continues Johnson. 'It doesn't have a bunch of winglets on it, and we extracted as much as we could from the underwing of the floor of the car and the diffuser.

'The top body looks relatively simple, but those are the parts that get damaged quite often and we didn't want to drive costs to our customers to replace complex components often.'


ATL
BEYOND SAFETY
OUTLAST
THE COMPETITION
ATL offers both standard and custom FIA Approved Safety Fuel Cells that feature the built-in performance that is required to tackle the harshest of environments.
PERFORMANCE IN-TANK OPTIONS
COLLECTORS, SURGE TANKS, BAFFLES, FUEL PUMPS & MORE... NEVER STARVE AGAIN
USA +1 201 825 1400 | atl@atlinc.com | atlinc.com
UK +44 (0)1908 351700 | sales@atlltd.com | atlltd.com


Lane MOTORSPORT
WE CONNECT TECHNOLOGY
WWW.LANEMOTORSPORT.COM
+44 (0) 1403 790 661
WE ARE EXHIBITING AT
AUTOSPORT INTERNATIONAL
ENGINEERING SHOW
STAND NO E330
11-12 JAN 2024 NEC BIRMINGHAM
EATON Powering Business Worldwide
LEMO
NICOMATIC
HellermannTyton
Weald ELECTRONICS
MOTORSPORT CONNECTORS AND ACCESSORIES
IMMEDIATE DESPATCH OR RAPID ASSEMBLY

Cool to the core

Wearable driver cooling technology is becoming increasingly popular. Racecar *investigates the options currently jostling for position in the market*

By DANIEL LLOYD

Events at the Qatar Grand Prix in October 2023 sparked debate about driver safety in high temperature conditions. Williams driver, Logan Sargeant, retired from the night-time race as he struggled with 'intense dehydration', having been ill with flu during the week. Other drivers were visibly exhausted as they stepped out of their cars.

Wheeling an F1 car for 300km under high *g* forces is hard enough, but Qatar – where track temperatures remained above 36degC for the duration of the race – demonstrated that extreme ambient and surface heat can escalate driver discomfort into a potential safety risk, even for some of the world's fittest individuals. That such a situation can occur in F1 means the danger is present on all levels of the motorsport pyramid.

The normal human core body temperature is 37degC. Anything above 38degC is considered high and potentially dangerous, but it's not uncommon for drivers to exceed that number during a race. Effects of high body temperature include dehydration, dizziness, cramps and heatstroke.

Usually, it's a case of fatigue reducing a driver's performance, but serious cases can lead to hospitalisation, even death in rare cases. Instances of the latter include Carl Scarborough at the 1953 Indianapolis 500 and Bobby Isaac at a late model short track race seven years after he won the 1970 NASCAR Cup title.

'When you exercise, or drive a racecar, your core temperature is going to go up,' says Dr David Ferguson, associate professor at Michigan State University's department of kinesiology. 'The hot blood from your core will be circulated to your periphery and then transfers the heat by sweating.

'However, in a racing scenario, wearing a fire suit, you can't cool yourself so easily. You have to find a way to dissipate heat from the blood in some other way.'

Fluid loss

On the current F1 grid, drivers wear vests stuffed with ice packs to keep their body core as close to the norm as possible. Ahead of the race start, they remove the vests and rely on hydration over the next couple of hours to battle the immense fluid loss they experience.

Single-seater drivers arguably have it much harder because the use of in-race cooling technology is restricted by weight and packaging factors. Some do have downscaled systems in place, but they are rare.

In closed-cockpit categories, there is more space to fit devices that can help reduce body temperature. This has led to the emergence of a market for wearable driver cooling products that aims to improve comfort and minimise risk. Many modern, closed-roof racecars also have air conditioning, and some series like the World Endurance Championship have a maximum cockpit temperature written into the regulations.

A helmet cooler blows cold air over the driver's head, although core body temperature is the important thing to manage during hot races

This Quantum Pro ice-free cooler from Chillout Motorsports works using a micro compressor that contains up to 51.7ml of freon. Some of the unit's command functions can be added to the car's dashboard for easy driver usage

There are also ways of getting right to the core, ensuring a driver's blood temperature does not rise to unsafe levels. Cooling shirts are a prevalent form of driver cooling technology, although other methods are currently being developed.

'Ice systems are where it started,' says Charles Kline, founder of Chillout Motorsports, which produces a range of cooling shirts. 'It was great because that's all there was, but it was a 30lb cooler in a car full of ice and water that's sloshing around. Things have come a long way with the new systems and micro compressors we now have.'

A cooling shirt is a base layer incorporating a set of long, circular diameter, PVC tubes that cover the driver's torso. The tubes carry a fluid – typically glycol blended water – that is drawn from a cooler in which it is chilled by a rotary compressor and connected to the car's power supply or a battery. In a NASCAR, the cooler is mounted behind the driver's seat, while in a GT car it typically sits adjacent to the driver in the 'passenger' compartment.

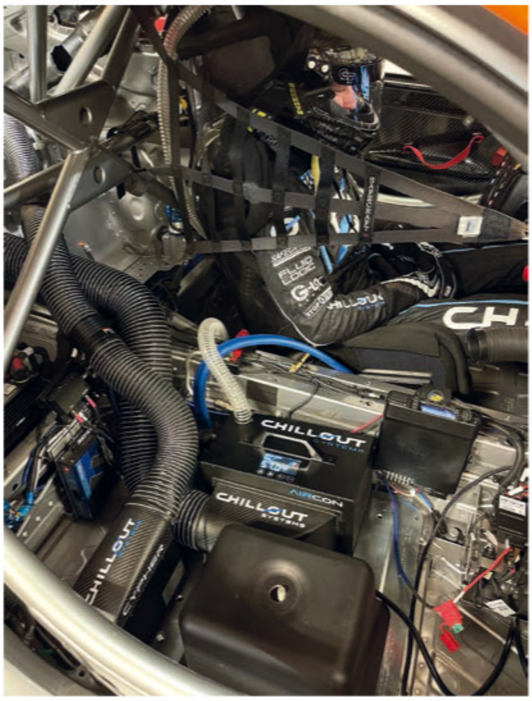
Chillout Motorsports' Quantum Pro cooler draws 18-20A and weighs 4.7kg.

XPB

Several drivers were visibly struggling with heat exhaustion after a gruelling Qatar Grand Prix held in high temperatures

Anything above 38degC is considered high and potentially dangerous, but it's not uncommon for drivers to exceed that number during a race

This Rini Technologies cooling shirt uses technology that was initially developed for the military. The fluid tubes are insulated from the body and have a quick-release connector, allowing for fast egress in an emergency situation



Chillout Motorsports

Example of how a shirt or helmet cooler can be fitted in a GT car's cockpit. Weight and space factors are important considerations

An updated version called the Cypher Pro weighs only 2.5kg and is intended for more weight-sensitive applications. Both are designed to keep the core body temperature at a consistent, safe level.

'If you introduce a temperature that's too cold to your skin, your body's way of protecting itself from hypothermia is to shut the blood flow down,' says Kline. 'So it's counterproductive to run [the cooling system] too cold.

'55degF [12.7degC] means, for most people, that you're not getting that tingling feeling, you're still getting blood flow to those areas. Your heart is then pumping all that cool blood through your body and keeping your core cool. It's more efficient than ice, as crazy at that sounds.

'We want to have as much surface area of the body covered as we can, so we can pull the heat away and exchange it out the back of the system.'

'If you introduce a temperature that's too cold to your skin, your body's way of protecting itself from hypothermia is to shut the blood flow down, so it's counterproductive to run [the cooling system] too cold

Charles Kline, founder of Chillout Motorsports

Military origins

Cooling shirts have arisen in motorsport over the last decade or so, but their roots can be traced to other industries, including military.

Florida-based Rini Technologies initially provided cooling shirts with small, transportable battery packs to American troops, helping them keep cool on high intensity combat missions. It then expanded into the civilian market, developing a motorsport cooler that works in a similar way to the Chillout one, by drawing in air and using a compressor to cool the liquid. Notably, the Rini system generates a smaller 10A electrical current, and is 1.6kg lighter than the Chillout Quantum Pro.

Cobra has lined one of its racing seats with Walero's base layer material to help regulate driver temperature

'We're a military company,' says Alejandro Hernandez, lead engineer of auto systems at Rini Technologies. 'We make these for hazmat suits and Blackhawk pilots, so it has to be light.

'That's where we started, but then six years ago, we received a call from Jimmie Johnson's crew chief [Chad Knaus] because he had heatstroke at a race. We sent him a set, and he was the first NASCAR guy to get it. We had a few guys in IMSA who tried it here and there but, once [Johnson] got it, it became [more common].'

Rini Technologies is affiliated with American equipment distributor, HMS Motorsport, which also counts British racewear supplier, Walero, among its clients. Walero produces antimicrobial base layers that regulate driver temperature without circulating cold liquid, saving the need for tubes and heavy coolers.

In 2019, *Racecar* reported on a simulator test at Cranfield University that saw the driver register lower levels of temperature increase, sweating and heart rate when using a Walero base layer compared to a standard Nomex one. Walero has also teamed up with Cobra to line its innovative material in race seats.

'The garments have a phase-change material inherent in them,' says Fiona James, a former driver who founded Walero in 2015. 'It's got nano capsules made by Outlast called Thermocules, which were originally developed for astronauts at NASA who go through extreme temperature changes. This actively regulates your temperature, meaning you get less heat stress because you're sweating less. Heart rate and respiration rates are lower too, and all of that can lead to


CHILLOUT
MOTORSPORTS
AIRCON
CHILLOUT SYSTEMS
LIGHTWEIGHT
FROM 2.1Kg!!
QUANTUM PRO
QUANTUM V3
HOW COLD? ICE COLD.
CUTTING EDGE DRIVER COOLING DESIGNED FOR RACING
sfi
APPROVED
COOLING SOLUTIONS FOR ALL LEVELS OF MOTORSPORT
NEW LEVEL OF FOCUS
FASTER LAP TIMES
INCREASED STAMINA
REDUCE PERSPERATION
DECREASE HEART RATE
INCREASE SAFETY
CHILLOUTMOTORSPORTS.COM
INFO@CHILLOUTSYSTEMS.COM
+1-404-695-0439
@CHILLOUTMOTORSPORTS
CHILLOUT MOTORSPORTS

improved lap times because they are more consistent due to reduced heat stress.'

Considering their shared American distributor, Rini and Walero are in the early stages of looking at how drivers could benefit from a double effect of active cooling and temperature regulation.

Seal of approval

Chillout Motorsports and Rini Technologies both have SFI certification for their cooling shirts and are currently working towards FIA approval, but one American company is already there.

Coolshirt Systems and OMP jointly produce a tubed cooling shirt connected to an ice-based cooler. OMP supplies the fireproof garment before Coolshirt integrates the cooling system. Its FIA homologation has been in place for about a decade and has kept up with some revisions along the way.

'The FIA is always updating its standards,' says Coolshirt director of operations, Jeremy Ellis, 'and any time they do, we have to go back through the homologation process.

'For example, the cooling tubes have to be completely covered by protected, fire-retardant material so, if the tubing were to burst, the steam wouldn't cause severe burns. Whereas on SFI shirts, the tubing can be directly against your skin.

'The fittings on the shirts must also have a quick release.'

Coolshirt Systems has its fingers in many pies, not just motorsport. Its cooling shirts can also be found on hospital patients, firefighters, nuclear power station engineers and even costumed mascots at theme parks.

In racing, the company used to sell compressor-based systems but now focusses on ice coolers because of challenges in bringing the price of the former down to a competitive level. Ice-based cooling is seen as an outdated method by those who develop compressor systems, but Ellis is keen to point out that any limitations can be addressed, and that it can still be a cost-effective option for grassroots drivers.

'It's using ice and water with pumps that send it through tubes and cool the body,' he says. 'We've been in business a long time, and one thing we kept seeing happen, especially in endurance racing, is crew guys freezing blocks of ice and throwing them in the coolers. If you throw a 5lb block in, sometimes it's going to hit that pump. We've seen it crack pumps, so we designed a shroud for the pump.

'Another thing we came out with in 2015 is a warm water return line. Until then, the water was pumped out and came in on the same side of the cooler. So effectively you were dumping the warm water from your body right back on top of the pump. We re-routed that water to go to the other side of the cooler, as far away from the pump as we could get, and we saw about a two-degree difference in water temperature. Not huge but, by the end of a race, that is pretty efficient.'

The pattern of tubes that puts the 'cool' in cooling shirt. These must be fireproof and cannot touch the skin to satisfy FIA 8856-2000

Cold under the collar

A cooling shirt enables core body temperature to be managed during a stint, but there is another type of driver cooling technology that takes a different approach.

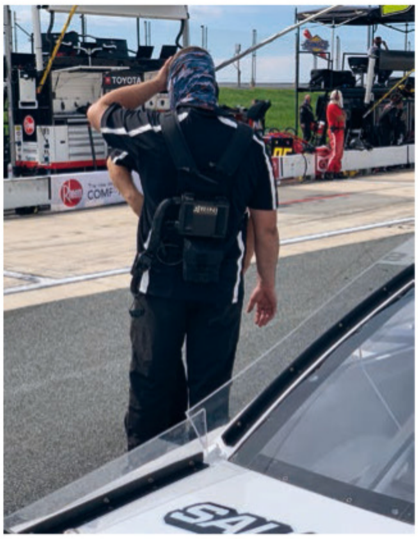
Italian distributor, Aviorace, is bringing to market a thermoelectric cooling collar that a driver wears before and after their turn behind the wheel. Its purpose is to lower the temperature of blood moving to the brain.

The collar, developed by Neuron Guard for the medical industry, is made of a fabric that contains graphene and includes two strapped-in Peltier cells. A battery power unit provides electrical charge to the cells through a tube, and contains a pump that encourages cooling fluid along the same route. The electrical current follows two small outer culverts of the tube, while a large middle culvert carries the liquid.

A thermoelectric effect inside the cells, instigated by the electrical current, creates a cold surface to each cell that emanates through the collar and onto the driver's neck.

The temperature of the cell can be programmed to as low as 5degC, using a mobile phone app connected to the power unit via Bluetooth.

5degC might seem frigid, but the sensation is said to be dull and soothing, rather than shocking. According to Aviorace commercial director, Lidio Patrizio, the feeling gradually wanes for 30 to 40 minutes after the driver removes the collar and gets behind the wheel, in cockpit temperatures of around 45-50degC. By the end of the stint, the effect has worn off completely and the driver is hot again, but soon re-adjusts to a normal body temperature by returning to the collar.



Rini Technologies

Cooling shirts aren't solely the domain of racing drivers; pit crew members work in extreme temperatures too

Aviorace is bringing to market a thermoelectric cooling collar that a driver wears before and after their turn behind the wheel. Its purpose is to lower the temperature of blood moving to the brain

DRIVER COOLING

BENEFITS:

- Mitigates heat stress
- Reduces dehydration risk
- Enhances driving effectiveness
- Light weight, High efficiency
- Continuous operation

MADE IN USA

RINI TECHNOLOGIES

SYSTEM	SIZE	WEIGHT	POWER DRAW
PCS AUTO	3" x 5" x 6.5"	4 lbs.	6 Amps
DRCS (2X Cooling of PCS Auto)	3.5" x 7" x 8"	7 lbs.	10 Amps
Helmet Cooler (Only with DRCS)	3.5" OD x 14.5"	3.6 lbs.	2 Amps

407/359.7138 • sales@rinitech.com

AVIO RACE USA

OFFICIAL DISTRIBUTOR

Neuron Guard

McLaren APPLIED

Variohm Eurosensor

FG91 FASTREAM

TE connectivity

AvioRace USA is committed to delivering cutting-edge solutions that elevate performance. As they distribute top-tier products such as TE Connectivity connectors, McLaren Applied and Variohm Eurosensors sensors, along with the FG91 Fastream streaming platform, AvioRace USA is now enlarging its range of products, reflecting their dedication to providing innovative solutions for optimal performance.

One of the latest product that is present in **AvioRace USA** portfolio is: CB70 system from Neuron Guard.

Exposure to heat stress impairs cognitive performance, with potential reductions of up to -26% in complex activities. Neuron Guard has developed a miniaturized brain temperature management system, inspired by the CB240_Aurora, offering a portable solution. Tested in motorsports since 2017, the technology is being refined in collaboration with Wayne Taylor Racing, Andretti Autosport, and Dr. David Ferguson. Neuron Guard aims to provide effective temperature management for critical workers, beyond motorsports, enhancing both performance and safety in challenging environments.

www.avioraceusa.com
info@avioraceusa.com
150 Ostwalt Amity Rd,Bldg: D-101, Troutman, NC 28166

'It's a completely different mindset compared to cool shirts or air conditioning systems that comes from the experience of post-surgery activities,' says Patrizio. 'A bigger version of the machine has been developed for hospitals and works by cooling down the patient's blood after a long surgery. It stabilises temperatures when they are in the recovery situation, before they wake up, and avoids the risk of brain troubles.'

With that foundation in place, Neuron Guard started working with Dr Ferguson from Michigan State as it sought to expand into new industries. A sports science expert, Ferguson has been working with IMSA front runner, Wayne Taylor Racing with Andretti Autosport, to improve the human side of its performance. Last year, WTR Andretti received two Neuron Guard units, one for the drivers and one for pit crew. Aviorace now hopes to turn the collar into a marketable product that will infiltrate the driver cooling market, which is currently dominated by shirts.

'The minute you get in a hot racecar, your core temperature is going to go up,' says Ferguson. 'The goal of pre-cooling is to keep you at 37degC so that when you get in the racecar, it takes longer for the body to hit the higher core temperatures.'

Split opinions

As the Neuron Guard / Aviorace example shows, there are different schools of thought when it comes to active driver cooling. But what is the most effective approach?

Besides shirts and collars, there are examples of air-cooled helmets on the market, where the helmet is fed with cold air from a tube connected to a cooler. The technology no doubt fosters a state of constant relief, like sitting next to a fan in a hot room, but it doesn't address the issue of core body temperature management.

Rick Dole / IMSA

IMSA prototype team WTR Andretti has been willing to try out new driver technologies for its GTP lineup, including cooling systems

While the cooling shirt is better at cooling the blood, Ferguson believes the method still has some limitations.

'Cool shirts circulate cool fluid into the shirt and onto the chest. That phenomenon will keep your core body temperature down. However, shirts fail about 40 per cent of the time. If the shirts have not been serviced, the coolant being circulated will eventually degrade the tube. Another reason is that the pump can only operate in a certain temperature range. So, if you're in a really hot racecar, and exceed that temperature, you're pumping hot water onto the driver's chest, and actually putting heat into the driver.'

Proper servicing comes down to the user, with some supplier touch points weaved in. Ellis acknowledges that tubes are prone to moulding, although the use of glycol blends and, for Coolshirt Systems, two drops of 'maintenance additive' in the cooler helps keep things clean.

'The goal of pre-cooling is to keep you at 37degC so that when you get in the racecar, it takes longer for the body to hit the higher core temperatures'

Dr David Ferguson, associate professor at Michigan State University's department of kinesiology

Draining the shirt for a day or two after usage is another important preventative step.

As for cooler maintenance, Ellis has encountered issues with compressors in the past, but the level of competition in the marketplace keeps the manufacturers of those products busy on ensuring reliability.

'If the compressor fails, the pump is separate from it, so the pump is still going to circulate that fluid,' says Ellis, 'but if the compressor is not chilling that water, the circulation is going to get hotter and hotter. For the same reason that in an ice-based system, your body temperature is transferring to the fluid.'

Room for improvement

It certainly appears there is room for improvement in all aspects of driver cooling, whether it's reducing cooler weight or enhancing durability. However, the level of competition in the market and the different approaches currently available suggest the technology has high potential to progress further in the future.

After Qatar, the FIA announced it would explore further ways of protecting F1 drivers in extreme climatic conditions. In December, its World Council confirmed teams next year will be permitted to install a 'cooling scoop' on their cars. Clearly, engineering is at the heart of minimising risk when it comes to dealing with high temperatures.

The Neuron Guard collar cools blood in the carotid artery. The wearer then has remote control over the temperature via their mobile device


GET THE EDGE
WALERO
No one else gives you performance and comfort.
Temperature regulation when the heat is on, and warmth when it's not.
Flame protection, and total peace of mind. Anti-microbial technology
to keep you fresh, and superior tailoring to keep you feeling it.
Walero. Designed, tested and relied on by racing drivers.
www.walero.uk
WALERO


SPORTECH
ENGINEERING
Sportech Engineering is proud supplier to
52 FIA WORLD TITLE WINNERS
www.sportech-engineering.com
DNV
TAILORED STEERING SYSTEMS
• Hydraulic power steering racks (prototype and from OEM) • Manual steering racks • Repackaging of electric power steering racks
• Hydraulic pumps • Electro hydraulic pumps (12V and 48V) • Ball joints
WRC | RALLY 2 | WRX | WTCR | GT | DAKAR | HYPER CARS | OFF ROAD | MOTORSPORT AND EXTREME ELECTRIC VEHICLES

The four that flew

From every angle, the Ferrari 750 Monza of 1955 onward was a handsome machine, with body by Scaglietti to Dino Ferrari's design

Aurelio Lampredi's concept for a four-cylinder sports racecar to compete in the world's best long-distance events broke all the rules, and took some of the sport's great talents with it

By KARL LUDVIGSEN

Hot on the heels of its creation of the World Drivers' Championship in 1950, the FIA turned its attention to sportscar racing. Endurance races like Le Mans and the Mille Miglia were acknowledged as great classics, but no championship linked them in a manner that might excite both racing fans and participants. That changed for the better in 1953 with the FIA's establishment of the World Sportscar Championship. Rightly enough it was for car makers, not drivers.

Here was fresh inspiration for the world's builders of sports racing cars: Jaguar, Aston Martin, Cunningham and Mercedes-Benz took notice. In the new trophy's first season, 1953, points were awarded for finishes in the Sebring 12 Hours, Mille Miglia, Le Mans 24 Hours, Spa 24 Hours, Nürburgring 1000 Kilometres, Tourist Trophy and Carrera Panamericana. While the races in Florida and Mexico were newcomers, the others were already great international events. Success in the new championship would surely bring major kudos and act as a spur to sales. How would Ferrari respond to this new challenge and opportunity?

By the end of 1953, Maranello had its answer ready. Having benefited from chief engineer, Aurelio Lampredi's, punchy four-cylinder engines in his grand prix cars, Enzo Ferrari approved Lampredi's plan to extend the technology to larger dimensions for a new 3.0-litre sports racer. This continued the gradual enlargement that began in 1952 with a 2.5-litre four for the Type 625, in preparation for the new grand prix formula coming in 1954. Such engines were installed in two Vignale-bodied spyders that had brief racing careers in Europe in 1953 before being sold to South America.

Type 735S

An even bigger four, nearing three litres, was installed in an open sports racer bodied by Modena's Autodromo to a design by Lampredi. Making a transition to Lampredi's definitive four, still using the original architecture, this was known as the Type 735S. It had 102 x 90 mm dimensions for 2942cc and produced 225bhp at 6800rpm. Early cars had bodies by Autodromo, Vignale and Pininfarina.

A spyder version of this Type 735S made a promising appearance at Senigallia on 9 August 1953. Thereafter, Alberto Ascari drove a sister car at Monza but crashed when avoiding another car. In January of 1954, the Senigallia 735S was taken to an endurance race in Buenos Aires, where it had the measure of one of the 4.5-litre Ferrari 12s until the four's torque shattered its final drive after a pit stop. A newly built 735S was driven to a conservative fifth place.

Impressive showing

Early in 1954, Lampredi developed the new model in parallel with Ferrari's struggles with Mercedes-Benz on the Formula 1 circuit. For a warm-up on 22 May, Clemente Biondetti won the three-hour race at Bari. The full Type 750's first racing appearance was on 27 June 1954 at Monza, where Mike Hawthorn and Umberto Maglioli took first and Gonzalez / Trintignant second in the 1000km Supercortemaggiore sportscar race.

In its 735S format, the Monza was to be was raced at that circuit by Alberto Ascari. Its body was fashioned by Autodromo, which coachbuilt several of the early Ferrari models

At the beginning of its production in 1954, a few Monzas were bodied by Pininfarina to this more tailored design, which featured several interesting surface treatments

Enzo Ferrari approved Lampredi's plan to extend the [four cylinder] technology to larger dimensions for a new 3.0-litre sports racer

In the light of this impressive showing, the newly christened 'Monza' was overhauled for a tranche of production in the winter of 1954 / '55.

The main line of development was via its engine, which the Ferrari drawing office called Type 105. In classic Lampredi style, its head and cylinders were integrated in an aluminium casting that included the ports, combustion chambers and water jackets, but not the cylinders. These were separate iron castings and screwed up into the chambers. Dimensions were 103 x 90mm, daringly close to the Class D limit at 2999.6cc.

By any standards this was a remarkable engine. Here was a four-cylinder unit with as much swept volume as many of Ferrari's 12s. A 12-cylinder engine of similar cylinder size would displace nine litres. Not since the years before World War I had a serious European racecar been powered by such a huge four-cylinder engine.

As a big four, its only rival in the 1950s racing world was America's Meyer-Drake Offenhauser, whose bore size of 4.375in / 111.1mm was only slightly larger than that of this astonishing Ferrari.

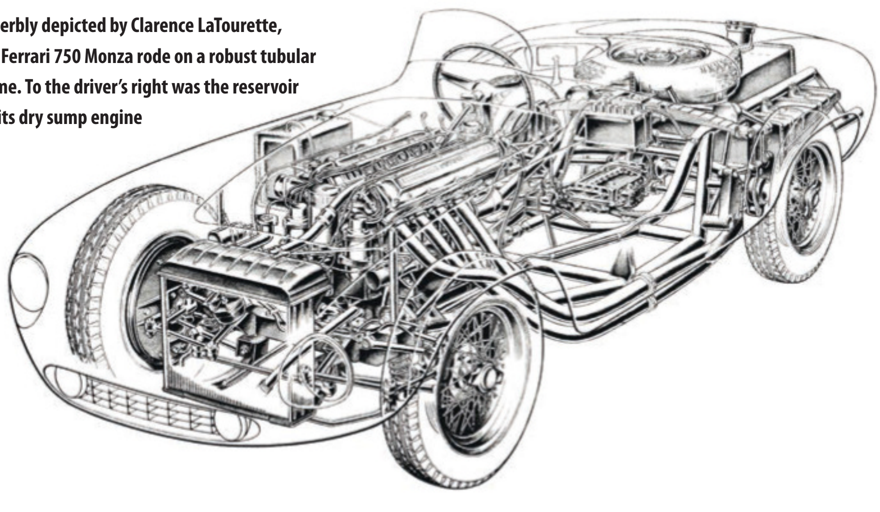
Unfashionable in the '50s

While the Offy boasted four valves per cylinder, which was unfashionable in Europe in the 1950s, the Monza made do with two vast valves. 50mm inlets were inclined at 45 degrees from the vertical and 46mm exhausts sloped at 40 degrees, the latter having sodium-filled stems. The combustion chamber was a modified hemisphere with dedicated contouring around its two spark plug holes.

Lampredi's proven techniques were incorporated in the Monza's elaborate valve gear. Placed in a fore and aft plane, twin clothespin springs closed the valves through a collar retained by split keepers.

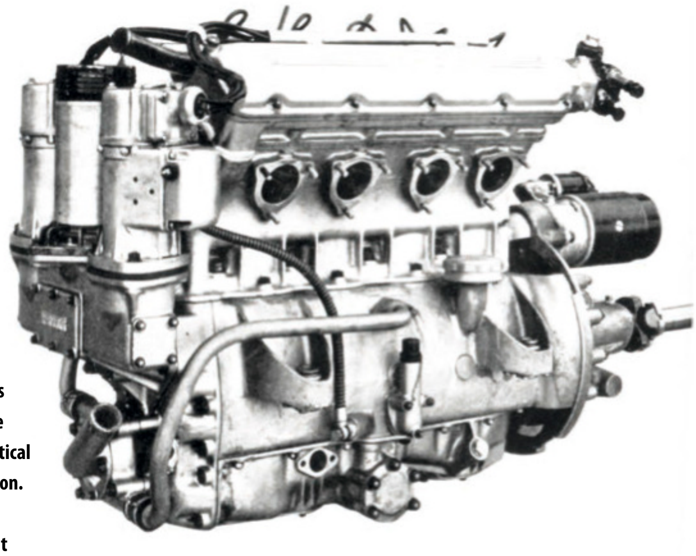
Above this, the tappets and camshaft were carried in separate, cast, light alloy boxes. Accounting for the unusually high and wide Monza cam boxes, the separate tappet boxes allowed thorough lubrication of cam and followers without forcing leakage down the valve stems.

T-shaped in cross section, light alloy tappets were guided by their stems and carried narrow rollers that protruded only slightly from their wide tops. Lower parts of the rollers rode in vertical slots, preventing them from rotating.

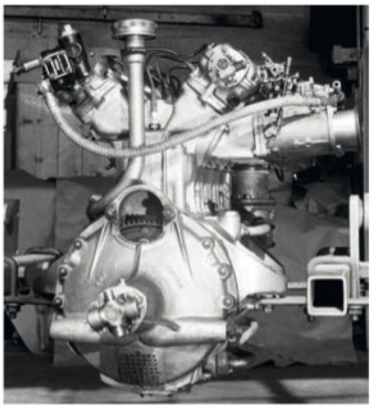


Superbly depicted by Clarence LaTourette, the Ferrari 750 Monza rode on a robust tubular frame. To the driver's right was the reservoir for its dry sump engine

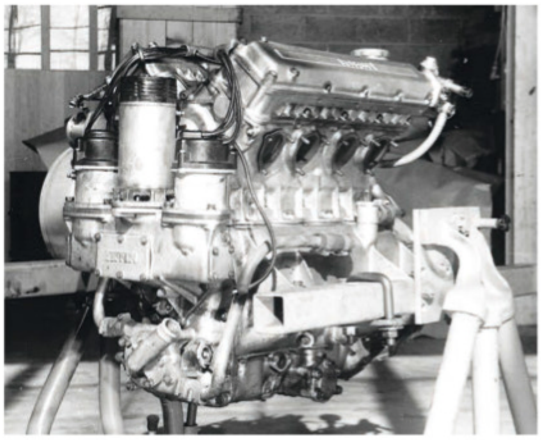
In classic Lampredi style, its head and cylinders were integrated in an aluminium casting that included the ports, combustion chambers and water jackets, but not the cylinders themselves



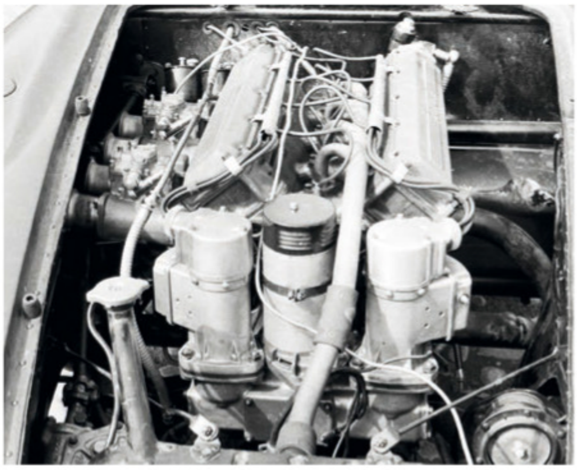
Two views of the Monza's 3.0-litre four showed the dynamo between its vertical magnetos for dual ignition. Oil pumps are external, mounted low at the front



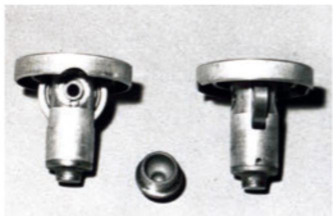
Below the opening for its starter motor, the 750 Monza had its clutch and a simple universal joint that connected to its propshaft



Ferrari's Monza four showed off its combined cylinder block and head, the steel cylinders being screwed into the head from below



So wide is the Monza's cam box that some take it for a vee engine. It served to allow valves and ports of considerable size



The 750 Monza's roller tappet was embedded below a circular top whose periphery accepted coil springs that served to close the tappet in action

A pair of concentric coil springs acted against each tappet only, leaving the clothespin springs to cope solely with the valves. This belt-and-braces system kept the valves in contact with cam lobes 3/8in wide that provided 310 degrees of inlet duration and 98 degrees of overlap. Induction was by two Weber 58DCOA3 twin-throat carburettors, the largest Weber made for cars, fitted with 44mm venturis. A heavy throttle linkage cross shaft was carried in two ball bearings.

Efficiency drive

Paul Frère quoted a volumetric efficiency of over 100 per cent at 5000rpm for the similarly equipped Ferrari grand prix engine, which would have been approached by careful intake and exhaust tuning on the Monza. Short, angled aluminium pipes connected the gas works to their ports and exhaust porting was impressive, the outer opening being flared considerably from the size at the valve.

The head / cylinder assembly bolted directly to the very deep Silumin crankcase, with rubber o-rings forming water seals at the bottoms of the individual cylinders. Solid webbing supported each of the five 60mm main bearings, while the Monza's forged steel crankshaft carried 50mm big end journals and no elaborate balance weights.

Connecting rods were short and simple, the sides of the I-section centres being perfect tangents to the outer diameter of the wrist pin end. Two bolts retained the big end cap, while the fully floating wrist pin received lubrication from splash alone. Pistons were completely skirted and carried two compression and two oil rings, one of the latter below the wrist pin.

An aluminium cover at the engine's front concealed the accessory and camshaft drivetrain of 3/8in wide spur gears. Upper gears dealt with the cams, while the water and oil pumps were placed low down at the front.

Lubrication was dry sump, two screened pickups scavenging the front and rear of the intricately finned aluminium pan. The scavenging pump had two idlers to ensure it kept up with demand. It delivered to a rivetted tank on the right-hand side.

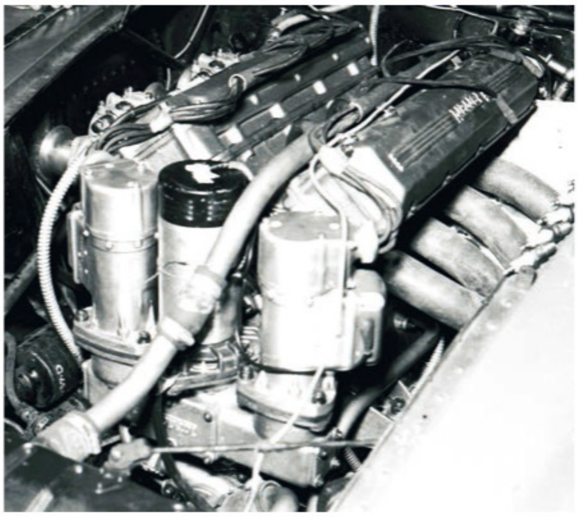
A single idler pressure pump drew from the reserve and replenished the mains through a sump-mounted, full-flow filter. Typically, Lampredi relied heavily on external and internal piping to carry oil around, not wanting to encumber his crankcases with too many cast or drilled-in passages.

Keeping cool

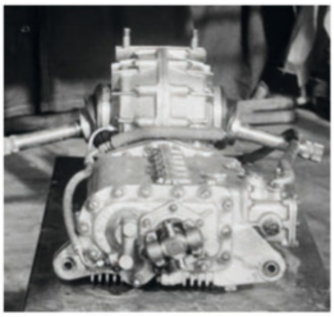
Simplicity marked the Monza's cooling system, which was kept in motion by a twin-outlet pump adjacent to the scavenged oil supply. Drawing from the bottom of the gilled tube radiator, the pump sent the coolest water to both

In the transition from the 735S to the 750, the peak power speed was cut back from 6800 to 6400rpm, the latter giving 260bhp with a 9.0:1 compression ratio

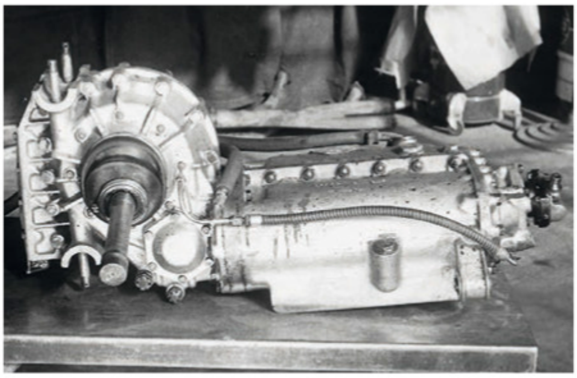
Embedded in its chassis, the Ferrari 750 Monza engine sat well back to provide racecar weight distribution



Generously dimensioned exhaust pipes blend gracefully into two pipes for cylinders one and four and two and three, before contracting into a large single pipe ahead of the rear wheels



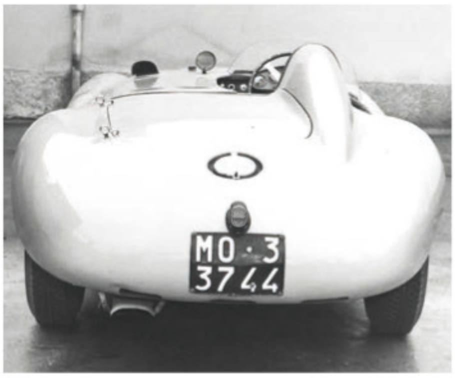
A front view of the 750 Monza transaxle reveals its shallow placing of two shafts side by side and the shift control, having only a short run forward to the lever



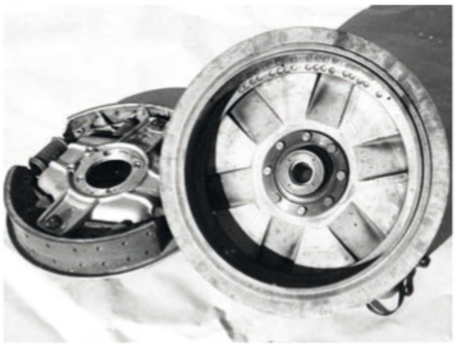
Transaxle side view shows its intermediate transverse gearing to the final drive and, at left, the vertical guide for lateral location of the de Dion tube

Robust radius rods (which sat parallel when under tension on the car) guided the 750 Monza's de Dion tube, with absorption taken care of by Houdaille rotary dampers

Room was saved above the 750 Monza's fuel tank for its mandatory spare wheel. Tyres are, naturally, Pirelli Corsa



The first 750 Monza with its final bodywork wore a Modena number plate when it went about its testing routine



While six exits centrifuged hot air out of the Monza's brakes, the backing plate shows the central guides for each brake shoe and double acting hydraulic wheel cylinders

sides of the crankcase, where it absorbed heat from the main bearings. From there, it rose past the cylinders to outlets above each combustion chamber, so the water was at its warmest when it reaches the exhaust valves, which do not receive a high velocity cooling stream, vindicating the use of sodium-filled valve stems.

An extension from the cam gear train bevel drove a cross shaft within a magnesium box at the engine front. Further bevels rotated the central 12V generator and the Marelli distributors at each side (earlier cars used magnetos, while some of the grand prix cars used this bottom end with a cover plate in place of the generator). Coil ignition was ultimately deemed better for the Monza's more moderate revs.

A Fimac mechanical pump driven from the rear of the exhaust camshaft supplied fuel to the back end of the carburettor system, while the front end was supplied by a rear-mounted Autolex electric pump. Four rubber mountings suspended the rivetted-aluminum fuel tank.

In the transition from the 735S to the 750, peak power speed was cut back from 6800 to 6400rpm, the latter giving 260bhp with a 9.0:1 compression ratio. Nevertheless, the four big pistons continued to impose a high level of stress on the rest of the engine and drivetrain. Its construction was such that it could compete well in a 12-hour race but was seldom asked to survive the day-long Le Mans.

Placed just ahead of the final-drive gears, the transmission was split vertically in line with the mainshaft and carried the countershaft on the right and the selector mechanism on the left. Dog clutches engaged constant mesh gears in the top four of the five speeds, while a jointed shaft transmitted the driver's desires from the centrally placed shift tower. A compact conventional gate was used, with a reverse blocking latch.

A few of the early-type Monzas had four-speed 'boxes, but the five-speed version was ready in time for early 1955 use on both the Monza and the Type 625 grand prix car.

Structural base

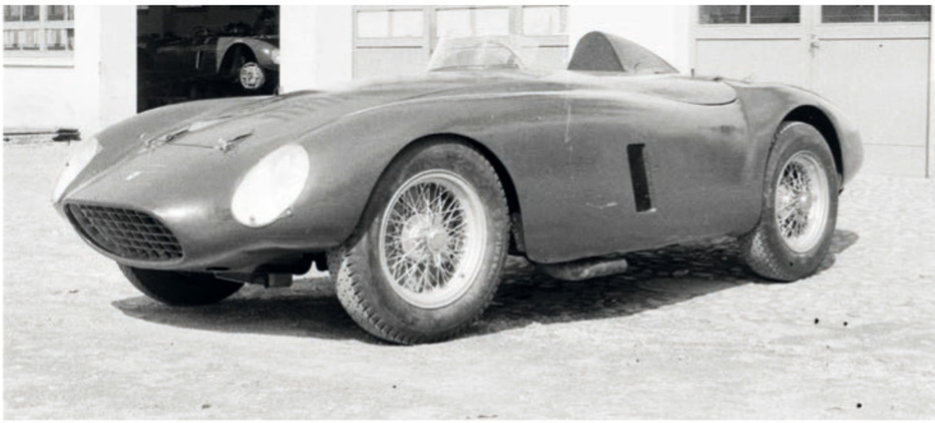
Ferrari's early angled-tube chassis experiments were refined into a smoothly contoured structural base for the Monza. Two oval section tubes were the main members, cross linked and integrated into the body by many smaller steel tubes.

Rear suspension was de Dion, its 2.5in steel axle tube curving behind the differential and connecting the fabricated hubs. At the tube centre, a ball carried a square bronze block vertically between steel plates in the back of the differential casing to locate the tube laterally. In the mode made good by Aurelio Lampredi, two parallel radius arms on each side guided the tube and absorbed braking torque. Since each set of arms forms a parallelogram, vertical movement of one end of the tube produced no twisting moment between hubs so floating mountings are avoided. Rubber bushings were used at the chassis connections, while the axle ends of the arms had ball joints.

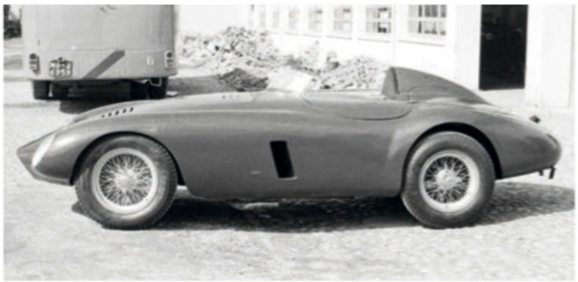
Frame mounted above the axle casing, a transverse leaf spring was connected to the hubs by long drop shackles. Rubber buffers acting against the de Dion tube limited jounce while dampers were Houdaille vane type.

The early Monza front suspensions also used transverse leaf springs, as was then current on the GP cars but, after Barcelona in 1954 proved the superiority of a coil layout on the Squalo Ferrari, a switch to coils was made on the parallel wishbone suspension of all Maranello models.

Front suspension geometry gave a roll centre near ground level. Thanks to an anti-roll bar, more

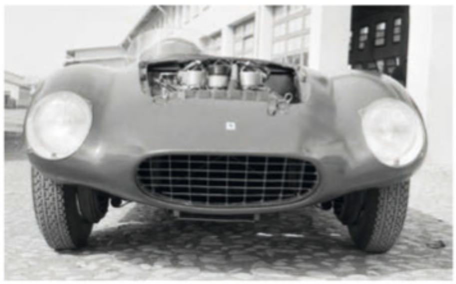


When Enzo Ferrari invited Rodolfo Mailander to photograph his new Type 750 Sport, it wasn't quite finished, as the lack of a complete exhaust pipe indicates



Though often obscured by racing paint schemes, this view of the 750 Monza shows off its fabulously curvaceous lines, mooted by Dino Ferrari and perfected by Scaglietti

Nominally 6.00 x 16, the rear tyres of this first 750 look larger sectioned – a bold attempt to deliver its higher power output effectively to the road



Serial numbered 0440M, this first of the Ferrari 750s lifted its skirts to deliver more air to its front brakes and minimise engine cooling airflow

In what had become a Maranello tradition, the 750's instruments were gathered together neatly in an aerodynamic nacelle, easily scanned by a busy driver

In its first long-distance race effort, Ferrari 750 number 0440M competed in the Reims 12 Hours on 7 July 1954. With Maglioli and Manzon onboard, it failed to finish

Chassis number 0440M looking poised to lunge past the no.57 Maserati A6GCS/2000. Hawthorn, driving, and Trintignant won the 1954 Tourist Trophy at Dundrod

Scaglietti fashioned saucy windscreens for Monza drivers, for whom the angled gear lever was a left-hand reach

Heading for third place in the hands of François Picard in the Coupes de Paris at Montlhéry on 17 April 1955, the 750 Monza shows off its fine shape


BURNS Stainless
CRAFTED TO WIN
THE DIAMOND STANDARD
Our customers have remarked on our quality of materials, the attention to detail in production, and exceptional customer service. Some have referred to Burns Stainless as "The Diamond Standard", and we appreciate that.
RELENTLESS INNOVATION
Burns Stainless, is dedicated to conducting extensive research and development to discover optimal performance. This ongoing pursuit begins with our proprietary X-Design Parametric Exhaust Modeling Design program. Not only does this system determine the optimal and sometimes subtle adjustments to maximize exhaust flow, but it also streamlines the design, development and production timeline.
When every bit of horsepower counts, use the handy online form: You can input the various attributes of your engine, such as port size and shape, stroke, lift dimensions, bore, and more. Once we receive this information, we utilize our program to generate the most suitable exhaust system that fulfills your unique needs.
< Scan to enter the portal.
BurnsStainless.com • 949-631-5120
BURNS Stainless


KRONTEC
HIGH PERFORMANCE COMPONENTS
Klimaneutral
Unternehmen
ClimatePartner.com/13934-2202-1001
WE INNOVATE MOTORSPORT INNOVATES US
FIRST CHOICE OF TOP-LEVEL MOTORSPORT TEAMS AND RACE SERIES
AIR JACK SYSTEM
NEW PRODUCT
STEERING WHEEL QUICK RELEASE
REFUELING SYSTEM
QUICK DISCONNECT COUPLING
NEW EQUIPMENT
SKATES (NEW PRODUCT)
ULTRASONIC FLOWMETER
RFC-FM20
COMPATIBLE WITH ALL COMMON REFUELLING SYSTEMS ON THE MARKET
RFC-89-K-LM
NEW LOCKING MECHANISM
KRONTEC MASCHINENBAU GMBH | Obertraubling, Deutschland | +49 (0) 9401 - 52530
KRONTEC DESIGN LIMITED | Swindon, England | +44 (0) 1793 - 422000
FOR MORE PRODUCT INFO
WWW.KRONTEC.DE

of the overturning couple was resisted by the front wheels, producing heavy understeer and leaving the rear wheels free to put power on the road. This, plus the limited slip differential, frame-mounted final drive gears and low rear unsprung weight gave the Monza excellent traction.

At the front of the chassis, tapered steering arms extended forward from forged stub axles and were connected by a three-piece track rod. A forward Pitman arm transferred motion from the worm and wheel steering box, balanced by a slave arm on the left-hand side. The revered Ackermann steering principle was judged inappropriate here, a trend also affecting other high-performance cars of the period. Three universal joints carried the steering column sharply around the protruding carburettors.

Racing experience was revealed by the disposition of the electrical equipment, which was readily accessible in the event of a petty breakdown. The battery was above the gearbox between the seats, while all junction boxes and relays were on a single panel under the cowl on the passenger side. Instrumentation included tachometer, ammeter, oil pressure and oil and water temperatures.

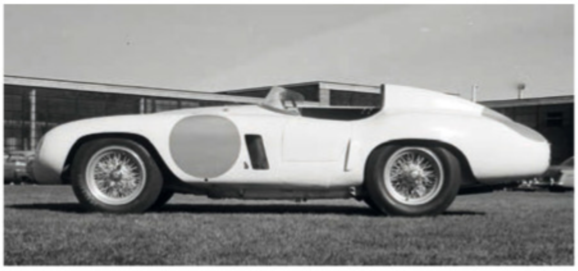
A handbrake lever was suspended on the right of the cockpit, applying the rear brakes through a cable system.

The Monza's drum brakes were of Lampredi's distinctive design, with a central guide for each shoe to balance the servo effect and wear. Two double-acting cylinders per wheel applied force equally to all four shoe ends. Radial ducts in the drum faces acted as centrifugal extractors to draw cooling air into the deeply finned drums.

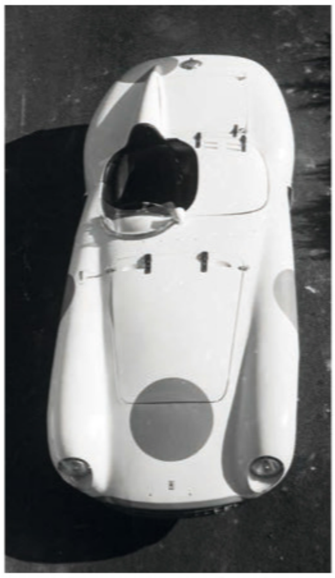
Treacherous drive

The final shape of the Monza and its smaller sister, the Mondial, was based on a concept by Enzo's son, Alfredo 'Dino' Ferrari. Executed by Sergio Scaglietti's coachworks, its splendidly aggressive lines were penetrative but susceptible to lift, especially at the rear. In combination with the Monza's heavy understeer, this promoted treacherous handling at the limit that caught out some of the world's best drivers.

Versatile Briton, Ken Wharton, was killed in a Monza crash in New Zealand early in 1957. In Sweden in 1955, the experienced Paul Frère described his Monza as, 'Like driving without suspension. There was considerable friction in



Tilp's 750 Monza displayed a new design of side scoop for rear brake cooling, and smaller rear tyres than were used on the first such car



This high perspective shot dramatises the lines of the Ferrari 750 Monza. This was chassis 0498M, bought by George Tilp for Walt Hansgen and Phil Hill to drive

A portrait of George Tilp's 750 Monza shows a purposeful-looking machine that no one wanted to see looming in their rear-view mirror

Changes from the 1954 prototype on Tilp's car were twin rear lamps instead of one in the centre and slots for cooling air

Wrangles over timekeeping relegated Allen Guiberson's new 750 Monza, chassis 0510M, driven by Hill and Shelby, to second position at Sebring on 13 March 1955

the steering, the brakes were very hard and not very efficient and understeer was monstrous.'

When qualifying, Frère understeered off the road, luckily escaping with only a broken leg. In 1960, the Belgian drove a Monza as a practice car for the Targa Florio and found 'its behaviour was completely unpredictable.' He went off the road twice and was heard to say he was 'not the only one to find himself in difficulty' with the 750 Monza.

Less fortunate was Italian star, Alberto Ascari, who was killed at Monza in a 750 that overturned at the corner that now bears his name. At the time of Ascari's death, no one dared suggest the great master might have made a mistake. Rather it was hypothesised that either his tie had flown in his face (he was testing in street clothes), that a strong crosswind had hit, that he swerved to miss a workman crossing the road, that he suffered a blackout following his accident the weekend before, that a wheel rim dug into the asphalt or that he was simply fated to die then and there.

It's more likely, however, that the Monza's deep understeer ended in a snap oversteer that not even the great Ascari could control.

That said, when driven with respect for its limits, the 750 Monza proved a lively competitor,

In combination with the Monza's heavy understeer, this [aerodynamic shape] promoted treacherous handling at the limit that caught out some of the world's best drivers

With his Monza chassis 0504M, Michel Poberejsky, who was racing at the time as 'Mike Sparken', won races at Agadir, Oulton Park and Goodwood. However, he and American co-driver Masten Gregory retired early from the 24 Hours of Le Mans in 1955

Setting a cracking pace from the start, Mike Hawthorn was always among the leaders in the BARC nine-hour race at Goodwood on 20 August 1955, but was eventually forced to retire with final drive failure

In his beautiful French blue, chassis 0520M, Louis Rosier retired at Oulton Park in 1955. The best 750 Monza performance here was second for Mike Hawthorn

its engine's rich torque range a boon to its drivers. There was no denying its lack of cylinders, though.

'In third gear, there is a permanent vibration at all revs, which makes you feel as if you have spent the day sitting on a steam hammer,' wrote Hans Tanner, who also found that 'at about 3500rpm, it sounds like a boiler factory working overtime.'

British journalist John Bolster reported: 'Although it is not smooth, the engine has an effortless feeling about it that has always been a feature of big four-cylinder units.'

Finest moments

After the Ferrari's successful debut at Monza, 1954 saw wins for José Froilán González at Portugal's Monsanto circuit on 25 July, and for Maglioli on 8 August at Senigallia on Italy's Adriatic coast. 11 September brought Mike Hawthorn and Maurice Trintignant outright victory in the demanding Tourist Trophy driving already veteran chassis 0440M. This would go down in Ferrari's history book as the model's finest achievement.

Spain's Alfonso 'Fon' de Portago failed to finish in November's Carrera Panamericana, but in December won the Bahamas Cup race and placed second in two other events. Further successes came in minor events at Agadir and Dakar in February and March of 1955.

Five Ferrari 750 Monzas contested the Oulton Park International on 27 August 1955. Masten Gregory came in fourth in his American-liveried chassis 0554M

In George Tilp's 750 Monza, number 0498M, Phil Hill won at Elkhart Lake, Seattle Seafair and Beverly Airport in 1955

An entry by Allen Guiberson at Sebring in March for Phil Hill and Carroll Shelby saw both the Ferrari and a Hawthorn / Walters Jaguar D-Type credited with 182 laps in 12 hours. The final verdict in this contested result saw the honours go to the English car. Luigi Chinetti's entry for Harry Schell and Piero Taruffi, meanwhile, placed fifth.

An important east coast customer was George Tilp, whose stable soon housed a 750 Monza. Indeed, as the '55 season matured, so did the population of Monzas in the hands of privateers. In California, Sterling Edwards decided to stop building his own cars and bought a Monza, with which he won at Bakersfield in May ahead of John von Neumann in a similar car.

Another early adopter was France's Louis Rosier, as was Swiss racer and hillclimber, Willie Daetwyler. Next door in Belgium, Jacques Swaters added 750 Monzas to his Equipe National Belge.

An important race for the Ferrari 750's namesake was the 1,000 kilometers of Supercortemaggiore at Monza on 5 May 1955. Hawthorn and Maglioli carried Ferrari's flag against Maserati's new six-cylinder 300S

The 750 Monza remains well remembered today for being the first of the Dino Ferrari body designs, and for 'sounding like a boiler factory working overtime'

in the hands of Jean Behra and Luigi Musso. The result, at an average speed of 110mph, was victory for the Maserati only 7.3 seconds ahead of the Ferrari. Monzas were also fourth and fifth, the battle between the Modena racecar makers now fully engaged.

Frustrating Maserati, however, the World Sportscar Championship went to Ferrari's Monza and its derivatives from 1954 to 1957, with the exception of 1955, when Mercedes threw a last minute 'Hail Mary' pass to take the trophy in Sicily. In 1958, the classic V12 would make a comeback.

The George Tilp Monza was still in good fettle on 4 July 1955 at Beverly Airport's SCCA National, which was won by Phil Hill in the white machine. Hill also prevailed at Elkhart Lake on 11 September. When in California, Hill drove the Monza of John von Neumann.

Elsewhere, another American driver, Masten Gregory was racing his Monza in Europe, winning at Monsanto in July.

In 1956, a newcomer named Carroll Shelby made his mark with a Monza from the Richard Hall stable. Hall's brother, Jim, then started racing the Monza in 1957.

The last of the 31 Monzas built battled it out with others in minor races in America into the 1960s. Other Ferrari engineers gave Lampredi's creation more life with still larger four-cylinder engines until the concept of the four reached its natural limit.

The 750 Monza remains well remembered today for being the first of the Dino Ferrari body designs, and for 'sounding like a boiler factory working overtime.' R

Britain's Ken Wharton raced his Ferrari 750 Monza 0514M to third place in the Australian TT at Melbourne on 25 November 1956. He stayed over to compete in the New Zealand Grand Prix in 1957 where he suffered a fatal crash

In profile, a restored Ferrari 750 Monza shows off the contours that marked a sharp change in direction for the Italian manufacturer's sports racecars

Scott Raymond (second from left) prepares to engange with Tower Motorsports drivers, Ari Balogh (left) and Kyffin Simpson (right)

Lingua franca

Exploring one of the fun, but sometimes exasperating, challenges of working with multiple racing teams

By SCOTT RAYMOND

Michael L. Levitt

Over the course of my career, I have had the good fortune of working with several teams. Some good, some not as good.

There can be many reasons for moving between teams, from career advancement to the desire to work with another type of car. Other times it is a matter of necessity, whether it be because the team has lost its budget and is shutting down, or because someone else has decided that your time with the team has come to an end (is that a polite enough way to say you've been fired?).

All the above situations have presented themselves to me over the years, and in every case the challenges associated with finding a new job don't go away completely when the ink has dried on the new contract. The next challenge that rears its head is figuring out how to work *with* the new team. Regardless of how good you are at what you do, this is probably the most difficult part of the transition.

The first instance of me being metaphorically hit in the face with a truck by this occurred earlier in my career when I worked in Champ Car. I had left the massively successful Newman-Haas Racing team for the equally successful Forsythe Racing Team.

Communication is key

At Newman-Haas, I was the assistant race engineer on Sebastian Bourdais' car, and was there for three out of four of Seb's championship wins. The team was successful, I had lots of resources at my disposal, and I am certain we were poised for continued success. So why leave? Well, at the time, Sebastian was departing to start his Formula 1 tenure at Toro Rosso, and this coincided with his race engineer moving from that position to more of a technical director / research engineer role.

With a race engineer position opening up, I figured it was the perfect time to make a move to advance my career. Unfortunately, the team had other ideas.

As with the current IndyCar chassis (which is now over a decade old), the Champ Car chassis was somewhat long in the tooth. An engineering team had more to gain from hiring an engineer from another team than promoting from within, as the outside engineer brought knowledge and experience that would help make the car faster.

As a side note, if you look at the pool of engineers in the current IndyCar series, you will notice a revolving door scenario where experienced engineers rotate from team to team, recycling knowledge about a stale technology. With Newman-Haas preferring this path, I figured it was time to look elsewhere and see if I could reach my racing goals a little bit faster.

In moving to Forsythe Racing I was to start out as an assistant race engineer, but with a clear path towards becoming a fully fledged race engineer. I was employed to work on Paul Tracy's car, which was ironic, because Paul and Seb were bitter rivals, both on and off the track.

Everything went well at the shop. The most difficult part of the job at the beginning was understanding what engineering tools the team had, and navigating a file structure I wasn't used to. Consequently, when we went to the track to do some testing, I felt like an idiotic bonehead fumbling over the simplest of tasks I'd done a thousand times before.

The telemetry workbook I was used to using to view live data wasn't working at all because the channel names Forsythe used were different. I could barely look at the car speed, and none of my maths channels worked. I felt blind, useless and unable to contribute. I actually remember saying, 'I feel like a moron. I swear I have done this before and know what I'm doing.'

Obviously, I wanted to make a good impression, but was failing miserably.

The above anecdote is a perfect example of, regardless of how talented you are, moving to a new team presents

Moving to a new team presents unexpected challenges that must be overcome before you can contribute to the goal of making a racecar go faster

XPB

Even if it is in a different series, working with the same driver (here, Sebastian Bourdais at Dale Coyne Racing in 2011) brings an element of familiarity that is very welcome to a race engineer, even if it is just in the way a car's balance and set-up is described unexpected challenges that must be overcome before you can contribute to the goal of making a racecar go faster.

The parameters that make working with a new team so difficult are numerous, and sometimes quite complex – especially for the typical engineering mind. Based on my own personal experience, I believe these factors can be broken down into the following themes: language; procedures; experience; culture; and expectations. I use the term themes here because each parameter is multi-faceted, having several components that contribute to the entirety of the problem.

In this article, I will focus on developing a fundamental understanding of why this can be difficult for an engineering mindset, and then discuss the language theme in detail. The remaining themes will be the subject of a future article.

Different mindsets

Before diving into the individual themes, let's talk about why working with a new team can be difficult for the typical engineering mind. Looking at the above themes, most of them have nothing to do with engineering, and are not technical in nature at all. The only theme that could be labelled technical in nature is procedures; the rest fall under the heading of psychology, in my opinion.

I am fortunate that my mind is somewhat capable of working within both the technical and psychological domains. Of course, this is a self-evaluation, so it is entirely possible I am completely and utterly wrong! But what is an engineer *without* a psychological mindset to do with all these touchy-feely things?

A team who works together well will often perform better than expected, due to a willingness to go the extra mile

I don't have a good answer to that question, but hopefully this article will help to at least make engineers a little more aware of what they are potentially up against.

If you're an engineer, another good option may be talking about this topic with someone on your team who is in a non-technical leadership role. For example, asking advice from a team manager may be useful, as they often have backgrounds more suited to the psychological mind. If they have a background as a mechanic, for example, it would be extremely valuable talking about how to work with the team mechanics on what language to use, how to present changes to the car and how to ensure you have their buy-in with respect to the direction you are taking on a vehicle set-up.

If it is applicable to your role on the team, discussing this directly with a chief mechanic may be even more important, as it demonstrates willingness to create a working environment founded on mutual respect.

Whenever I have taken a race engineer position with a new team, I have made it a point of priority to establish this rapport.

You say tomato, I say tomato. Or in this case, you say pit and I say box. The important bit is that you both know what it is you are referring to, and can communicate that effectively over the radio

XPB

When a car is out on track, there must be no chance of a misunderstanding over terminology. One missed pit stop because a driver didn't comprehend a command and the race can be all over

Michael L. Levitt

Rick Dole

You may be an expert in Canopy, or ChassisSim, or some other software, but if the team you are working for doesn't use the package you are familar with, you have to get up to speed, and quick

A team that works together well will often perform better than expected, due to a willingness to go the extra mile. I could probably write an entire article on this topic alone, but in short, don't underestimate the importance of your relationship with the people who are working on the car.

The good news is all these things get easier as you gain experience and mature. As long as you don't go into a new team with the belief that you are God's gift to engineering (unless you are Adrian Newey), you'll probably do fine.

Team language

I use the word language here to describe not only the vernacular of the team and drivers, but also the language and techniques the team uses to analyse data, post-process it and then communicate conclusions.

Adapting to the vernacular of a new team is not as difficult as transitioning from English to, say, German, and is more about understanding the preferences of your teammates when describing common things we come across in a racing environment. A good example of this is working in a multicultural team where people use different terminology (American English vs British English being a prime example), but also when the translation from one's native language to English is not so perfect.

The best technical example of this I have come across is whether engineers define the static toe angle of the wheel / tyre as positive out or positive in. One time when I started with a new team, I assumed the set-up value for toe was the convention I have always used (positive out) but it turned out the engineer used positive to represent toe in, so the front toe was actually inwards, something I had never experienced before.

My favourite example of a variation in pure language is the use of 'pit' vs 'box' to tell a driver it is time to come into pit lane. My preference is box, because it is clear and can only mean one thing over the radio (I once lost a race because instead a driver interpreted my request to 'pit now' as 'stay out' and consequently ran out of fuel on the next lap!) Remembering that, maybe the pit vs box conundrum is not my favourite at all.

With different teams come different drivers. In the case of endurance racing, you may end up working with one or two new drivers for long-distance events and the challenge here comes from deciphering the terms each driver uses to describe the car's balance, and then interpreting each driver's thresholds with respect to their limits of an acceptable car balance.

I've heard understeer described as push, tight, unresponsive steering, numb or some scale of the car's inability to turn or rotate, which is rarely the same as another's scale.

Michael L. Levitt

The fun part comes in getting to grips with the slang used by drivers and engineers from different backgrounds. Boots might mean something to protect your socks to you, but can mean a set of tyres to someone else. So, what do you make of a hooky differential?

Similarly, drivers may describe oversteer as loose, free, too responsive, or some self-prescribed scale of over rotation.

Once you've figured out the balance the driver is talking about, you then have to determine how much of a particular balance is too much. I ask drivers to use a -5 to +5 scale to rate oversteer (negative numbers) and understeer (positive numbers), where zero represents a neutral balance.

Maths channels

I then have a corresponding maths channel (US / OS) in the logged data that calculates understeer / oversteer with respect to the degrees of steering wheel input translated to the degrees of steer at the tyre / wheel. Some drivers want zeros across the board, while others prefer a one to 1.5 understeer balance.

Once I have correlated the driver's balance rating to a range of acceptable car balance, I can watch the US / OS maths channel live on telemetry and have an idea of the car balance before receiving any further driver feedback.

I've heard understeer described as push, tight, unresponsive steering, numb or some scale of the car's inability to turn or rotate

I recently worked with endurance driver, Charlie Eastwood, for the first time. As I went through his feedback and reviewed his ratings of car balance, I saw a lot of negative twos for a lot of the turns and corner phases. I was quite surprised, as this would have been undriveable for most of the drivers I have worked with before, but Charlie's response to that was, 'Oh no, that's fine, totally acceptable.' It seems his range is far more zoomed in than I have experienced in the past.


DESIGN DEVELOPMENT MANUFACTURE
STARTER MOTORS FLYWHEELS PRECISION MACHINING
ARk RACING
Start 2 Finish
MADE IN BRITAIN
Ark Racing excels at meeting the demands of the motorsport industry
with exceptional, high-quality Starter Motors & Flywheels.
• Starter Motors & Lightweight Flywheels
• Specialists in GT & Rally1/Rally2 Starters & Flywheels
• Fully Supported Product Development
• Contact us about Bespoke Designed Options
ARKBM 1.8kW Starter
• D.O.R. available CW + ACW
• Rear Steady Option Available
ARKBM 2.0kW Starter
• D.O.R. available CW + ACW
• Rear Steady Option Available
ARKBM 1.6kW Starter
• D.O.R. available CW + ACW
• Rear Steady Option Available
Ark Starter Motor
REBUILD/ SERVICING PACKAGE
Tested & proven at all levels of motorsport
in the world's most demanding race locations.
Ark Racing Limited | Units 8-15 Croft Street | Willenhall | WV13 2NU | United Kingdom
www.arkracing.com +44 (0)845 557 7408


LISTA STORAGE SOLUTIONS
FOR MOTORSPORT
BENEFITS
+ Proven expertise
Many years of experience equipping all areas of Motorsport
+ Completely universal
From a single mobile cabinet to full facility fit out
+ Customisation
Define your exact requirements
+ Modular design
Universal modular system
+ Top industrial quality
10 Year guarantee
CALL US NOW
OR SEND AN E-MAIL
01908 222333
info.uk@lista.com
www.lista.com
LISTA

Another fun thing is getting to grips with the slang drivers use for different things. IndyCar driver Scott McLaughlin calls tyres 'boots', and is always excited by a fresh set of them. 2003 Indianapolis 500 winner Gil de Ferran quantified the traction characteristics of the car by his ability to 'mash' the throttle, or not. Eastwood recently mentioned a 'hooky' differential, which I initially interpreted as a good thing, suggesting the car's ability to 'hook up' on throttle application Apparently, though, 'hooky' is more akin to sketchy, janky, ghetto or any other term meaning generally suspect. To compound matters further, when I was growing up, hooky meant skipping school…

Data language

The last topic I want to cover under the language theme revolves around data analysis, specifically channel names in logged vehicle data, and preferences used to view the logged data. As I mentioned at the beginning, not understanding a new team's terminology can leave you feeling blind and helpless. If the raw channel names from a data logger are different to what you have used before, the link between the workbook channels and the logged channels breaks down.

There have been times when I have had to recreate entire workbooks from scratch, building up the data plots and maths channels using the new naming convention of the team I am working with.

I even came up against this during the 2023 season, when I worked for both Wayne Taylor Racing with Andretti Autosport and Tower Motorsports. At WTR Andretti, I was doing simulation work on its Acura ARX-06 LMDh car using software called Canopy, while at Tower I was working on the ORECA 07 LMP2 car doing simulation using ChassisSim and on-track performance engineering.

I like to analyse data using specific plots and graphs, and those methods apply to most racecars, so I prefer to use the same workbooks to analyse all the data where possible. There was no way that was going to work, though, in this situation. Firstly, because the raw data from WTR Andretti and the raw data from Tower used different naming conventions for the channels and constants. Secondly, the naming conventions for the Canopy and ChassisSim outputs were different from each other, and not the same as the raw vehicle data!

I ended up creating different workbooks for the LMDh and LMP2 cars, and then used some fancy, and some crude (manual), methods to re-name the simulation outputs to match the logged data. Then, with the simulation outputs matching the logged data, I was able to overlay the two data sources and properly correlate simulations to real life.

One of the first things a new engineer in a team needs to understand is the data channel names and workbook references being used

One tactic I have used since the trauma of my Newman-Haas / Forsythe transition is to make base maths channels that effectively re-name the raw channels to common terms I use across all my analysis tools. From there, all other maths channels and data plots are based on the re-named channels. That way, all I have to do with an unfamiliar data set is change the input channels that define the re-named channels and everything magically works again.

Channel hopping

As a practical example of this, let's look at the LMP2 car I work with at Tower. The raw lateral acceleration channel from the ORECA 07's Cosworth logger is I_ACCEL_LAT, while ChassisSim uses Lateral Accel[g]. The common name I use is gLat. For the ChassisSim output, I manually re-name the channels using a text editor, so Lateral Accel[g] becomes gLatSim. Without going too far down the rabbit hole, just believe me when I say I need separate input names for logged data and sim data (which reminds me that I really need to write some code to automate that process).

In my analysis workbook, I have one maths channel called gLatCar that serves to re-name the ORECA channel, i.e. gLatCar = I_ACCEL_LAT. I then have another maths channel called gLat that selects either the car-based or sim-based lateral acceleration channel, depending on which channel exists in the data set. From this point, all maths channels and data plots that use lateral acceleration directly, or indirectly, just work.

As we have seen here, there is a lot more to transitioning to a new team than just securing a new job

One data company that has figured this out is MoTeC, by providing a tool where you can create channel name aliases, which greatly simplifies this process.

Clearly, there is a lot more to transitioning to a new team than just securing a new job. As engineers, we have to use a part of our brains we don't normally use to negotiate the psychological minefield of being a new member of an established culture. From there, we have to adapt and learn new languages. It's difficult, but can also be a lot of fun, especially when the guy you are working with is a Kiwi (who would kill me if I called him an Aussie) who just wants to put on a new set of boots…

OPTIMUMG vehicle dynamics solutions

TWO OPPORTUNITIES TO CONNECT THE DOTS IN RACE CAR ENGINEERING SPECIALTIES

We believe that every piece of ***knowledge shared is knowledge ²***. *That is why OptimumG was founded: to empower race teams and engineers with the knowledge and experience gained in* ***26 years of race car engineering*** *research and consulting shared in over 400 seminars.*

ADVANCED VEHICLE DYNAMICS

4 days | *950 pages binder*

This seminar is a blend of an academic course and a practical workshop inviting questions and answers as well as interactions between the participants. Previous seminar attendees have reported an increase in the quality of communication among the individual team members as well as new perspectives on race car design and development.

You will learn:

- *Vehicle dynamics fundamentals*
- *Tire testing, modeling, and analysis*
- *Aerodynamics*
- *Kinematics and compliance*
- *Lateral, and longitudinal load transfers*
- *Steady state and transient vehicle dynamics behavior*
- *Simulation and simulation validation*
- *In lab and on track testing*

DATA-DRIVEN PERFORMANCE ENGINEERING

4 days | *750 pages binder* | *guided exercises*

Learn and practice dozens of Key Performance Indicators to measure, compare, and improve cars and drivers' performance. Gain an overview of data-driven performance analysis and decision-making. Bring your laptop and be ready to put all this knowledge into practice with guided exercises.

You will learn:

- *Data Acquisition Hardware and Software*
- *Vehicle and Driver Data Analysis*
- *On-Track and Laboratory Vehicle Testing*
- *Tire & Vehicle Modeling and Simulation*
- *Practical Racing Performance Engineering*

Register now with the coupon ***"RACECAR"*** *and get 10% OFF at*
optimumg.com/rcem

LifeCheck

STAY ON TRACK AND DRIVE UP PERFORMANCE

Intuitive Part Lifing and Management software provides:

- **Reliability and results**
- **Safety reassurance**
- **Reduced costs**

Let LifeCheck manage your Component lifecycle while you concentrate on the racing

For further information contact
trenchant-tech.com/lifing

To book your FREE demo of LifeCheck call:
+44 (0)1724897318
Or email
sales@trenchant-tech.com

MIA MOTORSPORT INDUSTRY ASSOCIATION MEMBER

Racing for all

How UK-based Team Brit is widening the scope for disabled drivers to compete in all forms of motorsport

By LAWRENCE BUTCHER

Few drivers could claim to have bettered the likes of Stirling Moss, Roy Salvadori or Tony Brooks, but Archie Scott Brown, a fearsome competitor in sportscars, did just that. Clearly the equal of his peers, Scott Brown only took a single grand prix start, at Silverstone in 1956 (he was due to race at Monza that year and ran one practice session, drawing praise from none other than Juan Manuel Fangio, but the Italian racing authorities would not let him enter the race).

The reason he was denied entry? Scott Brown only had the use of one hand, a condition he'd lived with from birth (just one of the consequences of his mother contracting rubella during pregnancy). During his childhood, he underwent a host of operations on his legs, which were both shortened, leaving him standing around five feet tall. None of this impacted his ability to mix it with the very best of the 1950s racing gentry.

The point of mentioning this story is that motorsport has always been the great leveller. It is one of the very few sports where all are – ability notwithstanding – equal. A racecar doesn't see gender, race or disability, only inputs to the steering, throttle and brake.

Sadly, Scott Brown was taken before his time, while battling Masten Gregory for the lead in his Lister-Jaguar at Spa in 1958, but had he survived he would hopefully be heartened to know that attitudes towards disabilities have changed significantly for the better in the years since.

Tech development

At the forefront of current efforts to ensure racing is accessible to all is UK-based Team Brit, which is not only backing disabled drivers, but also developing technology that facilitates those with a range of disabilities to compete at all levels. It is the brainchild of team principal, Dave Player, a former

Jakob Ebrey

Through technical innovation, Team Brit has developed advanced hand control technology to enable drivers with a range of disabilities to compete on a level playing field with able-bodied racers

Team Brit's hand control system features paddles for throttle and brake and buttons for gearshift mounted on the wheel

Royal Engineer who suffered a spinal injury after leaving the armed forces.

Player initially setup KartForce, staging karting events for injured veterans, for which he developed a set of basic hand controls to fit any kart. Team Brit was a logical extension of this programme, giving drivers the chance to step up into full-sized machinery and, since 2015, the team has continually expanded, while also developing its groundbreaking assistance systems.

Hand controls

Looking at the standard road car arrangement of hand controls, these invariably take the form of a lever mechanically linked to the pedals. The driver pulls to accelerate and pushes to brake. Fine for pootling down to the supermarket; far from ideal for racing. Firstly, because the driver must take their hand off the wheel to operate the lever. Secondly, it does not allow for the fine modulation of throttle and brake needed to extract maximum pace from a racecar.

Team Brit's system places all the controls on the steering wheel and removes the mechanical link to the brake and throttle. Behind the wheel are a pair of paddles, where one would normally find the shifters on a sequential gearbox-equipped car.

‘We’re converting the electronic position of the paddle into a pneumatic pressure, and then into hydraulic pressure in the brake system’

Al Locke, engineering director at Team Brit

To allow adapted cars to race in established championships, Team Brit has fostered a close relationship with Motorsport UK and the FIA, and converted cars are issued with an adaptations passport

The right-hand paddle is the throttle, the left the brake, while gear changes are handled by buttons on the front of the wheel.

Al Locke, engineering director at the team, explains: ‘The steering wheel is the thing people see, but that’s quite easy to get right. The ergonomics of the steering wheel are fairly straightforward, the sensor etc, it’s the back end of the system that is more complex.’

Braking system

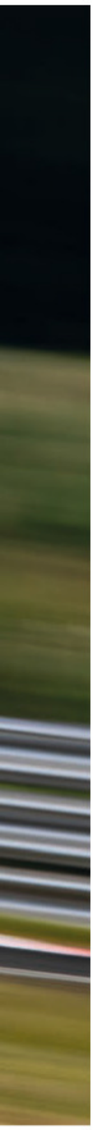
The throttle is purely a potentiometer, and drive-by-wire is nothing new. Creating a system for hand actuation of the brakes took longer to refine, and relies on a combination of electronics, pneumatics and hydraulics.

The braking paddle movement is detected by a sensor, which provides a 0-5V signal to the braking control unit. This, in turn, operates a proportional valve connected to a pneumatic actuator driving the brake master cylinder.

‘We’re converting the electronic position of the paddle into a pneumatic pressure, and then into hydraulic pressure in the brake system,’ summarises Locke.

Dan Bathie

Team Brit racers, Bobby Trundley (left), and Aaron Morgan celebrate victory in the 2023 McLaren Trophy race at the Nurbürgring



Stevie Borowick

Team Brit has had to develop much of the hardware for the braking system from scratch, working in conjunction with Slovenian company, MME Motorsport, which has extensive experience in pneumatics. It initially used an industrial proportional control valve intended for factory automation purposes to control the pneumatic actuator, but found this could not handle high vibrations over extended periods.

'We re-engineered the valve, and now use essentially the same valve and electronics but within our own casing, taking out the weak points,' explains Locke. 'We had to start with what was available, then find the faults over time and design mitigations for those.'

The valve is controlled by a dedicated micro controller that Locke describes as 'a super-reliable Arduino device, with lots of general purpose inputs and outputs,' run by algorithms written in-house by Locke and his team.

The pneumatic ram itself is a substantial piece of kit but, rather than having a housing machined from a solid billet of material, it is designed to be easily serviceable in the field.

'If it was one piece, it might be lighter, but doing it this way means if we have a failure during a race meeting, we can fix it quickly and get the car back out on track,' says Locke.

Automatic bias

The ram interfaces with a brake pedal box equipped with a bias balance bar, as one would expect. The team has developed a system with two rams and proportional valves, which can allow for automatic brake bias adjustment for drivers who may not have the ability to adjust the bias themselves.

It might seem odd to have a pneumatic actuator in the system, rather than simply use hydraulics throughout, but Locke explains the thinking: 'There are a few reasons for this. Firstly, it is very easy to accumulate pneumatic pressure in a racecar in a way that is safe, reliable and lightweight. It is not so easy to do that with hydraulic pressure.

'If you are talking about gear shifting, there isn't that much energy required, but for the forces we need – replicating a driver standing on the brakes – if you wanted to accumulate that hydraulically, in a way you can release instantaneously, that takes you into the realms of high-pressure systems and very heavy equipment.'

The pneumatics operate on a system pressure of below 10bar. This, says Locke, keeps the regulatory bodies, and the team's conscience, happy. 'What we then do is just replicate the action of a foot on a brake pedal with the pneumatic ram.'

The added bonus of this approach is that the hand control system runs in tandem with the existing braking system so, whether drivers have use of one or both legs, no adaption is needed.

'Our brains are wired to work in a linear fashion, and anything that is non-linear, or exponential, takes us much longer to figure out'

Al Locke

As you might imagine, Team Brit has made some interesting discoveries during the development of its system. 'One of the concerns we had early on was the lack of feedback from the brakes,' says Locke. 'You would assume the feedback loops the body uses are based on how hard you press the pedal. But what we found quite quickly is that is not the case. How hard you press the pedal has no relevance to your body, the only thing that matters is the deceleration rate of the car.'

An upshot was that the need to process pushing a pedal hard was removed from the equation, so drivers could adjust their braking inputs more rapidly.

'You can be more reactive, adjusting for changing grip, or the tyres going off, because you're not thinking about the force, or fatigue. You can adjust the braking force very finely by hand. The other big benefit was we could linearise the brake response.'

Linear thought

Locke points out that road car manufacturers realised a long time ago that linear throttle response was desirable, and the same is true for brakes.

'The driver is able to understand the input / output system of the car much more quickly,' he says. 'Our brains are wired to work in a linear fashion, and anything that is non-linear, or exponential, takes us much longer to figure out.'

However, Locke highlights that the ability to map brake actuation is a sensitive area when it comes to competition. 'It's an unbelievably powerful tool, to the point where we have to be careful we aren't giving our drivers a performance advantage!'

Peter Marwick

Whilst very successful at what it already does, and growing rapidly, Team Brit's ultimate aim is to field the first ever all-disabled team to race in the 24 Hours of Le Mans endurance challenge

The drivers' view

Team Brit runs drivers with a diverse range of needs in racing machinery, from hot hatches all the way up to GT4. These include drivers who have experienced disability later in life, having previously driven regular cars, as well as those who have no prior experience. So, how does the learning process differ for these drivers when getting to grips with hand controls?

Steve Crompton is currently racing in the Citroën C1 series, having previously campaigned a VW Scirocco, and was already an experienced driver when he lost the use of his legs following a car accident.

'Switching to hand controls took some getting used to. I would find myself trying to use my legs and I've had a couple of hairy moments [on the road] where I've had to stop hard, and I've automatically tried to use my legs.'

He found simulator racing helped him develop the requisite muscle memory with his hands to control the throttle and brakes and the first time he used Team Brit's controls, 'It took me five minutes to be used to it.'

For teammate Noah Cosby, an 18-year old former FMX rider who broke his back in 2022, there was no such unlearning process. Having never driven cars with regular controls, but with gaming experience, the use of hand controls came naturally to him, particularly as his motorcycle riding had already ingrained the idea of fine throttle control by hand.

Crompton even goes so far as to say there are facets of the hand controls that he feels are beneficial over pedals: 'You can be very progressive, and feather the throttle and brake at the same time very intuitively, for example when navigating a hairpin.'

However, Cosby does suggest that a degree of force feedback would be welcome. 'It is just a paddle with a spring so, when the ABS comes on, for example, you don't get the feedback you would through the pedal,' he says. Having a spinal cord injury, I can't feel what half of my body is doing, so that means it is quite hard to feel the movement of the car underneath you, which is challenging.' In response, Locke says there are ideas in the pipeline to provide the sort of feedback Cosby mentions, and that the team has already developed systems to vary the 'feel' of the brake paddle. This relies on, of all things, R/C car dampers, which provide the resistance of a spring but with the option to vary rates and damping.

James Roberts

Steve Crompton (left), Paul Fullick (centre) and Noah Cosby (right), with fellow driver, Asha Silva (standing), alongside Team Brit's newly acquired Citroën C1, its entry-level car for rookie drivers entering the sport

Peter Marwick

The team is discovering that some of its drivers, with no previous motor racing experience, find the hand controls come as second nature due to prior video gaming experience

Though the capability is there, Locke and his team have been conscious not to include any functions into the system that would automatically adjust for the inconsistencies one would find with a regular brake set up.

'Inconsistency in braking is something a racing driver should expect,' explains Locke. 'Pad knock off is a good example, and we don't account for that at all in the algorithms. If a driver is not conscious of pad knock off, they probably shouldn't be behind the wheel of a racecar.

'Our aim is to put our drivers on a level playing field with the rest of the grid. If we went to the lengths of compensating for things like brake temperature, tyre degradation, that sort of thing, we would not be fulfilling that.

'Our drivers have always been – excuse the pun – driven to perform to the best of their abilities, and to be good enough to beat someone who is able bodied. That is the normaliser, and we are very careful not to include anything that might compromise that.'

Safety net

Unsurprisingly, Team Brit has ensured there is multiple redundancy built into the hand controls, and a comprehensive warning system in place in case of issues.

'The driver is warned if there is a fault, either via the dash or steering wheel,' Locke explains. 'For example, low air pressure, or a sensor that is out of its normal range. We have a lot of fault detection with multiple sensors, much as you would with the throttle, to ensure there is no erroneous detection going on.'

There is also a back-up mechanical brake, in the form of a hand lever directly connected to the pedals. So, provided there is not a complete loss of the hydraulic system, the car can always be brought to a halt.

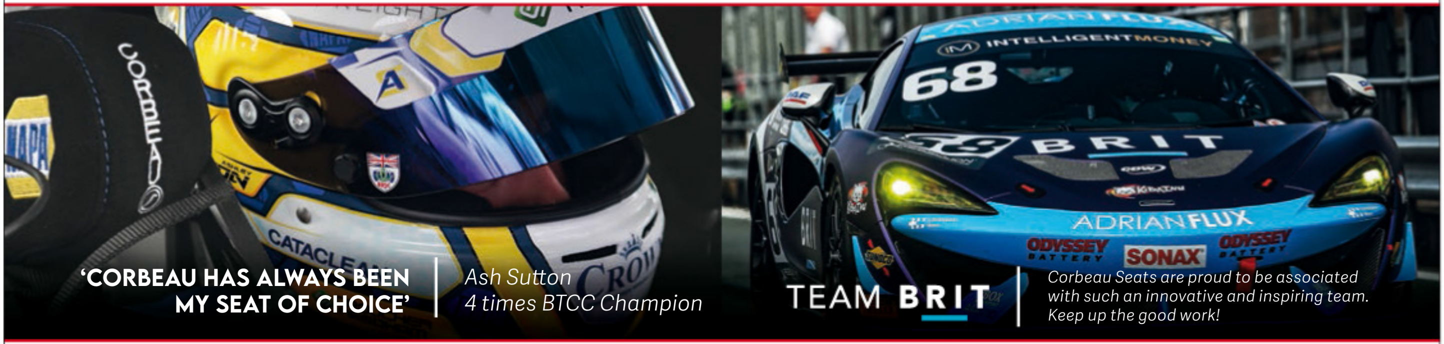
'The lever is where the hand controls would be on the driver's road car, so they have the muscle memory there already in an emergency,' notes Locke. 'We also drill the drivers on using the handbrake. When

CORBEAU

MOTORSPORT SEATS – HARNESSES

EST 1963

17 Wainwright Close
Churchfields Industrial Estate
St Leonards-on-Sea
East Sussex
TN38 9PP



corbeau-seats.com sales@corbeau-seats.com +44(0)1424 854499

FIA 8862-2009
4 Point & 6 Point Seats

FIA 8855-2021
Available in standard & large
Tall versions of both size available

Full Range of
FIA 8855-1999 Seats

6 Point Formula Harness
8853-2016

6 Point HANS Harness
8853-2016

4 Point FIA Harness
8854/98

SUPPLIERS TO

MINI CHALLENGE · GINETTA · LOTUS · TCR UK

CHAMPIONSHIP SPONSORS

MME MOTORSPORT

Gearbox Shifting Technology

www.mme-motorsport.com

Gear Actuator With Integrated Valves

Compact and powerful air gear actuator with integrated valves for almost all sequential gearboxes. Features world's fastest hypervelocity valve that we have specifically designed for this actuator. Multiple diameters (powers) available. Plug & play options for many gearboxes including, but not limited to Quaife, Tractive, Porsche, Mitsubishi, Subaru, Yaris GR, Samsonas and other.

Gear Control Unit 8

Small and fast gear control unit (GCU) to control everything from flatshift to full paddle shift. Unit comes in 3 different options: low cost LITE version for closed-loop sequential flatshift and throttle blip (drive by wire is supported), RACE with added 3D control tables for almost all parameters + logging and PRO for full paddle shift control. Comes with free software.

Over Rev Protection

Never over-rev your engine again. ORP will block your gear lever mechanically if down-shift would result in an engine over-revving, while always allowing up-shift. Push (in front of the gear lever) and pull (behind the gear lever) lockouts available. Can also be mounted directly to the gearbox. Unit is fully electric and has low power consumption. Can be used as a standalone protection unit over CAN BUS or externally controlled by your ECU/GCU.

Todraz 20, 4224 Gorenja vas, Slovenia • Phone: +386 41 979-000 • info@mme-motorsport.com

they are testing, they will use it on a certain number of laps through every corner.'

The entire control system is built into the steering wheel, interfacing with the car via a connector on the quick release boss. This means each driver can have a wheel tailored to their specific needs and, during endurance races, different steering wheels can be swapped at pit stops.

The controls can also be tailored to different disabilities. For instance, some drivers may only have use of one hand, while a system developed for a quadruple amputee racer has brake actuation achieved via pressure pads in the seat.

Special dispensation

Of course, the modifications to Team Brit's cars need to be encompassed within regulatory frameworks, which entails a close working relationship with series organisers, as well as Motorsport UK and the FIA.

'From a Motorsport UK perspective, we have an adaptations passport, which allows scrutineers to very quickly see what is on the car,' outlines Locke. 'They don't have to understand the system, they just have to know that what is on the car matches the passport.

'The FIA has a slightly different system, with a guidance booklet with specified best practice. Once you build your hand control system to their guidelines, they send an engineer to inspect the system who reports back to the FIA disability and inclusion committee. You then get issued a certificate of adaptations from the FIA.'

However, it is notable that there is no requirement in series below those with world championship status for an adaptations certificate, it is simply considered best practice.

'That's something I think will change, but at the moment [the FIA] don't want to stifle innovation, and to make sure people are free to go out and drive any racecar they want,' suggest Locke.

Racing has certainly come a long way in removing barriers for those with disabilities since Scott Brown's day, but there is still work to be done. So what is Team Brit's ambition? One day, to field the first all-disabled team at a global race such as the Le Mans 24 hours. But it is mainly to continue providing disabled drivers with the tools they need to compete.

As Locke concludes: 'If you're on track, trying to make a corner, and are alongside someone else, you don't care if they have legs or not, and they don't care if you do. You're just racing, and there is a purity to that.' R

Untapped market

As Crompton's example shows (see box out on p58), sim racing can be a valuable gateway for disabled drivers to approach real-world motorsport. However, more can still be done to increase accessibility. That's the opinion of former IndyCar driver, Robert Wickens, who suffered a spinal cord injury in a 2018 accident at Pocono and now relies on hand controls.

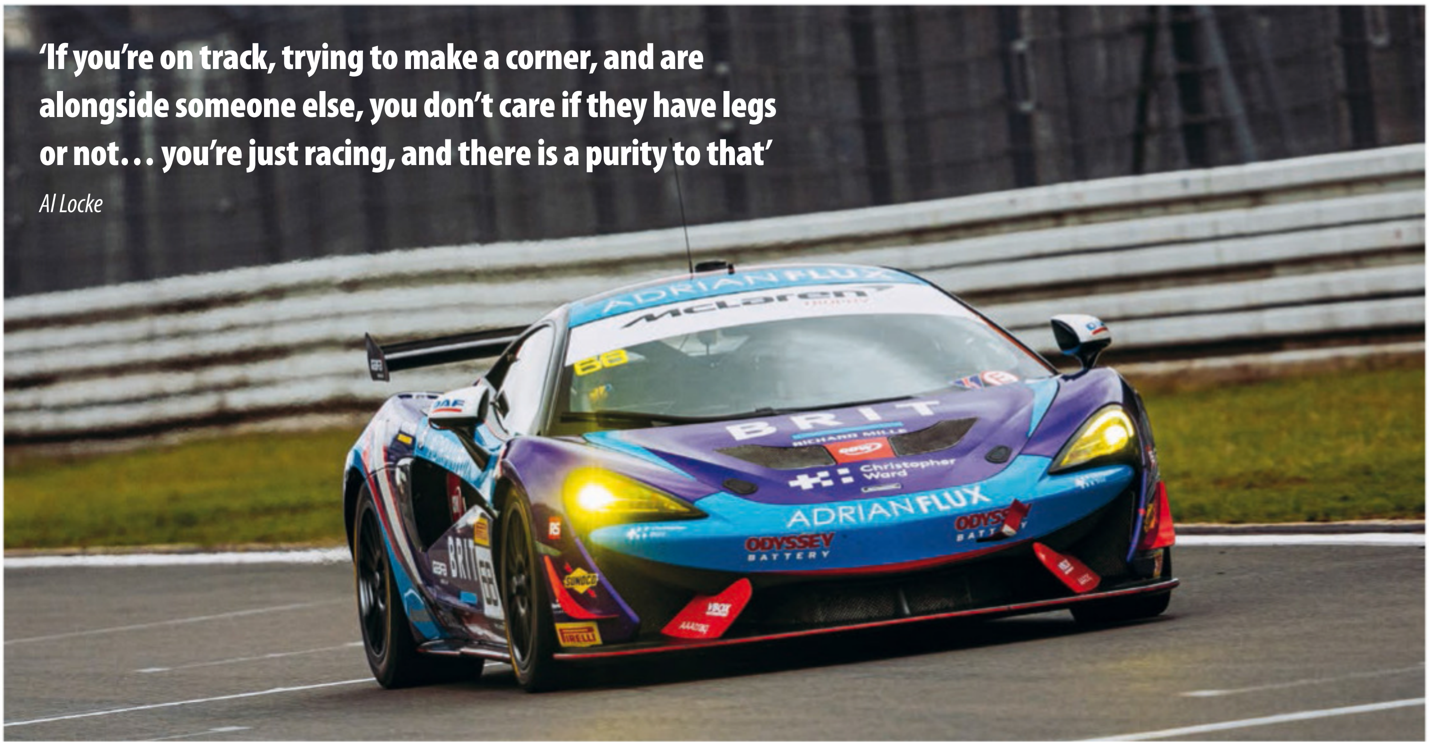
The Canadian received an adapted sim rig to enter esports events at home during the Covid pandemic, which led to his return to real-world racing in Touring Cars in 2022.

'At the moment, adaptive motorsport in general is such an undercover industry,' he says, noting that he often gets messages from other disabled drivers sharing their creative homemade rigs. Through this, he has realised that each driver does things differently, even in cases where physical requirements might be similar. Wickens is now keen to ensure there is adaptive esports equipment for all, and is talking to engineers about developing a plug 'n' play kit that eases the transition to any real-world car, because there is no standardised layout.

'I'd like there to be a rig that's more accessible,' he says. 'Maybe have a grab bar that's easy to transfer in and out of because, right now, it's a handful. I would love to make an impact, not only in reality, but in the virtual world too, just by trying to raise awareness. There are a lot of us out there, and I'm lucky to have that platform to help it grow.'

Michael L Levitt

Wickens won the IMSA TCR title driving for Hyundai in his second year racing with hand controls



Dan Bathie

As well as the more photogenic McLaren 570S GT4s, Team Brit runs a BMW 240i in the Britcar Trophy, a BMW 118i in its Racing Academy and a Citroën C1 in the Citroën C1 Endurance Series

Proud sponsors of Team Brit

bott

From design & manufacture to supply and installation, bott has a strong reputation for high product quality, innovation, service excellence and value for money. Choose a workplace storage solution from bott, and help drive efficiencies in your business.

- Made in the UK
- 10 Year guarantee
- Built to Last

Download our projects brochure by scanning the QR code or visit us:

www.bottltd.co.uk

.work .smart .bott

CARTEK MOTORSPORT ELECTRONICS

GO TO OUR WEBSITE TO VIEW OUR FULL RANGE OF MOTORSPORT ELECTRONICS

www.CARTEKMOTORSPORT.com

DIGITAL GEAR INDICATOR

The NEW Digital Gear Indicator from CARTEK is a dashboard mounted device that is designed to indicate to a driver the current selected transmission gear but also incorporates a sequential shift-light display which can indicate to a driver the optimum time to shift up a gear.

- CONFIGURE THE LOWER AND UPPER RPM SETTINGS WITH OR WITHOUT THE ENGINE RUNNING.
- SELECT FROM 6 LED DISPLAY PATTERNS FOR THE SHIFT LIGHT SEQUENCE AND 7 GEAR INDICATOR DIGIT COLOURS
- CONFIGURE DAY AND NIGHT BRIGHTNESS OF THE LEDS. SWITCH BETWEEN BRIGHTNESS LEVELS BY PRESSING PUSH BUTTON AT REAR OF GEAR INDICATOR.
- CAN DISPLAY 8 FORWARD GEARS AS WELL AS REVERSE (R) AND NEUTRAL (N).
- GEAR INDICATOR (CLUB) HAS A DEDICATED ANALOGUE INPUT FOR SEQUENTIAL GEARBOXES.
- GEAR INDICATOR (OBD) COMES WITH A DEDICATED OBD2 CONNECTION LEAD SO NO ADDITIONAL WIRING IS NECESSARY.

CK-LRS-15RM
Rectangular Model

CK-LRS-16RM
Circular Model

2019 SPEC FIA RAIN LIGHTS

Homologated to the latest FIA 8874-2019 regulations these latest Rain Lights can be used in Static or Flashing 4Hz.

- 3 TIMES BRIGHTER THAN PREVIOUS GENERATION
- FITTED WITH MIL-SPEC CABLE (TYPE 55 WIRING)
- IP65 COMPLIANT - FULLY POTTED AND PROTECTED FROM DIRT AND WATER
- CAN BE WIRED UP AS A MULTIPURPOSE RAIN/BRAKE LIGHT

Check points

If you're after a technical involvement in motorsport but can't find a job with a team, why not consider signing up as a scrutineer?

By MIKE BRESLIN

There are a huge number of people who want to get involved in motorsport on the technical side, but jobs are scarce, and it's very difficult for a beginner to find a place on a race team. One way to become involved, and also burnish your CV, is to help with smaller outfits on a voluntary basis, which is a great way to get experience. But what if you could tinker with a vast array of different racecars at a wide range of meetings? Wouldn't that be something?

It is something, and it's called scrutineering. What's more, the clubs that run championships and the British governing body, Motorsport UK, are crying out for volunteers to train as scrutineers right now, and there is a set procedure for someone to become a part of this rather unsung group of technical experts.

Before we get to any of that, though, it's important to understand that there is more than one type of racecar scrutineer.

The three degrees

'There are three types,' says Rod Bennett, a Motorsport UK national scrutineer and chief scrutineer for Castle Combe Racing Club. 'First, the basic safety scrutineer who checks all the safety equipment in the morning. That's the personal kit of the driver – helmet, overalls, that sort of thing – but also the car, making sure it's got a rain light [high intensity red rear light] and the seatbelts and fire extinguisher are in date.

'Then there's the noise scrutineer, or environmental scrutineer, who makes sure a car's not too noisy. Each car is checked statically before it goes out on the track and is then monitored throughout the day.

'The third type of scrutineering, which is the most interesting, is eligibility. Making sure they're not cheating,' adds Bennett, who is also the eligibility scrutineer for the Castle Combe Formula Ford Championship and has fulfilled this role for many other series in the past.

'After the race, or after a session, it might have to be a particular weight, and it must be the right ride height. Or you can get really detailed technical stuff, like taking the cylinder head off and measuring the bore and stroke of the engine, which we don't tend to do too much these days, but it can be done. Alternatively, you might seal the engine on site, and then at a later date you could take it apart.'

Paul Hewer is a Motorsport UK technical commissioner, and also the British GT Championship eligibility scrutineer.

'If you see something that stands out [in terms of performance] you might have a look at it,' he says of the way eligibility scrutineering works in the GTs. 'But generally, it's anybody from the top six that you'd look at. And then a random sample, too.

'Weight is the most common issue, more specifically being underweight, but we do get issues with fuel. It's usually housekeeping, especially when you have a control fuel in a championship. The car goes testing and they'll put another driver in it to test them and not run the control fuel. Some of that fuel might then be left in the car. That sort of thing.'

Common issues

Starting out, you will only be involved in safety scrutineering, and while there is no set checklist the scrutineers follow, some things are always looked at.

'The third type of scrutineering, which is the most interesting, is eligibility. Making sure they're not cheating'

Rod Bennett, national scrutineer at Motorsport UK

Examining a driver's kit is an important part of the safety check. Helmets, their stickers, and fire-retardant overalls are all looked over

Cars queuing up for scrutineering at Snetterton. Pushing the car to the bay is one of the first jobs for a team or driver / owner at a race weekend

Noise tests by environmental scrutineers have become a common feature of modern motorsport. Pictured are static tests, but the decibel level of cars on track is also monitored

'Essentially, you're really just making sure the competitor's equipment is up to date and correct, but you're also looking at the stuff around them in the car,' confirms Bennett. 'You might look at the tyres, wheels, wishbones and brakes, and perhaps the chief [scrutineer] might suggest, on an individual day, right, today we're going to look at this, or that.'

Perhaps unsurprisingly, it's usually the little things that catch people out: 'Seized cables, particularly cut-off cables or fire extinguisher cables,' says Bennett. 'That's quite common, because they corrode. Also, they might not have the right stickers on the car. Perhaps they repainted it, and then forgot to put the stickers for the cut-off or fire extinguisher back on. Also, seatbelts which are out of date.'

More worryingly, there's also the issue of counterfeit kit to be considered.

'We do occasionally get some fake stuff through,' confirms Hewer. 'Things like fake labels in helmets, though you can usually spot a fake helmet, or a fake sticker on a helmet.'

Sometimes rollcages, particularly the quality of welding on them, will be examined, especially with recent procedural

'We do occasionally get some fake stuff through. Things like fake labels in helmets, though you can usually spot a fake'

Paul Hewer, technical commissioner at Motorsport UK

changes, and the rise in lesser quality materials being sold as the good stuff.

'At Castle Combe, we have the same guys turning up regularly, so you get to know the cars, and whether they've been welded properly or not,' says Bennett. 'If you get a newcomer coming in, then you need to spend a bit more time on it. Checking the quality of the weld is certainly something we have to do on a car we haven't seen before.

'Also, the way the 'cage is fitted to the car. That's quite a common problem. They sometimes don't have a big enough, or a suitable, spreader plate fitted. Or it's not fitted to the vehicle correctly. Perhaps it's got a shoulder on it or something, where it goes over a pipe or a step in the body of the car.'

A car also tends to be examined after it's been crashed, especially if it's due out in a race later in the day, which means a scrutineer will have to liaise with other officials at the circuit, such as the recovery team and the people running the meeting.

Bedside manner

There's plenty to do, then, but it's important to note from the start that being a good scrutineer is not just about identifying defects.

'You need to be able to communicate with competitors and the teams, especially when you do find something wrong,' says Bennett. 'If you find a car that doesn't comply with the regulations, you try and help them make it work. At the end of the day, you always want to try and allow them to compete. You're not there to take everyone's fun away.

'Though you also have to comply with regulations. So, you've got to have a good bedside manner, shall we say.'

Hewer agrees: 'Customer handling is the biggest thing for me… respect should be both ways, not just from the competitor, you should treat competitors with respect as well.'

As a scrutineer, respect is about as much as you can hope for. For while expenses are paid to those who are fully trained – typically a daily allowance, mileage and hotels – it's very much a volunteer position. And on top if this, you will usually have to be in the scrutineering bay very early in the morning and stay at the track for the entire day.

'We're usually the first there, and very often we're among the last to leave,' says Hewer.

Checking the seatbelts on a Formula Ford. Out of date belts are one of the most common failures at safety scrutineering

How the seat is fitted, and the quality of welds on a rollcage will be carefully examined, particularly if it's a selective scrutineering meeting where perhaps only 25 per cent of the cars racing are checked, the others being self-certified

But then people don't do this for the money, or the comfort. It's very much a labour of love, though for your pains you do get unrivalled access, while it's also intellectually stimulating.

'It's very interesting work, having conversations with competitors about whether something complies or not,' says Bennett. 'Someone interprets the rules one way, you interpret the rules a different way. There's often an interesting intellectual discussion to be had about whether it complies or doesn't.'

Detailed level

Ian Smith, technical director of Motorsport UK, agrees: 'It's an opportunity to get involved in the sport at quite a detailed level and, if you're passionate about it, you can get a huge amount of reward being a scrutineer.'

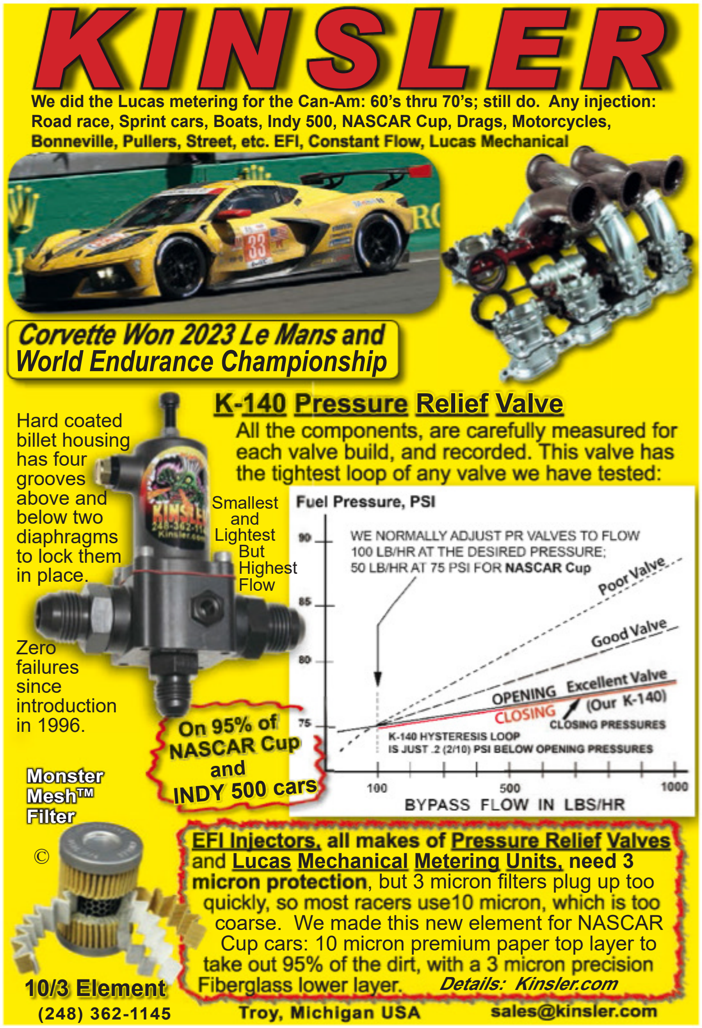
Nevertheless, the fact remains that there is a shortage of people wanting to become scrutineers, and very few youngsters involved.

'Basically, the majority of people have either had a family and then come back into the sport, or have stepped away from competing and started officiating,' says Hewer. 'But if you get somebody interested from a young age, even if they do go away for a few years and then come back, it's a winner, isn't it?'

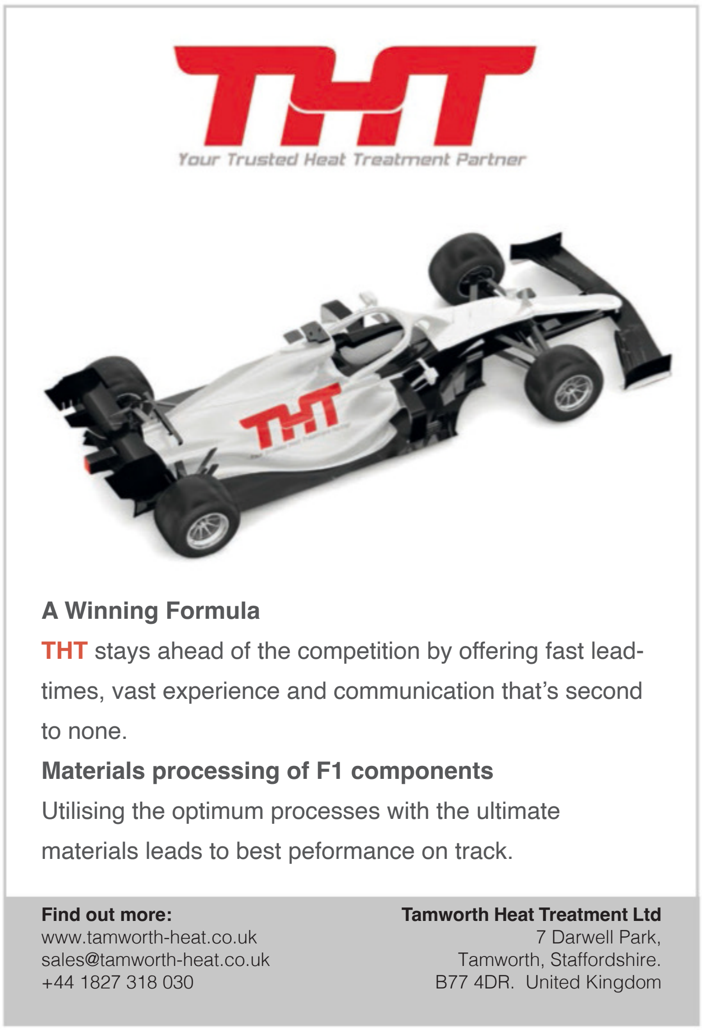
'I think we should tap in, absolutely, to younger people who are at the start of their careers and give them an opportunity to become involved in the sport,' concurs Smith. 'There's quite a strong groundswell of opinion that we should be encouraging youngsters to get involved as volunteer technical officials. And I think that is great.

'The trap that is then possible to fall into is one of frustration, when the 18-year old gets involved as a scrutineer whilst undertaking their academic journey finds, within two to three years, their career path takes them into motorsport and immediately makes them unavailable to participate as a scrutineer.


From Entry Level To
Top Level Motorsport
We Can Help
Autotel
Digital
Race Radio
NEW Press to Talk over Cellular Systems(POC)
3G or 4G LTE system No Licence Needed
Professional Team
Radio Systems
Autosport
stand 2351
Autotel Race Radio 0044(0)1508 528837 Email sales@autotel.co.uk
www.autotel.co.uk
28 years in Motorsport


KINSLER
We did the Lucas metering for the Can-Am: 60's thru 70's; still do. Any injection:
Road race, Sprint cars, Boats, Indy 500, NASCAR Cup, Drags, Motorcycles,
Bonneville, Pullers, Street, etc. EFI, Constant Flow, Lucas Mechanical
Corvette Won 2023 Le Mans and
World Endurance Championship
K-140 Pressure Relief Valve
All the components, are carefully measured for each valve build, and recorded. This valve has the tightest loop of any valve we have tested:
Hard coated billet housing has four grooves above and below two diaphragms to lock them in place.
Smallest and Lightest But Highest Flow
Zero failures since introduction in 1996.
On 95% of NASCAR Cup and INDY 500 cars
Fuel Pressure, PSI
WE NORMALLY ADJUST PR VALVES TO FLOW 100 LB/HR AT THE DESIRED PRESSURE; 50 LB/HR AT 75 PSI FOR NASCAR Cup
Poor Valve
Good Valve
OPENING
CLOSING
Excellent Valve (Our K-140)
CLOSING PRESSURES
K-140 HYSTERESIS LOOP IS JUST .2 (2/10) PSI BELOW OPENING PRESSURES
90
85
80
75
100
500
1000
BYPASS FLOW IN LBS/HR
Monster Mesh™ Filter
©
10/3 Element
EFI Injectors, all makes of Pressure Relief Valves and Lucas Mechanical Metering Units, need 3 micron protection, but 3 micron filters plug up too quickly, so most racers use10 micron, which is too coarse. We made this new element for NASCAR Cup cars: 10 micron premium paper top layer to take out 95% of the dirt, with a 3 micron precision Fiberglass lower layer.
Details: Kinsler.com
(248) 362-1145
Troy, Michigan USA
sales@kinsler.com


CENTRALSCANNING
3D Printing and 3D Scanning
BRING
YOUR IDEAS
TO LIFE
Come and see us at
STAND
E175
AUTOSPORT INTERNATIONAL
11-12 JAN 2024 NEC BIRMINGHAM
OUR
SERVICES
At Central Scanning, we are specialists in:
The production of functional 3D printed components.
3D Scanning to provide the best quality for your application.
Providing CAD models to the software package of your choice.
Independent inspection using optical measuring techniques.
Supplying 3D scanners and software from Artec3D and #HandsOnMetrology with comprehensive training and ongoing support.
Providing quality 3D scannig rental equipment.
Selling AESUB 3D scanning spray and reference markers.
CONTACT US TODAY
To find out more on our products and services.
#HandsOnMetrology
01527 558282
info@central-scanning.co.uk
www.central-scanning.co.uk
WE 3D SCAN, WE 3D PRINT, WE 3D CARE...


THT
Your Trusted Heat Treatment Partner
A Winning Formula
THT stays ahead of the competition by offering fast lead-times, vast experience and communication that's second to none.
Materials processing of F1 components
Utilising the optimum processes with the ultimate materials leads to best peformance on track.
Find out more:
www.tamworth-heat.co.uk
sales@tamworth-heat.co.uk
+44 1827 318 030
Tamworth Heat Treatment Ltd
7 Darwell Park,
Tamworth, Staffordshire.
B77 4DR. United Kingdom

'There's quite a strong groundswell of opinion that we should be encouraging youngsters to get involved as volunteer technical officials'

Ian Smith, technical director at Motorsport UK

'If you train and engage them on the basis that they're going to be a volunteer for life, and then you lose them after three years, that could be considered a wasted effort. It's definitely an opportunity, but it needs to be managed.'

Whatever age someone wishing to become involved as a scrutineer might be, what skills and knowledge do they need?

'Some have a very strong view that you need to have a mechanical / technical background in order to be a scrutineer,' says Smith. 'I don't necessarily subscribe to that completely. I think it's about working with people in the first instance. Yes, of course you need to be interested in, and be able to apply yourself to, technical detail and situations, but you can learn that. You can experience it.'

Mentoring role

It's also quite easy to become involved, with all the paperwork you need to become a trainee scrutineer available at www.motorsportuk.org. Once someone becomes a trainee, they are then overseen by a mentor, a senior scrutineer, who takes them through the different grades. Scrutineers can begin training from as young as 16 but can only become fully licensed at 18.

'The majority of the scrutineer's development pathway is on the job training and building of experience, because that's really where a scrutineer adds value; being out amongst competitors, looking at cars, understanding what goes right, what goes wrong,' says Smith. 'So, whilst Motorsport UK issues the licence, we have a network of scrutineering mentors who support trainees through their development and are scrutineers themselves.

'We also have a network of scrutineering assessors, who will undertake assessments of trainee scrutineers as part of their upgrade process. And I think that's really important, because it means there truly is a network of experts immersed in what they're doing – pretty much every weekend for a lot of them – and they are supporting each other through the process.'

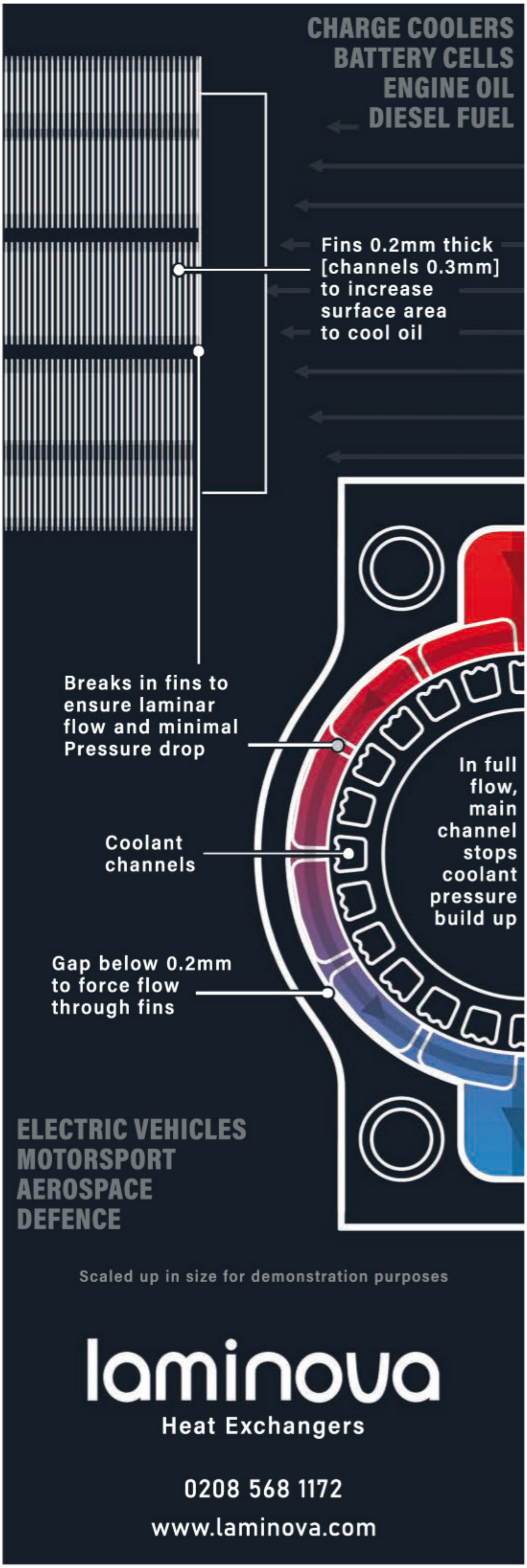
As part of their assessment process, trainee scrutineers need to experience more than one discipline, too.

'You can't just do circuit racing,' says Bennett. 'You have to go to a rally and be

While there is no one-size-fits-all check list for scrutineering, some things, like seatbelts and dates on safety kit, will *always* be checked, regardless of car or series. On single seaters, critical suspension components are often given the once over, too

The Classic Sports Car Club (CSCC) in the UK has embraced the concept of self-declaration and selective scrutineering, feeling it gives scrutineers a chance to look in more depth at fewer cars. Pictured is one of the club's Special Saloons and Modsports races at Thruxton


BREDA RACING EQUIPMENT
REFUELLING
AIR JACKS
TROLLEYS
SET-UP
BREDA RACING
racing components and equipment
for our complete equipment range please visit
bredaracing.com
or contact us at info@bredaracing.com


CHARGE COOLERS
BATTERY CELLS
ENGINE OIL
DIESEL FUEL
Fins 0.2mm thick
[channels 0.3mm]
to increase
surface area
to cool oil
Breaks in fins to
ensure laminar
flow and minimal
Pressure drop
In full
flow,
main
channel
stops
coolant
pressure
build up
Coolant
channels
Gap below 0.2mm
to force flow
through fins
ELECTRIC VEHICLES
MOTORSPORT
AEROSPACE
DEFENCE
Scaled up in size for demonstration purposes
laminova
Heat Exchangers
0208 568 1172
www.laminova.com

Cars that are not part of the chosen 25 per cent that go through the bay at a selective scrutineering meeting will still be checked for obvious issues in the assembly area

signed off, or go to a hillclimb. You have to do two or three disciplines to get your licence. And then you work your way through [your module booklet] with your mentor and do as many events as you can over the course of – I like to make it last two years – and have all your modules signed off.

'Once you've completed your booklet, your mentor will send a letter to Motorsport UK. You then send them your completed booklet and they give you a licence.'

Taking responsibility

One thing any new scrutineer will have to be aware of is that recently there have been some shakeups in the process in the UK, which initially came about during the recent pandemic.

'During Covid, there were issues about how we manage race meetings, and that's when we started introducing remote sign-on [for drivers],' says Tim Hoverd of the 750 Motor Club.

'We also did quite a lot of self-declaration scrutineering, and we've moved to a world now where some formulae at each meeting are doing the sort of thing we always used to do, and some are doing self-declaration.'

Self-declaration means just that. The entrant is given a checklist and then makes a declaration that their car complies. Some cars will still be checked, around 25 per cent at each meeting, with each competitor scrutineered at minimum once every four events.

'Self-declaration was a necessity to restart the sport nationally [after Covid],' says Smith, 'but the team that were involved put a lot of thought into it, and also looked at what other national governing bodies around the world were doing. They found there was a really good case study in New Zealand where they had been using a similar approach to the selective scrutineering, self-declaration approach.

'The key reason why they [in New Zealand] advocated this approach was it gave their scrutineers more time with each competitor,' Smith adds. 'Admittedly, not at every single event, but they could have a more meaningful conversation around areas where there could potentially be problems, areas where there were opportunities to improve how the car was prepared. And they felt quite strongly that it was a more collaborative process.

'Once that became the way of doing it, people became more comfortable with it and were able to take more ownership of the preparation of their vehicle. That's the fundamental basis of our regulations in the UK, and with any national governing body, that you enter your vehicle and, through submitting that entry, you take responsibility for your safety and its standard of preparation.'

Working group

A working group made up of scrutineers, club representatives and officials was subsequently set up and a trial held throughout 2022 and 2023. By all accounts, it seemed to go well. 'Rather than a cursory four minutes, which was typically just a few basic checks that got done every time, in theory it now gives a scrutineer more time to lift the bonnet, lift the boot lid and have a look at more things,' says Smith. 'A few things have been picked up this year, for example, that had gone unnoticed for years. Welding on rollcages and things like that.'

> **'You can't just do circuit racing… You have to do two or three disciplines to get your licence. And then you work your way through [your module booklet] with your mentor'**
>
> *Rod Bennett*

David Smitheram, director of the Classic Sports Car Club (CSCC), is another who very much approves of this approach.

'From a safety point of view, I think how a driver that's built a car themselves has bolted the seat to the floor, that and rollcage welding, is probably more significant to somebody's health than checking a label on a perfectly serviceable set of belts,' he says.

Bennett also sees the sense in it: 'You pick 25 per cent of them and bring them in, you've got them for longer in the scrutineering area, so you can look at them in more detail.'

Not all clubs chose to go down the self-declaration and selective scrutineering route and take part in the trial. The British Automobile Racing Club (BARC) and Historic Sports Car Club (HSCC) did not, and now


Measurement without Compromise
Gain the competitive advantage with on-car aerodynamic measurement
EvoScann® miniature pressure scanner range includes:
- Absolute or True-Differential measurement
- 8 or 16 channels of digital data
- Full-scale accuracy up to 0.1%
- Scan speed up to 1000 Hz
- Plug and play
- Small, robust and lightweight
Book a demonstration or request a quotation.
Call: +44 (0) 1264 316470
Email: enquiries@evolutionmeasurement.com
US Office: +1 512 210 2288
E: alberto.villani@evolutionmeasurement.com
EvoScann®
www.EvoScann.com


SUPERTECH
PERFORMANCE VALVES
ENGINEERED WITH PRECISION
VALVES | PISTONS | RODS | HEAD GASKETS | COMPONENTS
2024 CATALOG
DOWNLOAD
Magnetic Friction Welded Wafer
One Piece Forged
Black Nitride Coating
Undercut Stem
Back-Cut Angle
SUPERTECH WWW.SUPERTECHPERFORMANCE.COM

that the trial is over there will still be a split between 100 per cent inspection and what Smith calls the 'future of scrutineering' method. But one club that is onboard is the CSCC.

'We're also a leisure industry,' notes Smitheram. 'Time is precious, and costs keep going up.

'A few years ago, if you turned up to one of our paddocks on a Friday evening, it would be rammed, because anyone racing on the Saturday knew they would have to scrutineer, and would have to queue up to do so.

'The routine was always the same. Scrutineering, which often involved a push, in the darkness in the spring and the autumn. Then you'd queue up again for signing on, and then go to your briefing, all before the fun stuff could begin.

'So, we've removed the first two things, and now it means a lot of drivers, certainly if they live within an hour or two of the track, just turn up on the day. It saves them another night away from family, it saves them another hotel bill and meal out for the team. From the driver's point of view, I think it's so much better.'

To clarify, the CSCC selects 25 per cent of the series at a particular meeting to go through scrutineering, then a different 25 per cent at the next, which means each car will be checked every three or four meetings. Other clubs might just look at a random 25 per cent of the entry across all championships on a particular day.

This doesn't mean a car from the other 75 per cent will go out on track in a dangerous condition: there will always still be checks in the assembly area to pick up any obvious problems.

'Oil leaks, fuel leaks, rain lights… the basics are checked,' confirms Smitheram.

Another change with some clubs and individual series is the scrutineer going to the car in the paddock, rather than the car coming to the bay, though this is dependant on whether the paddock is set up for this, and compact enough to allow it. If the series has pit garages at a meeting, it works particularly well.

Searchable data

Not all scrutineers are fans of selective inspection, but one thing most scrutineers do seem keen on is a new database, another aspect of Motorsport UK's 'future of scrutineering' drive.

'Essentially, cars are going to eventually have a QR code,' says Hoverd. 'The main reason for this is that if the scrutineers at one meeting say, "you ought to fix this by the next meet," previously there was no record of that. You'd turn up for the next meeting and, if no one noticed, no one noticed.

With highly modified cars, the new database will offer a permanent, easily accessible record that shows what has been cleared beforehand, making the scrutineering process far simpler for both scrutineers and competitors

'Now, there's going to be, "you were told last time to fix this." That's going to be done with a QR code and a searchable database, so people will know what the scrutineer said to people at previous meetings.'

This is now well advanced, with some QR code stickers already printed.

'It's an active project,' says Smith. 'It has been piloted at three events with Motorsport Vision and with Lydden Hill and we're now taking the lessons learned, and the issues and the bugs with the system, back to the developer to be resolved. When that's done, we'll move on to the next stage of deployment, which will be engaging more clubs to start bringing their championships and the registered vehicles in those championships into the system.'

The system is being developed by German company, Leomax, which has done something similar with the German Motor Sport Federation (DMSB) national vehicle passport system. A possible by-product of this could be a record of every active racecar in the UK.

'Initially, there was a desire to go to the extent of a full vehicle passport document,' says Smith, 'but it was felt that would be too much of an initial step. There are certain championships in circuit racing that do have vehicle documents to that level, and more, but as a universal regulation, the starting point is a very simple record.

'The idea is that those conversations where recommendations are made to

When a car is deemed safe to go out on track, it's usually presented with a little sticker similar to this to prove it

'[with the database] your time would be much more targeted, and more intelligence led, and you could specifically look at the vehicles that last weekend had issues'

Rod Bennett

improve the overall safety of a vehicle, whatever that may be, can be consistent. On the flipside, if you've got something different, or unique, you won't find yourself having to explain a particular thing to a scrutineer every time you want to race. The record will simply follow the vehicle.

'A persistent frustration for scrutineers – and competitors as well, I'm sure – is "it was okay last time…" Well, if it was okay last time, there'll be a record of that.'

Scrutineers certainly see the sense in this.

'Your time would be much more targeted, and more intelligence led, and you could specifically look at the vehicles that last weekend had issues with, for example, seatbelts,' says Bennett.

The same applies for accident damage.

'If a car has had a particularly serious accident, that could be flagged up on the database, so that the next scrutineer that sees a shiny car on the outside might want to have a look at the chassis legs and other bits that were reported to have been in a very crumpled state,' says Smitheram.

If this sort of mechanical detective work sounds like something you might like to get involved in, have a look at www.motorsportuk.org and click on 'volunteers'. If you do go on to become a scrutineer, one thing's for sure: within a couple of months, you will have tinkered with more far racecars than the majority of motorsport engineers.


APT
ACTIVE POLYMER TECHNOLOGIES
Design • Analysis • Manufacture
We specialise in the design and development of technologically advanced polymer products for use within motorsport, defence and industry.
Our design activities are dominated by expert use of the latest Finite Element Analysis software.
We manufacture high performance polymer products including:
• Low Profile CV boots
• High performance PTFE Lined shaft seals
• Bladder accumulators
• Custom polymer solutions
• AV mounts
For more information visit: www.active-polymer.com
Tel: +44(0)7756 515772 • Email: support@active-polymer.com


f-POD
Intelligent Race Fuel Bowsers
SILVERSTONE
STROLL
0.00 kg
PUMP
QUEEN'S AWARD WINNING MACHINES - HANDLING FUEL SAFELY & ACCURATELY FOR PROFESSIONAL TEAMS WORLDWIDE
e-POD
Wireless Endurance Fuel Rig System
22.1
Wireless Fuel Stop Monitoring & Logging
Including: Endurance Fuel Rig Scales
Wireless Intelligent Fuel Timer
Wireless Fuel & Air Temperature Sensors
EEC
ESSENTIAL EQUIPMENT CONSORTIUM
EEC Performance Systems
00 44 (0)116 232 2335
enquiries@eec-ltd.com
www.eec-ltd.com


Cyprium
MOTORSPORT SYSTEMS
SUPPLIERS OF HIGH QUALITY ELECTRICAL HARNESS SYSTEMS
Cyprium designs product for the Global motorsports industry with our in house expertise, knowledge and know how generated by many years of experience.
TEL: 01379 897262
Contact: Michelle Osborn michelleosborn@cyprium.co.uk
or Nigel Barber nigelbarber@cyprium.co.uk
www.cyprium.co.uk


Getecno
INDUSTRIAL PRODUCTS
ROD ENDS
SPHERICAL BEARINGS
BUSHING
ACCESSORIES
AURORA®
RODOBAL®
Seals-it®
PERMAGLIDE®
Broadest range in Europe!
Your demand, our efficiency
www.getecno.com
EPTDA
Member

Generation game

The issues currently faced in training the next generation of motorsport engineers, and what could be done about it

By DANNY NOWLAN

At time of writing, I've been doing my world tour. The volume of engineering students I have met in that time has really got me thinking about the best ways of mentoring the next generation of motorsport engineers.

Unlike 30-40 years ago, you now have dedicated motorsport engineering courses running around the world. That in itself is a good thing, and I have a few of them as customers. However, what is raising alarm bells for me is getting those attending these courses the practical experience they desperately need to be effective. This will be the focus of this month's article.

To put this in perspective, let's wind the clock back those 30-40 years, because I was on the tail end of this system. If you wanted to be a motorsport engineer back then, there were two primary roads you went down. You either started as a mechanic, and then graduated to an engineer (I have a number of close friends and trusted colleagues who chose this route, and they are outstanding engineers). However, there were other engineers who completely distrusted anything that couldn't be fixed using a spanner, so that path could be a bit hit and miss. For the sake of argument, let's just say it was typically 50 / 50.

The other road was to complete a degree in aerospace or mechanical engineering, and then work your way up the ranks in motorsport. Typically, you would start in something like Formula Vee or Formula Ford 1600, and work until midnight for a pie and a beer. Then you would do Formula Ford 2000 / Formula Renault, and then perhaps F3, F3000 (which morphed into F2) before maybe getting your shot at one of the senior formulae, such as F1, IndyCar and the like.

That route worked pretty well for most that took it, and I'm a graduate of that system myself. However, that road is now starting to break down. I'll return to why shortly.

First things first

If we fast forward the tape to today, if you want to work in, say, Formula 1 or factory sportscars (and let's face it, in this age of instant gratification, every young engineer with an interest in motorsport wants to go straight in at the top level), you need to have Formula Student on your resume.

For the uninitiated, Formula Student / FSAE was designed specifically as a competition for undergraduate and recent postgraduate university engineers to compete against each other in designing, building and running a racecar. The cars themselves sit halfway between a go kart and a Formula Ford, but offer many valuable lessons in racecar engineering. Some key parameters of a Formula Student car are shown in **table 1**.

Table 1: Formula Student / FSAE key parameters

Item	Value
Front / rear track	1.3m
Wheelbase	1.55m
C of g height	0.23-0.35m
Total mass	280-300kg
Vmax	112km/h

One of the great things Formula Student brings to the table is that students have to make their own cars, and there is significant technical freedom. That is one of the most endearing properties about the formula.

Horse and buggy

However, it is often said the road to hell is paved with good intentions, and Formula Student is a classic case in point. Firstly, if you look at the car specs, it's clear they were created by a bunch of OEM engineers, amateur motorsport runners and lawyers to make sure a bunch of undergraduates didn't kill each other. This is where the speed limit came in. Consequently, you have a lot of focus on fixed velocity circle track running (a favourite of American-based automotive OEM engineers), straight line acceleration and slalom events typically done on runways.

To understand why this is a problem, the data you'll get from a typical FSAE car is most revealing. **Figure 1** shows some data obtained from a typical slalom course from a Formula Student machine.

Pay attention to two particular bits of data here. Firstly, note the combination of low speeds and extremely high curvatures. We are talking mid-corner speeds in the order of 30km/h, combined with curvatures in the order of 0.2/m, or peak corner radius of 5m. What all this means is the dominant effect on steering is the trajectory of the vehicle, not the slip angle of the tyre.

To illustrate this, let's do a worked example of your typical neutral steer value for an FSAE car, as shown in **equation 1**.

$$\begin{aligned}\delta_{NS} &= wb \cdot iR \\ &= 1.55 \times 0.2 \\ &= 0.31 rad \\ &= 17.7^{0}\end{aligned} \qquad (1)$$

The neutral steer at the tyre here is 17.7 degrees. Yes, slip angle does play its part, and the peak lateral *g* of 1.5 shows this very clearly, but oversteer won't manifest itself in the usual way as it does when the steering reverses on an actual car. There are exceptions to this, of course, but what you see in **equation 1** is the norm.

What I find particularly disturbing about this is that it enforces the horse and buggy era of vehicle dynamics in the students. And this is most certainly not the case for motor racing applications.

Playing catch up

The other devil in the detail with Formula Student is when the students start playing with aerodynamics. You'll see some student entries with bodywork plastered with wings and tunnels. That is no accident. The reason is they are desperately playing catch up because cornering speeds are so low, and they have an artificial speed restriction. The numbers, however, are very revealing, so let's look at what happens with a car that has a CLA value of four as we progress through the speed range, assuming sea level International Standard Atmosphere (ISA) conditions.

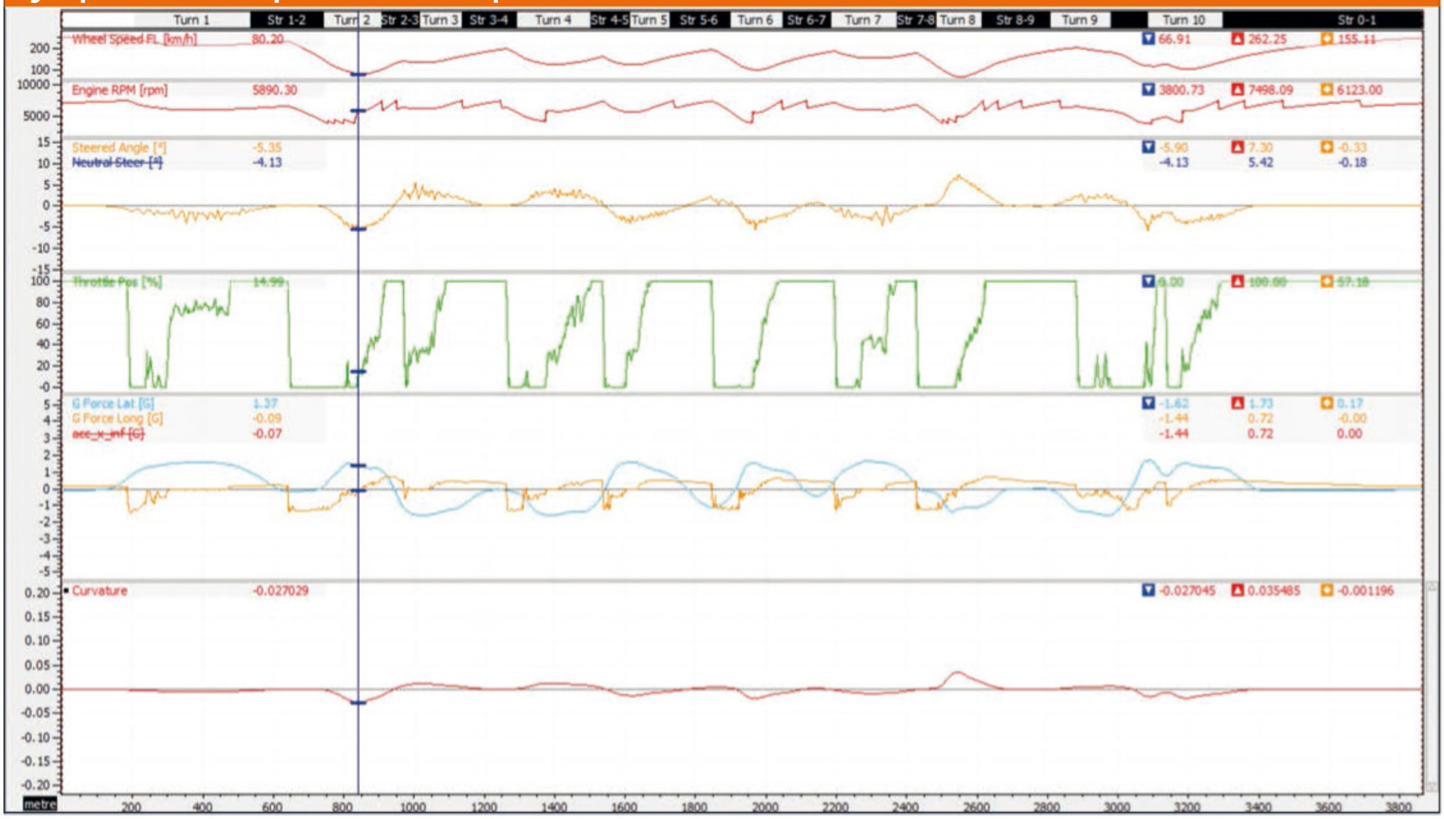
Table 2: Variation of vertical load due to downforce with a CLA of four

Speed (km/h)	Vertical load (kgf)
30	17.4
50	48.2
100	192.9
150	434
200	771.6

Here is where the comparison between a Formula Student and an LMP2 / LMP3 car is revealing. A Formula Student car will weigh 300kg. Given that typical cornering speeds are around 30-60km/h, downforce will account for a 10-20 per cent increase in the vertical load from the base weight of the vehicle.

Fig 1: Data from a typical Formula Student car on a slalom course

Fig 2: Speed and curvature parameters for a V8 Supercar



An LMP2 / LMP3, on the other hand, weighs in at around 1100kg. So even at a relativity low cornering speed of 100km/h, the downforce is already adding 17.5 per cent load to the base weight of the vehicle.

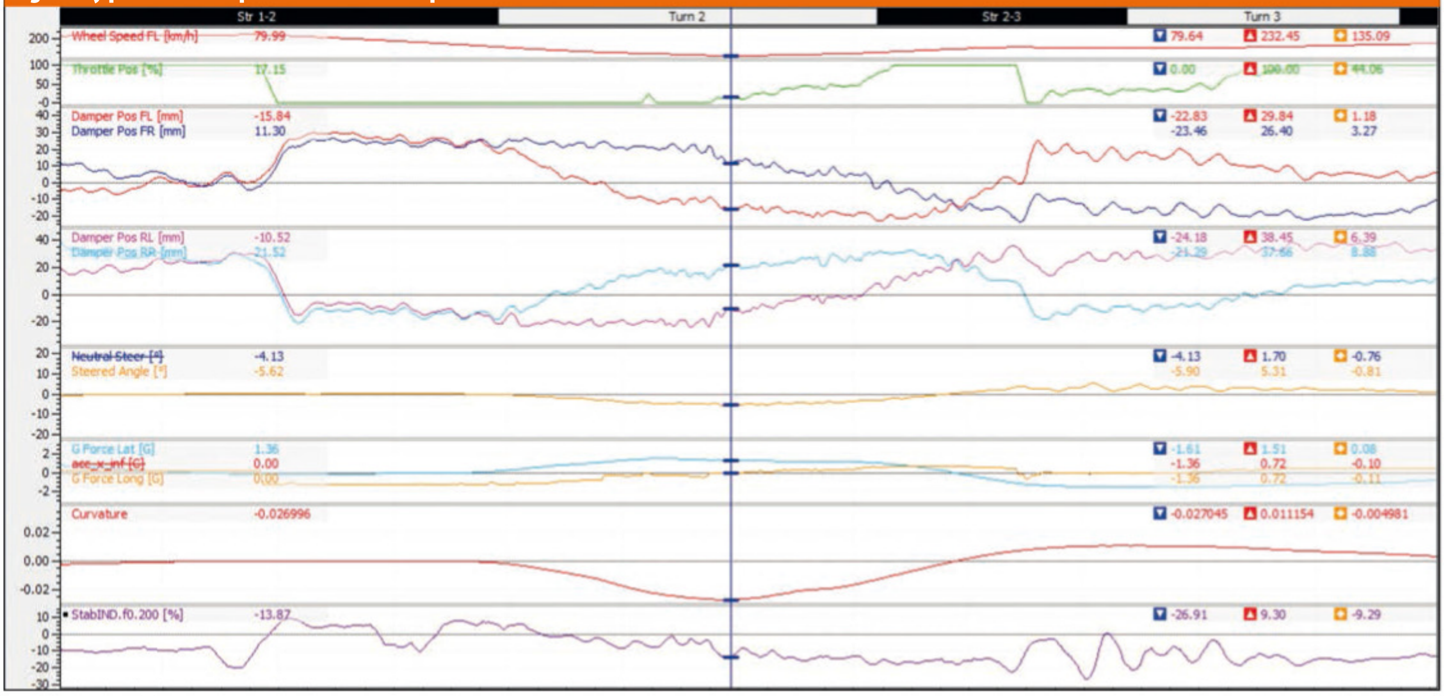
As can be seen from **table 2**, this rapidly increases. Consequently, there is a huge disconnect between what you see on a downforce Formula Student car and what you see on an actual downforce car.

What puts this into even sharper relief is the discrepancy in the Reynolds numbers of a Formula Student car versus an actual racecar. Given the lower cornering speeds of a Formula Student car, the Reynolds numbers are much lower than an actual racecar, for both the floor and the wings.

This means from an aerodynamic perspective they are fundamentally different animals, analogous to the comparison between model aircraft and their full-size counterparts. You just cannot scale down a full-size aircraft and expect it to work on a model aircraft. In the same way that if model aviators want to fly full-size aeroplanes, they have to go through a proper conversion course. Does their experience in model aviation help? Absolutely, but they can't expect to hit the ground running straight away. Ditto with Formula Student / FSAE.

To put this into even sharper relief, let's review some actual race data. To really ram the point home, I'm going to demonstrate data from an Australian V8 Supercar that isn't particularly quick in the corners. This is shown in **figure 2**.

Fig 3: Key performance parameters for a Supercar mid-corner



Let me direct your attention to the last trace, which is curvature. I have deliberately left the curvature scalings the same as in **figure 1**, but note how much lower the values are. We are talking numbers in the order of 0.027 or so, which is around 10 per cent of Formula Student numbers. **Equation 2** shows how to calculate the neutral steer for this.

$$\begin{aligned}\delta_{NS} &= wb \cdot iR \\ &= 2.8 \times 0.027 \\ &= 0.0756 rad \\ &= 4.3^0\end{aligned} \qquad (2)$$

As can be seen from the magnitude of the neutral steer, slip angles are going to have a much bigger influence over what the car is doing, particularly the steering input. Also note the curvature traces themselves. There is very little steady state behaviour, which shows the relevance of the constant radius / constant speed test.

To expand on this point, let's zoom in on a low-speed corner to discuss the relevance of the constant radius / fixed speed test. The key performance parameters are shown in **figure 3** and, for ease of illustration, I'm using simulated lap time data.

A couple of things to pay attention to here are the front and rear damper traces (traces three and four) and the varying stability index (the last trace). The steady state behaviour doesn't last particularly long, however it has a huge influence on tyre loads, which in turn dictate where the mid-corner tyre loads land. A static approximation will get you close, but it's not going to give you the full story.

In my assessment, the slalom tests in Formula Student are of much greater value to the students then the constant radius / constant speed test

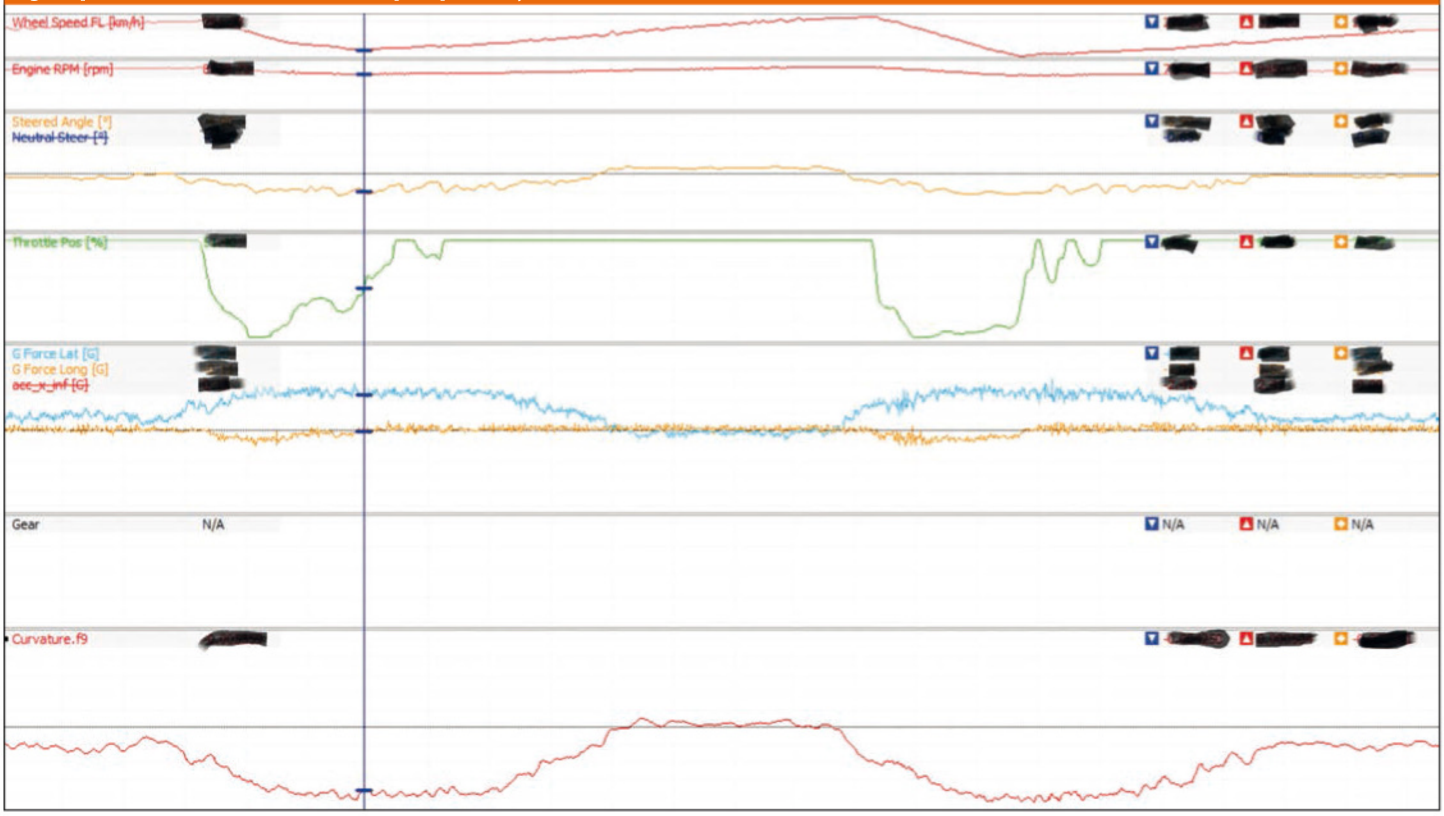
Put to the test

It's one of the biggest traps I see in vehicle dynamics. This is why ChassisSim went down the transient lap time simulation route. In this condition, while you will get some value out of the steady state / constant radius corner test, it's far from the full story. This is why, in my assessment, Formula Student slalom tests are of much greater value to students than the constant speed / radius test.

When looking at some super speedway data, on paper you would think a constant

Understanding the forces involved at the cornering speeds experienced in Formula Student are a good start for an engineer, but the numbers are very different on a full-size racecar

Fig 4: Speed and curvature data for a super speedway car



radius, fixed speed, skid pan test should translate to an oval, but let's review **figure 4** to see if this really is the case.

Since this is live customer data, all scalings have been removed and all numbers blanked out. However, I can say the curvature numbers are in the order of 0.004/m. I would refer the reader's attention to the top trace (speed) and the last trace (curvature). Note we have sections of near constant radius with the curvature so again, on paper, you would think the constant radius test should apply. But look at the top trace again. While I can't tell you the numbers, the speed variation mid-corner is over 10 per cent. Also look at the driver inputs, in particular throttle. Again, note the variation.

The question therefore needs to be asked: is a constant speed / radius test still relevant for this condition? I would say no.

Broken ladder

Formula Student does have an important role to play in teaching racecar engineering, but what is abundantly clear from the examples shown here is the big disconnect that exists between the way a Formula Student car works and a real racecar. Which means it's a very big ask to take someone from Formula Student and expect them to hit the ground running with a real racecar.

I know of people who have made this transition and performed very well, but they are the exceptions to the rule.

The reason we find ourselves in this situation is due to the breakdown of the traditional ladder, thanks to ever tightening technical regulations. As a case in point, when I was doing Formula Ford 1600 in the mid-'90s, no one blinked about using four-way adjustable dampers. When I was doing Formula Holden, we were adjusting hydraulically connected third springs. And when I first came to the UK in 1998 and was doing British F3, if someone wanted to adjust their front wing position, or go to the shaker rig to tune their dampers, they did just that.

Did I get everything right? Hell no, there were plenty of times I screwed up monumentally. But did I learn? Hell yes, and that experience all formed a critical component of what I do today.

As the 1990s progressed, and beyond, motor racing authorities began guzzling the Kool-Aid of spec formulae and Balance of Performance. What suffered as a result is the key engineering lessons you would learn by progressing through different formulae have now been robbed. The ability to make those all-important mistakes has been eliminated.

Formula Student has plugged that gap to some extent but, given what a unique beast the formula is, young engineers are still left with big gaps in their knowledge when it comes to applying what they have learnt to a real racecar. The sooner motorsport regulatory authorities wake up to the folly of spec formulae and BoP, the better.

There is a further consequence to abandoning the traditional route, and that is the lack of grizzled veterans mentoring young engineers

There is a further consequence to abandoning the traditional route, and that is the lack of grizzled veterans mentoring young engineers. When I screwed up – which happened often – I was told about it in no uncertain terms by people with the experience base to instruct me.

In contrast, what I see in a lot of Formula Student / FSAE teams is a distinct lack of the very necessary mentoring.

So, what is my advice to any Formula Student / FSAE team member reading this? Ironically perhaps, it's keep doing what you're doing. The whole process of car design / building / running / tuning is still invaluable, but I would suggest also doing things like hillclimb and Time Attack, as well as getting time on, say, a GT team. That sort of real-world experience will help plug the knowledge gap between a Formula Student and a real racecar.

In closing, the process of mentoring future motorsport engineers is something that needs to be addressed. While endeavours such as Formula Student / FSAE have their place, and an important role to play, there is a huge difference between how a Formula Student car and a real racecar works. This can be mitigated by experience but, ultimately, the over technical regulation of junior formulae must be addressed. The future of the sport is counting on it.

IN BRIEF

Hankook has won the tyre contract to supply the FIA World Rally Championship from 2025. The manufacturer will replace Pirelli and the deal will be for three years.

Teams competing in the **WRC** will be allowed a maximum of three new hybrid units per season in 2025 and 2026, fitted to the Rally1 cars that are entered to score points in the Manufacturers' Championship. The move to reduce the number is to satisfy the FIA on cost and sustainability.

A 'battle of technologies' system has been approved by the **FIA WMSC** in the World Rallycross Championship, where electric cars will compete against ICE-powered machines on an equal basis. At time of writing, no further details were released on the mechanism for balancing the cars. Tyre company, **Hoosier**, has been nominated as sole supplier for the series.

Hyundai Motorsport has announced a re-structuring of its senior management, effective from January 2024, elevating team principal, **Cyril Abiteboul**, into the role of company president. **Sean Kim**, who has held the president position since April 2022, will hand over the reins and move to a new role within Hyundai Motor Company. The announcement of Abiteboul as president is accompanied by several other internal re-structures, with the objective of improving performance and efficiency as the company looks to next season and beyond.

New Zealand manufacturer **Rodin** tested its closed-top prototype, the FZERO, on track for the first time in November and has plans to provide its RC.Ten 4.0-litre V10 engine as a crate motor for other motorsport applications. The engine, two prototypes of which were built in the UK by Neil Brown Engineering before production of the car switched to the New Zealand base, produces more than 1000bhp at 9500rpm while only using 11psi of boost. The company is also working to produce a naturally aspirated version of the engine.

AI to aid F1 track limit calls

The FIA has confirmed it will start using artificial intelligence (AI) to help monitor track limits in Formula 1, aiding the small army of human judges currently used.

The topic of track limits came into focus at last year's Austrian Grand Prix, where 1200 incidents were analysed by four people. That developed throughout the season, so that by Qatar the number had doubled and, between them, monitored a total of 820 corner passes.

The use of AI technology is not to make a final decision, says the FIA, but instead to eliminate incidents where there is clearly no case to answer.

Tim Malyon, head of the FIA's remote operations centre and deputy race director, says the use of AI in such a way will allow the small number of legitimate potential transgressions to be better analysed.

'It might sound strange, but the methodology with this AI has a lot of parallels with discussions going on in medicine at the moment, and the use of Computer Vision, for example, to scan data from cancer screening,' he said.

'What they have concluded is they don't want to use the Computer Vision to diagnose cancer. What they want is to use it to throw out the 80 per cent of cases where there clearly is no cancer in order to give the well-trained people more time to look at the 20 per cent. That's what we are targeting.'

The plan is to take the number of cases reviewed by humans down from more than 800 to around 50, which will then reduce the need for extra bodies.

The parent company of SBG, the firm that supplies the RaceWatch AI platform to the FIA, is called Catapult and provides technology to identify players in major sports using small receivers fitted to vests.

'We can use that technology on our live feeds,' says Chris Bentley, single seater head of information systems strategy. 'That will be the same as the new tool, and then we will be able to draw the 'lines of interest'. The AI would then learn as it goes along.'

The AI system was tested at the Abu Dhabi Grand Prix, alongside human judges. 'I've said repeatedly that the human is winning at the moment in certain areas,' says Malyon. 'That might be the case now, but we do feel that ultimately, real time automated policing systems are the way forward.'

XPB

Track limit transgressions are currently monitored by humans, but AI could weed out non-incidents, allowing real people to focus on the relevant ones

Podium AT wins Formula E contract

Italian firm, Podium Advanced Technologies, has won the contract to supply batteries to Formula E when the Gen4 series cars are released for 2026. The company will take over from WAE, which supplied the original battery and the most recent, currently in use.

Podium has more than 10 years' experience in engineering and building advanced battery systems for motorsport, automotive, aerospace, marine and railway applications, and also developed the Glickenhaus LMH and GT cars for endurance racing, as well as being heavily involved in the design and build of the Glickenhaus hydrogen Boot.

At a recent meeting of the FIA World Motor Sport Council, it was also confirmed that Spark Racing Technology will continue to be the sole chassis supplier, making it the only company to have supplied chassis to the electric series.

'A thorough analysis of the submitted bids evaluated the technical specifications of each product, as well as manufacturing capabilities and proposed on-event support… and was accompanied by inspections of the respective candidates' premises,' read the FIA statement. 'As with Gen3, sustainability was also an important consideration in the Gen4's tender process.'

It was also confirmed that Marelli will provide the front powertrain kit and the cars will run on Bridgestone tyres, marking the Japanese tyre manufacturer's return to an FIA world championship after a decade and a half away.

FIA reveals F2 safety evolutions

The new generation Formula 2 car will feature a host of evolutionary safety improvements and upgrades, largely based on findings from analysis of scenarios with current generation cars

The next generation FIA Formula 2 car that will be introduced in 2024 features a number of key upgrades, following the pathway established by the FIA to improve safety throughout the single-seater pyramid, *writes Corrado Casiraghi, head of technical: single seater feeder categories*.

All single seater cars competing in FIA championships carry accident data recorders and data is transferred from these to a research group that works with industry experts and manufacturers to analyse accidents and reduce the risk of them happening again.

As a result of these investigations, the 2024 Formula 2 cars will have a number of safety improvements, including:

- Extended anti-intrusion panels that now cover the full side of the survival cell, from the front bulkhead to the fuel tank area. A front anti-intrusion panel has also been added to protect the chassis from longitudinal intrusions.
- The main roll structure (roll hoop) has been significantly upgraded following the analysis of recent accident and the forces that were measured on a real case scenario. The new structure has been tested at 170kN (equivalent to 17 tons, compared to 140kN on the previous generation), with a higher horizontal component of the force.
- The sidewall of the survival cell around the cockpit area is now tested with a load of 300kN. This new test, which didn't exist previously, simulates the condition the car would experience in a T-bone crash.
- The cockpit environment has been evolved, adding a further fixation to the headrest in order to improve its stability. The extractable seat is now surrounded by a foam 'outsert', improving the control of driver displacement in case of side impacts.
- The survival cell itself is subject to a dynamic test generating a deceleration of 52*g* (previously 40*g*) and front bulkhead loading of 450kN (45 tons, previously 350kN / 35 tons). This test ensures the survival cell can withstand forces higher that those generated by the front impact structure, which is fixed to the loaded bulkhead in race conditions.
- The front impact structure has been subject to major upgrades, aiming at improving the stability of the nosebox in angled impacts. Based on findings from accident analysis, the front impact structure is now tested with a higher push-off load (the equivalent load has increased by around five times) and can absorb 50 per cent more energy than the previous generation.
- Similar evolution has been applied to the rear impact structure, increasing its capability to sustain angled impacts and its energy absorption capability (+15 per cent).

The new car will also be equipped with the latest FIA-spec restraining cables, improving the retention capability of wheels and debris such as the rear crash structure, and will also feature an evolution of the current anti-stall system, helping protect the spectacle while also improving general safety during competition.

IndyCar delays hybrid introduction

Joe Skibinski

The latest date for the proposed hybrid IndyCar debut is after the next Indianapolis 500 in May 2024

IndyCar has confirmed it will introduce its proposed spec hybrid system after the Indianapolis 500 in May 2024.

The announcement to delay the introduction of hybrid is a further blow to the series, which has already shelved plans for a new car and a new engine, despite partner manufacturers Honda and Chevrolet producing new powerplants ahead of the decision.

Testing for the hybrid system, which comprises an MGU and super capacitor energy storage system that will be fitted inside the bellhousing, has been ongoing since August 2023, with the existing 2.2-litre V6 engines racking up more than 15,000 miles of testing between 13 IndyCar drivers.

Multiple strategies for regeneration and deployment have been tested as the power unit builds and transmits energy through the MGU.

The hybrid system is not intended to have a restriction on the total time used over the course of a race. Additional testing will continue throughout the winter ahead of the first race in 2024.

TCR earns FIA recognition

The inaugural TCR World Tour, which has been awarded FIA status after a one-year hiatus, will feature nine events on its 2024 schedule, held across six continents.

The TCR World Tour was introduced in 2023, consisting of nine rounds, with the competitors joining the grid of existing national or regional-level Touring Car series running TCR-spec cars.

The agreement between the FIA and TCR will last for three years. Race formats and duration will vary, adapting to the regulations of the given series that hosts each round of the World Tour.

'We are immensely proud that, after only one racing season, the concept of the TCR World Tour has already met with general approval from the motorsport community,' said Marcello Lotti, president of series promoter WSC. 'To now be able to award an FIA title is the icing on the cake and provides us with powerful motivation to do our utmost to make this platform even stronger and more popular.

As well as the TCR World Tour, a new class will provide a home for existing first generation TCR cars

Lotti also approved a new class, TCR Gen 1, for cars that comply with TCR technical form before 31 December 2017. It is estimated there are hundreds around the world, and promoters have requested they be allowed to continue racing.

'Nearly 10 years since the TCR concept was launched, there are still hundreds of first-generation cars competing in different series around the globe and we want to assure them a longer and competitive racing life,' said Lotti.

IN BRIEF

A cooling scoop may be fitted to **Formula 1** cars that race in extreme conditions next season, following incidents of drivers overheating at the Qatar Grand Prix. Other changes to cars include limitations on the number and mass of certain metallic components used in the floor that have been identified as a safety risk should they become dislodged from the car.

Marelli has presented its first hydrogen fuel system solution, including injectors with a patented design and an advanced engine control unit. The state-of-the-art system builds on the company's established expertise in direct injection technology and is said to ensure precision, efficiency, performance, easy integration and complexity reduction.

Come and see the ***Racecar Engineering*** editorial team on stand E504 at Autosport International at the NEC, Birmingham on 11-12 January 2024

Rallying's future direction under scrutiny

XPB

As well as considering aspects of the existing World Rally Championship, the working group aims to address the path into the series from amateur racing

The future of rallying has been placed under the spotlight with deputy president, Robert Reid, and David Richards working together to create a working group to evaluate and recommend the future direction for the sport. Work has already started, with meetings taking place early in December, and will focus on developing the feeder series to the World Rally Championship and making the sport more accessible.

'Under consideration will be the technical, sporting and promotional aspects of the FIA World Rally Championship,' notes an FIA statement. 'The group will also address the pathway for grass roots development of rallying.'

The team was given two weeks to produce an initial working paper for consideration by the World Motorsport Council and WRC Commission before Christmas 2023.

Xtrac introduces electronic shifter

British company, Xtrac, has introduced an electronic gearshift actuator onto its IndyCar gearbox that will be used in 2024. The company developed the mechanism in off-road competition before putting it into competition on track at Le Mans, in the Garage 56 Gen7 NASCAR.

The system proved reliable enough that the company, which is the sole supplier of gearboxes to IndyCar, will roll it out throughout the field in the coming season.

Xtrac's new electronic gearbox actuator, as used in the NASCAR Garage 56 entry at Le Mans

The Telegraph

Enjoy 1 year for just £19

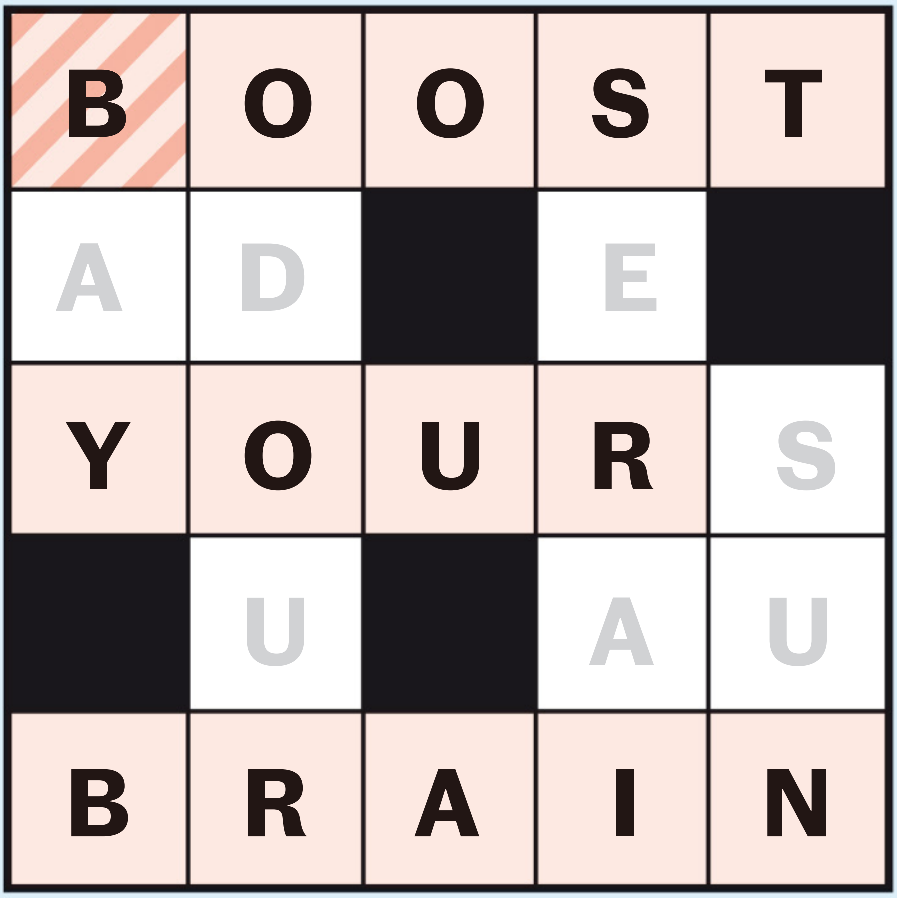
Get a head start in 2024 with The Telegraph's expert insight and advice. Unlock full access to our award-winning website and app, including Telegraph Health: your complete guide to living well.

Scan the QR code to subscribe or visit telegraph.co.uk/tmgnewsuk

To scan the QR code, open your phone camera, point it at the code and tap the banner that appears on screen.
On older phones, you may need to download a QR code reader first.

PUZZLES

Enjoy 6 months free



Get every day off to a winning start with Telegraph Puzzles. Play thousands of brilliant brain-teasers, from PlusWord, Panagram and Killer Sudoku to their classic Quick and Cryptic Crosswords.

Scan the QR code or visit telegraph.co.uk/puzzles-tel

To scan the QR code, open your phone camera, point it at the code and tap the banner that appears on screen.
On older phones, you may need to download a QR code reader first.

Popularity contest

Motorsport is currently enjoying a growth spurt, so make sure that you don't miss any opportunities in 2024

With a great year behind us, 2024 is shaping up to be even better. Motorsport suppliers are busier then ever, with major series seeing increasing grid numbers and new technology creating high demand in many diverse areas. F1, in particular, is riding a wave of outstanding popularity at the moment. And as fan numbers increase, so more sponsors are secured, which is good for everyone.

On 6 February at Gaydon, the MIA EEMS24 Discussion Forum is attracting a larger audience than ever before, and interest in 'Tomorrow's World of Motorsport' is growing across many sectors. For details, see the-mia.com/events.

The variety of international speakers at EEMS24 will discuss and demonstrate the wide range of options for new energy sources, be that hydrogen, e-fuels, electric and anything else in between, for which exciting technologies are all being developed around the world and particularly in the UK.

A panel of young graduates will give their views on tomorrow's motorsports challenges, and share invaluable insights and new ideas for F1, IMSA, touring cars and even E1 electric powerboat racing.

There are so many technology showcases to visit, and so many new contacts to be made, you will leave with bright ideas for 2024 and beyond.

Exciting prospects

One exciting prospect is the increasing demand from OEMs for low volume, high quality solutions delivered quickly. They are searching out and engaging niche suppliers from Motorsport Valley to trial and develop these concepts. Agile, active suppliers are securing this new business every week.

Our discussions will also embrace the likely impact artificial intelligence (AI) will have on the future of motorsport. An outstanding specialist in the field will clarify the subject for us.

AI is rapidly growing in importance across the sport and industry, yet little is known about it by many, and the technology is even feared by some. The legendary head of design at Apple, Sir Johnny Ive, is part of a powerful group developing an 'iPhone of Artificial Intelligence'.

ChatGPT, the AI-powered language model developed by OpenAI, demonstrates just how powerful this future technology will be. The platform generates 'human responses' to any questions that the user sets. Quite remarkable, but also somewhat disturbing!

The UK has a good reputation and is highly regarded for applying new technologies to commercial use. There is certainly great potential for AI across our motorsport community, but companies must move fast to take full advantage of this. Valuable, experienced advice is to make sure your company rapidly learns how to use new AI technologies well and to best effect for your business.

The MIA regularly hosts insightful discussion groups, with our many members from across our industry. A recent group made it clear that recruitment is going through a difficult and confusing time. On the one hand, more and more young people are being attracted to study relevant engineering up to degree level, driven in part by the popularity of motorsport. This is the good news, though attitudes displayed by these new recruits causes some concern. For starters, there is very little loyalty to employers being shown. New recruits move rapidly to other employers, chasing higher income but before building essential experience.

XPB

New technologies such as biofuels and renewables will be discussed at EEMS24

The overview from employers is to now recognise that a new employee's 'mindset' is more important than their qualifications, and that a good attitude and resilience are more essential attributes than experience. In changing times. These words from leading employers are worth consideration.

There is real enthusiasm that the number of women working in motorsport, particularly engineering, is growing quickly. More are studying engineering in general and many choose to go on to secure roles in all aspects of motorsport.

Valuable assets

As local and international demand increases, we need more young people to join our labour force. The boost in popularity of motorsport is a real and valuable asset in this.

MIA member, Xtrac, commented that 40 per cent of its apprenticeships this year are female. To maintain this impetus, the MIA is preparing an initiative focused on 'women working in motorsport' to ensure we welcome more talented individuals into our business community efficiently and to best effect.

In summary, we enter 2024 in a positive frame of mind as we always do. Exciting technologies are in demand and being developed, major motorsport series are expanding and there is huge growth in motorsport popularity that is attracting investors and sponsors.

All this is helping build a fast-growing community in Motorsport Valley to service this success.

The Motorsport Industry Association is proud to serve this international community. You are welcome to join MIA business development groups to Modena, Italy in March, and to Charlotte, USA in May. We will deliver an increasingly large CTS 24 motorsport and technology trade show, at the Silverstone Wing in October, which already looks set to be a sell out.

I hope that 2024, our 30th anniversary year, will be the year *you* choose to join us as a member so you can benefit from all our new initiatives to build *your* business.

I wish you all a very prosperous new year and further success in motorsport.

Chris Aylett is CEO of the MIA (Motorsport Industry Association) www.the-mia.com

More and more young people are being attracted to study relevant engineering up to degree level, driven in part by the popularity of motorsport

Dominance effect

Will 2024 see a shake up in the current motorsport world order?

While it's true that motor racing, like all sport, relies on unpredictability to retain audience interest, it is also true that any team that dominates in a highly competitive field is the epitome of excellence. Red Bull achieved just that in Formula 1, Toyota in the World Endurance Championship.

The dominance of Red Bull in F1 is not without precedent. Team boss, Christian Horner, has called it a 'unicorn year', in which the RB19 was superior to the competition, mainly in the hands of Max Verstappen who remains on top of his game, plus an almost perfect team.

There have been times when a car has dominated, such as in 1988 when the McLaren MP4/4 Honda won 15 of the 16 world championship races, but those wins were shared between Ayrton Senna and Alain Prost, whose season ended acrimoniously in Japan. No one could touch the MP4/4 that year, other than Williams stand-in Jean-Louis Schlesser, who wiped out Senna's leading McLaren at Monza and left Gerhard Berger free to take victory for Ferrari.

The further you dig into the facts behind this season, the more incredible it seems. Red Bull will invest in a new wind tunnel, having developed the RB19 in a facility housed on an aircraft research site originally built in 1946. Horner describes the facility as a 'Cold War relic', and yet on it was developed the RB19.

The fact Red Bull was found to have breached the cost cap regulations in 2021, and punished with a reduction in wind tunnel testing allowance, makes me wonder how much use the facility really was, at least compared to the minds of the technical team that designed the car.

Early advantage

The computational might of Red Bull was also restricted as part of the penalty, which was heaped on top of its already reduced tunnel and CFD allowance for winning in 2022.

There is no doubt that the team understood and controlled the ground effect and ride control better, and earlier, than anyone. Having found an advantage, Red Bull managed to maintain it, despite the restrictions placed on the team. If rumours turn out to be true, the team will retain some of this potential into the next regulation set in 2026.

It seems that Red Bull has entered a golden era, but they don't last forever. Ask McLaren, Ferrari and Mercedes for recent examples of how the mighty can fall. All I hope is that, when Red Bull's era does come to an end, it will be by a team that does not go on to dominate the following years.

As impressive as Red Bull was in 2023, there does need to be a change to prevent one team carrying an advantage from year to year, as Mercedes did with its engine, and as Red Bull has done with its overall car concept.

The seven samurai

Despite the appointment of a team, labelled the 'seven samurai', to cut spending at Toyota in 2018, the Japanese manufacturer dominated the WEC in 2023, and has also taken back-to-back titles in the World Rally Championship.

Elsewhere, the end of the '23 season saw the FIA state that Robert Reid and David Richards, both experienced rally men, will lead a team to look at the future of the sport.

Rallying to me has always been about the adventure. Speed, yes, but reliability and team work, coupled with extreme terrain. The old stages weren't great for TV, so there was less money around, but my childhood rally hero was Markku Alen, who always looked grumpy and never wealthy, but was *always* fast.

Financial ambition and cost control seem to have overtaken the sport in many areas

While Toyota is dominant with its GR010 in the WEC, there are changes afoot in that the series will go to hydrogen in 2027, and intends on taking big manufacturers with it. Not all, though. At least one says hydrogen is not a performance fuel. But then nor is electric, yet we have world championships using that method of propulsion anyway. It will be interesting to see how that technology plays out, and whether something else will pop up to replace it.

IndyCar continues to struggle with introducing hybrid technology and rumours suggest one of its two major manufacturers, Honda, is looking to withdraw, citing high costs of supplying half the field (though saying it would look at NASCAR instead suggests mere sabre rattling).

IndyCar wanted to introduce a new engine for 2024, and a new chassis for 2025, but both plans have been shelved. Rather than be held hostage by manufacturers, why not bring in independent engine companies such as Ilmor and Cosworth? Sure, there would be less money about, but drivers still want to race, and win.

Financial ambition and cost control seem to have overtaken the sport in many areas to the detriment of competition. I'd love to see a return of grumpy, quick drivers, customer teams taking it to the big guns, and for independent companies to be able to develop young engineering talent on a world stage.

ANDREW COTTON Editor

Racecar engineering
Inside the world of modern motorsport technology

PIT CREW

Editor
Andrew Cotton @RacecarEd
Email andrew.cotton@chelseamagazines.com

Deputy editor
Daniel Lloyd @RacecarEngineer
Email daniel.lloyd@chelseamagazines.com

Sub editor
Mike Pye

Art editor
Barbara Stanley

Technical consultant
Peter Wright

Contributors
Mike Breslin, Lawrence Butcher, Dejan Ninic, Karl Ludvigsen, Danny Nowlan, Scott Raymond

Photography
Dan Bathie, Rick Dole, Mike Levitt, James Moy, Christian Hartung

Group sales director Catherine Chapman

Head of sales operations Jodie Green

Advertisement manager Lauren Mills
Tel +44 (0) 20 7349 3796
Email lauren.mills@chelseamagazines.com

Advertisement executive Doug Howard
Tel +44 (0) 20 7349 3700
Email doug.howard@chelseamagazines.com

Marketing executive Bret Weekes
Email bret.weekes@chelseamagazines.com

Publisher Simon Temlett
Managing director James Dobson

Editorial and advertising
Racecar Engineering, Chelsea Magazine Company, 111 Buckingham Palace Road, London, SW1 0DT
Tel +44 (0) 20 7349 3700

Subscriptions
Tel: +44 (0)1858 438443
Email: racecarengineering@subscription.co.uk
Online: www.subscription.co.uk/chelsea/help
Post: *Racecar Engineering*, Subscriptions Department, Sovereign Park, Lathkill St, Market Harborough, Leicestershire, United Kingdom, LE16 9EF

Did you know you can manage your subscription online?
Oversee your print and digital subscriptions online today simply by signing up at
https://www.subscription.co.uk/chelsea/Solo/
Stay up to date with the latest issues, update your personal details, and even renew your subscription with just a click of a button.

Subscription rates
UK (12 issues) £84
Europe (12 issues) £100/€120
ROW (12 issues) £120/USD$165
racecar@servicehelpline.co.uk

Back Issues
www.chelseamagazines.com/shop

News distribution
Seymour International Ltd, 2 East Poultry Avenue, London EC1A 9PT
Tel +44 (0) 20 7429 4000
Fax +44 (0) 20 7429 4001
Email info@seymour.co.uk

Racecar Engineering (ISSN No: 0961-1096, USPS No: 463) is published monthly by The Chelsea Magazine Company Limited, and distributed in the USA by Asendia USA, 701 Ashland Ave, Folcroft PA. POSTMASTER: send address changes to Racecar Engineering, 701 Ashland Ave, Folcroft, PA. 19032.

Printed by William Gibbons
Printed in England
ISSN No 0961-1096
USPS No 007-969

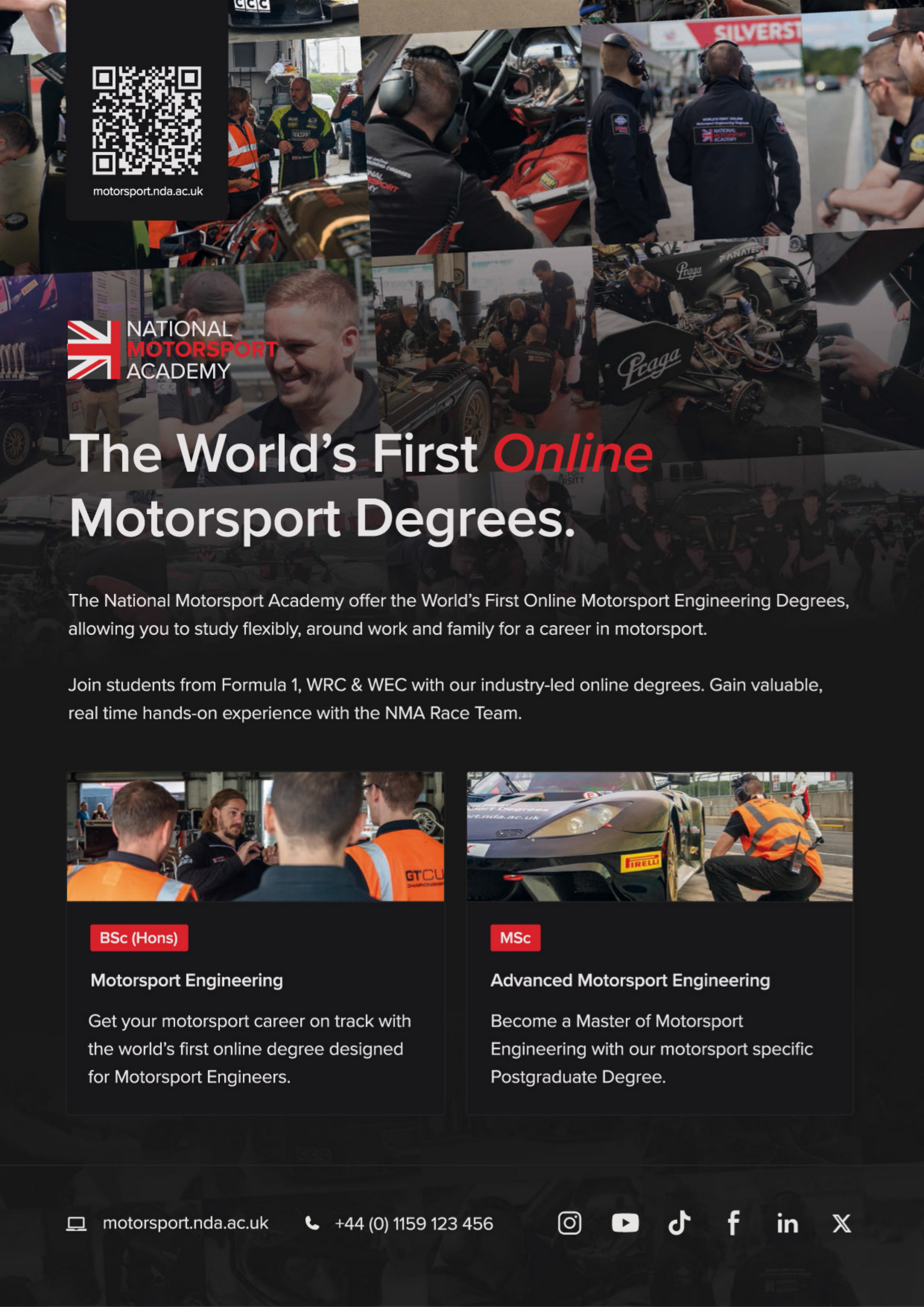
THE CHELSEA MAGAZINE COMPANY LTD
TELEGRAPH MEDIA GROUP

www.racecar-engineering.com

To subscribe to *Racecar Engineering*, go to www.racecar-engineering.com/subscribe or email racecar@servicehelpline.co.uk telephone +44 (0) 1795 419837

• *Racecar Engineering*, incorporating *Cars & Car Conversions* and *Rallysport*, is published 12 times per annum and is available on subscription. Although due care has been taken to ensure that the content of this publication is accurate and up-to-date, the publisher can accept no liability for errors and omissions. Unless otherwise stated, this publication has not tested products or services that are described herein, and their inclusion does not imply any form of endorsement. By accepting advertisements in this publication, the publisher does not warrant their accuracy, nor accept responsibility for their contents. The publisher welcomes unsolicited manuscripts and illustrations but can accept no liability for their safe return. © 2024 Chelsea Magazine Company, part of the Telegraph Media Group. All rights reserved.

• Reproduction (in whole or in part) of any text, photograph or illustration contained in this publication without the written permission of the publisher is strictly prohibited. *Racecar Engineering* (USPS 007-969) is published 12 times per year by Chelsea Magazine Company in England.



motorsport.nda.ac.uk
NATIONAL MOTORSPORT ACADEMY
The World's First Online Motorsport Degrees.
The National Motorsport Academy offer the World's First Online Motorsport Engineering Degrees, allowing you to study flexibly, around work and family for a career in motorsport.
Join students from Formula 1, WRC & WEC with our industry-led online degrees. Gain valuable, real time hands-on experience with the NMA Race Team.
BSc (Hons)
Motorsport Engineering
Get your motorsport career on track with the world's first online degree designed for Motorsport Engineers.
MSc
Advanced Motorsport Engineering
Become a Master of Motorsport Engineering with our motorsport specific Postgraduate Degree.
motorsport.nda.ac.uk
+44 (0) 1159 123 456

Be last.

Being the last on the brakes isn't just a test of skill, it's also a test of how much confidence a driver has in their brakes.

With unique Fade Resistant Technology™, Halo P1 has a far lower and far more stable level of compressibility over a wide temperature range than the competition—giving drivers the confidence that their brake fluid will perform as well on the last lap as the first.

Formulated for the art of braking.

halo.
By Orthene.

halobyorthene.com