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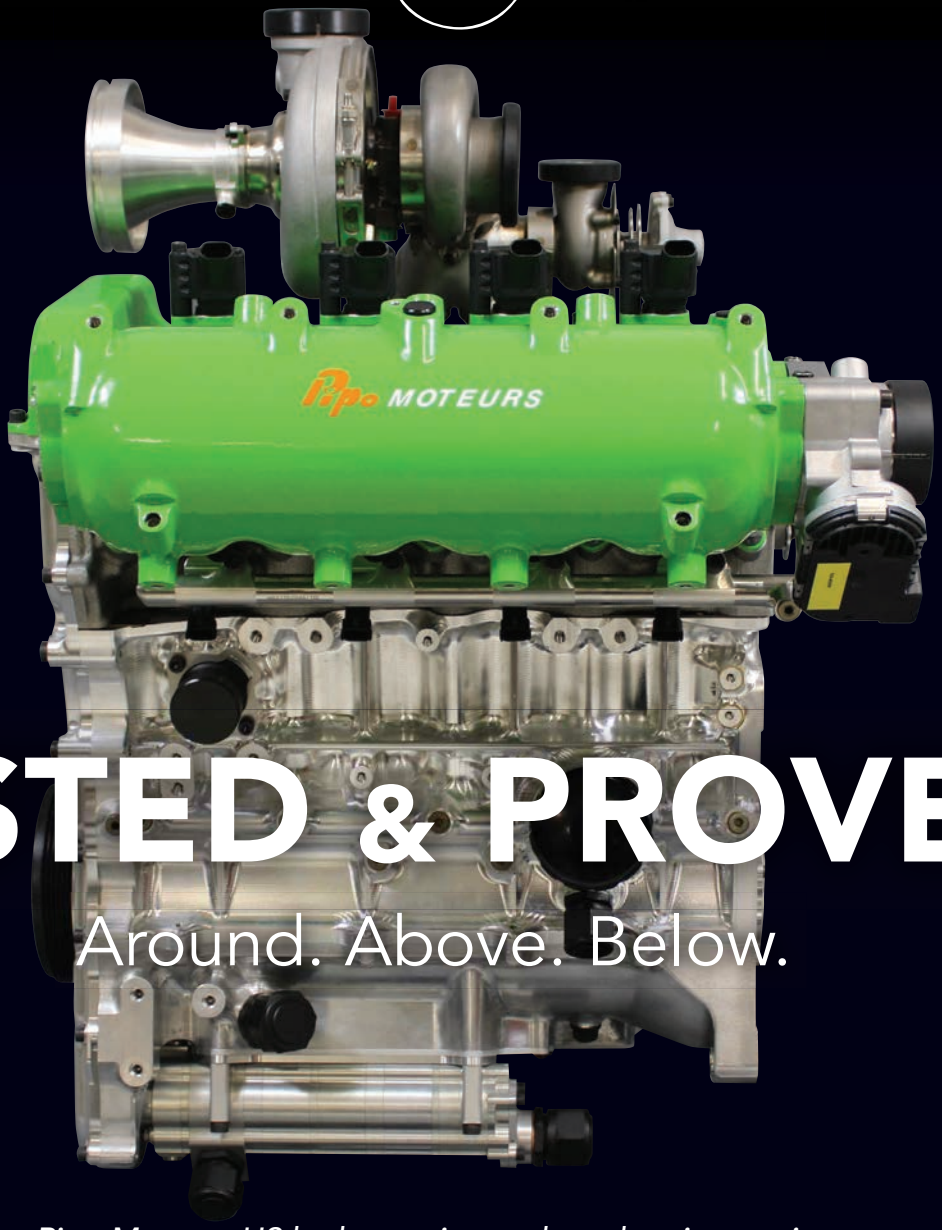

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From race to road

The mad Irishman and major Tom a few years later

Having left Eddie Jordan, it was a matter of out of the frying pan and into the fire, as I joined Tom Walkinshaw Racing (TWR) soon after. The company was different, but there were still some stories to tell. At TWR, *all* the drivers were being paid to drive so the performance of the car in a racing situation was the major criteria. It was incredibly hard work, but the success it could bring became almost addictive.

I was fortunate to be surrounded by a really hungry team and some great drivers. In Tom's eyes, wins were what mattered, and consequently I was given a bonus with each one of them, but absolutely nothing for any minor placings. That suited me just fine, and I was able to return the faith Martin Brundle had shown in me with a World Sportscar Championship, and wins at Le Mans and Daytona, which went some way to make up for what happened in Formula 3 in 1983.

Tom was also able to take me into a whole new road car world with the Jaguar XJ220 project, where I was able to learn a completely new set of skills. I mean, what real petrolhead wouldn't want the opportunity to develop what was at the time the world's fastest road car?

The Tom Walkinshaw Racing-developed Jaguar XJ220, where race car world met the road car world head on

Worst case scenario

However, the gulf between racers and road car people was brought home to me the very first day I sat behind my new desk. My certification manager's very first question was to ask if we should hold a 'worst case' meeting, something unheard of in motorsport! There, you just had to get it right, as the timeframes didn't move.

The next shock was driving a rough prototype, finding the gear ratios all wrong and being told I could have a new set in 'about four months'. I was used to a ratio change in about 15 minutes!

Nevertheless, the car was going to go like a racecar, and so I had to apply some racecar principles to the prototype builds and testing to get the car to engineering sign off by the end of 1991.

To achieve this, I brought in a key worker for each of the five prototype cars for testing, and had some of my number one mechanics from racing come and join me.

One of the many jobs I was given was to drive the prototype for the *Sunday Times Magazine* supplement, *Quality Cars*. If I look petrified in the image, it's because I'm driving what was the only running car of its type at the time virtually underneath the tailgate of a photographer's Range Rover at 50mph with zero visibility. I can vividly recall that experience to this day, and can honestly say it was much scarier than driving the car at 200mph for the very first time.

Road test

Much of the car's basic testing was done at the Millbrook test facility near Bedford, UK and I would regularly drive the cars there and back from Bloxham, just south of Banbury. Tom would often drive the cars too to check on progress… and just to enjoy himself.

Meanwhile, my old boss, Eddie Jordan, was moving into his new factory at Silverstone, which I really wanted to see. And he *really* wanted to see this new road car I was playing with. So, as Silverstone is almost, ahem, on the way to Millbrook, I dropped in one morning to look at his new facility. Eddie, of course, wanted a go in the car, and asked if we could take it back to his old workshop to show designer, Gary Anderson.

I agreed, and Eddie drove sensibly… up until we were at the main entrance. He them hit the gas and signed the road with a huge 345-sized eleven, which rather unexpectedly announced our presence.

The following day, I had a message from Tom's secretary asking where all the development cars had been the previous day. It appears someone had told Tom they thought they heard, and saw, one of his new cars at the Silverstone circuit.

Little did I know that Tom was chairing a meeting of the BRDC at the time of the offence, in an office right at the old entrance to the circuit.

I hastily made a list of where all the cars were that day and, fortunately, nobody thought to verify the Millbrook check-in times, or else I might have had some explaining to do.

What real petrolhead wouldn't want the opportunity to develop what was at the time the world's fastest road car?

Ferrari is back

Ferrari's Finali Mondiali at Imola in October saw the Italian manufacturer unveil the 499P, a prototype it hopes will deliver world championship and Le Mans glory

By ANDREW COTTON

It has been a much-anticipated return to top-level sportscar racing for Ferrari, and its new prototype, the first since 1973, has already delivered. Unveiled at Imola, near to the Ferrari factory, and with a number of Ferrari employees in attendance, the 499P that carries the manufacturer's long-term endurance racing hopes was revealed to the world for the first time.

Ferrari has long been present in GT endurance racing, but it has been more than 50 years since it last won at Le Mans. In the interim, the brand has been successfully represented in GT racing by the Squadra Corse arm of the company for over 20 years, in partnership with Amato Ferrari's AF Corse team, and that relationship will continue with the new prototype.


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World Championship titles have gone the way of the Scuderia in GT racing, but the chance to step back into top-flight prototype racing came with the new set of regulations that limited development scope and reduced cost, at a time when Ferrari's racing activities were changing due to external factors.

Changing times

The first of those was that the Scuderia took endurance racing seriously enough to bring the design and development of the GT3 car in house for the first time. Its last factory foray into GT racing came with the 575 in 2004, but that car was not a patch on the Prodrive-built 550 Maranello that dominated GT racing in the early noughties.

Since then, Ferrari's GTE and GT3 cars have been designed and built by Michelotto, but for the latest 296 programme, which was unveiled in July 2022, the design part of the operation was brought in house and the build outsourced to ORECA, which already claims to have pre-sold more than 200 cars before the first has even been homologated.

The second factor was the Formula 1 regulations changing, with a cost cap forcing teams to re-think all elements of their structure. Ferrari consequently had engineers left over from its F1 programme although, according to the team, only 30 of them are now working full time on the Le Mans prototype project. However, that's not to say other departments are not involved.

From design to hybrid system, from aerodynamic and simulation to engine development for production cars, the various groups within Ferrari are feeding into each other to lift the manufacturer's racing activities as a whole.

The final part was that the Automobile Club de l'Ouest and the FIA came together and finally produced a set of regulations that suited manufacturers wanting to return to Le Mans, including Ferrari. The top-class prototypes now have to hit a certain point on the lift / drag graph, are performance balanced within that window, and homologation is effectively frozen for five years. That was all expected to make racing cheap(er), which was attractive.

Prior to making its return to sportscar racing, the manufacturer stated that it would focus its attention on fixing the issues it faced in Formula 1 first, before adding the distraction of another programme. However, although the Scuderia has yet to win a Formula 1 World Championship since Kimi Raikkonen in 2007, it seized on the chance to join the FIA World Endurance Championship for the 2023 season, and to compete in the Centenary of the Le Mans 24 hours.

The aero regulations allowed the design team to work with Ferrari's Centro Stile studio without penalty. Rather than search for outright performance, the point on the lift / drag graph is relatively easy to hit, and the performance balancing system means road car styling cues don't have a large effect on overall performance. The complication of that is the window leaves very little room to move within, and the car must remain within that window of performance in all conditions.

The launch car was extraordinary, its aerodynamic detail surpassing what we were told to expect in terms of complication

Ferrari has yet to homologate the prototype, and says it won't have that process completed until the end of 2022. At that point, homologation will be fixed for five years (just five performance updates are allowed within that timeframe), and performance testing will begin ready for the competition debut at Sebring in March 2023.

Aerodynamic detail

All that being said, the launch car was nothing short of extraordinary. Its aerodynamic complications surpassed what we were told to expect. Under the nose is a series of wings, much like a Formula 1 car, mounted centrally and cascading down towards the front splitter in steps.

The new regulations allow, if not actively encourage, road car styling cues and, because of performance balancing, the primary focus has been on hitting the required point on the lift / drag ratio graph

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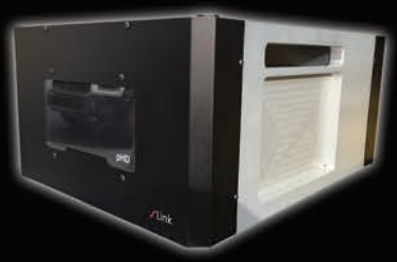

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From its agressive, Formula 1-style front wing through its longitudinal strakes to the huge rear wing, the 499P's design is all about aerodynamic stability and reducing tyre wear

The underside of the car looks like a Formula 1 tub, with the leading edge under the driver seat extended like a tea tray. Tight packaging over the radiators and sidepods suggest that much of the cooling flow comes from underneath, rather than over-body airflow, and Ferrari is particularly proud of its looks.

The team says it has not focused on outright performance as Balance of Performance would take care of that anyway. Instead, it has concentrated on creating a car with a wide operating window. Not only will that help over the course of a season in the WEC, but also in IMSA if the car does run in the US. Convergence between the European and American regulations mean this is now possible, and Ferrari has confirmed it is on the agenda in the near future.

'If you analyse the performance window, the range is not that big, so what is important is to minimise as much as possible the aero sensitivity and how it is in the corners,' says Ferdinando Cannizzo, head of Ferrari Attivita Sportive GT. 'Of course, we have to guarantee the aero stability. As long as you are constraining the efficiency of the car, that is the most important thing.

'We tried to design the car for a very wide range of tracks, considering we have to go to the US for the WEC. I hope the car can digest this standard of tracks, and we will discover that soon.

'I think that as an engineer, what we can do is have a car concept and suspension that hurts the tyres the least. We are looking for consistency and, even though the tyres are facing aggressive asphalt, the wear [should be] less than our competitors. For this kind of stuff, the simulation tools are not enough. We need some real experience to see if what we designed is actually there.'

What is striking about the car, initially, is the longitudinal strakes over the mirrors, front wheelarches, nose and roof. Plus the fin and the large rear wing endplates. Ferrari says these are to help correct the car in high yaw angles, as there are strict regulations surrounding stability in the event of a spin.

However, the large fin on the engine deck and the enormous rear wing end plates, in contrast to other cars such as the Peugeot, suggest these strakes have other functions. The likelihood is they will help the car on turn in and in high-speed corners, such as the Porsche Curves at Le Mans.

Rivals note that they, too, experimented with strakes over the front wheelarches for this reason, and suggested in this case they were more in place to help the airflow correlate to the underfloor.

At time of writing, Ferrari has yet to confirm whether or not it will have its permitted single-adjustable aero device at the front of the car, or at the rear. It can choose one, and with such a complicated arrangement under the nose, it is easy to see how it could trim the car with ease using either of these devices. However, insiders suggest it more likely the team will select the rear wing as it's easier to access.

That is something of a surprise. The tyre regulations changed at the end of 2021, and cars that were homologated before the end of the 2022 had the option of a narrow front tyre and wider rear to match the LMDh cars that will race in IMSA, or the same size tyre all round. Toyota switched from the latter option for this year's car as the hybrid deployment criteria changed, but Peugeot did not, and is the only car to run the same size tyres all round.

Narrow thinking

By regulation, then, with the car not racing until 2023, Ferrari had to take the narrow front, wider rear combination. However Toyota, in particular, noted the team had focused its set-up this year more on protecting the front tyre than the wider rear to maintain performance over a stint. The thinking is that the wider rear largely takes care of itself. A front-adjustable wing might make caring for the narrower front tyre a bit easier to manage.

Michelin is currently involved in a massive tyre testing programme for next year. Working with all the manufacturers, it is evolving a tyre with a higher bio content than this year's version, and is continuing to push for no tyre warmers in 2023.

Tight packaging over the radiators and sidepods suggest that much of the cooling flow comes from underneath, rather than over-body airflow

The car has been designed to suit a wide range of track and track surfaces as the new regulations allow prototypes to race in both the WEC in Europe and IMSA in the United States

Ferrari has not yet confirmed if it will use its single permitted adjustable aero device at the front or rear of the car, but it is thought likely the manufacturer will use the rear wing

Although a bespoke engine was briefly considered, using the 3.0-litre, V6, 296 engine as the base was more cost effective, and enhances the company's road car credentials to boot

A decision on that is expected in December this year but, if it happens, the idea is to increase the lap time penalty for taking on new tyres, encouraging teams to put more mileage on older tyres.

In order for teams to be prepared to do that, though, the tyre companies need to come up with a different chemical formula to help heat the tyres quicker, particularly in cold temperatures such as the night time at Le Mans. But if they do this, drop off over a stint will then be higher.

Either way, tyre management will be an even more critical part of overall car performance in the coming years.

Test plan

None of the teams have yet seen, or tested, the new 2023 tyres, and Ferrari says this will be a priority in its winter testing. Before that, though, the first step in the car's development was to confirm the tyre in simulation, while the first phase of track testing was to correlate what the team found in simulation with track data, and then tune the simulator accordingly.

'If you have your tyres that you can develop, you can have a higher degree of freedom to play with,' says Cannizzo. '[With this regulation] you need to match your design to the existing tyres. One of the most important jobs was to ensure the model used for simulating the tyres in the simulator were correlated with the track. That was our first priority, to clarify, and for now the results are interesting. We then started testing and feeding back, tuning our simulator.

'We are trying to use the tyres as soon as possible. At the moment we have just tested with the existing option. That is good when we are more caring about managing the car, increasing the reliability level of the systems and parts in small details. But then for sure at some point we need to start pushing in a proper way, and we need to have the right tyres to do so.'

At the launch, Ferrari was busy explaining the nomenclature of the car's name; 499 is one sixth of the engine capacity, said the Scuderia, and it confirmed the engine was based on the architecture of the 296 GT3. That makes it a 3.0-litre V6, with the turbos mounted inside the vee angle of the engine, but that's pretty much where the similarity ends between the two engines.

Base engine

'The base is the 296 engine,' confirms Cannizzo. 'It shares the same architecture as the 296, so 120-degree vee and the turbos inside the vee, but [in the prototype] the engine is stressed. The design and structural requirements are different [compared to the GT3]. You need to carry the gearbox and suspension. Everything is passing through the engine structures.

'All the rest is different. The turbochargers are different, inside is different, and the weight is unbelievably different.

'At some point we need to start pushing in a proper way, and we need to have the right tyres to do so'

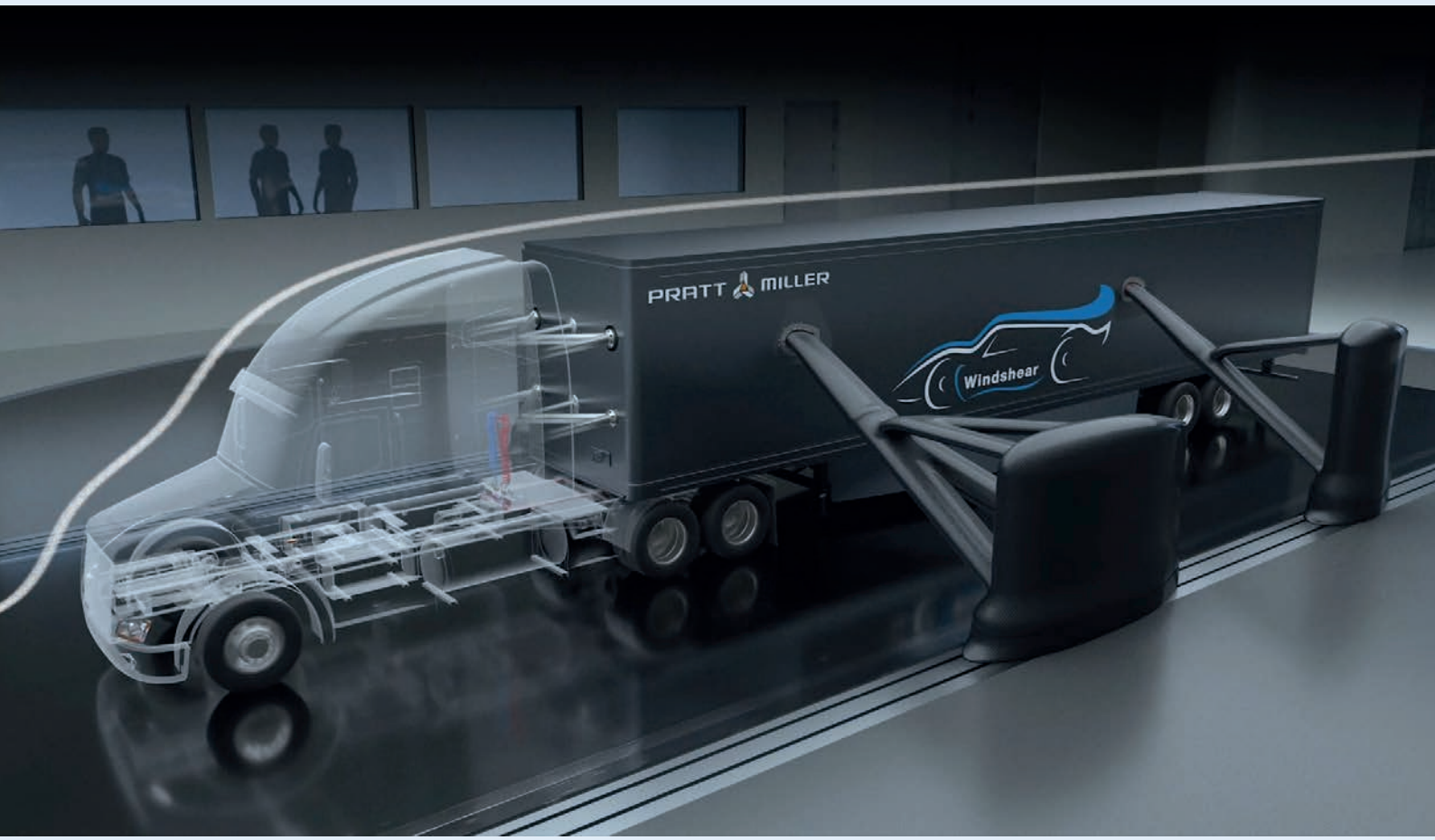
Ferdinando Cannizzo, head of Ferrari Attivita Sportive GT

'There is no reward for using a production-based engine [from a regulation or performance perspective]. This is an engine derived from production, so it shows that the technology in the road car is already looking like it is ready to race. We had a quick look at a bespoke engine, but we never considered it in terms of reality.'

Sharing the configuration of the engine between GT3 and prototype is therefore more of a marketing ploy, but Cannizzo says that knowledge gained from the reliability testing and application of the hybrid system will be fed back into the road car department with a view to perhaps improving reliability.

Bespoke 'box

Further back from the engine, Ferrari considered using an existing gearbox to ensure the car was reliable from the start, but in the end had to go with a bespoke unit to mount the suspension properly, and to meet the mandated 75kg minimum weight limit.



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'The main reasons for making a new gearbox were to have proper pick-up points for the suspension to optimise the kinematics. Second was packaging of the suspension, and the third was matching the gearbox with the engine,' says Cannizzo. 'Everything required a different gearbox specification. We were forced [to do this]. Initially, we tried to start from an existing transmission for reliability. Not GT3, because it is a different specification. We used the experience of the GT3, but were forced to make a number of changes, first of all because of the suspension.'

Information crossover

Ferrari was similarly tight lipped about the hybrid system it has developed for its car. By regulation, a manufacturer competing with a hybrid LMH must have a front-mounted MGU-K, turning the car into a four-wheel-drive car at a certain speed.

All that could be said was that the high voltage battery and the control systems were developed in conjunction with the Formula 1 team but, due to application differences, there was not much crossover of information.

'The battery is collecting the experience from Formula 1,' confirms Cannizzo, 'but the system is completely different. We have four-wheel drive with one electric motor, and Formula 1 is different. But in terms of controlling the electronics, yes, there is definitely some crossover.'

Due to the convergence between LMH (a ground-up design) and LMDh (commercially available chassis, spec hybrid system), the four-wheel-drive function has been castrated to the point that it is almost not worth having. That was a deliberate move by the rule writers as they had to create a condition where the two concepts have equal chance to win.

The LMDh concept featured a cockpit-adjustable front anti-roll bar and so, with the hybrid system changed to an open diff' and deployment speed set high, this was also introduced to the LMH car. As the change came late, many of the LMH manufacturers, including Ferrari, had to retrospectively find room for it.

'It has made our life more complicated,' admits Cannizzo. 'It happened at a later stage, which is not easy to manage when you are designing a car. I hope the regulation will stabilise and, of course, we have implemented this adjustable anti-roll bar and will try to understand if we can get some performance from it, but there are more important areas.

'It would have been better to ban the adjustable [anti-]roll bar in the LMDh category. That would have been easier because we would not have had to spend money to put it in, and for them it would be cost free to take it out, or even cheaper. But, no problem, in the end we will cope with it.'

Homologation will be complete by the end of December 2022, and the car will debut at Sebring in March, 2023.

Initial thoughts

***Racecar* speaks to James Calado, GTE Pro Champion 2022, development driver**

RE ***How was it making the transition from GT to LMH?***
'What was more surprising was a GT and an LMP2 test to get used to the downforce. That was a lot different. Going from GT to LMH, there were a lot of similarities. It works in the same way, just with a lot more power and a lot more downforce. You also have more things that you need to do on the steering wheel.

'Going to the LMH, it was five to six laps and you are there, so it is hard to compare lap times. That said, I feel we are all adapted well and all on the limit.'

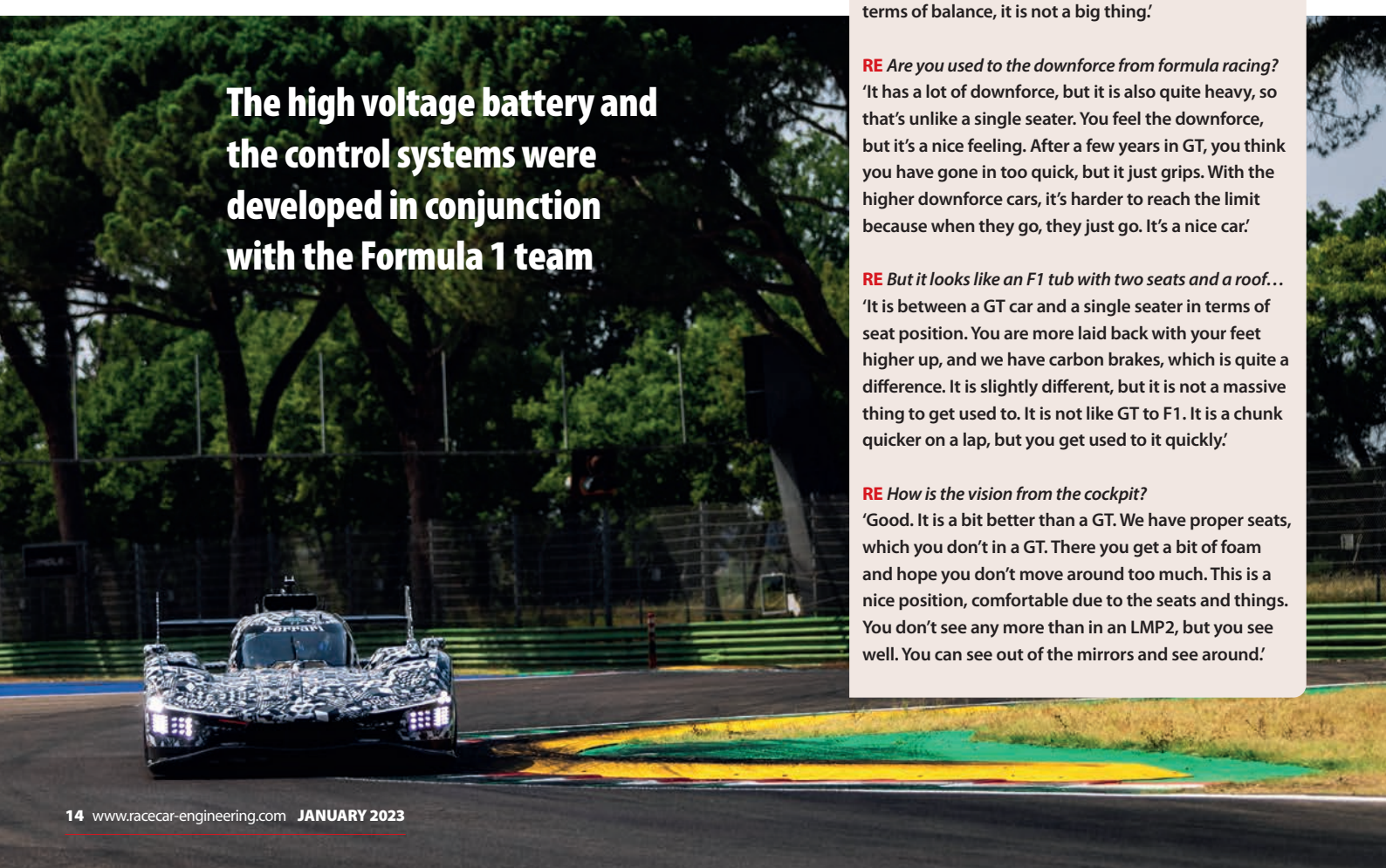
RE ***Tell us about the power delivery from the hybrid***
'Activation comes in at 190km/h, so really late. It comes in for the majority of the time in a straight line, and the transition is smooth. You can only really feel it because you hear the noise of the motor coming in, the whistle. Going through the high-speed corners, you can feel it kicking in because you feel the torque on the steering wheel, but it doesn't affect anything really. It has its advantages of course, but in terms of pure traction it doesn't make a difference.'

RE ***Does it change car behaviour on the brakes?***
'Yes. For me, it's a good thing with the regen' into the corner. If it is set up well it works really well, but it's hard to set up. It is beneficial, and the whole idea of the hybrid is to save fuel and be more efficient. During the test we try different combinations and, honestly, the difference between hydraulic and combustion, having the regen' and the acclimation of the energy in terms of balance, it is not a big thing.'

RE ***Are you used to the downforce from formula racing?***
'It has a lot of downforce, but it is also quite heavy, so that's unlike a single seater. You feel the downforce, but it's a nice feeling. After a few years in GT, you think you have gone in too quick, but it just grips. With the higher downforce cars, it's harder to reach the limit because when they go, they just go. It's a nice car.'

RE ***But it looks like an F1 tub with two seats and a roof…***
'It is between a GT car and a single seater in terms of seat position. You are more laid back with your feet higher up, and we have carbon brakes, which is quite a difference. It is slightly different, but it is not a massive thing to get used to. It is not like GT to F1. It is a chunk quicker on a lap, but you get used to it quickly.'

RE ***How is the vision from the cockpit?***
'Good. It is a bit better than a GT. We have proper seats, which you don't in a GT. There you get a bit of foam and hope you don't move around too much. This is a nice position, comfortable due to the seats and things. You don't see any more than in an LMP2, but you see well. You can see out of the mirrors and see around.'



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Young at heart

Peugeot has had a challenging start to its FIA WEC project with the 9X8 but, says technical director, Olivier Jansonnie, the programme is still young and has potential

By ANDREW COTTON

Peugeot will go into the next year of the FIA World Endurance Championship slightly buoyed by the performance of its 9X8 hybrid in the final race of the 2022 season. At the eight-hour stint in Bahrain, Scotland's Paul di Resta set fastest lap of the race, before retiring with a gearbox failure. The story of the race rather closely matches that of the season so far – flashes of promise and excitement followed by disappointment.

However, the team's technical director, Olivier Jansonnie, remained optimistic after the retirement of one car in Bahrain, the other delayed by technical issues, saying this was still only the third race and the team is still learning how to set the car up, operate it properly, and then extract performance.

There is a lot to unpack from the first season of racing with the 9X8. The team tried to have the car ready for the 24 Hours of Le Mans in June, but then elected not to do so, instead focusing on testing as it knew it was not ready. Quite why the new race team did not compete in last year's FIA WEC with an LMP2 car is not understood, but it was clear the team was not race ready, even when it did arrive in Monza in July.

Race debut

Little was expected of the car at the Italian race. Its 50 / 50 weight balance, with as much weight pushed forwards as possible in order to counterbalance the engine and gearbox, and the relaxed aero target figures allowed the team to run without a rear wing.

The Peugeot 9X8 has had moments of promise showing its potential, and continues to be developed without a rear wing and running on the same size tyres all round, making it a double anomaly on the WEC grid

All photos: XPB

'The target is Le Mans… We will do reliability testing in the winter, then there will be two or three endurance tests before Le Mans'

Olivier Jansonnie, technical director at Peugeot

In order to run competitively, however, the car had to take advantage of a regulation that, after Bahrain, has been withdrawn. But as the car officially raced in 2022, it could be homologated with the same size tyres all round. This is a novelty. Toyota ran the same size tyres in 2021 but, with regulation changes reducing the impact of the front-mounted hybrid system, it chose to switch to the narrow front, wider rear combination used by the Glickenhaus, the LMDh competitors and next year's entry from Ferrari.

Any car that is homologated now will need to run the narrow front, wider rear tyre package but, despite political pressure, Peugeot has resisted calls for it to fit a rear wing and adapt the design to the same tyres as everyone else.

With a major tyre development programme underway for next year, it could be argued that Peugeot will have an advantage over the rest of the opposition. If it came with a big enough cheque, Michelin would undoubtedly bring a bespoke tyre for the brand. However, without that large injection of cash, Michelin is hoping the tyre compound and construction will be the same for all prototypes competing in the Hypercar class, and that it will just need to stretch a bit for the front and squeeze a bit at the rear to make the rubber right for the Peugeot.

'There is no plan to change this from our side,' confirmed Jansonnie in Bahrain. 'From a regulation side, as long as the car is homologated in 2022, we can keep our concept and still have evolutions on the car. At some point we can decide that we don't have the right tyre dimension, but right now that is not the case.

Toyota's GR010 has had a better run in 2022, but the team have had to adapt the car to an open front diff' due to regulation changes

'Everyone will have a new range for 2023. Michelin is using all the track mileage they can to test those tyres and we have been part of this big testing plan. We have done our share of the testing.'

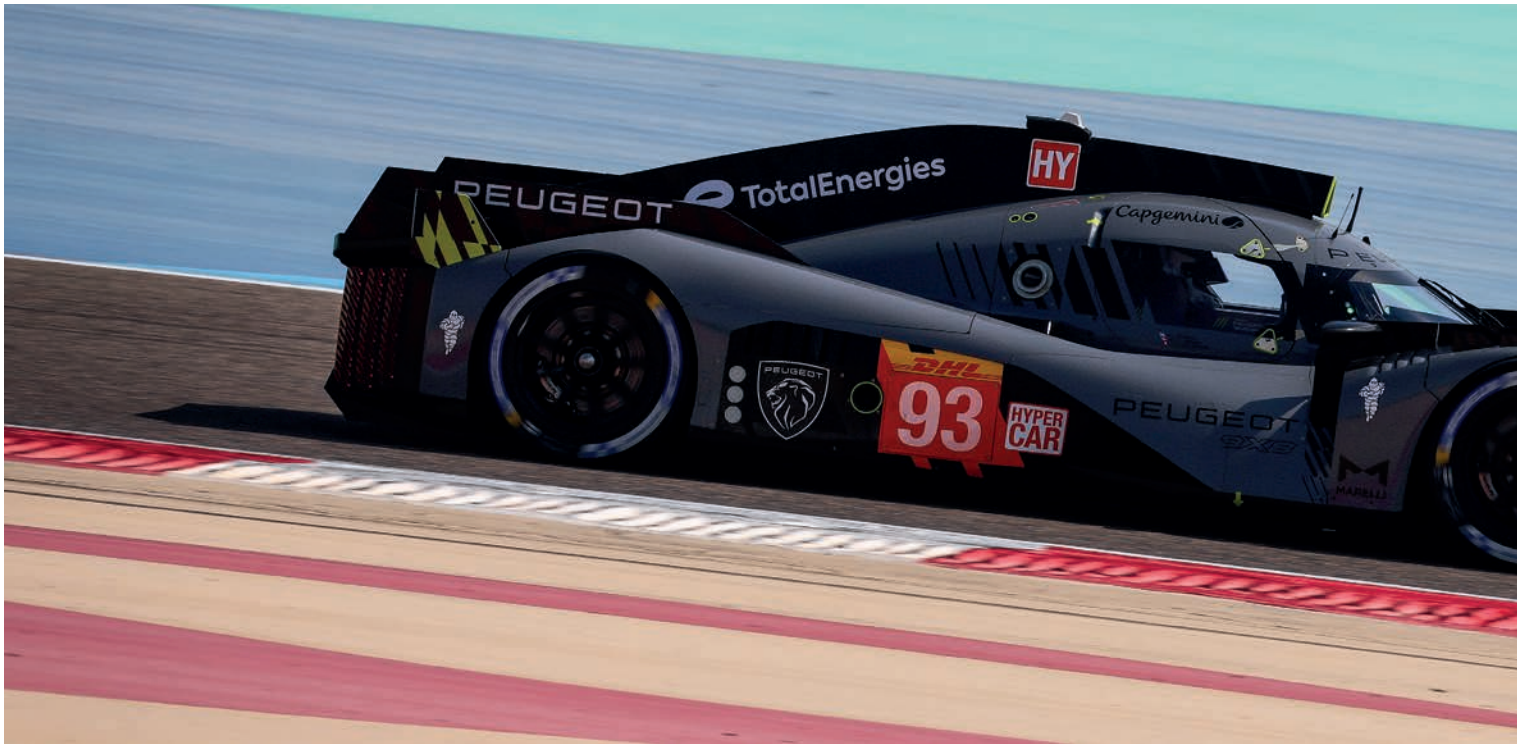
Behind schedule

However, in order to be competitive, Peugeot first has to concentrate on making its car reliable, and then performance testing before it can make a meaningful contribution to the tyre specification. Here, Jansonnie is clear the team is behind schedule.

'This was only out third race here, we are improving the car and the team every race,' says the Frenchman. 'It is a big step forward.

Peugeot has resisted calls for it to fit a rear wing and adapt the design to the same tyres as everyone else

At the same time, you can see that we are on the edge on many aspects of the race operation. Car performance is getting better, so that has improved a lot, but every hour we are finding new problems and that is not so far away from Monza.



One of the Peugeot's fundamental weaknesses so far has been a lack of top speed, but Jansonnie says much of that is down to car set-up, and that is a normal part of a car's development

Austrian company, AVL, is to help with performance balancing, which is expected to be easier with the prototypes than the GT3 cars

'At Monza we had electrical problems, but we made mistakes operationally over the weekend. We don't make them any more, but we found out new things from doing them.'

One of the major deficiencies of the car was top speed, as evidenced at Fuji in October. There, the car was nearly 7km/h down on the Toyota with one car, and 13km/h slower with the second. That sent Peugeot back to Monza to conduct some high-speed testing, running without the first chicane to try to establish what happened in Japan.

'It is set-up related,' says Jansonnie of the lack of top speed. 'There are a lot of things that you can improve. Some of the things are set-up, so ride height, suspension, whatever, but the software and logics behind it all give you performance, and how you use what is given by the BoP is very important.

'On this we improved as well, that was part of the plan. We went to Monza with something that was fairly basic and safe, but now we are pushing it race by race.'

Running updates

The rumour at the start of the year was that Peugeot was seeking to update its car even before it had homologated its first version. This was as ridiculous as it sounded, and was refuted by Peugeot, but it was clear the car needed a lot of updates through the year. Once the car is homologated, only five updates can be made for performance gain over a five-year period.

'It is more about reliability,' says Jansonnie. 'The Balance of Performance is all about power. We can change for next year. Any change we do now is new homologation, new joker. We are in discussion with the FIA and ACO over what we are allowed to change on the car. We are discussing often with them to see what we can do for next year.

'First you can do as many reliability jokers as you like. It just has to be agreed they are for reliability and not performance. After that, there is a discussion to prove what you are doing. The ACO has a deep understanding for what we are doing because we are supplying a lot of information and they are in the position to judge if it is [for] reliability.

'If [they judge it to be for] performance, you have five [changes] before 2025. There is always a discussion showing the options for what you want to do. [They can] agree that it is for reliability, or that the argument is too weak and it's performance. Then you decide what you want to do. Any change to performance and you have to accept you will have a BoP change against you. That is part of the game. It is always a balance between us and the FIA what it is that we are doing.

'There will be some updates for next year, but the question is if it is only reliability. We have made reliability changes already since Monza and Fuji. Reliability updates can happen any time, and performance-wise we have some ideas, but the administrative part of it, working out how you build your joker package, is an ongoing discussion. It is not 100 per cent clear what we will do or when.'

'We went to Monza with something that was fairly basic and safe, but now we are pushing it race by race'

Olivier Jansonnie

Behind closed doors

Unlike the American IMSA schedule, performance balancing will take place behind closed doors, and this has led to disharmony in the paddock. IMSA presents its findings to the competitors and invites manufacturers to comment on any anomalies, so everyone is aware of what is going on with other homologated cars.

The WEC has had to manually adjust its BoP for its GT cars this year, overriding the automatic system that was supposed to govern the category. That demonstrated a weakness in the system, that it could not cope with the data, despite years of running at the same tracks and with the same cars. That sounded alarm bells as the top class will be balanced next year.

The series will turn to Austrian company, AVL, to help balance the cars. AVL has previously been involved in the DTM series, where again manual adjustment has come often in the series that runs GT3 cars. The argument is that the prototypes will have a much narrower performance window than GT3, so should be easier to balance.

Whatever the outcome of the balancing act, it is imperative for its success that each of the cars achieves its maximum potential before accurate balancing can take place. For that, the teams need the 2023-spec tyre and, in Peugeot's case, also to run reliably.

'The target is Le Mans,' says Jansonnie, looking aahead to the Centenary race in 2023. 'The test plan is written for Le Mans. We will do reliability testing in the winter, and then there will be two or three endurance tests, so we have to schedule them at the right time so we can bring the right stuff to test.'

It is clear from the experiences of both Toyota and Peugeot this year that these are not easy cars to operate. Both have had difficult first seasons and, while Toyota has had a much more reliable run in 2022 than in 2021, Peugeot can expect a similar rate of improvement in 2023.

Running to stand still

Toyota brought an upgrade package to the FIA WEC this year without penalty, but it still had changes to make to its GR010 mid-season that negatively affected performance. When the GR010 was designed, the rules stated that the front hybrid motor had to be commercially available, hit a minimum weight, and have a closed differential that helped with set-up. Toyota was allowed to run that closed diff' until Le Mans in June, as it had already signed off on the car before the regulation was changed. After that, it had to run with an open diff' and adapt the set-up and operation of the car accordingly.

'When the regulation came through, we went to the sim' to try to prepare, but you have to spend extra time setting up with the limits, to get the speed from the different controls,' said Toyota's project leader, John Litjens. 'The differential didn't help because you had different stability on braking and turning, so you have to adapt your set-up and that all costs time. You can say it's an old car but, if you change the working environment, what you know will not work as it did before.'

One of the changes the Japanese team was able to make without penalty was switching to the narrow front, wide rear tyre concept, having run the same size tyre all round in 2021. This was due to the agreed change in front differential regulation, and the castration of the front hybrid system. It meant the team had to adjust the set-up of the car to protect the narrower front tyre, particularly at hotter races.

'You have a more forgiving rear, and the front is more limited,' confirms Litjens.

A further change to the regulation was the deployment speed of the hybrid system. This electrical power does not add to that produced by the internal combustion engine, it merely replaces it for the time it is deployed. The minimum deployment speed was raised to 190km/h to help balance the two and four-wheel-drive cars, but that only made the front hybrid system even less relevant to overall performance.

Non-hybrids

There were two non-hybrid contenders in the Hypercar field this year. Alpine ran the full season, its last with the old LMP1 ORECA chassis that had been performance balanced down in pace in order to compete in the top class. The Alpine was competitive at times, and won at Monza in July as Toyota adapted to the new differential settings, and Kamui Kobayashi crashed his GR010.

The two non-hybrid cars in 2022 competition were the Glickenhaus and Alpine (behind), but both suffered from a performance defecit

The Alpine drivers took the fight to the final race, heading into that last event at Bahrain level on points with Toyota, but the shortcomings of the car were graphically illustrated at that event. It simply did not have the speed, the economy or the tyre management to compete with the Toyota, and consequently dropped back.

'It was frustrating to lose [the race] like this,' said Alpine driver, Nicolas Lapierre. 'Toyota deserved it as they were better overall, but it was still disappointing to finish it like this. We extracted the maximum we could from this car, but it was just mission impossible. There was no battle in the end, which is not the way we would like to have ended the season.

'We were always hoping we would be strong, but the package we had was just not fast enough. There was no one area where we were stronger than them.'

[Alpine] did not have the speed, the economy or the tyre management to compete with the Toyota

Competition also came from Jim Glickenhaus' team, but only at a limited number of races. The team has not yet raced in a full season of competition, and this year limited its involvement to Sebring, Spa, Le Mans with two cars and Monza. The team is short of testing days and the car's biggest weakness is high-speed change of direction, according to its designer, Luca Ciancetti. It led comfortably at Monza before a turbo failure put the car out of the competition. The team did not then travel to Japan or Bahrain and finished third in the final standings.

Tyred out

One of the major differences between the LMDh cars that will run in the IMSA series, compared to the WEC, is they will have a single choice of tyre per race, while the WEC is expected to have a choice of two slicks per race (to be confirmed in December).

IMSA will allow teams the choice of hard or soft tyres at the opener at Daytona, simply because of the extremes of temperature – from upwards of 25degC during the day to near freezing at night. However, for the other races, sole tyre supplier, Michelin, must decide whether to bring a hard or soft option to the track, and teams will not have a choice.

For the WEC, it's a different story. There, teams are expecting the FIA and ACO to remove the option to heat tyres in an oven before fitting them to a car.

Michelin will therefore change the mixture of the rubber to allow for faster heating of the tyre and the sporting regulations will also have to change to allow drivers to spin the wheels leaving the pit to generate heat in the tyres. But even then, teams are worried their cars will not suit all the different conditions.

'If you have no tyre heating and only one spec then it will have an effect,' says Toyota's project leader, John Litjens. 'If you are lucky, you are in the good window, and if you are not, you are not. It depends if the car has a wide window or not. With the tyre specs you can work to the optimum but, with that, the one that has the wider window will be better.'

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McLaren's journey in 2022 was something of a rollercoaster, but the team's design philosophy leaves scope (and hope) for higher performance in the future

Baselining

Racecar *talks to McLaren F1's technical director, James Key, about how the team have progressed throughout this first season of the new 2022 regulations*

By STEWART MITCHELL

All photos: XPB

McLaren appeared to hit the ground running in early 2022 pre-season testing with the fastest lap of all the new cars in Barcelona. The team's spirit was therefore high before the next test in Bahrain. However, the second test session was not the trial McLaren needed to get mileage under the car's belt, or to prove the pace delivered in the previous session.

Following the Bahrain test, James Key, McLaren's technical director, said, 'it was a storm of so many different factors. We'd had a brake issue in the [Barcelona] test just a week before, and Bahrain was the closest winter test ever to the first race. There was very little time to react to that, but it also meant that, testing-wise, we got very little done, which put us back in terms of learning more about this new car.

'Consequently, we didn't get three days [of testing] and, what's more, everyone else did. So we went into the [first] race very much on the back foot.'

That pre-season testing set the scene for the rollercoaster of a race season to follow and, with 22 races completed for the season, on 15 occasions at least one McLaren achieved no points. Surprisingly, despite all this, the team finished fifth in the Constructors' Championship.

The MCL36 features a stadium-shaped outlet at the back of the engine cover to reject heat from underneath the skin

Conservative start

The MCL36 started 2022 in a relatively conventional way, with a conservative design and layout, despite the new chassis regulations allowing for many design philosophies to be used.

On making the most of the new rules in 2022, Key says, 'my philosophy going into this season was focusing on optimising the car for the track, and configuring the team to operate at the track level. Only when you get to the track can you truly see how the tyres are behaving, your aero balance, and your mechanical set-up. These new cars have new problems associated with them.

'We've all seen this porpoising phenomenon, which isn't surprising with a ground-effect car. We've been lucky not to suffer from it too badly, but that's been something new for many of the current engineers here in Formula 1.

'I don't know if the new cars are harder to tame beyond things like that. It's a massive learning process because we had no reference points whatsoever coming into this season. We all worked independently for about two years on these cars because it was delayed for a year after the Covid situation, and we had no idea what we'd all find when everyone else turned up.'

The first iteration of the MCL36 took a conservative approach. The upper side impact structure supports the top leading edge of a stadium-shape heat exchanger intake on either side of the driver cell. The leading edge of the intakes was perpendicular to the flow field, making no use of leading-edge flow conditioning as other teams appeared to be doing.

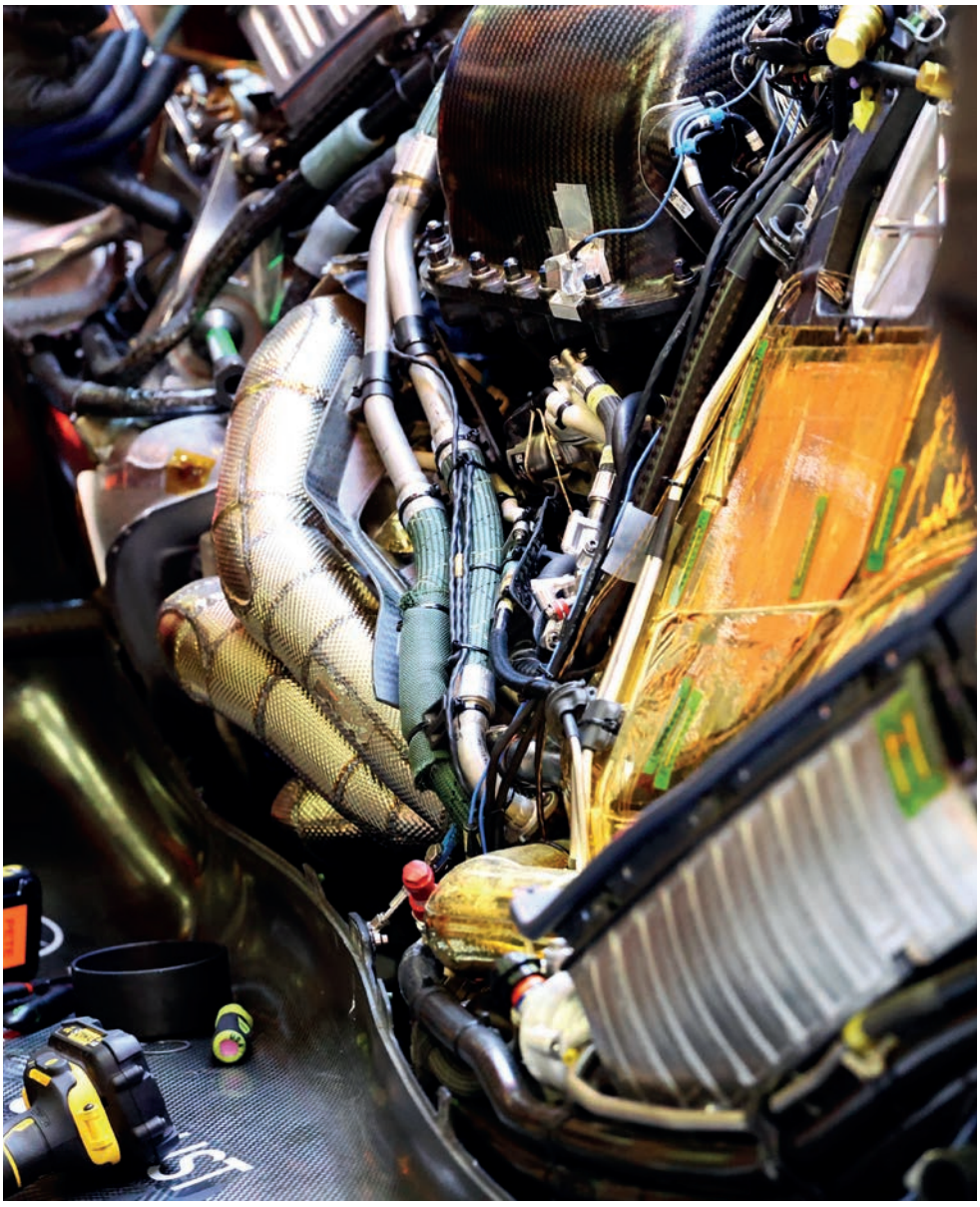
The first car also made no use of the louvres seen on many others on the grid. Instead, it featured a sizeable opening at the back of the engine cover bodywork to reject heat from underneath. This was a feature used in McLaren's previous generation cars.

The sidepod bodywork saw little curves to the upper surface sweeping downwards towards the car's rear, instead of sweeping inwards, sculpting under the engine cover. The underside of the cooler housing was wide and not heavily sculpted for aerodynamic benefit on the floor's upper surfaces.

Flexible friends

Unlike many of MCL36's rivals, the sidepod does not leave space for the upper floor surface to interact with the underfloor flows and other aerodynamic furniture. Instead, the sidepod bodywork runs down to the floor. This was all intentional. McLaren built considerable flexibility into its concept to give

Early on, McLaren used flow viz to gain a trackside understanding of the aerodynamics at play on its 2022 challenger



The highly respected Mercedes M13 E Performance power unit packaged neatly into the MCL36

'We made sure the car gave scope for us to develop its mechanical handling and aerodynamics without having to do resource-expensive work'

it scope for change as the team learnt more about the physics at play in this new era, ensuring it could be track-specific optimised.

'When we started the 2022 car, we wanted to make sure we left space for development because we knew there would be a lot of changes,' notes Key. 'We made sure the car gave scope for us to develop its mechanical handling and aerodynamics without having to do resource-expensive work.'

McLaren therefore built the car's sidepod geometry, engine cover and bodywork design with reliability in mind. By doing so, the team hoped to be able to make well-engineered changes to the cars rather than constantly fighting fires of unreliability in this new and unknown era.

Reference points

The layout of side impact structures, electronic control systems and the water-to-air charge air heat exchanger position for the car's Mercedes HPP M13 power unit sets a series of reference points for most of the development opportunities.

On the Mercedes M13 E Performance power unit, Key is candid: 'Mercedes has a brilliant history with their power units since the start of the hybrid era in 2014. They led the way with innovations with the engine's architecture. I think it's levelled up a lot in terms of output since then, as their long-standing PU performance advantage at the start of this era saw a huge disparity in performance and capability and how you use it. Mercedes set the standard, and they continue to be in excellent shape.

'Although it's a lot closer now, many very clever, incredibly competitive people at Bricksworth are keen to ensure they remain on top of the game, and we're enjoying working with them.

'The M13 has the compressor at the front and the turbine at the back. Various knock-on effects come from that, particularly the volume you've left in your gearbox, and the volume you have in the front of the chassis, all that sort of thing.

'You've got various ways of cooling as well, which are different between all the power units, and there are lots of bits and pieces around that you need to package and place to give you a bit of flexibility. Other power units are very compact and contained but less flexible in distributing various components.

'The Mercedes PU is a pleasure to work with in chassis design because it fits perfectly. The power unit installation and related systems gave the aerodynamicists and mechanical teams freedom around the chassis structure to make performance gains.'

Push and pull

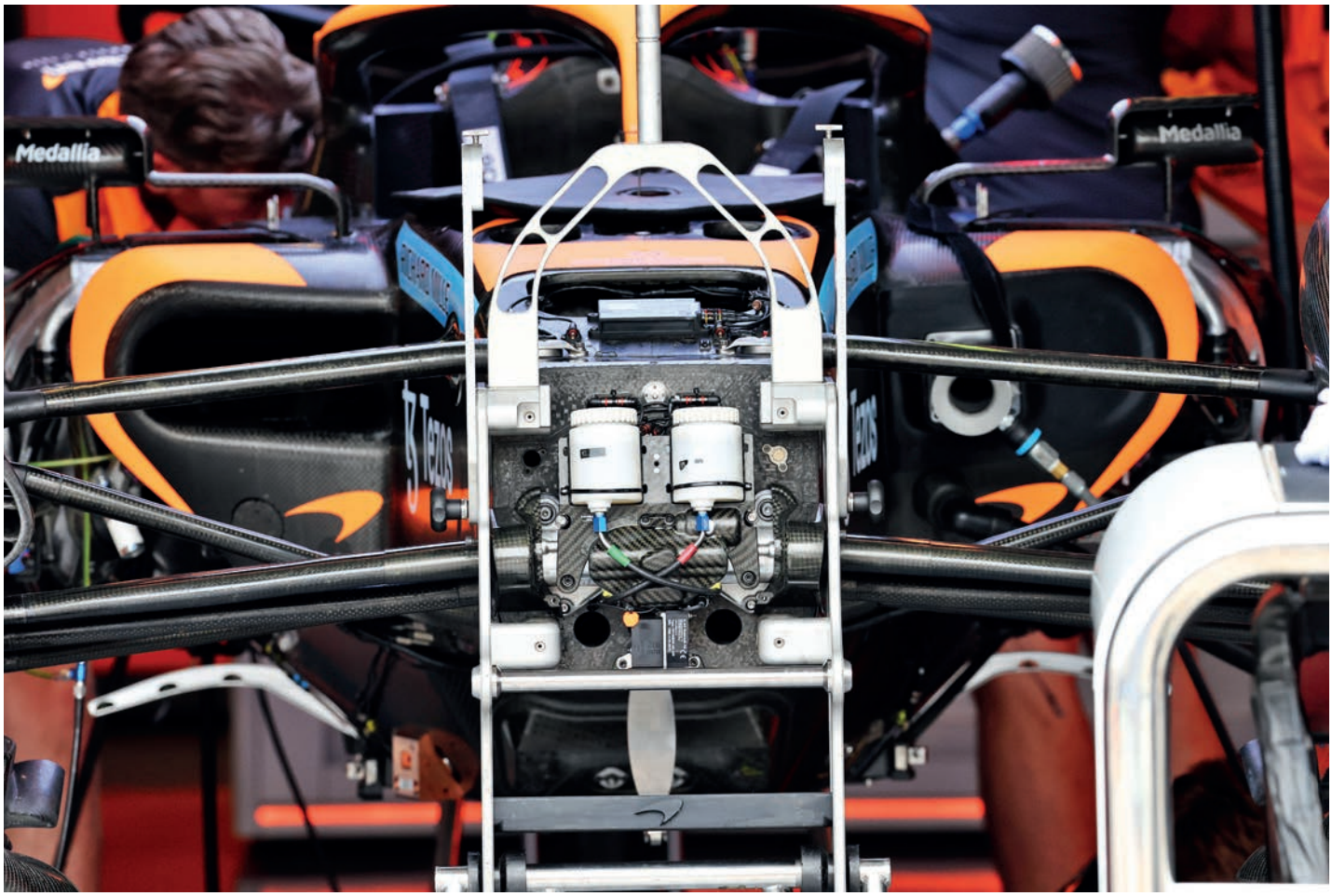
Part of the MCL36's installation revolves around its suspension geometry, which, for 2022, runs pull rod front suspension. The popularity of this sort of suspension design has ebbed and flowed in Formula 1, depending on how favourable it is to exploiting the technical regulations. With the 2022 regulations emphasising under-floor, ground-effect aerodynamics, most teams opted for a pushrod suspension design at the front to leave more area for the flow field going into the tunnel entries at the front of the floor. However, there are benefits in pull rod suspension when it comes to flow conditioning before the floor.

'The position of the front suspension components, given they are directly in the airflow coming off the front wing, means they have a considerable influence on that air' explains Key. 'Adjusting the position and shape of the pull rods can therefore help move the air in a controlled manner into the underfloor tunnels.

'We knew there were downsides mechanically to implementing pull rod front suspension, which is why it's traditionally always been push rod. But the other thing with these cars is they're a lot more ride-height sensitive with the ground-effect floors. Therefore, the benefits of mounting the springs and dampers on the underside of the chassis allow the nose to be higher, giving a less obstructed path for air to the underfloor. The suspension arm angle affects how much air is moved outboard from the front wing and how much is kept inboard.

'We knew there were downsides mechanically to implementing pull rod front suspension… [but] the benefits of mounting the springs and dampers on the underside of the chassis allow the nose to be higher, giving a less obstructed path for air to the underfloor

'However, mechanically speaking, it is harder to make a pull rod work optimally when packaged in the tight confines of



The McLaren is one of just two cars on the grid with pull rod front suspension, the other is the Red Bull RB18. Key asserts the aerodynamic advantages on the MCL36 outweigh the disadvantages

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a Formula 1 car's nose, sometimes to the detriment of mechanical grip. So, the robustness of your suspension is essential due to that. We worked hard to mitigate any of the negativities you get from a suspension point of view, and pretty much got back to a level we felt was comfortable versus a push rod suspension. There was never any doubt about that.'

Aero authority

The 2022 regulations lower the wings' authority on the car's performance in this new era, which see a much higher performance weighting on the car's ground-effect floor. The front wing, especially, isn't the dominant force it used to be, and McLaren was aware that significant resources could better be spent in other areas.

'As we get more familiar with the rules in later seasons, we will understand more about what makes these cars performant,' says Key. '2022 is just the beginning, and we wanted to develop quickly without having to do a lot of extra work to get the aerodynamic surfaces you wish onto the car.'

The early part of the season saw McLaren, like many other teams on the grid, suffering from so-called 'porpoising' – the bouncing phenomenon caused by the cars' inability to control its platform, stemming from extreme swings in downforce generated by the new, ground-effect aerodynamics.

McLaren, like many other teams, brought newly designed floors to the track as a primary upgrade to the MCL36

Though the front wing is no longer the dominant aerodynamic element it was, the MCL36's front wing showed a detached lower element used for conditioning the flow field towards the floor

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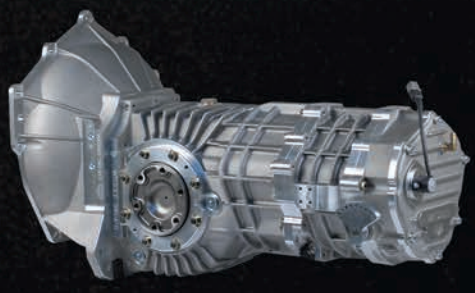

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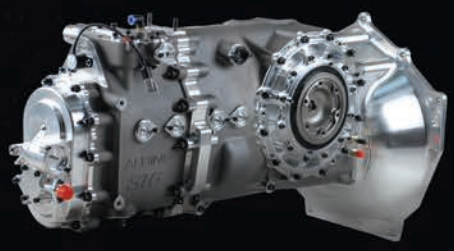

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Key explains the catch 22 situation. 'Getting the most aerodynamic load means running the floor as close to the ground as possible but, the closer you run the car to the ground, the higher the risk of damage to the underfloor and porpoising,' he says.

It became apparent early on that trackside set-up wasn't the solution to McLaren's porpoising issues, so an aerodynamic re-design had to be employed to keep the car's platform under control. Like other teams suffering the same undesirable effect, McLaren introduced new floors hoping that would help the car's behaviour and handling.

Despite the data collected in the early stages of the season, McLaren's performance has been all over the score sheets.

'Because the cars are immature, and our knowledge is not fully there as to what makes them work and stay in their most performant windows,' explains Key.

'Because of the vast number of changes [to the regulations], we don't have any data that correlates from last year to this year. We don't yet really have the opportunity to move one element at a time and then figure out what effect that has on the car's behaviour. So, it is a case of a blank sheet of paper and then filling in the blanks once we have been to a certain track on the calendar and then logging that performance as the baseline for the future races.'

Development phases

Making things even more complicated, the development steps are out of phase for each of the teams. Some brought numerous upgrades early in the season, while others brought more significant, more aggressive changes when the calendar visited tracks better suited to their car's behaviour.

Despite a conservative design at the start of the season, the MCL36's evolution came thick and fast. Rather than driving a very aggressive design route and, therefore, the overall behaviour of the car for the races throughout 2022, the team developed flexible packages designed to suit different tracks and conditions on the race weekends, and not limit the car from further change.

The MCL36 consequently received several updates to the bodywork, particularly with the sweeping down of the upper surface of the sidepods, downwashing the air flowing over it towards the upper surface of the rear floor. Meanwhile, the sidepod intakes have seen a vast number of changes, displaying what appears to be modular leading-edge concepts with varying triangular openings in the later stages of the calendar.

The use of louvres in the bodywork has also increased, likely stemming from the tightening of the bodywork around the 'Coke' panel, and the knock-on effects that has on the cooling of the systems under the skin.

The use of louvres has increased with changes to the sidepod design, which features aggressive downwashing of its upper surface

Development continued on the MCL36 to the end of the season, but the changes were more than just the car. 'We're still on a journey within the team at the moment,' says Key. 'We've got a lot of ongoing investment in infrastructure, which hasn't influenced any of our cars yet. We also knew we had a few compromises that affected the start of the 2022 car design process, revolving around Brexit issues, Covid etc. These affected us slightly differently from other teams because our wind tunnel is currently remote in Europe.

Tunnel vision

'Having the wind tunnel in Cologne costs us a lot in terms of day-to-day efficiency. I think that's been one of the biggest things. We've had some brilliant support from Toyota's wind tunnel for a long time, and it's served us incredibly well, but you can't just rush into the tunnel and look at something – an aerodynamic element or even a model design – in a bid to change that for tomorrow. The reaction time to turn something around is too delayed. We don't have that agility. We have to pre-plan an awful lot and freight development pieces and personnel out every day. We must have a defined development plan that works with the wind tunnel plan and then react afterwards. From an efficiency point of view, that's definitely detrimental because the agility of aerodynamic development, particularly in the environment of new regulations, is incredibly important.

'When you haven't quite got the ability to walk next door to your wind tunnel – which is how it will be when we finish building our own wind tunnel hopefully later this year, or early next year – it means you just have to be a little bit more structured and plan your approach well in advance.

'I think we were realistic about where we could be. We have an opportunity to get to the front, but we've still got a few things below the standard you need to be at to achieve that'

'To guarantee we will be at the front, we must consolidate a top-four or top-three capability. These new regulations put a massive perturbation in that process because if you've got stability, you can build, and with new regulations you kind of start again. We've got a team that is certainly capable of doing that. We can then build on that with the new car within these new regulations and then begin to use the coming infrastructure to take the next steps.'

The team finished fifth in the Constructors' standings, more than 100 points ahead of Alfa Romeo in sixth, but next year must target Alpine who finished just ahead of them.

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Steady progress

Racecar *talks to team principal, Fred Vasseur, about how Sauber is tackling the challenge of Formula 1 in this new era*

By **STEWART MITCHELL**

Every year, each team is convinced they can make progress compared to what they achieved in the previous season… This is the magic of F1

While Sauber has had a challenging decade in Formula 1, team principal, Fred Vasseur, evidences the team's determination to stop at nothing to regain fighting form and demonstrate its full potential. Since joining the team, he has made numerous changes to its structure, operations, and strategy. We recently had the opportunity to put some questions to the Frenchman and he was candid about the team's approach.

RE: ***How has your journey been with Sauber to date?***

'I came to make significant changes and, when I started with Sauber in 2017, we were P10 on the grid. Despite the circumstances when I joined, I didn't underestimate the inertia a team with the right direction can have in Formula 1.

'Of course, the teams are set up to react to technical challenges very quickly but, if you want to make changes to the structure of the team and the personnel, operations and so on, things are often very slow. This is sometimes to do with things like gardening leave, which safeguards the technical insight that personnel carry with them when they transfer from one team to another. Very often, when we identify someone to join our team, they will participate between six and 18 months later, and their influence on the car will be two or three seasons later still.

'You can have the budget available, but this might only come true for a short while. From the external point of view, it is strange because it seems that Formula 1 is very agile, but this is only at the trackside and in the technical output of these teams. In the long-term view, when you must change the project's direction, it takes a long time.

'For example when Red Bull joined Formula 1, it took them seven years to become successful in the championship. When Jean Todt joined Ferrari, it also took seven years to win. It took four years and a completely new power unit regime for Mercedes to become successful.

XPB

Sauber Motorsport team principal, Fred Vasseur

'If you look back at the history of Formula 1, it's evident it takes significant time to become competitive. Additionally, the Covid challenge has profoundly impacted our progress recently.'

RE: ***So, what was happening at Sauber before that you wanted to change?***
'Nothing in particular, we changed everything. In 2017 we were P10 and, as a team, you can't keep the same structure and approach if you are P10. It needed a refresh in every department and every sub-department, and we changed it all to make a decent step forward.

'The pace of development in Formula 1 is a function of the structure of the teams. We are between 500 and 600 people, and they all know their own tasks. Each of them knows their duties, the target, what they have to do, and when to deliver.

'If you look back at the last 10 years of Formula 1, you can see that the development of the companies that operate here is evolving faster than the technology itself. When the organisation performs at its maximum, the results are awe inspiring. Every year, each team is convinced they can make progress compared to what they achieved in the previous season and that, if the cards fall in their favour, they can take home the maximum prize. This is the magic of F1.'

RE: ***How has working in F1 evolved over the last 10 years, whether in management, engineering, or another role in the sport?***
'The weight of teamwork is much more important than the weight of individuals nowadays, much more so than it was just a few years ago. It is more a matter of team achievement because of the size of the teams and the operations within operations. A single person's influence is less, but that isn't to say they are less critical because they are now more specialised than ever.

'Formula 1 is evolving in a way that responds better to specialists than individuals with an overview of a particular subject. However, with that, there has been the requirement to more effectively coordinate those specialists who previously would be able to do much more than they do now.

'This dramatically changes the structure of the teams and the output from that in terms of the rate of change. Another influence is that we have a new generation coming into Formula 1, and this talent has an entirely new point of view. They respect different technologies and physics in various ways to the previous generation. It is therefore essential to have management with a lot of experience to do this coordination as effectively as possible without letting too many points of view interfere with each other.'

Sauber Group

Exterior view of Sauber's modern, and very elegant, factory in Hinwil, Switzerland

RE: ***How do you balance between what a piece of software suggests the next step should be vs an engineer's philosophy?***
'We ask this question each day! Part of the company works before the event, in terms of operation rather than design or production. Before an event, we do many simulations that scan all the set-up variations, including the wings, ride height, suspension etc. This group's task is to predict how best to use the tools we have to finish as high as possible. But then you have the event itself, which offers a multitude of other variables that are very difficult to predict, let alone use in your favour. So, we constantly have to balance theory and practice.

'Nowadays, the theory is very close to reality, much more than a few years ago. So, it is safe to say we lean on it more, but to say it provides all the answers is far from the truth.

'The margins across the field are extremely tight now, so if your delta from your target is out by just a tiny per cent, your position could be from the front to the back of the field. For a long time, there has been less than five per cent across the field on most circuits, which is the difference between P1 and P20. A small percentage between your simulation and reality can make a huge difference.'

RE: ***How do you approach correlation?***
'We have an excellent example because we recently developed our simulations and simulator. Once we had this part of our operation up and running, the rate of development was extreme at the beginning, and then it became a case of diminishing returns. In those early stages, we made so much progress that we became comfortable with the output from our simulations. We can now confidently use our simulation technology to influence what takes place during the race weekend because we have a high enough correlation between the two.

XPB

Vasseur in discussion with current Sauber driver, Finn Valtteri Bottas, at a race weekend

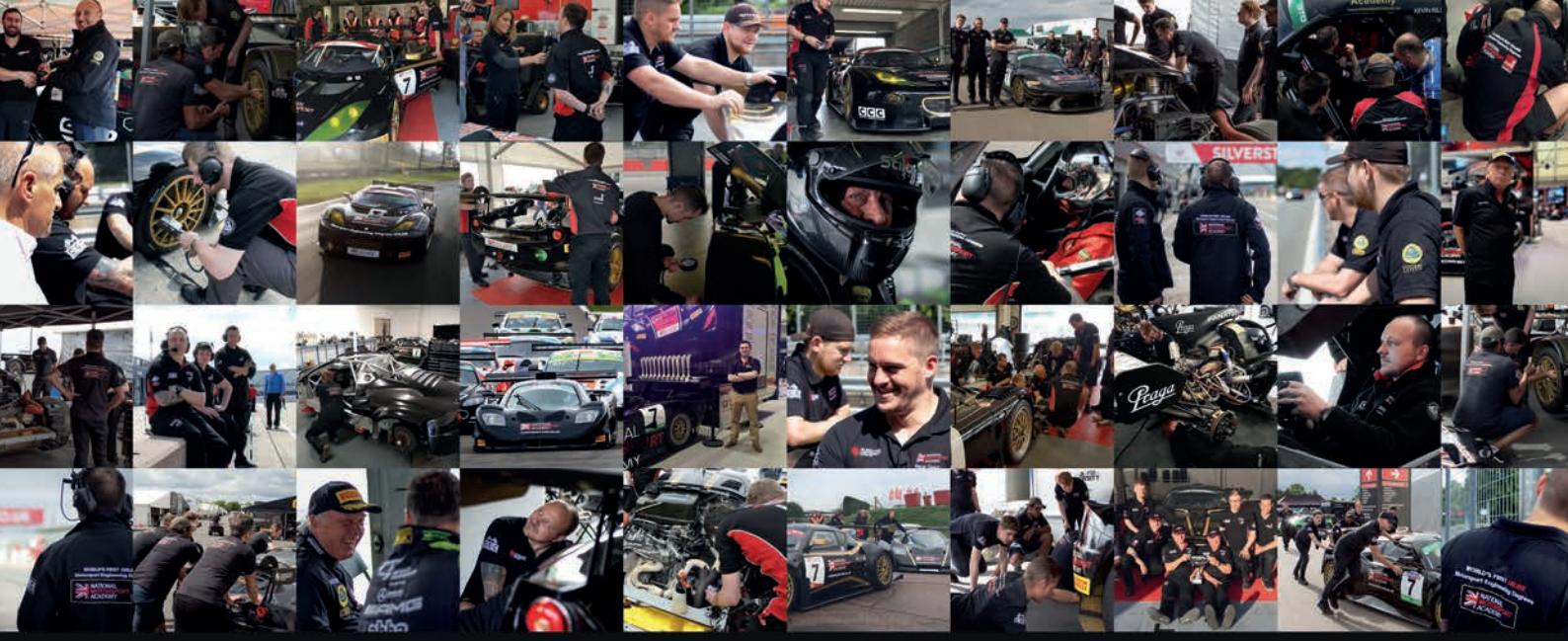
We can now confidently use our simulation technology to influence what takes place during the race weekend because we have a high enough correlation between the two

'These departments need coordinating, and it is a matter of trust between the team that runs the simulations back at the factory during the race weekend and the team on the ground running the car at the racetrack.

'Now we are confident with our correlation, we know the decision made back at the factory can be performant if implemented on the car. The team at the factory will run simulations for set-up throughout the night after taking trackside data in from the car on Friday. They will then arrive at a set-up they believe is most performing before the team on the ground reaches the track on Saturday morning.

'The four pillars are the wind tunnel, CFD, simulator and the actual car. Correlation and coordination between these elements are essential to a current Formula 1 team. If one is operating differently, you are non-performant.

'The worst-case scenario would be that one of those operations was considered the weakest, because they are all critical.'



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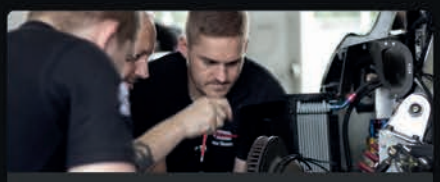

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XPB

The current car, the C42, has taken Sauber off the back of the grid. It finished sixth in the 2022 Constructors' Championship

RE: ***How vital are drivers in developing these cars with all the technology available in Formula 1 now?***

'The contribution of drivers is mega. The first part of their contribution is at the track, keeping consistent and pushing the car to its limit, as well as the race craft regarding wheel-to-wheel battles and making steady progress in every stint.

'The second part is to understand the physics at play, and to work together with the engineers to exploit the car's potential under development.

'The third element is personal, which is maintaining their desire to keep pushing themselves, and motivating the team to keep pushing and exploiting all of the hard work that goes into producing the car and running the car at the track. This is not trivial.'

RE: ***How do you view taking rookies on board and the impact that they can have in the team?***

'It is an interesting balance because rookie drivers don't have the same experience, so they won't necessarily know how to react under certain circumstances that they haven't seen before. However, without that experience, they operate much more subjectively, which can also be very helpful.'

RE: ***How does Sauber approach strategy?***

'Strategy is a critical part of Formula 1. However, it is made complex by specific allocations such as tyres, the timing of sessions throughout the race weekend, and developing and bringing new parts to the circuits where they're going to be most performant. The closer you are to peak performance, the more dramatic the effect of any single mistake will be in the operations or strategy.

'In the weekend approach, you have to be sure you're doing the right thing at the right time to exploit the opportunities you have to collect data and make progress.

'Strategy during the race is entirely different. It hinges on what's about to happen next and how to make the most of that. We are constantly looking at the next lap and simultaneously checking what our rivals are doing to see if we have to manipulate what we're going to do next because of what they are going to do next.

'It's also knowing whether there are particular races, or points in some races, where your competitors might make mistakes. Typically, this will be around the time tyre degradation is high, or some drivers are fighting for position. In moments like this, you can change your entire race. If there is a safety car, for example, you can make giant jumps in the field, or just make good progress on a new set of tyres when others are not putting in the best lap times.'

The database for the use of artificial intelligence for doing the complete strategy of the race isn't there yet, but we are well on the way to being able to do something like this soon

RE: ***How could artificial intelligence be used to influence Formula 1 strategy?***

'The database for the use of artificial intelligence for doing the complete strategy of the race isn't there yet, but we are well on the way to being able to do something like this soon. You could imagine that the software could eventually have the information to take into consideration the track, track conditions, the number of pit stops, the relative position between drivers and when there is a chance for an incident to give you the probability of a safety car on the upcoming lap, or something like this. But it will take a very long time to collect this kind of information at the size we would need it to be able to make the right kind of calls from the output.

'In my previous life, I worked on a project that studied road accidents for trucks. The database for this was mega, with millions of trucks worldwide. These databases considered the hours the trucks had been running on that shift, whether it was am or pm, summer or winter, and many more factors. It also considered the number of high braking events over the previous two hours, and whether there were any incidents of over speed on some sections of the road. In the end, the software could consider all these elements and identify a percentage risk for an accident to occur. But this took many millions of data points in a very consistent framework.

Sauber Group??????

Sauber Group's autoclave facility for composite part production

'In Formula 1, we already take in billions of data points annually, but teams don't want to share this in a single database because it is a competitive advantage. Additionally, you cannot manoeuvre straightforwardly using data because the margins are just so tiny. We would have to consider a sub-one per cent margin of error, and even then the variables are still considerable.

'Due to the specificity of our business, I don't think Formula 1 will use this yet.'

RE: ***How do you approach the new tracks in Formula 1?***

'New tracks are happening in Formula 1 all the time. We had this in Mugello, Qatar, Miami, Jeddah, Portimão and many others in recent years. These aren't that difficult for us because we can design the simulations around them and make the most out of them. The challenge is understanding the track surface and how the conditions will affect

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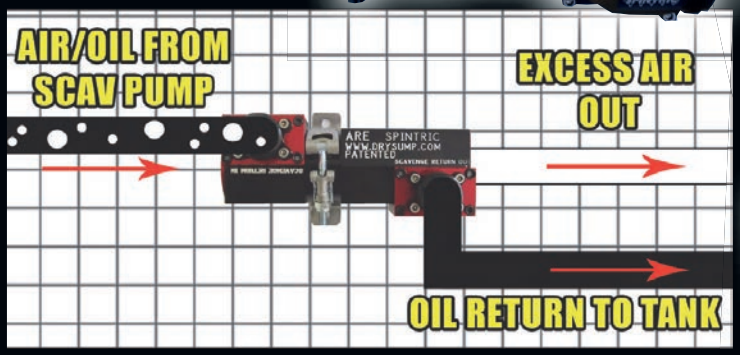

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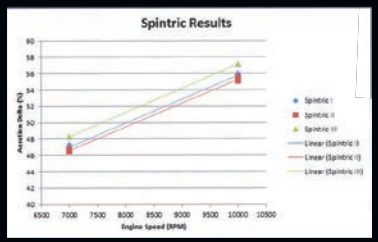

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the nominal performance on the day, but this is the same for everyone.

'The level of grip is also a factor in the events that happen on the same weekend as the Formula 2 races and so on.'

RE: ***When did the development of the 2022 car get underway, and what was the transition period like for Sauber?***

'We started major work on the 2022 car at the end of 2020. We didn't skip the 2021 car by any means, but we pushed forward the development and the resources of the 2022 car into primary focus at the end of 2020. Therefore, we did marginal development on the 2021 car and felt it was the right choice, given that Formula 1 somewhat froze the regulations from 2020 to 2021.

'It's fair to say we had relatively poor performance in the 2021 season, and we could have pushed forward to beat the teams immediately around us. Still, a P9 or P8 in the Constructors' Championship in 2021 would not have been revolutionary for the team. We knew that the resources we put into the 2022 car early on could be a game changer for the team, given the lack of technical carryover from the previous generation.'

RE: ***How have the recent changes to the rules affected how the team approaches the challenge of Formula 1?***

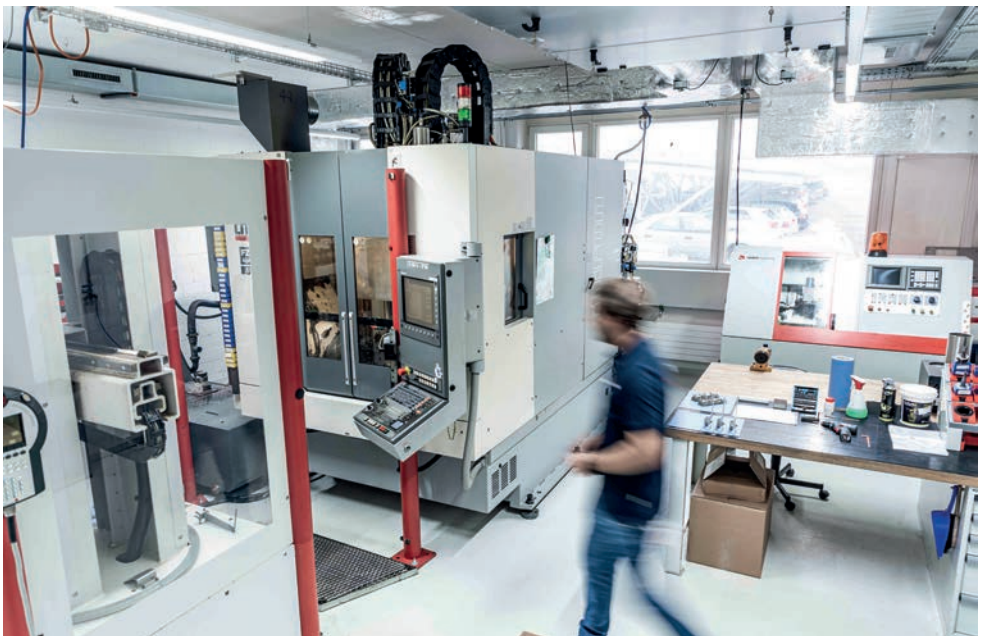
'I would say, mainly, they haven't had an effect. We were below the cost cap before introducing the cost cap regulations, and we still operate below the cost cap now. The changes we've seen as a function of the new rules, which have been vast, do not affect us financially. However, I have to consider the cost cap for the future.

'In the past, the main driver for the team's effectiveness was the budget, but we were forced to be more resource efficient to be more competitive in this sport. We made some choices, like being strategic about our engine suppliers and considering the options for the future. After all, we don't want to be as dependent on external companies and suppliers in the future because we want to make the most out of the resources we have.

'Of course, the cost cap is set to be further reduced, and we want to make progress, which will cost more money if we are not strategic. So, we are developing the changes we need to make the most of the opportunity in Formula 1. By the time we get to the start of 2023, we will be at the limit of the cost cap.'

RE: ***What are your thoughts on the 2022 regulations?***

'The regulations are good if we are in front! Jokes aside, they have changed dramatically over recent years with the cost cap regulations, technical regulations, sporting regulations for using wind tunnels, etc.



Sauber Group

Inside the Sauber Group's hi-tech engineering facilities

Sauber Group

Sauber Technologies' design offices take Formula 1 learnings and applies them to other industries

All of these are going in the direction of the convergence of performance.

'Even the fact the engines are frozen. We are going toward a tighter championship fight, and it is working. Comparing qualifying times of the last few years, in 2017-2018, teams were spread around four to five per cent away from across the grid in qualifying, and now we are between one and two per cent. Below one per cent are five teams.

'It will be a fantastic sport if we maintain these regulations for a while.'

RE: ***Sauber will become the Audi factory team from 2026 onwards. What effect will that have on the team?***

'Formula 1 is taking a big step towards sustainability with the new regulations coming into effect in 2026. The power units will be more efficient than they are today, and the proportion of electric power will increase significantly. The electric drivetrain will have nearly as much output as the internal combustion engine, reaching 400kW.

'Sustainable synthetic fuel that is CO_2 neutral will power the 1.6-litre turbocharged engines, which will no longer have an MGU-H.

The partnership between Audi and Sauber Motorsport is a crucial step for our team as we continue to make progress towards the front of the grid

'Formula 1 has also set itself the goal of being CO_2 neutral as a racing series by 2030. This was an essential prerequisite for Audi to decide to enter the championship. The partnership between Audi and Sauber Motorsport is a crucial step for our team as we continue to make progress towards the front of the grid.

'To become Audi's official works team is not only an honour and a great responsibility, it is undoubtedly the best option for the future, and we are fully confident we can help Audi achieve the objectives they have set for their journey in Formula 1.'

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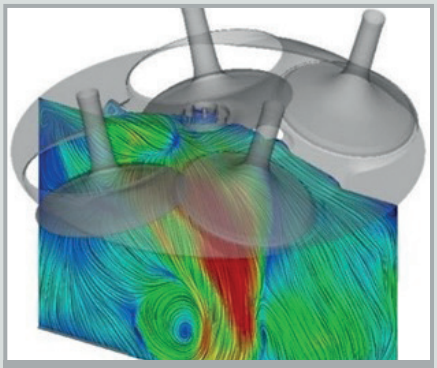

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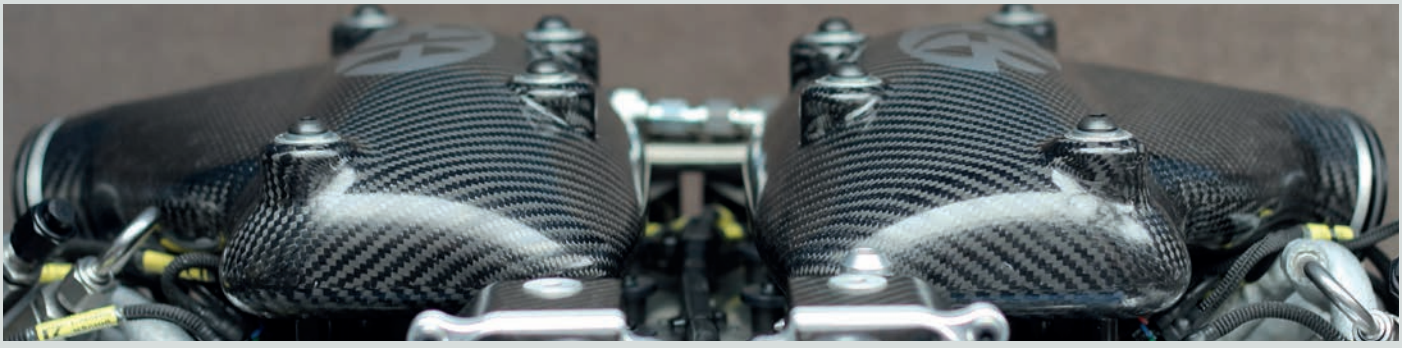

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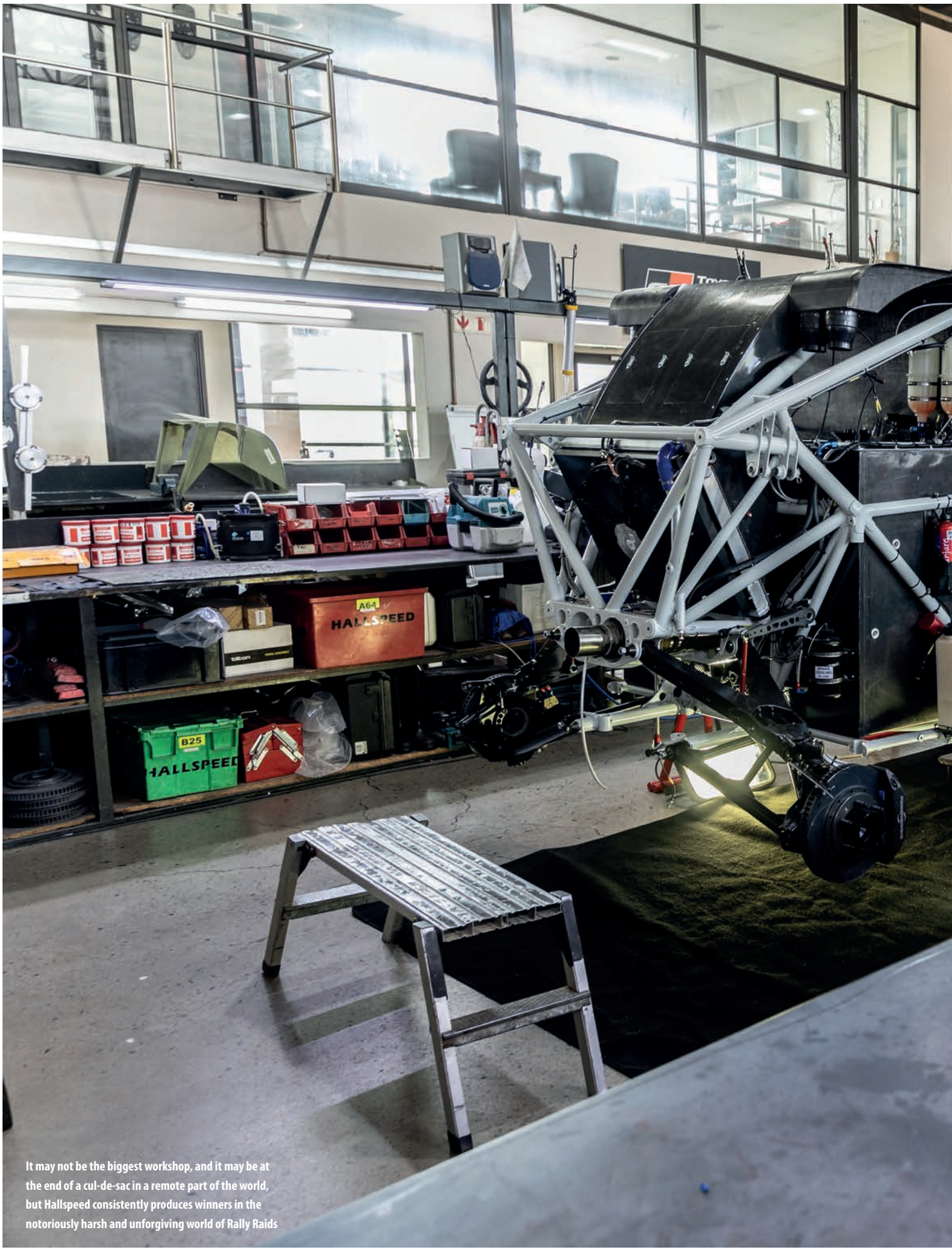


It may not be the biggest workshop, and it may be at the end of a cul-de-sac in a remote part of the world, but Hallspeed consistently produces winners in the notoriously harsh and unforgiving world of Rally Raids

Hall effect

How an ex-pat Brit working in South Africa is producing Dakar winners for Toyota with a small team and, wherever possible, locally sourced components

By DIETER RENCKEN

Toyota Gazoo Racing South Africa

'It's amazing what they do. They are working out of a normal building in a street, but making these impressive cars,' said Fernando Alonso in Austin during the US Grand Prix when asked by *Racecar Engineering* about Nasser Al-Attiya's overall victory in the FIA World Rally Raid Championship. Following that observation up with, 'okay, the cars are run by Overdrive, but Glyn and his people are the ones building them.'

The Spaniard's 'they' references Hallspeed, the Kyalami-based, Toyota Gazoo Racing-sanctioned builder and purveyor of the Oval T-branded off-road Hiluxes of the type driven to victory in both this year's WR2C and the Dakar by Al-Attiya.

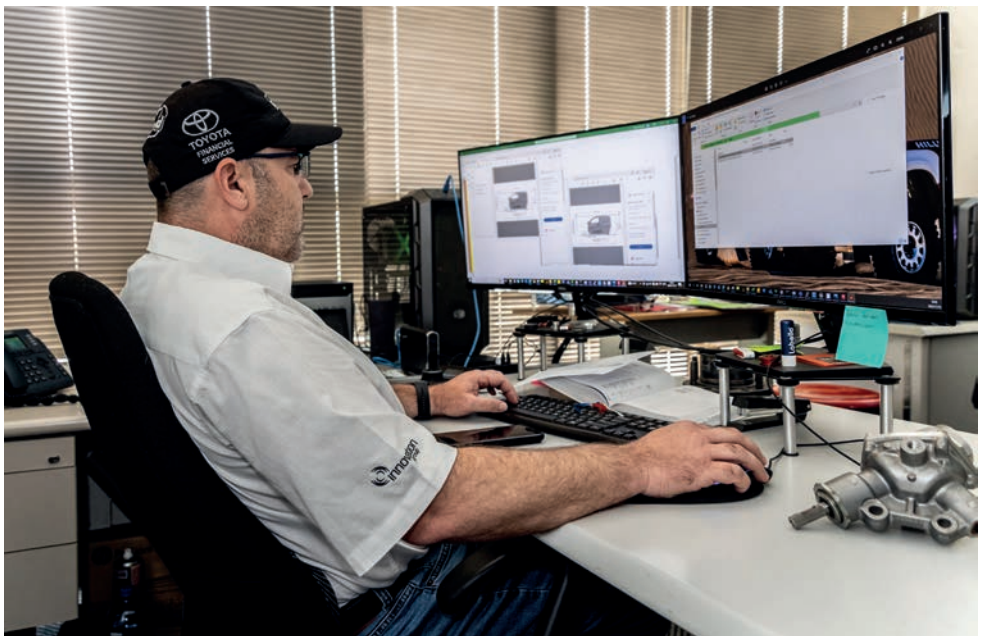
Indeed, the Qatari won the South American marathon event with a similar vehicle in 2019, having placed second three times with the team, and double F1 champion, Alonso, credits him with 'teaching me everything I know about off-road.'

The Glyn mentioned is Hallspeed founder, Glyn Hall. An ex-pat Brit, Hall (66) emigrated to South Africa in 1980 to join ace South African driver / engineer, Geoff Mortimer's, Chev Dealer Team. Prior to that, he cut his racing teeth with Chrysler UK's motorsport division, building Avengers and Talbot Sunbeam Lotuses for such drivers as Henri Toivonen, Guy Frequelin and co-driver Jean Todt – the latter later leading Ferrari of course before becoming FIA president.

'I was seconded to teach Henri English. We were the same age and got on very well, Stoke-on-Trent-born Hall recalls of Toivonen, reckoned by many to have been the fastest of all Finns before his untimely 1986 death. 'His was a pure talent…'

Finally, Overdrive is Hallspeed's international (Belgium-based) partner, founded by Jean-Marc Fortin, former co-driver to Grégoire de Mevius, Bruno Thiry and Francois Duval, with whom the Belgian won numerous rallies before turning to team ownership.

The company provides sales and service support – both pre- and on event – to teams competing with Hallspeed-built vehicles, whether in the Dakar, WR2C or the FIA World Cup for Cross-Country Bajas, a (more) compact Raid-type, eight-leg series now in its fourth year. At time of writing, Saudi driver, Yazeed Al-Rajhi, leads the chase in a Hallspeed Hilux with one round left to run.



80 per cent of the components used on the trucks are either produced in house using CAD technology or to Hallspeed's specification

Direct contact

'Every car we sell basically goes through Overdrive to ensure there's a direct contact in Europe to provide continuity,' explains Hall. The customer has to know where to go in Europe. 'That applies to local sales as well, unless we have approval from Toyota South Africa that [the team] will be part of our local family. Otherwise, every car goes through Overdrive.'

Understandably, Hall won't reveal numbers or prices, but a bit of research shows that seven or eight ready-to-race Hilux DKRs are produced per annum, with prices running to around €550,000 (approx. $570,100) depending on final specification. That's substantially less than a turnkey WRC, for example. Equally, try picking up a range-extended Audi Dakar quattro e-Tron for that price. Or at any price for that matter.

Talking of Audi, after his GMSA spell, Hall moved with Mortimer to VWSA, running Quattros and AWD five-cylinder Passats, and then joined Ford before accepting Nissan SA's top motorsport job. He formed Hallspeed in 1998 after Nissan outsourced its competition activities, culminating in a string of Super Touring titles with future Dakar star, Giniel de Villiers, before turning to local off-road racing, scoring national honours on a serial basis.

Broad experience

The next step was putting Hall's broad experience base to the test on the Dakar with Nissan. Top five placings were the result via the likes of Ari Vatanen, Colin McRae and de Villiers. Then in 2010, Toyota came knocking. Simultaneously, Hallspeed moved into bespoke premises in a cul-de-sac located in the shadow of Kyalami Grand Prix Circuit in Midrand, north of Johannesburg, where he felt he could do the project full justice.

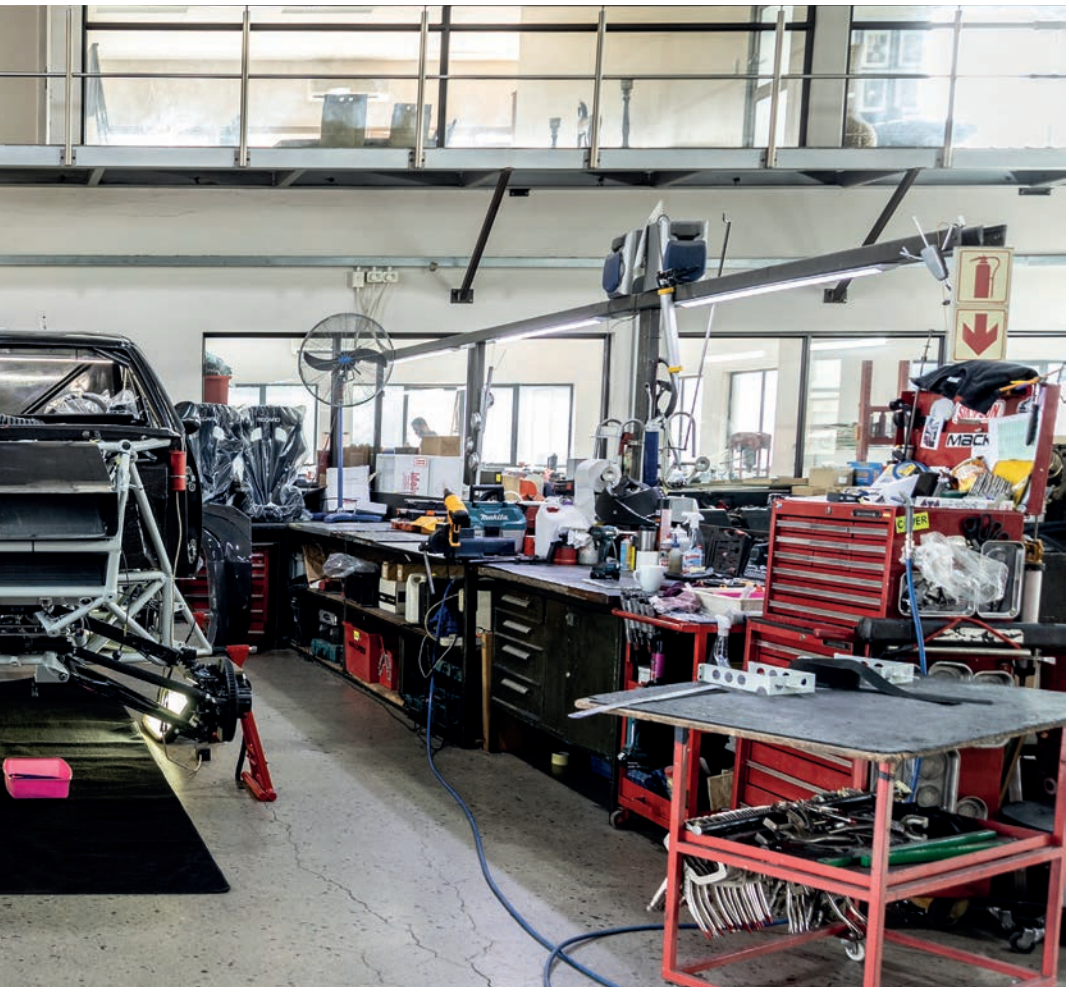
Spaceframe chassis are built in house and utilise fabricated suspension components, while body panels and brakes are sourced from local suppliers

Hallspeed is effectively a three-tier business. Apart from supplying Overdrive, the company represents Toyota Gazoo Racing South Africa's interests in local championships. Hall is listed as team principal, and off-road is now arguably the country's premier series due to the popularity of 'bakkies', as pick-ups are colloquially known after the Afrikaans for open tub.

'Every car we sell basically goes through Overdrive to ensure there's a direct contact in Europe to provide continuity'

Glyn Hall, founder and team principal at Hallspeed

Engines are now mostly based on Toyota V6 twin-turbo units, but modified in house at Hallspeed and utilising MoTeC electronics



Then, Hall oversees Toyota GR's Dakar effort. The automotive brand is the market leader in South Africa and the wider continent, and is obviously determined to maintain that position. Hence its efforts in the off-road motorsport platform.

We caught up with Hall in his Toyota-branded offices overlooking the workshop where technicians are crafting an assortment of spindly tubes and weirdly shaped plates into a batch of high-speed trucks designed to take on the world's best on the roughest and toughest of terrains. These are Hiluxes with a difference: spaceframe chassis with composite bodies powered by engines modified in house.

The company has a staff complement of between 38 and 44 heads, the reason for this variance being twofold, as Hall explains. 'There is a ramp up pre-Dakar and for the event itself, plus we have first or second-year university students doing vacation work here,' he says. 'We're limited to a maximum of three.

'We try and have an engineering student permanently here for training for the future. If they're good, they stay…' summarises Hall.

'Everybody in the company is offered the opportunity of working on the Dakar – albeit depending on workload going forward – and usually we take around 25 staff, plus a few outsiders: a local physiotherapist; two local [support] truck drivers who have been with us for years; two technicians, one of whom joins us from Surrey, plus Nasser's mobile home driver who also works with us. That's about 30 in total.

'Overdrive is integral to all of our international work,' says Hall. 'During Dakar, we get all the [support] trucks from there and we are one big family in the [service point] bivouac. That's the only way it can work. So, they've got about 40 people, together with our 30. As a group we will be around 70 strong on the next Dakar, so we have a lot of strength in depth to help a lot of people.'

'We changed power units because of the alignment with Toyota's core qualities, namely QDR (quality, durability, reliability)'

Glyn Hall

Power units

Hallspeed's engine development section, which modifies the Landcruiser V6 twin-turbo engines after a switch from the previous V8s at Toyota's behest, is manned by a staff of two who undertake mainly performance, durability and dynamometer work.

'We changed power units because of the alignment with Toyota's core qualities, namely QDR (quality, durability, reliability), and the company wanted to use the new turbo engine on the Dakar to showcase it.

'The pressure on us – on me – was huge, because suddenly we had the whole of Toyota global on our shoulders and we could not afford a failure on the Dakar with this engine, even though we'd only been running it for six months.' Thankfully, for Hall, history records that it won.

'All of our internal wiring of the car, we are basically running with MoTeC. We have an extremely close relationship with MoTeC and

we do a lot of development work with their agents here on our engine and dynos.'

Chief engineer, Michael Jardim, has worked with Hall for 25 years and has a team of two designing, developing and testing every one of the 2400-odd individual items that make up the sum of the winning parts using the latest CAD programmes. Impressively, 80 per cent of these components are either produced in house or to Hallspeed's specification.

Where feasible, Toyota parts are used, primarily from the Hilux range, either standard or modified to suit. Thereafter, Toyota family products are given preference, with the rigours of off-road racing and regulatory stipulations ensuring the engineering trio have their hands full designing not only specific parts, but the whole car from scratch.

Concept car

Consider their challenges. 'First, we got to conceptualise the car we're planning on doing,' explains Hall. 'Then we go to the regulations, and then from there to the drawing board, or computer, before we can refine it as we discover how best we're going to adapt it to the regulations with regards to practicality and cost.

'Practicality to us is both ease of manufacture and ease of service. For our customers, ease of service is absolutely critical because they're 12 days out of the workshop on one race, and usually have only got pretty rudimentary tools in the bush, or desert.'

Unsaid – but obvious if you think about it – is that the cars need to be sold at a profit for Hallspeed (and Overdrive) to stay in business. Hence the equally critical cost consideration.

Hallspeed sources locally wherever possible due to South Africa's underperforming Rand currency. He cites a simple example: a rubber slipper made locally to Hallspeed's design comes in at one per cent of the cost of the imported equivalent, with the material used coming from a non-automotive source.

Composite body parts – non-stress bearing as per regulations – are supplied by another local company, whose day job is making racing watercraft from carbon Kevlar.

'It's a canoe business situated near one of our major dams, and we've helped them transform the business into making all the carbon work on the car. They had some experience [with composites] but we machine the plugs, design the body shape machine, the moulds and the patterns. They don't have an autoclave, so we use infused vacuum carbon, which is fine as these are not structural parts.

'The only structural [composite] part is the fuel tank box, which he makes for us as well, and we've never had a problem with it.'

Reliability is everything in Rally Raid vehicles, so where feasible Toyota parts are used, ideally from the Hilux model range

The cell itself is sourced from Premier Fuel Systems in the UK, Hall clarifies.

Special components such as driveshafts and knuckles and various custom-built mountings are produced in house, with the basic designs often leaning on previous projects. Every component is numbered and lifed, with a parts tracking system making it possible to trace the full manufacturing data. This is a crucial process where safety-critical parts are concerned.

'We're improving it all the time,' Hall says. 'Record keeping seems to suffer when you're in a rush, but with this there always should be urgency. We're improving our logging system continuously so, when we have failures, we know what to look for. We just keep drumming it into the guys all the time – winners make it happen, losers let it happen.

'We also don't get too clever. Basic engineering is what keeps aeroplanes in the sky, and we have to keep our race cars reliable. When we've got a new car like this [gestures towards the workshop] we push some components further and further until we're too scared to go any more.

'If we find a failure, we immediately decide internally what the factor for its life is. With the benefit of the past 30 years of experience, we have a feeling for it, and we try to retain failed parts for at least three or four years so we can refer back to them and try to understand the failure.'

Brakes, too, are locally produced. 'They're made for us to our specification by Power Brake in Centurion [a Pretoria dormitory town]. We've been working together for over 10 years developing the hydraulics and the new discs as well.

'For our customers, ease of service is absolutely critical because they're 12 days out of the workshop on one race, and usually have only got pretty rudimentary tools'

Glyn Hall

'They're billet aluminium, six-piston, liquid-cooled calipers front and rear. And they're brilliant. The discs are ferrous cast – have to be due to the regulations – all designed by Power Brake.'

From near and far

Transmissions are sourced from French specialist, SADEV, situated south of Nantes, but Hallspeed produces the rest of drivetrain hardware, including aluminium differential housings, after the supplier withdrew them from the market. Crown wheels and pinions come from afar but have a local flavour, being UK-sourced from SA-born gearbox guru, Andrè Verwey, who also supplies F1 teams under his Gemini Transmissions brand.

'Everything else we do ourselves. We make the exhaust system, we fabricate radiators and coolers, build the whole chassis, machine the uprights…'

Which neatly brings us back to Alonso's opening statement. The Dakar-winning Toyota GR Hiluxes come together in a facility

The Dakar-winning Toyota GR Hiluxes… [are] designed in a three-man office at the far end of the world's least motorised continent

way smaller than the average F1 wind tunnel building, having been designed in a three-man office at the far end of the world's least motorised continent. Yet despite this, Hallspeed and Toyota Gazoo Racing South Africa have not only taken on the best rough-stuff teams in the world, but trounced them.

Open door

In closing, what does Hall think of the FIA's (and Dakar's) regulations, more particularly the horrifically expensive Audi project?

Hall won't be drawn on the latter, save to say that in his opinion the car possibly runs counter to the spirit of the regulations, but that these do currently permit such technology to be developed, so Audi clearly found 'an open back door.'

As for the former, he is bullish. With the introduction of the T1+ regulations (which effectively mandate production-based power units and standardised tyres sizes) he firmly believes the current formula offers a healthy future for off-road racing.

'The drivers are enjoying the cars much more, and it's going to have a much wider appeal to the type of customers who race the Dakar. We proposed this formula in 2017 and it was overruled then, but our suggestions were very close to what we are now using.'

Ford Ranger

Mileman/Ford South Africa

Also in South Africa, Neil Woolridge Motorsport is using a similar formula to build competitive Dakar racers out of Ford's Ranger

Hallspeed may be South Africa's best-known motorsport exporter, but the company is not the only game in town. Situated 600km south of Johannesburg in Pietermaritzburg, Neil Woolridge Motorsport (NWM) is busy carving out a fine reputation with its Ford Ranger-based off-roaders.

Woolridge, a former off-road champion, notable for being the only winner of the gruelling Roof of Africa Rally on both bikes and cars, switched three decades ago, initially to a buggy, before moving to Works Mitsubishi Pajeros, and then Ford Rangers. In doing so, he started a 25-year relationship with the Blue Oval, one blessed by current Williams F1 boss, Jost Capito, whilst Ford's motorsport director.

Woolridge progressively modified and upgraded the Rangers, eventually going the spaceframe route. The next step was to export them, with his products finding favour in the Americas, Australia and the Middle East.

'We've won a championship almost every year that we've been with them in one class or another,' Woolridge states quietly but proudly. 'Indeed, so successful has the partnership been that Ford recently launched a driver development programme with NWM.'

Although engines, transmissions, dampers and electronics are all imported, NWM builds the chassis in house and sources composite body panels locally. During our visit in July, two wrapped Rangers were awaiting export documentation, while a further chassis was in progress in a bespoke jig. Every non-imported part is designed in house and logged by part number and production date.

However, Woolridge's big news was that he had recently closed a deal for Malcolm Wilson's M-Sport to acquire 50 per cent of the company – a logical move given their respective long-standing relationships with Ford.

'Malcolm and his son, Matthew, came here at the beginning of the year. We'd spoken a lot and I've been there a few times, but then Malcolm said, "I'm a touchy feely type of guy. I want to come and see what and how you do it, and just look at everything." We hit it off immediately.

'We have similar values, and both have the same goal to win the Dakar. We're under no illusion that it is going to take time, it's not going to happen overnight.

'But with our experience in cross country, his experience in motorsport in general and, hopefully, input and help from Ford, maybe [we could have] a three-way partnership.'

Speaking exclusively to *Racecar Engineering*, Wilson admitted to being impressed by NWM, saying, 'With the resource Neil's got, he's done a really good job. We'd been looking at cross country – I took some of my guys out to Abu Dhabi last year – so we've been talking about it. Neil was looking to get somebody to try and market his cars in Europe. So, with both our similar connections, and long histories with Ford, it made a lot of sense.'

It seems there could soon be two South African 'bakkies' fighting for Dakar honours.

Malcolm Wilson's M-Sport recently acquired a 50 per cent stake in NWM and, with input from Ford, has eyes on the Dakar prize, too

Mileman/Ford South Africa

G56 in action in the Ginetta 2022 GT4 Supercup. The car has been engineered to favour the power of its potent 6.2-litre V8 in Balance of Performance calculations

Grand tour

Ginetta has built everything from LMP1 to road cars, but now it's firmly focused on its core business of entry-level motorsport, one-make racing and GTs. Racecar *visits its Yorkshire, UK factory*

By MIKE BRESLIN

Jakob Ebrey Photography

Ginetta's head of motorsport, Mike Simpson, stands by the G60-LT-P1 he raced at Le Mans in 2018. A painting of company chairman, Lawrence Tomlinson, taking 2006 Le Mans GT2 spoils in a Panoz Esperante hangs in the background

You can ask questions over the 'phone, dredge the internet and read a tottering stack of press releases, but you will only get to the beating heart of a racecar manufacturer by visiting its factory in person. For while the physical foundations are buried deep beneath the floor, the philosophical underpinnings, what the company truly stands for and aspires to be, are displayed in the attitude of the people working there.

At Ginetta's impressive base at Garforth, near Leeds, in the English county of Yorkshire, you almost immediately feel you're among racers. There's a real buzz about the place, a passion, a quiet urgency of business. Which is perhaps not surprising, for this is a motorsport company that's actually headed and run by racers. Chief amongst these is hugely successful businessman and Le Mans class winner, Lawrence Tomlinson, who took over the company in 2005 and opened the impressive 75,000ft^2 Garforth facility two years later. Since then, close to 1000 cars have rolled out of its gates.

There are about 80 people working at Garforth now (around 120 worldwide), although Tomlinson, now chairman, was not among them at the time of *Racecar's* visit. His influence, though, is all-pervading.

'He's instrumental in every major decision here,' says Mike Simpson, head of motorsport and former Ginetta LMP1 driver. 'Lawrence has the vision, he's very good at thinking ahead. In motorsport, people don't think far enough ahead because you're ducking and diving and things are so fluid and dynamic. But Lawrence has his eye three to five to seven years ahead, and it's always his strategy.'

Development plan

Simpson was speaking in the reception area at the factory, in which sits one of the firm's two G60-LT-P1 LMP1 cars, a project the company is immensely proud of.

The car finished Le Mans at its first attempt in 2018, and Ginetta was aiming at a two-car assault in 2020, but what would have been its second full season, and second Le Mans, was scuppered by Covid. Since then, there have also been significant changes in the regulations for WEC's top class.

'Our plan was not about WEC,' says Simpson. 'We were using WEC to grow as a team to develop the car for Le Mans. Lawrence had one objective, and that was to try and take it to Toyota at Le Mans. So, for a normal track like Silverstone or Bahrain, we lacked a bit of downforce, but we ran the WEC programme with our Le Mans configuration and you could see our top speeds were awesome, so we were tipped to do well at Le Mans.'

Business decision

The LMP1 project grew out of the company's success with the first iteration of LMP3, for which Ginetta was one of the four selected manufacturers in 2015. Since 2020, it's produced one of the four second generation cars too, along with Ligier, Duqueine and Adess. But a quick glance at current grids for this category show Ginetta is not especially well represented in P3 competition.

'It's Ginetta's choice,' explains Simpson. 'LMP3 as a business, to be brutally honest, is a challenge. There is a maximum price you have to build the car to, which is €235,000 [approx. £205,000 / $238,750]. Then you have to give 10 grand of that to the ACO as a technical passport. We can't build that car for €225,000. So, we only build cars for the correct partners and programmes. I could sell more cars than we do, but why would you?'

So, while Ginetta is proud of its prototype involvement, Simpson says its focus now is more on the base of the motorsport pyramid.

'We start off with a big hopper, with track days, the simulator, and people just starting racing. By the time you get up to that point [LMP3], you're looking at somebody putting a half million to £700,000 programme together. We're not going to sell many cars, and there's no LMP3 in the UK, so for us to then go and support customers around the world, financially and logistically it's a challenge.'

SimTrack operates an immersive driving simulator at the company's Garforth facility. The rig has force feedback steering plus full brake and clutch assemblies, amongst other features

Jakob Ebrey Photography

A Ginetta Junior field streams through Paddock Hill at Brands Hatch. One-make racing remains the company's main line of business

'Lawrence [Tomlinson] had one objective, and that was to try and take it to Toyota at Le Mans'

Mike Simpson, head of motorsport at Ginetta

This last point is important at Ginetta, because support at the track is a key aspect of its approach, especially with its one-make race series, of which there will be three in the UK in 2023: Ginetta Junior (see box out on p56) using the G40; the Ginetta GT Academy (for the G56 GTA) and the all-new Ginetta GT Championship (for G56 GTP and G40 GT5 in two classes). Meanwhile, its GT4 will run in national and international GT events.

Income streams

Such a range of racecars also means a wide variety of transmissions, and the gearbox build part of the factory – reached after a visit to the state-of-the-art, fully-immersive simulator facility run by SimTrack under the Ginetta umbrella – is a very busy place, with 'boxes from Xtrac (LMP1 and GT4), Hewland (G55) and Quaife (G40 Junior) on the benches.

As the transmission is controlled in the one-make categories, overhauling them is a big part of Ginetta's business. 'One of the main income streams is rebuilding the gearboxes,' says Simpson. 'The gearbox, among other areas, is sealed. It has a tag seal from Ginetta, so only Ginetta can go into that.

'If you need a refresh, or you feel something's gone wrong, it comes back here. The main point is it guarantees equality. And in single-make racing, we're all about creating a level playing field.'

The same is true of the engines, which for the G40 Junior is an 1800 Ford Zetec. Because the Junior cars are restricted to 100bhp, there's not much Ginetta has to do to it, but all engines still have to come back to the factory for a rebuild each year. 'They are dyno tested here and then sealed and tagged up, so we control that,' says Simpson. 'We're not blueprinting, we're just freshening them up.'

Incidentally, all Ginetta engines also come with a 60-hour race warranty, which is pretty unusual for motorsport power units.

The engine department shares the same space as the gearbox builds, and deals with around 75 rebuilds a year, 50 of those for Juniors. There's also an ORECA Nissan V8 spec LMP3 engine on the bench on the day of *Racecar*'s visit, as well as examples of the Ford 3.7-litre V6 used in the G55.

It's not just servicing engines, though, as Ginetta also builds its own units, such as the 500bhp, 6.2-litre V8 that now powers the G56 and G58, the latter a no-holds barred track car based on the LMP3. The base engine came from GM, but that was just the start of it.

'The V8 started off as a GM LS3 engine,' says Anthony Thompson-Hayes, engine shop manager. 'We started with essentially off-the-shelf components, and then worked out the weaknesses of each part.'

This meant changes to a whole gamut of parts, including new bespoke pistons, valves and valve springs, cam and rocker systems,

while Ginetta also made some parts itself, such as the dry sump oiling system and the fuel pump, to the point where the company has no qualms in badging the end product as a Ginetta engine.

'We had to change a lot of parts, because you buy your performance LS3, but when we put it in the application we wanted, which was a structural member as well, that led to problems. It also didn't produce the power we needed,' notes Thompson-Hayes.

Chassis fabrication

Moving on to chassis build, via a visit to the very busy fabrication workshop, most of Ginetta's cars feature extremely beefy-looking T45 steel spaceframe chassis, and these are constructed on revolving chassis jigs, taking around six days each to complete.

The carbon tubs for the LMP3 cars, incidentally, are made off site.

Ginetta is a great believer in the advantages of spaceframe construction over monocoques, particularly when it comes to dissipating forces in an impact.

'The protection structure in a monocoque chassis ultimately goes down on to a foot or a pad, that then needs to engage and spread load through a monocoque chassis, which probably hasn't been designed to do that,' says Ginetta technical director, Clive Seddon, who has a background in power unit building and originally ran the engine workshop at Garforth.

'It just, in theory, hits a flat surface and then it engages with a sill. Whereas on our tubular chassis, our sill is another box section, which means that is still playing a part in the collective of the cross of the door bars.

'Our diagonal door bars are convex, to allow the driver more room, but also because if you hit that point, you can't hit it inside out,' Seddon adds. 'You hit it outside in, which means it has to spread. And if it has to spread, we've got a straight tie on the sill, which isn't the sill, it's a box section.

'We've also got horizontals going under the seat to the centre and across, supporting the other side. So, in terms of dissipating the load and the side impact, that's your advantage. And it's a huge advantage.'

GRP bodies are bonded to the spaceframes at the bodyshop – housed in a separate building, but still on site – while carbon skins are mounted to the bulkheads and the tube structure is bolstered with aluminium or carbon honeycomb side panels. These cars are not just silhouette racers, then, as there is more to them than simply body panels fixed to a frame.

It is still unusual for a GT car to have a spaceframe chassis, but this hasn't held Ginetta back, and the company has been a stalwart of GT4 for a while with its G50, G55 and its new G56. It's also built GT3 versions of its products and is currently seriously contemplating a GT2 car. 'That's definitely top of the list,' concurs an enthusiastic Simpson.

Ginetta's Garforth, Yorkshire facility is always busy, and always buzzing. This G56 GTA under construction in one of the build bays is destined to serve as a motorsport experience day car at Jonathan Palmer's Bedford Autodrome-based PalmerSport

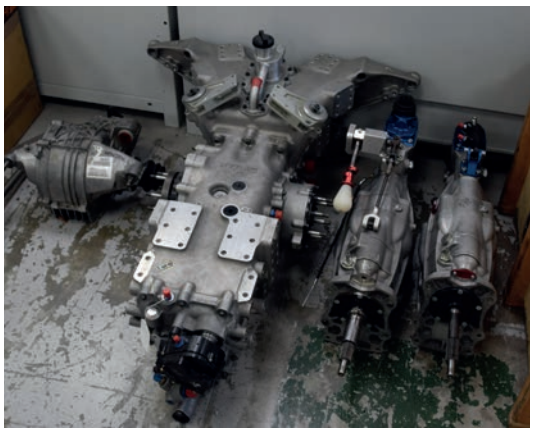
It's also built GT3 versions of its products and is currently seriously contemplating a GT2 car

Reverse engineering

GT racing is all about compromise, of course. 'The OEM road cars are stripped back to become racecars, but when we compete against them, we actually have to add weight, as everything is done on a Balance of Performance,' says Simpson. 'The Ginetta has always been too fast in the corners, so we have now purposely designed a GT4 car [the G56], to engineer it to be worse, which sounds daft, but that's the only way we'll be allowed to use more power.

'We've got a very capable, high-horsepower V8 engine, but at the moment it's quite restricted. So, the amateur driver, which is your customer ultimately, won't enjoy it if they're super quick around a corner but get mugged down the straight. Or if they put all their effort in and get the car on the front of the grid, only to be in seventh by the first corner because you've got a drag race to it.

'So, the idea of the G56 over the G55 [the homologation for which finished in 2020] is it's a heavier car and actually not quite as good as it was around the corners, but we're allowed to make time back with the power.'



One-make racing differentials and gearboxes are sealed and tagged by Ginetta and no one else is allowed to break them open. The sub-assembly in the middle here is from the LMP3

A Nissan LMP3 V8 block being assembled in the engine 'shop. Ginetta builds its own version of a GM LS3 V8 for its G56, while the G40 Junior uses a very mildly modified 1.8-litre Ford Zetec unit

The G56 is very high spec for a GT4 offering, with many of the parts developed for the LMP3 handed down to it

The G56 is also very high spec for a GT4 offering, with many of the parts developed for the LMP3 handed down to it, such as an Xtrac transaxle and other high-end components like Ginetta's machined billet uprights.

Road and race

All this is assembled in the build bays, which at the time of *Racecar*'s visit housed a car being optimised for cooling in warmer climates and a G56 GTA that's been developed as a driving experience car for PalmerSport. The latter, in particular, fits nicely with Ginetta's objective of interacting with customers at the very beginning of their motorsport journey.

Beyond the bays, there's a large open area for car storage and display, amongst which is an example of the company's Akula road car, a low volume, 6.0-litre, 600bhp, 200mph supercar, which is very much a halo project.

There is a nod to Ginetta's pre-Tomlinson past parked up here, too – the G10 V8. This showed great promise in 1960's sportscar racing but, for a variety of reasons, chief among them that it wasn't given the homologation needed for it to race in the US series it was designed for, was not as successful as its performance figures might suggest. Consequently, only three were built in period. However, Ginetta plans to market a roadgoing G10 RM (RM for 'remastered') model to selected customers, using the original tooling to build it and equipping it with a 495bhp billet V8.

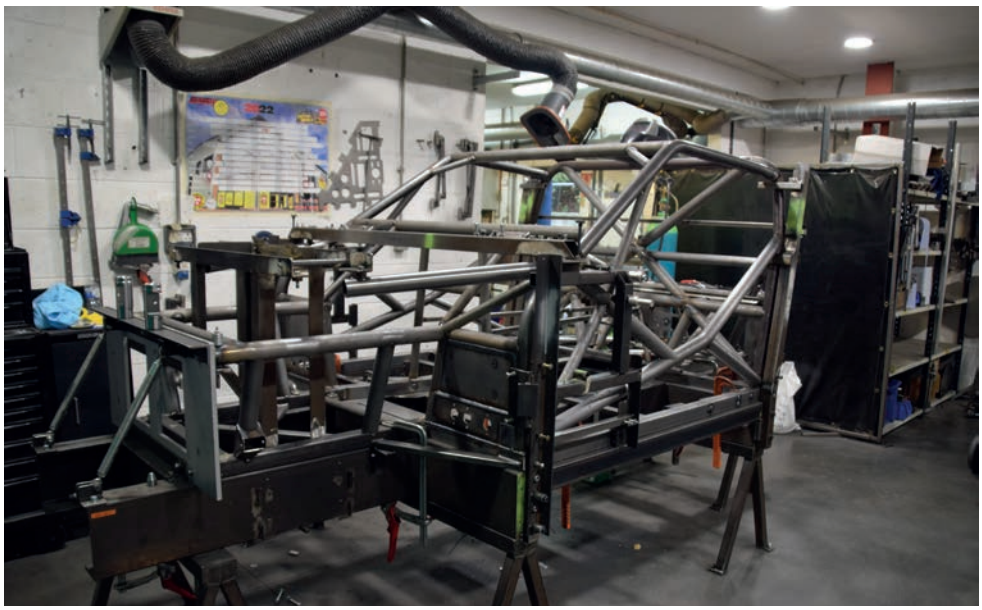
As is the case with many of the cars that roll out of Garforth, the G10 RM will carry numerous parts produced on site, using the firm's well-equipped machine room, which features a complement of Haas CNC equipment. There is more state-of-the-art kit upstairs in the design office too, where SolidWorks CAD is used, plus Catia for both CAD and FEA. CFD is usually outsourced.

Yet it's important to note here that, while the company has access to all the computing tools a high-level motorsport concern needs these days, this is just part of its unique design philosophy, one which, as noted, is very much driven by its chairman.

'We invert some of the design process, or some of the methods you would use to find a solution, and we accelerate that into a very practical approach. That's what Lawrence's spin on it is,' says Seddon. 'We will – I'm not going to say jump stages, we'll always visit stages – but we don't do it in the order other [racecar manufacturers] might do it. We first prove the concept in a very manual, hands-on method, as quickly as possible.

'I think, when you pick up the mouse and you identify a problem, it's very easy to get swallowed up in a computer screen for endless hours and not actually know you're going to come out the other side with something that will work,' Seddon adds. 'So we will try and go to a practical solution very early on, because we have the track [Ginetta's test facility at Blyton Park], we have the drivers, and we have the test cars.

'We use the same principle in the engine 'shop, where we use the two dynos to investigate and find practical solutions.'



Ginetta spaceframes take six days to build, after which they are powder coated for durability before GRP bodies are bonded to them. The structure is also bolstered with aluminium or carbon honeycomb side panels

The billet aluminium hub Ginetta developed in house for LMP3 competition is now also used on its GT4 car, along with other high-end components from the Sports Prototype project

One of only three Ginetta G10s ever built. The company is now developing a roadgoing version of this car, which will pack a 495bhp V8

That's not to say computers don't have their place in the operation as well.

'Half of my time is spent behind a computer screen,' admits Seddon. 'I'm not knocking it, but trying to get to a practical test is super important to us, as soon as possible. Then, once you know you've got a certain amount of room to resolve a problem, *then* you turn to CAD.'

Pub talk

Alternatively, you go to the pub. That's right, to discuss Ginetta's plans for the future, a visit to the factory's very own pub was in order (for balance, there's also a gym on site, too), where the company's second LMP1 is on display. Sure beats a picture of dogs playing pool for a talking point in a bar!

Speaking of talking points, Ginetta has recently taken the surprising, for some at least, decision to leave the BTCC-supporting TOCA package and field its UK championships on the SRO-run British GT bill. This is partly for reasons of logistics – it's much easier to operate all the series on the same race weekends – but also for market fit.

'Global growth is key, and that's about franchising the series out,' says Simpson. 'We've just aligned ourselves with the SRO. Supporting British Touring Cars on ITV is good, but we don't build a front-wheel drive Touring Car. We build GT cars. The SRO is the world's biggest organiser of GT racing, so it's an absolute no brainer for us.'

'Our goal is quite a simple goal. We want to make 200 cars per year, and support them around the world, but also with some halo projects'

Mike Simpson, head of motorsport at Ginetta

Another LMP1 car sits in the company pub. Ginetta has no immediate plans to return to top-flight prototype racing, focusing its efforts on GT and one-make competition instead, albeit with some halo projects in the pipeline

With a 60,000ft^2 US facility in South Boston, Virginia, which buys and sells in dollars and so insulated Ginetta from the recent money market turmoil, the company is well placed to expand into a more global market, and has already started to do so. In 2021, 39 Ginettas were sold in the US, while there are emerging markets in Australia, New Zealand and many other countries. But beyond global expansion, the main thrust is to simply keep progressing, and expanding carefully in well-considered markets.

'We're always moving forward,' says Simpson. 'We will look back and learn from things, but the focus is forward. And that's in design, it's parts, it's commercial aspects, and we're continuously trying to push that. Our goal is quite a simple goal. We want to make 200 cars per year, and support them around the world, but also with some halo projects, which will be a fun element.'

Which is just the sort of thing you might expect from a firm run by racers but, more importantly, run for racers.

Learning curves

There are many ways to gauge the success of an entry-level championship but, whichever measure you choose, Ginetta Juniors comes out on top. For a start, it has alumni in pretty much all the major series, including Lando Norris in F1. It also produces the best and most ferocious racing since the heyday of Formula Ford 1600, and it is immensely popular with race fans. On top of that, it is a great way for young drivers to learn their craft.

Which is no accident, for the G40 Junior cars have been designed with driver education very much in mind. There's a six-speed manual sequential gearbox, with no flat shift system or auto-blip, which means drivers need to heel and toe, for instance, while the mysteries of weight transfer have not been forgotten either.

'They're really soft,' says Simpson. 'They're under-damped and under-sprung. There is a roll bar, but it's not hugely stiff. And then there's the lack of aero. The idea is that the car sort of falls over itself. So, you come up to a traffic light in your road car, you hit the brakes, you go towards the windscreen. It's that dynamic, what that does at speed, that we're trying to teach. It's teaching drivers at their entry point, where all the senses are alive, to help them figure out what's going on, where the balance is.'

Another thing Junior drivers, who are aged from 14 to 17, need to learn is on-track discipline, which is why you sometimes see the G40s circling with their front-hinged bonnets flapping merrily in the wind.

'The bonnet is held on by just a couple of pins,' says Simpson. 'It's superficial. It's there to teach the kids a lesson, because all that happens if you hit another car is you snap an aluminium pin. The bonnet can then lift up a bit over the windscreen, and it can look bad on TV, so it's a big kick up their arse to say that was the wrong move. It's teaching them a lesson.'

Who said learning wasn't fun?

The Ginetta Junior championship is an exciting and proven training ground for young drivers looking to build a career in racing. F1 driver, Lando Norris, is among its alumni

Jakob Ebrey Photography

Reality check

Driver-In-the-Loop (DIL) simulators have become an indispensable tool for engineering racecars. They are also now finding their way into mainstream automotive, with manufacturers recognising the considerable benefits they bring

By LAWRENCE BUTCHER

In Formula 1, nearly every team has an engineering-grade simulator, and in the past few years NASCAR teams have also started to adopt the technology. For some time, it was thought there was little benefit to be gained from driver simulators in Stock Car racing, but now there are multiple set-ups around NASCAR's North Carolina hub.

Teams in the WEC, Formula E and other series also make use of DIL, while many vehicle manufacturers now have in-house DIL capabilities that share duties between road car and racecar development. BMW, for example, recently opened its FIZ research and innovation centre in Munich, containing no less than 14 DILs of different types.

When linked to a team's vehicle physics model, a properly designed DIL can be used by engineers to work on the development of a car, with the driver acting as another input to the vehicle models. An input that can be of vital importance. For example, sometimes a set-up that a computer simulation says should be fast proves not to be in the real world, if it introduces handling traits that prevent the driver fully exploiting the potential performance. Second, and this is only something that has become apparent after teams have started using simulators, driver involvement can show up flaws in the validity of a particular vehicle model.

Sensory inputs

It may sound obvious, but the basic requirement for a full-motion DIL simulator is that it comes as close to reality as possible. However, that does not mean it needs to exactly replicate the movement of a racecar, only that it must make the driver's brain and body *think* they are undergoing the same loadings and forces as would be experienced in a real car. It is here that the world of engineering crosses into that of physiology, because being able to create the necessary sensations requires an in-depth understanding of the way the human brain reacts to and interprets sensory inputs.

The main challenge is how, within a limited footprint of a simulator (which admittedly can be quite large), can the driver be given the sensation of acceleration along all axes, creating a similar perception as those experienced in a car on track? The answer is motion cuing.

Imagine you are in an aeroplane, and it banks gradually, your body will register the change of attitude. But, if the 'plane continues to bank at a constant rate, the brain loses interest, moves on and the sensation of banking decreases. That is why pilots fly blind on instruments rather than feel, as the brain cannot always accurately ascertain the body's attitude in space.

BMW is also now using DIL for its road car programmes

Two views of BMW's Formula E simulator

The lastest simulators, such as this one at BMW Motorsport, offer a driving experience so close to reality that they, and the drivers that operate them, have become a vital tool in the car development process

Being able to create the necessary sensations requires an in-depth understanding of the way the human brain reacts to and interprets sensory inputs

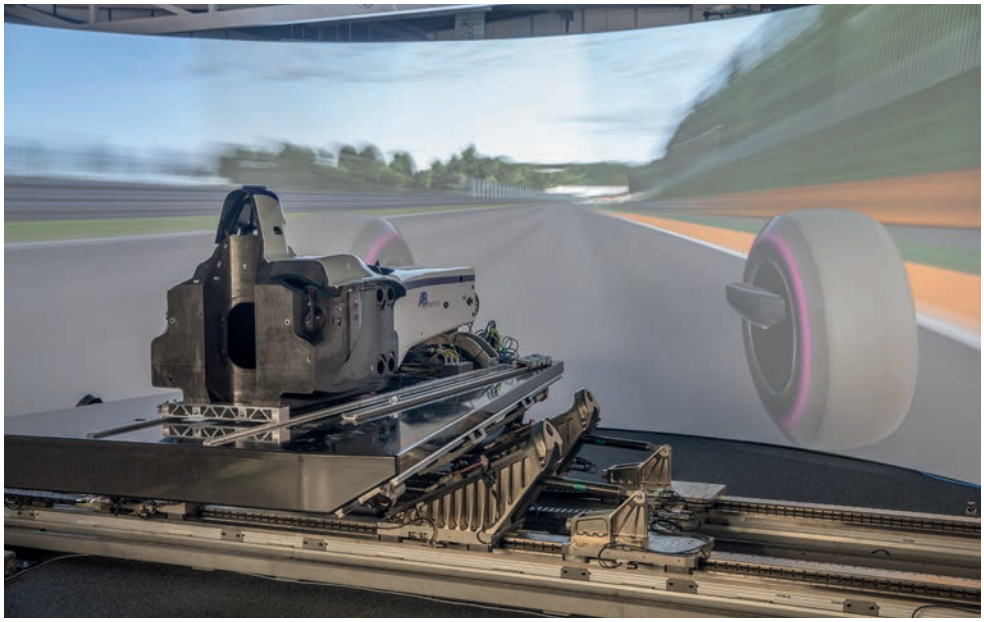
It is this same phenomenon that allows a simulator operating in a confined space to convince the human brain that it is on a racetrack, experiencing rapid changes in acceleration and direction. Racing drivers are particularly attuned to these changes, which inform how they drive a car.

Motion cues

The algorithms that drive the simulator generate motion combinations, the cues, which trick the driver's brain into thinking an event is occurring. A simplified example would be that if the driver brakes, the simulator will move backwards to simulate the braking force, with the intensity and duration of the motion dictated by a mathematical model based on the brain's perception of such motions. That way, the driver will feel the car decelerating through a braking zone, though the simulator may only move by a metre or so.

It is in ensuring the correct cues are used, and in the right order, that makes a simulator not just feel realistic, but provide a genuinely accurate representation of a car on track.

As you might imagine, finding the correct combination and order of cues is not straightforward. There are a lot of subtleties in the way the brain processes things, and the way it prioritises cues. It will prioritise new cues over old so, as a new cue comes in (such as the onset of turn in while the driver is trail braking, for example), the intensity of the initial braking cue can be reduced, without the driver noticing.



AB Dynamics now owns sim' manufacturer Ansible Motion. Both images on this page show the company's aVDS Motorsport simulator

Motion platforms

Looking to the top of the DIL performance tree, simulators will have a full range of movement in six degrees of freedom, able to recreate acceleration, yaw, pitch and heave motion. This can be achieved in a variety of ways, ranging from hexapod set

[the best] simulators will have a full range of movement in six degrees of freedom, able to recreate acceleration, yaw, pitch and heave motion

ups to systems that combine tracks for the simulator to move on, creating both lateral and longitudinal forces, as well as actuators for roll, pitch and heave.

The motion space of a simulator is the envelope within which it can move to generate motion cues. Ultimately, it is the size of the motion space that dictates how the motion cues are applied. For example, how long and at what rate the simulator can be accelerated in any given direction.

It is interesting to note that the relationship between the motion space of a simulator and the sensations experienced by the driver is not a linear one. A jump from a 1 x 1m motion space to a 2 x 2m motion space will not double perception. This is because a driver senses acceleration rather than velocity, with velocity building up as the square of acceleration. So, acceleration can be doubled but, provided the correct motion cues are used, the motion space available can be preserved for further movements.

Ensuring there is always motion space available to execute multiple cues is something of a challenge. After the onset of a cue – say a cornering event – the simulator needs to be able to return to a neutral position, ready for the next movement, but do so in such a way that the driver does not realise it is doing it. If the simulator is pushing one way and then returns too fast to the neutral position, suddenly the driver is getting an incorrect cue. This is a classic problem with pure hexapod-based simulators (ones where the platform cannot slide laterally or longitudinally) with a limited motion space. These will deliver a good braking cue, but then on lift off the driver will receive an acceleration cue as the platform returns to its neutral position. The return motion always has to be below the driver's perceptual threshold.

The human brain is a very complicated organ, and the sim's job is to try and recreate the way the brain processes and prioritises cues

Dynamic performance

To achieve the necessary fidelity and dynamic performance, motorsport DIL simulators need a motion platform driven by motors with low latency and high bandwidth, coupled with minimal backlash and cogging to near-instantaneously deliver forces directly to the platform.

To prevent the possibility of unexpected movements giving the driver false cues, any compliance in the motion platform must be minimised. However, the platform also requires low mass to minimise inertia (which would add to the response time) without sacrificing stiffness. Low mass and high stiffness improve the high-frequency dynamic capabilities of a simulator, reduce the motor power requirements and improve the conveyance of nuanced dynamics that professional drivers rely on.

One often discussed performance attribute for simulators is latency. Put simply, this is the time delay between the issuance of a command by the vehicle model, be that a driver input or other change, and its physical manifestation through the motion platform. Any serious motorsport DIL will have a latency under 15 millisecond (ms), with

To achieve the necessary fidelity and dynamic performance, motorsport DIL simulators need a motion platform driven by motors with low latency and high bandwidth, coupled with minimal backlash and cogging

Top-flight DIL simulators, such as this one at Mercedes F1, will have a full range of movement in six degrees of freedom and be able to recreate the sensations of acceleration, yaw, pitch and heave

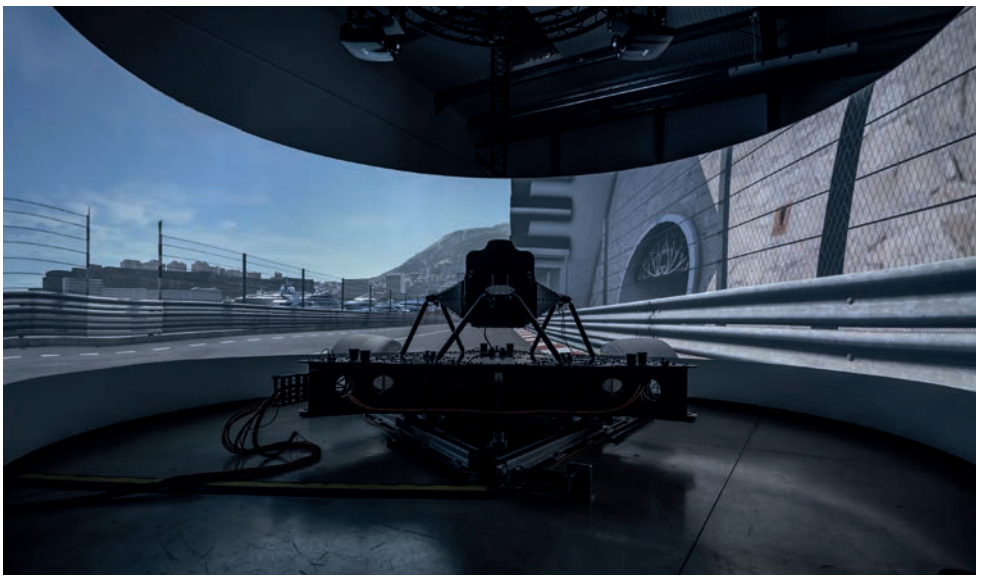
some of the latest systems dropping below 5ms. By comparison, the type of full-motion simulators used for aircraft training have system latencies in the 150ms range.

There are some variations in how different manufacturers measure the latency figures of their systems, though generally, most will record a latency figure as the time between a command and 90 to 100 per cent of the demanded acceleration being achieved.

Payload

Beyond the mechanical platform that constitutes the motion platform, there is the actual driver cockpit, referred to as the payload. This will, depending on the use – be it a single team of an OEM – provide a representation of the car being simulated, and most systems allow for payloads to be quickly swapped.

Considerable effort is taken to ensure the cockpit feels correct for the driver, so it will also feature a variety of systems to add further cues during driving. For example, seatbelt tensioners assist with braking cues, while speakers can be used to help create not just realistic sounds, but also high-frequency vibrations that would be felt through the chassis (though some simulator manufacturers create these using movement of the motion platform as well). The very latest, high-performance DIL simulators are pushing the boundaries of motion space, latency and frequency response to provide ever more realistic feedback to drivers. Take the offerings from new market entrant, Bristol, UK-based Dynisma, which has supplied Ferrari's racing team with its latest simulator. The company's motion platforms offer sub-5ms latency, accelerations up to 15m/s2 and there is even the option for a version capable of 360 degrees of yaw.



UK-based Dynisma offers a range of Motion Generators said to be among the most dynamic, realistic and scalable in the world

Any serious motorsport DIL will have a latency under 15ms, with some of the latest systems dropping below 5ms

Simulators try to trick the driver's brain into thinking it is in a real situation, so an immersive visual environment that covers the full field of view, such as this one at Toyota Gazoo Racing, is key

Meanwhile, established DIL manufacturer, Ansible Motion (recently bought out by AB Dynamics), has its latest S3 platform, which is available in a regular and H, or high performance, version, the latter being dedicated for motorsport use. This features an almost infinitely expandable (in the x and y axis) base, limited only by the installation space available, and the company has already supplied a 5 x 5m unit.

The use of direct-drive motors on the motion platform means that not only can it make larger excursions (allowing for higher velocity movements), but it is also capable of rapid accelerations with low latency, all while carrying up to a 500kg payload.

Variations of the S3 platform are already in use with Honda R&D and BMW for both racecar and road car development, with several other racing outfits, including Ford Performance, also using similar equipment.

Visual environment

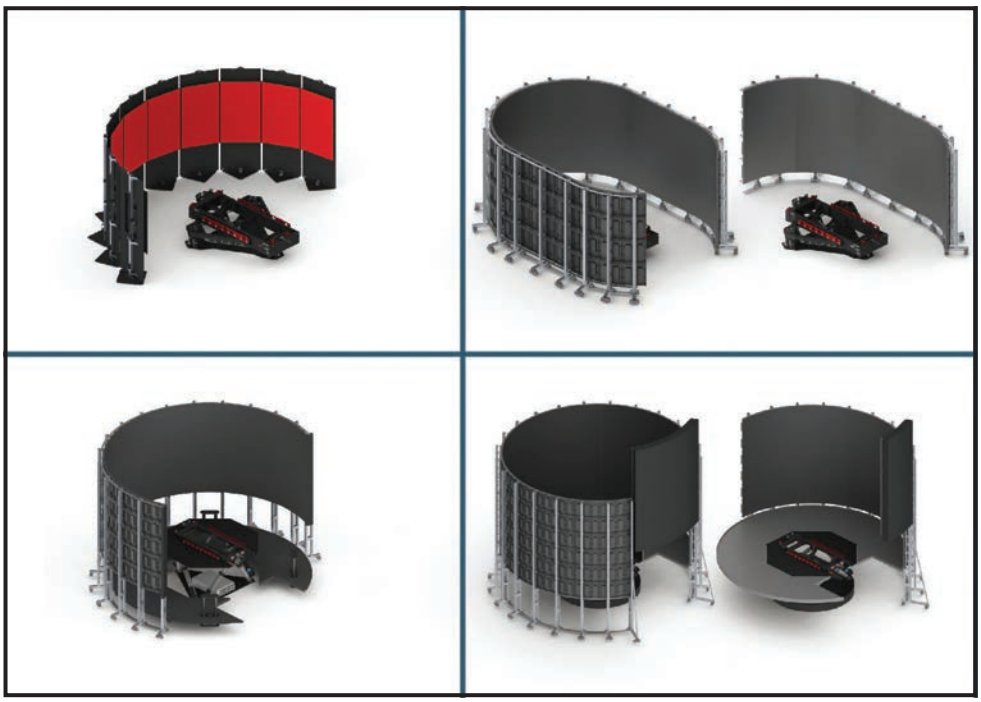
It's important to immerse drivers in a compelling visual environment. There is no way to trick someone into believing they are not in a DIL simulator, but it is possible to reduce the presence of 'spell-breakers', so drivers quickly forget they're in a simulator.

This means using a visual system with eye-limiting resolution (better than 2.4 arc min/OLP) that covers the full field of view for the driver, and with a frame rate of more than 120fps to ensure smooth visuals. Of course, latency between the driver's inputs and a reaction from the display also needs to be minimised.

Projector-based visual systems have been the main display type for driving simulators since their mass adoption, and the latest LED projectors are now replacing the old-style, lamp-lit ones, with benefits for both image quality and the longevity of parts. Projectors are ideal for creating a large format image at a sufficient distance from the driver that they feel they are looking into the distance, rather than at a close-up screen. But they do have some disadvantages.

These include the fact that the images from each projector need to be overlapped, which requires careful synchronisation. Furthermore, the projectors need a direct line of sight to the screen. If the motion platform crosses the light path, it will block the image in that area. The result of this is that projectors sometimes need to be positioned in less-than-ideal locations, which can lead to issues such as variable brightness from the top to the bottom of the image, or changes in perceived resolution across the projection screen due to elongation of the pixels.

One of the most recent developments in DIL displays has been the arrival of LED panels, rather than projection screens. These are the same type of screens found at large sporting events, where they tend to be viewed at a distance and, as such, the pixels can be quite widely spaced without the viewer noticing. When up close, this pixel spacing, or pitch, is easily seen. However, the latest LED technology has seen this pitch slashed, from around 2.5mm to as little as 0.9mm, making such technology viable for use as simulator displays.



LED panels, pioneered by Cruden, are now replacing projector-based visual systems, and can be used in almost any configuration

There are multiple advantages to using LED screens, not least improved contrast as they are able to display true blacks, a particular benefit when simulating low light conditions. Issues around blending panels and overlapping images are also removed, making better use of graphics processing power, while the latest advances allow for low latency and high frame rates to be achieved up to 120fps, ensuring the necessary graphics realism.

Maintenance costs are also reduced, thanks to the modular nature of LED displays, allowing for the rapid replacement and easy calibration of any new sections.

Though curved LED panels are available, they do not have the same resolution as flat panels so, where curved displays are required, they are assembled from a number of flat segments (as shown above). Dutch simulator manufacturer, Cruden, which has led the implementation of LED technology, is able to supply screens in cylinder, u-form or any other shape or aspect ratio, simply by stacking the panels horizontally and vertically in the right combination.

One of the most recent developments in DIL displays has been the arrival of LED panels, rather than projection screens

Ansible Motion Delta S3 series Motorsport simulator

DIL simulators are, of course, much more than simply a motion platform and a visual display. Without accurate vehicle dynamics and track models, they would be next to useless. However, covering the complexity of this topic would require at least a standalone feature. For now, then, we'll just say that DIL is also increasingly being combined with other processes, such as software and Hardware-In-the-Loop (HIL) testing. For example, it is now feasible to directly link an engine running on a dyno to a DIL simulation, allowing for highly representative testing to be undertaken, or to a complete vehicle on a dynamic rig. Similarly, the DIL can be used to test software models, such as those for battery, hybrid system or brake-by-wire management in real time with real driver inputs. And if the advances made in the past few years are anything to go by, you ain't seen nothing yet.

Dynamic drive part two

Putting the core theories of vehicle dynamics into practice

By DANNY NOWLAN

Danny Dzenis/dd-photography

Important to grasp is that steer angle is shown at the tyre, not the steering wheel, so when you plot a neutral steer channel anything above the line is understeer and anything below is oversteer

In the first part of this series about the core of vehicle dynamics last month (*RE* V32N12) we talked about what drives a lot of the common misconceptions around the fundamentals of vehicle dynamics. Now it's time to apply this knowledge and give you the numerical tools to put the correct theory into practice.

The first spin of everything we discussed in part one is the concept of a neutral steer channel. I have mentioned this before in my articles, but it's such a powerful concept that it is worth repeating here.

The first port of call for using the following equations is to deduce the steer angle if the car was completely neutral.

If we take the slip angle equations we discussed in part one and apply a bicycle approximation, we arrive neatly at **equations 1** and **2**.

$$\alpha_{FRONT} = \delta - \frac{a \cdot r + V_y}{V_x} \quad (1)$$

$$\alpha_{REAR} = \frac{b \cdot r - V_y}{V_x} \quad (2)$$

If the car is neutral, then the front and rear slip angles are equal, so equating these two equations yields the result for the steer angle if the slip angles are equal.

$$\delta_{NEUTRAL} = \frac{wb \cdot r}{V_x} \quad (3)$$

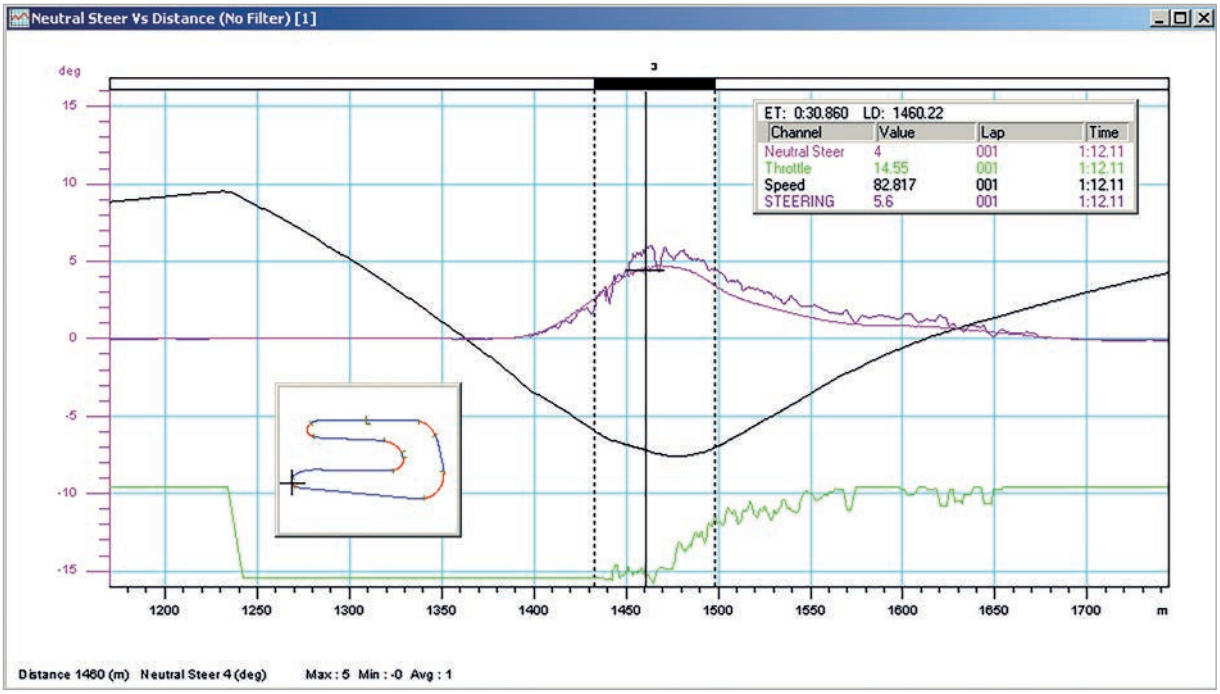
The astute reader will quickly realise that **equation 3** is completely devoid of slip angle. The neutral steer angle is a product of wheelbase, yaw rate and vehicle speed.

The following also needs to be stated:

- The neutral steer angle is the steering angle of the tyre, *not* the steering wheel.
- The natural units we are using in all these equations are metric.

The understeer case… tends to fall apart if you have a muppet driving because they invariably apply too much steering lock

Fig 1: Plot of actual steer vs neutral steer



Now we have done the warm up… we can move onto the main event

In practice, this means all angles presented here are in radians, not degrees. To convert between the two, you must multiply the results by 180/π (approximately 57.2958). Also note acceleration is in m/s^2 so, in practice, multiply the acceleration by 9.8.

Any steering angle above this is referred to as understeer, and any steering angle below is referred to as oversteer. What does this mean in practice? See **figure 1**, which is about to become one of your best friends.

The first thing to note is that steer angle is shown at the tyre, not the steering wheel. Understand this concept, and then when you plot the neutral steer channel anything above the line is understeer and anything below is oversteer.

That said, there are some significant caveats to that shown in **figure 1** but, as a first pass, it is still a fantastic tool. The major one being that for the understeer case, it tends to fall apart if you have a muppet driving because they invariably apply too much steering lock. Still, as a first pass when you download the car between sessions, **figure 1** is a life saver, and everything else flows downstream from there.

The main event

Now we have done the warm up with neutral steer, we can move onto the main event where we dial in tyre loads, a tyre model and the equations in part one.

$$TL_1 = \frac{wdf \cdot m_t \cdot g}{2} + \frac{awf \cdot C_L \cdot A \cdot \frac{1}{2} \cdot \rho \cdot V^2}{2} + \frac{prr \cdot m_t \cdot a_y \cdot h}{tm}$$

$$TL_2 = \frac{wdf \cdot m_t \cdot g}{2} + \frac{awf \cdot C_L \cdot A \cdot \frac{1}{2} \cdot \rho \cdot V^2}{2} - \frac{prr \cdot m_t \cdot a_y \cdot h}{tm}$$

$$TL_3 = \frac{wdr \cdot m_t \cdot g}{2} + \frac{(1-awf) \cdot C_L \cdot A \cdot \frac{1}{2} \cdot \rho \cdot V^2}{2} + \frac{(1-prr) \cdot m_t \cdot a_y \cdot h}{tm}$$

$$TL_4 = \frac{wdr \cdot m_t \cdot g}{2} + \frac{(1-awf) \cdot C_L \cdot A \cdot \frac{1}{2} \cdot \rho \cdot V^2}{2} - \frac{(1-prr) \cdot m_t \cdot a_y \cdot h}{tm} \quad (4)$$

The first thing to talk about is tyre loads. Again, this is something I have discussed at length in previous articles, but **equation 4** sums it up quite succinctly.

Where,

TL_1 = tyre load on the front left in N
TL_2 = tyre load on the front right in N
TL_3 = tyre load on the rear left in N
TL_4 = tyre load on the rear right in N
wfl = weight distribution at the front
wrl = weight distribution at the rear
awf = distribution of aero on the front axle
C_LA = downforce non-dimensionalised by dynamic pressure
V = velocity of the vehicle in m/s
ρ = air density in kg/m^3
Prr = lateral load transfer factor at the front
m_t = total vehicle mass in kg
h = c of g height
a_y = lateral acceleration in m/s^2
tm = mean track of the vehicle

Equation 4 will happily spit out tyre loads and, if you have a well measured car and a fair idea of its aero, for a given lateral acceleration you can get a first pass at the tyre loads that can be plugged into Excel. However, it is not the complete picture. Once we have this, we need a rough idea of what a tyre model is. By far and away the simplest representation is the second order traction circle radius approximation vs tyre load shown by **equation 5**.

$$TC_{RAD} = k_a(1 - k_b \cdot F_z) \cdot F_z \quad (5)$$

Where,

TC_{rad} = traction circle radius (N)
k_a = initial coefficient of friction
k_b = drop off of coefficient with load
F_z = load on the tyre (N)

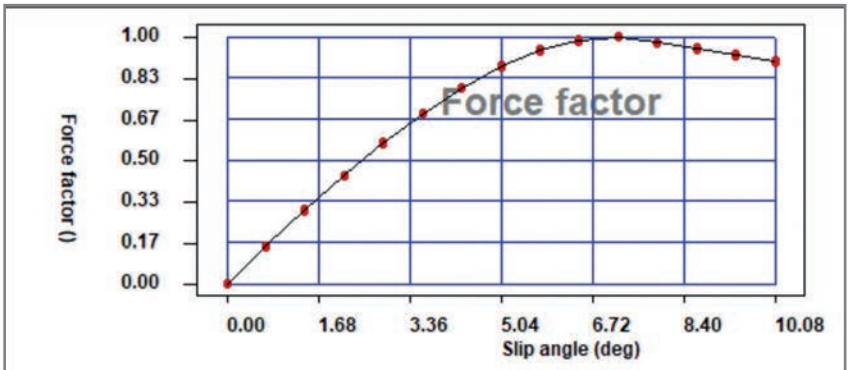
The traction circle vs load characteristic is the heart and soul of the tyre

Some typical values are presented in **table 1**.

Table 1: Typical open wheeler numbers for maximum tyre force with the coefficient of friction dropping off linearly with load

Parameter	Value
ka	2
kb	5.0 e-5 (1/N)

Fig 2: Plot of normalised force vs slip angle



angle	0.00	0.72	1.44	2.16	2.88	3.60	4.32	5.04	5.76	6.48	7.20	7.92	8.64	9.36	10.08
FFact	0.00	0.15	0.30	0.44	0.57	0.69	0.79	0.88	0.94	0.99	1.00	0.98	0.95	0.92	0.90

While the traction circle vs load characteristic is the heart and soul of the tyre, what we have done here is still strictly a first pass. In reality, when you reverse engineer this from race data the curve represents a tanh function. That said, what we have in **equation 5** is easy to implement and, if you know what you are doing, can get you a fair way down the road.

The last piece of the puzzle with regards to tyre models is the normalised slip angle function. For those of you familiar with Pacejka, a very simple approximation of this is that shown in **equation 6**.

$$fn(\alpha) = C_1 \cdot \alpha - C_3 \cdot \alpha^3 \quad (6)$$

You choose C_1 and C_3 to fit where you want the peak slip angle in radians, and α is the slip angle in radians. As a case in point, a peak slip of six degrees will produce a C_1 of 14.323 and C_3 of 323.23. This function breaks down very quickly in the post-stalled regime but, when you are within the peak slip angle, it will get you by quite adequately, and will also serve you well when you have to calculate control power. As an example, a plot will look like that shown in **figure 2**.

In this diagram, I have deliberately clipped the post-stall region, but you will still be pleasantly surprised at how far this will get you. Now, finally, we can put together a pure lateral model for the tyre model, as shown in **equation 7**.

$$\begin{aligned} F_y &= fn(\alpha) \cdot k_a (1 - k_b \cdot F_z) \cdot F_z \\ &= \left(C_1 \cdot \alpha - C_3 \cdot \alpha^3\right) \cdot k_a (1 - k_b \cdot F_z) \cdot F_z \end{aligned} \quad (7)$$

$$m_t (V_y' + V_x r) \approx F_{YF} + F_{YR} \quad (8)$$

$$I_z \cdot r' \approx a \cdot F_{YF} - b \cdot F_{YF} \quad (9)$$

Yes, this is simple, but it's still valuable.

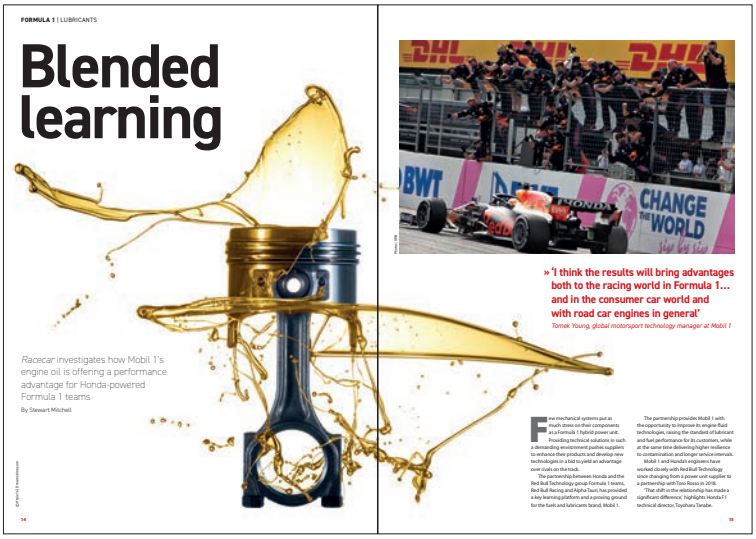
Now that we have discussed tyre loads and a representation of tyre force, we are ready to put this all together with the equations of motion we discussed in part one last month. **Equations 8** and **9** are here to refresh your memory.

Danny Dzenis/dd-photography

The methodology we have shown here will give you the tools to start doing some basic calculations on racecar vehicle dynamics. It's also great preparation for using a simulation package properly

Evolution of a Racecar

A must read for racing, environmental and technology enthusiasts!



FORMULA 1 | LUBRICANTS

Blended learning

Racecar investigates how Mobil 1's engine oil is offering a performance advantage for Honda-powered Formula 1 teams

By Stewart Mitchell

» 'I think the results will bring advantages both to the racing world in Formula 1… and in the consumer car world and with road car engines in general'

Tomek Young, global motorsport technology manager at Mobil 1

ELECTRIC MOTORS | EFFICIENCY

Efficiency drive

With the growth in EV racing, the quest to improve efficiency in electric motors has gained pace in recent years, with new technologies and wonder materials emerging. *Racecar* assesses their impact

By Lawrence Butcher

» Both ICE and electric motor losses tend to manifest themselves as heat

MATERIALS | NATURAL FIBRE COMPOSITES

Sustainable thinking

Racecar talks to Johann Wacht of Bcomp to find out how technology transfer from motorsport can play an important role in preserving the future of our planet

By Gemma Hatton

» When we first entered motorsport, the regulators were mostly interested in the safety benefits of our natural fibre composites

Johann Wacht

» The technical sweet spot of our natural fibre composites lies in stiffness. We can achieve the same stiffness and weight as an 830gsm monolithic carbon fibre lay up

Johann Wacht, manager of motorsports and supercars at Bcomp

Much has been made of the way in which cars of the future are powered due to the focus on emissions from the tail pipe, but there is so much more to having an enviromentally sustainable car. In this special issue we highlight the full range of advances that have been made by racing companies through their motorsport activities. We look at the major advances in efficient motors, battery storage, using natural fibres instead of carbon fibre, and also at how the tyre companies involved in the FIA World Endurance Championship have focused their attention on producing less enviromentally impactful products.

In doing so, *Racecar Engineering* has highlighted the effect that racing can have on a wider community. Racing is about prototypes, experimental machines that can be used to test new technologies and this is where the organising bodies have headed. Now in most major FIA World Championships there is some form of electrification, be it hybrid or full electric. Yet in others, notably in the US, series have yet to take on this technology and are looking in other areas to maintain the relevance of racing. On the track, particularly in Europe, companies are working hard to bring evolving technologies to a level that they can be proven to work or discarded as unworkable.

There is so much more to the impact a car can have on the planet than what is put in the fuel tank, or how far a battery can take the car. We do look at the options that are available for powering our cars, including hydrogen and synthetic fuels, but we also take a look at weight saving ideas, as weight is the biggest penalty that can be caried by a vehicle. While we worry about the fuel and emissions, we are also as a society buying heavier and bigger cars.

Evolution of a Racecar is not an exhaustive product, but it is intended to highlight the impact of the whole car, and get our readership discussing the full range of options that are available, and what has to be done to maintain our transport needs.

Order online at www.chelseamagazines.com/evolution-of-a-racecar, priced at £9.99 including postage and packing (UK only), $19.99 including postage and packaging (US).

We can use this to better understand the dance between grip and balance

$$F_{YF} = fn(\alpha_1)\cdot k_a(1-k_b\cdot TL_1)\cdot TL_1 + fn(\alpha_2)\cdot k_a(1-k_b\cdot TL_2)\cdot TL_2$$
$$F_{YR} = fn(\alpha_2)\cdot k_a(1-k_b\cdot TL_3)\cdot TL_3 + fn(\alpha_4)\cdot k_a(1-k_b\cdot TL_4)\cdot TL_4 \quad (10)$$

Where,

V_y = sideways velocity of the vehicle
V_x = forward velocity of the vehicle
r = vehicle yaw rate (rad/s)
a = distance from the front axle to the c of g
b = distance from the rear axle to the c of g
I_z = moment of inertia about the z axis (kgm^2)

Remember, for circuit racing we are making this approximation because the lateral forces dominate the longitudinal contributions due to the low slip angles present. This assumption, however, breaks down on dirt and ice.

Beyond assumption

The question now becomes what do we do about the F_{YF} and F_{YR} terms? This is where all the work in this article comes into play. Combining what we discussed with our tyre loads and tyre models, we have as shown in **equation 10**. Here α_1 represents the slip angle of each corner of the car with the subscript matching up with the tyre loads. There is a further simplification you can make here, but I will leave that to you to work out. Hint: look at **equations 1** and **2**.

What I have given you so far can now be used in multiple ways. The first way is to set the normalised slip angle functions to one, cycle through the speed and *ay*. What this returns to you is a first pass of the car's envelope using **equation 8**. You then use **equation 9** to plot all the moments at the limit.

This is a rough and dirty way to combine a *gg-V* and moment method plot. It won't be particularly pretty, or accurate, but it will give you a rough idea. Also, because this is so computationally cheap, you can plug it straight into Excel.

The second way is to go the full hog with **equations 8** and **9** and make this into a Matlab Simulink model. One of the nice things about Simulink is you can use actual exported race data to run it, which means you also have a rough track replay feature.

The final method is to use a constant speed test and vary the steer angle.

Fig 3: Total lateral force vs lateral load transfer distribution at the front

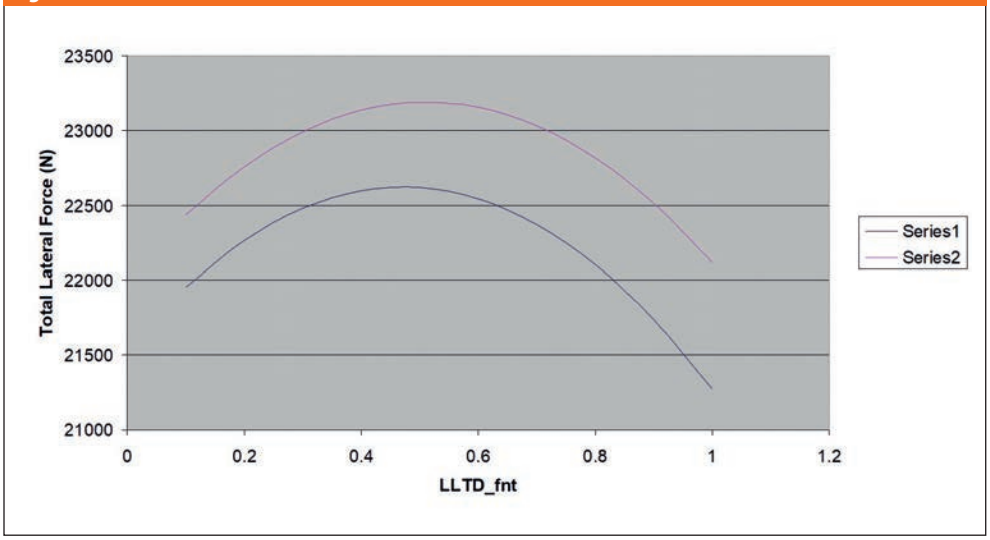
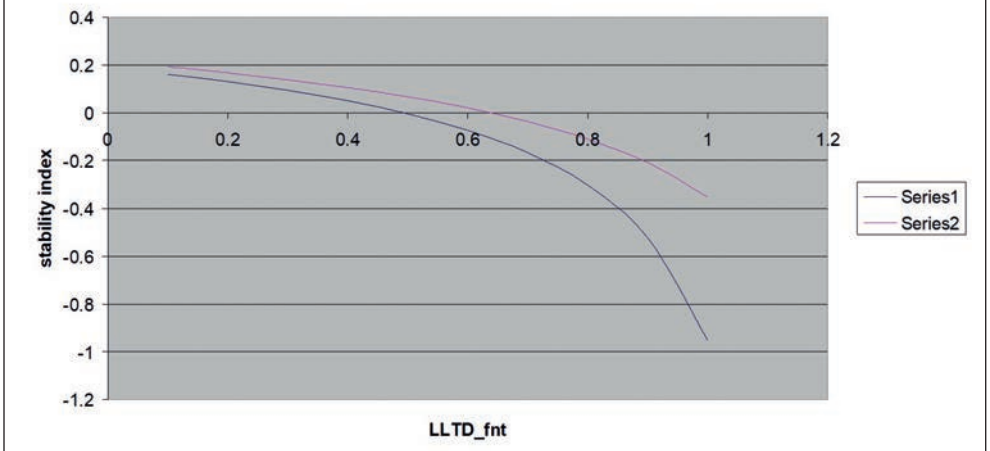


Fig 4: Stability index vs lateral load transfer distribution at the front



The pay-off for all this work is a great little calculator, and the tools to start doing some basic calculations to get a feel for the numbers. It is also a great preparatory tool to using a simulation package properly.

Balancing act

Likewise, you will now have all the information required to get a firm grasp of your car's balance. The tool for this is the stability index, and there is no need for me to repeat the formulation for this here, other than to say it gives you the ability to construct curves like those shown in **figures 3** and **4**. (Note: **figures 3** and **4** have been plotted for two different tyre compounds, but everything we have discussed in this article will put you in the position to do similar plots yourself).

In closing, there are a number of spin-offs from understanding the fundamental equations of motion of vehicle dynamics. The first is understanding the neutral steer channel and how to employ it. Second is constructing a car's envelope and a simple simulation you can use as a calculator. Lastly is better understanding the dance between grip and balance.

Any one will give you an advantage, but using all three is a game changer.

For circuit racing we are making this approximation because lateral forces dominate the longitudinal contributions due to the low slip angles present

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IN BRIEF

AP Racing has launched its latest round of industrial placement opportunities at its Coventry, UK-based factory. The placements are due to start in July 2023 and are available in design engineering, industrial engineering, advanced analysis engineering and mechatronics engineering. The deadline for applications is 8 January 2023. For more information, please visit https://apracing.com/about/vacancies

Toyota has introduced an update to its Supra GT4 that competes in the Grand Sport class of the IMSA Michelin Pilot Challenge. **Toyota Gazoo Racing Europe**, based in Cologne, has produced an evolution kit that includes revised dampers, a modified rear anti-roll bar and upgraded brakes that include recalibrated ABS software. The body gains front dive planes to improve aero stability and a modified rear wing that allows for mid-race set-up changes.

Extreme E has confirmed it will have a schedule for 2023, but details are scarce. The series will start in the Saudi Arabia desert on 11-12 March before heading to Scotland on 13-14 May, then Sardinia in July, Brazil or the US in September and Chile in December.

The **FIA** has completed the first phase of its Race Direction Development Programme debriefing. The purpose of the exercise is to quantify the performance of race direction and stewarding and create a culture of reflection and constant improvement. The programme comes on the back of controversial decisions made in Formula 1 over the last 12 months.

The FIA will use AI technology to detect and reduce toxic online content on social media. The FIA has partnered with AI company, **Arwen.ai**, and says it has already completed a successful trial.

IndyCar has re-branded the Indy Lights series as **INDY NXT**, with support from tyre manufacturer Firestone. The series will complete 14 races in 2023, starting at St Petersburg in March.

NASCAR's Garage 56 entry continues testing

NASCAR's entry to next year's 24 Hours of Le Mans took a step closer to becoming reality when the Hendrick Motorsport Chevrolet Camaro ZL1 tested at Virginia International Raceway in mid-November.

The car was driven by Mike Rockenfeller, who completed the initial test of the car earlier in the year, but the team says it has a long way to go before it can be confident of completing the race in France in June next year.

Fitted with a hybrid system, the team has been stripping weight from the car, while at the same time trying to keep it reliable, and ensure that it is different enough to the Cup car that it cannot take advantage for its NASCAR programme.

The car, which will be featured in full in the next edition of *Racecar Engineering*, has run with significant updates to the chassis, engine and suspension, plus with dive planes fitted to the front, a more robust splitter and diffuser, and development Goodyear tyres.

'We have less weight and a bit more downforce,' said Rockenfeller when comparing the second test to the first. 'The tyres are the same because we did some tyre testing in Atlanta. Power is a bit different – we increased it a little bit – we now have paddle shift, traction control and a new dash, so we are pretty close to what we think will be the racecar in Le Mans.'

'This is the first step, and over the course of the next six months or so there's going to be a huge amount of iterations,' said Chad Knaus, Hendrick Motorsports VP of competition. 'Obviously, you are always trying to get yourself more margin from a pace standpoint, so we want to continue to push and make the car fastest from a weight and performance standpoint.'

NASCAR

Based on a Chevy Camaro ZL1, the Le Mans-spec NASCAR features different aero, paddle shift, traction control and a more powerful engine

WEC to outlaw oven ready rubber

Plans to eliminate tyre heaters are expected to become reality in the FIA World Endurance Championship for 2023, with Michelin and Goodyear both pushing for the tyre ovens to be removed from the paddock, along with the FIA.

Michelin has long campaigned for the abolition of the ovens, saying they are not necessary and encourage teams to change tyres more often during the race.

The French company says it can easily produce a compound that will heat up quicker on leaving the pits to reduce the chance of accidents on the opening laps on cold tyres.

XPB

Tyre warmers are said to encourage waste

Goodyear, which supplies the LMP2 class in the championship, has been tasked with bringing harder compounds into an arena that has seen performance levels reduced by removing downforce from its cars. The company completed its fourth test at Silverstone in October and says it, too, is ready to dispense with tyre warmers.

A final decision is expected to be confirmed at the FIA World Council meeting in December. A further plan to reduce the number of options available to each team to one slick and one wet is expected to be dropped for next year, although the plan does still form part of the roadmap for the near future.

F1 to introduce mudguards?

XPB

Spray has become worse with this generation of car, leading to more red flags and delayed starts as visibility has been deemed too low. Changing bodywork could help, says the F1 Commission

Following the events of the Japanese Grand Prix in October 2022, the FIA has commissioned a study to reduce the amount of spray coming from the cars in order to increase visibility in wet conditions.

This year's cars have, according to the driver feedback, been particularly difficult to drive in the rain due to spray from cars ahead, and so the FIA agreed to look at the 'definition of standard bodywork kit, aiming to suppress the tyre spray from running in wet conditions by use of minimal bodywork over the wheels.'

The study will also consider the contribution of surface water picked up through the underfloor tunnels, and ensuring any changes to the bodywork will not hinder pit stops. Currently, bodywork can only be fitted before a race, or under a red flag.

Further updates to the proposal are expected throughout 2023.

Other areas under consideration in Formula 1 are the penalties for excessive number of power units used during a season, *parc fermé* conditions following Sprint races and an allowance for teams to pay for accident damage within the cost cap. The F1 Commission approved the proposal to double the amount to $300,000.

Despite opposition, the use of tyre blankets will continue in 2023.

Supercars complete aero parity test

The Australian Supercars series has taken a step closer to the introduction of its new Gen 3 cars with the completion of the Vehicle Control Aerodynamic Testing programme carried out on the Ford Mustang and Chevrolet Camaro prototypes.

The VCAT was carried out at Wellcamp airport near Toowoomba and saw the most comprehensive aero testing yet for the new cars that will debut next season (2023).

VCAT is a programme devised by D2H Advanced Technologies and allows the cars to be tested using an active ride height control system, which ensured performance parity. The cars completed more than 1600km of running over a five-day test at the airport to ensure they were well balanced.

Performance balancing was the name of the game for the Wellcamp airport VCAT programme

'Ultimately it's about trying to achieve parity and close racing,' said Adrian Burgess, Supercars' head of motorsport. 'Supercars and the two homologation teams are working hard and closely together. We've gone through all the processes and requirements and we'll now have a full debrief.'

The first round of the 2023 season will be the Newcastle 500 that will take place on 10-12 March 2023.

Red Bull to take penalty

Formula 1 team, Red Bull, has been awarded a financial and technical penalty for breaching the new cost cap regulations that were in place for the 2021 season.

The British team was found to have overspent the $114m budget cap by $1.8m, termed a 'minor breach' by the sport's governing body.

The FIA found that Red Bull did not fraudulently overspend and were at all times open and transparent, accepting an equitable settlement over the breach.

Alongside the financial penalty, the team will also lose 10 per cent of its aerodynamic testing ability and CFD allowances for next year's grand prix campaign.

Bold claims for Audi RS Q

Audi has claimed its RS Q e-tron will save more than 60 per cent carbon dioxide when it competes on the 2023 Dakar Rally.

Three desert prototypes with electric drive and energy converter systems will line up at the start of the rally on 31 December 2022 and Audi says the tank contents of its contenders will comprise 80 per cent sustainable components, including ethanol to gas (ETG) and e-methanol. This fuel is required by the energy converter, the combustion engine part of which is taken from a DTM car, and operates with high compression and efficiency to supply electricity for the electric drive.

'WIth this fuel mixture, the Audi RS Q e-tron saves more than 60 per cent in carbon dioxide emissions,' says Dr Fabian Titus, application and thermodynamics development.

Audi's vision is to compete in the highest profile races with 100 per cent renewable fuel, and the use of eFuels such as this opens up an additional opportunity for the brand, utilising combustion engines and hybrid drive together to make an effective contribution to reducing greenhouse gases.

'Our battery vehicles and renewable electricity are the lead technologies,' adds Oliver Hoffmann, board member for technical development at Audi. 'To complement this, renewable fuels offer the possibility of running internal combustion engines in a more climate-friendly way.

The Audi RS Q e-Tron returns for another go at the Dakar Rally, with a development of its electric drive and energy converter powertrain that is said to reduce the car's CO_2 emissions by 60 per cent

'The Audi RS Q e-tron combines both systems in its innovative drive. As a result, we are now even more sustainable on the road in the toughest motorsport imaginable for electric drives.'

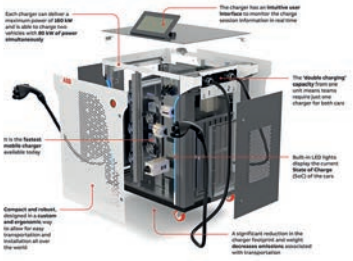
Formula E reveals its in-race charger

The FIA Formula E World Championship intends to introduce mid-race fast charging and has unveiled the equipment that will be used when the feature is finally a part of the series.

Formula E started out with the drivers needing to change cars mid-race, meaning each driver required two cars for every weekend. From there, it progressed to completing the race on one charge, and this is the third phase of the development process.

Designed by ABB, the partner for the series, the charger will be capable of delivering up to 160kW from one outlet, or 80kW when charging two vehicles at the same time.

Frank Muhlon, CEO of ABB E-mobility, said: 'We're delighted to bring our innovative charging solutions to the biggest global e-mobility stage, continuing our drive to use the series as a testbed for new, more sustainable technologies.



The ABB fast charging system that is due to offer in-race options for teams this season

'Charging the Gen 3 cars will give us valuable testing infromation in charging in a high-paced, competitive environment. The experience and knowledge we gain will be used to continuously improve ABB chargers for customer and consumer use.'

The series faces a race against time to prepare its cars for the first race of 2023, due to supply chain issues that have affected the global racing industry. Nevertheless, it will introduce the new Generation 3 cars this season, which are expected to have a significant performance advantage compared to the Generation 2 cars (see *RE* V32N12).

The Gen 3 cars are expected to test in Spain at the end of 2022, but it is unclear whether the cars will be ready to adopt the in-race charging plan, due to a shortage of parts.

The fast chargers will allow 'for the introduction of 'Attack Charge' at selected e-Prixs,' says a statement by the FIA. This will take the form of a mandatory 30-second pit stop that will then allow two 'Attack Mode' periods, during which the power output of the cars will increase from 300 to 350kW.

IN BRIEF

Carless Racing Fuels has been confirmed as the supplier to the TCR UK series. The company will be the official fuel provider to the championship, with the on-track distribution service being provided by Vital Equipment, its official UK service partner. 'We are delighted to have signed a multi-year agreement that will see us supply our control fuel to TCR-UK,' says Carless sales executive, Adrian Stewart. 'The championship has certainly gone from strength to strength over the last few years and boasts a very competitive grid.'

One of the worst-kept secrets in endurance racing was finally confirmed when Iron Lynx was named as the official Lamborghini team, starting in 2023. The team will take part in GT racing in the US and Europe, starting at the Daytona 24 hours in January, and will be the development team for the company's new LMDh programme that will race at Le Mans in 2024.

The FIA has confirmed Shaila-Ann Rao will leave her role as secretary general for sport, having replaced Peter Bayer on a temporary basis. Her time in the role saw the issues of responsibility for porpoising require a solution, and she was also involved in the Red Bull cost cap saga.

NASCAR's JR Motorsport has shaken up its driver and crew chief line ups for next season. The team has welcomed back Jason Burdett and Taylor Moyer as crew chiefs on the numbers eight and nine cars respectively, while Jim Pohlman joins the team to crew chief the number seven car, and Mardy Lindley the number one. 'While we performed at a very high level this season, a tweak here or there can help us push even further,' said JRM's director of competition, Mike Bumgarner.

Advanced Material Development (AMD), has announced a collaboration with NASA's Jet Propulsion Laboratory for AMD's thin-film coatings technology. The deal will see AMD supply the Europa Clipper spacecraft.

Engineering in sharp focus as Autosport International returns

After several years away, Autosport International is set to kick off the 2023 racing season by making its long-awaited return to the National Exhibition Centre in Birmingham, UK. Exclusive trade tickets are now on sale for Thursday 12 and Friday 13 January, giving industry professionals the opportunity to visit ahead of the packed public days at the weekend.

The trade days, which include the three main themed areas of the Autosport Engineering Show, Racing Car Show and the Performance and Tuning Car Show, are perfect for global networking opportunities. From top automotive marques to specialist engineering brands, Autosport International has been the hub of the automotive and motorsport industries since the 1980s.

Visitor research shows that over 60 per cent of trade visitors attend Autosport International to keep up with what is happening in motorsport, and 85 per cent of attendees are key decision makers. This makes the show an unparalleled opportunity to showcase and network with an international audience, particularly as it is the first industry networking opportunity of 2023.

Located in the heart of the show, Autosport Engineering offers trade visitors an exclusive opportunity to meet like-minded professionals, discover the latest industry innovations and investigate collaborations with new business partners.

This trade-only exhibition zone offers an unparalleled opportunity to network with a truly international audience, at the best time of the year to reach influential industry leaders.

Features of the show include the Autosport Stage, where exhibitors and race teams will launch new products and cars and discuss the upcoming season. The Business Forum will also be back in 2023, along with the International Business Networking Lounge, EV Feature Area and Pavilion.

Ben Whibley, Autosport International event director, said: 'Our trade visitors are a crucial pillar to the show's success. Over the years, the show has become renowned for the opportunities it presents for those who work in motorsport, whether you manufacture parts for racecars or run a team.

'After three years away, we cannot wait to see both new and familiar faces when the show opens its doors in January.

See new products and cars launched throughout the weekend on the Autosport Stage, and listen to live industry comment on the race season ahead

Exhibitors return for 2023

Among the list of returnees, long-standing exhibitors such as Demon Tweeks, XTrac and AP Racing will have a major presence. Industry-leading brands such as Helix Clutches, Brembo, Pagid, PFC brakes, VDO Instruments, Lifeline and SPA will all be represented. Goodridge will return too, celebrating over 50 years of supplying brake lines and fittings to OEMs and high-level motorsport teams.

In the tool sector, brands such as Lista, Sealey and Draper will be showing their range extensions at Autosport International, joining car component suppliers such as RaceShocks and Powerflow as loyal show returnees

The Live Action Arena promises some spectacular displays of motorsport technology and driving skill

AUTOSPORT INTERNATIONAL

ENGINEERING SHOW

Attending the show

Autosport International will take place between 12 and 15 January 2023 at the NEC in Birmingham, with Thursday and Friday being trade-only days.

The Autosport Engineering Show will also only take place on the Thursday and Friday.

Tickets are available to buy now: www.autosportinternational.com

While Thursday and Friday will be trade and engineering-focused, there's good reason to return at the weekend, too. Not least because weekend ticket holders get access to one of the 45-minute Live Action Arena shows, where the NEC will reverberate with the hair-raising thrum of revving engines from a diverse range of categories.

World-class talents from disciplines including Rallycross, motorcycles and Stock Cars will thrill the audience with stunts, tricks and demonstrations.

Sir Jackie Stewart to open Motorsport Memories gallery

Ahead of the 2023 Autosport International show, Europe's largest motorsport exhibition, fans will be asked to vote for their greatest Motorsport Memories.

The Motorsport Memories poll will highlight the magical moments that led to fans falling in love with the sport, and signed prints will be raffled to raise funds for the Race Against Dementia charity. The top ten memories will be displayed as prints in an art gallery zone.

Memories collected range from Stirling Moss winning the Mille Miglia in 1955 to Toyota's last-minute heartbreak at Le Mans in 2016.

Race Against Dementia is a global charity, founded by Sir Jackie Stewart OBE, to fund pioneering research into the prevention and cure of dementia. The three-time Formula 1 World Champion explains: 'Working faster and smarter, and harnessing the mindset I experienced in the motorsport world, together we can beat dementia. We raise funds to accelerate global research and development in the race to find a prevention or treatment.

Sir Jackie Stewart OBE

'Autosport International's Motorsport Memories gallery and the campaign will help engage fans around the world in great moments from the sport we love, whilst raising awareness and funds for Race Against Dementia.'

Sir Jackie was part of the committee choosing the top ten memories from the fans' suggestions, and he will officially open the display and sign the prints before talking about his personal involvement with Race Against Dementia and sharing memories of his motorsport life on the Autosport International main stage.

To win one of the top ten signed prints, text MEMORY to 70215 and follow the simple instructions to enter the free raffle.

The top ten Motorsport Memories will be represented in print form in a dedicated art gallery at the show

Academic focus and opportunity

The engineering sector plays a key role in the UK's economy, accounting for 18 per cent of UK employment, and the demand for engineers is higher now than ever.

In motorsport, this translates to seven of the 10 current Formula 1 teams being based in the UK, with dozens of national and international championships calling the UK home.

Students will have the opportunity to attend Autosport International on both trade and public days to get a flavour of the industry. Whether it's taking inspiration from the hundreds of displays, or seeking career advice, Autosport International is a fantastic opportunity to get ahead.

One example of how the academic sector is using the show to attract students is the University of Wolverhampton Racing team (UWR). This innovative project immerses undergraduates in real racing environments, including preparing and developing cars for leading British championships. Its courses in Motorsport Engineering, Automotive Engineering and other disciplines offer hands-on, professional practice in motorsport through UWR.

Professor Amar Aggoun, head of the School of Engineering, Computing and Mathematical Sciences explains: 'Students can become part of a fully-functional racing team while studying. Our racing team is unique in higher education as our student engineers compete in single-seater racing in the Praga Cup, as well as being the works team for the Morgan Motor Company, where they have a direct impact on road cars in production. We also compete in the IMechE Formula Student competition, and in 2021 won our class in the F3 Cup Championship.

'We have exhibited at Autosport International every year since 2015 because the show has fantastic access for students to explore options within the motorsport industry. Our Praga R1 will be on display and guests can visit our stand and see how we engineer the car and chat with current students working towards a motorsport-related degree.

'For us, Autosport International is a unique chance to speak to fans, industry professionals and members of the public to raise the profile of our degrees and the opportunities they bring to work in motorsport. For our students, it's a chance to meet potential employers and start building their own networks.'

Engineering highlights

Other key exhibitors who will be revealing new products and technologies at the show include Samsonas Motorsport's latest racing transmission and suspension solutions, MSL showcasing its high-quality 3D scanning, 3D software and 3D metrology solutions and services and Intercomp, whose RFX wireless weighing technology is the most advanced of its kind.

Another recently confirmed exhibitor is Hypermotive. With the show's increased focus on electrification solutions, the company, with teams in the UK and Germany, will be demonstrating its wiring systems, EV and fuel cell solutions at the show.

3D scanning and additive manufacturing is accelerating across the industry, too. Central Scanning will show its industry-leading technology, including 3D printing and reverse engineering solutions.

Bcomp, the Swiss cleantech company will be using the event to showcase its latest developments in sustainable and lightweight solutions. Its proprietary natural fibre-based reinforcement technologies, ampliTex and powerRibs, reduce environmental impact in a wide range of high-performance applications.

Tribol Braking and Hel Performance will exhibit together to demonstrate their lightweight composite solutions, bringing benefits to all aspects of the braking corner assembly while also protecting against heat and corrosion. With heat-resistant shims to protect the caliper already in the market, Tribol is now finalising its patented composite brake pad technology, designed to fit seamlessly into Hel's range of lightweight aluminium brake calipers.

EXHIBITOR PRODUCTS

Allengra sensor and Italtechnica V6

Germany-based Allengra, renowned for its fluid flow measurement technologies used across oil and gas and food and drink markets around the world, recently homologated a high precision ultrasonic fuel flow sensor for FIA motorsport championships.

The sensor features dual ultrasonic channels, making it suitable for many types of fuelling applications where high-speed dosing is required and accuracy paramount.

It can handle a flow range between 0.3 and 240 litres per hour with a fuel flow accuracy of +/-0.5 per cent of measured value, and can operate anywhere between zero and 110degC with a precision temperature measurement of +/-0.15degC.

Its power supply is the same as other fuel flow meters in the motorsport marketplace – between 5.5 and 24V DC – it operates at a nominal pressure of 10bar and can be fitted using a regular -6AN connector.

Italtechnica, the Italian technical experts with 35 years' experience in racing and high-performance powertrain development, revealed a new, top class, 3.0-litre, 90-degree V6 engine. The motor features patented passive pre-chamber ignition, weighs less than 200kg and delivers 850Nm of torque and 750cv (approx. 740bhp). It is boosted by two turbochargers working sequentially to reduce turbo lag. At low rpm all exhaust gases are forced into one turbocharger and then at higher rpm the two are engaged in parallel.

Ancillary components are all integrated to ensure a ready-to-assemble system that does not require any hardware or software modifications. It's compact size, low weight and high performance make it ideal for racecar applications.

Porsche 962 – the works

Ultimate Works Porsche 962. The Definitive History is the second set of books detailing the history of one of Porsche's most extraordinary cars, the 956 / 962.

Written by *Racecar Engineering* contributor, Serge Vanbockryck, the books continue the theme set by the first edition on the factory 956s, with all the chassis history, driver history and race details of a car that dominated the endurance racing scene for a decade.

The Porsche 962 was the updated version of the 956, introduced after the death of Formula 1 driver, Stefan Bellof, who was killed after a high-speed front-end impact at Spa. The 962 was safer, and came about following lengthy negotiations between Porsche and the International Motorsport Association (IMSA) on how to adapt the model for the American Camel GT Championship.

The negotiations are detailed in the book, as is the development process of the car as it morphed from 956 to 962, before the volume goes into the details, race-by-race, of the specification for each car.

It's an exhaustive body of work, one that has taken Vanbockryck most of his life to compile, and it is certain there will never be a more comprehensive book on these cars.

Porsche raced the car as a factory team from 1984 to 1988 in the FIA World Endurance Championship, at Le Mans, in the ADAC Supercup, in which Hans Stuck debuted the manufacturers' PDK gearshift system, and, of course, IMSA. That is all well known, but what makes this book stand out above all others is the previously unseen technical developments that were tried and tested between the races.

The lines between factory and privateer became blurred after Le Mans in 1988, when Reinhold Joest was tasked with running a car in the world championship, with Porsche support. Joest promptly beat the factory Mercedes at Dijon in 1989, scoring the last world championship win for the model.

These books detail the full range of the 962, from the factory years run by Peter Falk and Norbert Singer, through the Joest years and right up to Jochen Dauer's efforts in 1994, when the regulations required road homologation to compete in the 24 Hours of Le Mans. The 962 was indeed adapted for highway use at that point, and was then converted back to a racecar for the 1994 race, which it won.

In the third volume, the people behind the programme receive just recognition. It is not only the drivers, teams and development engineers who are profiled though, Vanbockryck also lists the cars' past and present owners.

The book comes as a Limited Edition, Collector's Edition and Owner's Edition and is not cheap. At £850 for the entry-level Limited Edition, you have to be a particular fan of the car to invest in this product, the second of three that are planned. The book comes in three hardback volumes, all held within a covered slipcase, and comprises 1400 pages with 1800 images.

This is a rare book in the publishing world – it is hard to imagine anyone having such passion for a single model of car in endurance racing history – but, if you feel the same way about the Porsche 956 / 962 then it's a powerful body of work. A word of warning though: should your love of the model extend to investing in this edition, you might want to start saving now for the final instalment.

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Racecar engineering
Inside the world of modern motorsport technology

Visionary thinking

Hybrid is now widespread in FIA regulations, but is it the answer?

As the curtain comes down on the 2022 season, it is a good time to look back on some of what has been achieved this year. The World Rally Championship has completed its first season with hybrid powertrains and, while development is ongoing, the formula has been a lot more successful than many had predicted ahead of the season.

Peugeot has introduced its 9X8 to the FIA World Endurance Championship, taking on Toyota with a rear wing-less car, proving that the Hypercar regulations do in fact offer alternative solutions to traditional racecars.

Porsche, Cadillac and Acura have all pushed on with track testing their LMDh cars, not without issues. They seem to be getting on top of them, though, and the hybrid system is becoming more reliable. These cars will do their final checks in December, ahead of the Daytona 24 hours that will take place at the end of January 2023, and then embark on a five-year racing programme in both FIA WEC and IMSA WeatherTech series.

Touring Cars have also introduced hybrid technology, notably in the British Touring Car Championship, the first domestic championship to do so. Others, such as the Scandinavian Touring Car Championship, have gone all in with electric racecars, but it is interesting to note that the BTCC teams have been able to afford hybrids, run with them, and not broken them. For a domestic series, that's an achievement to be applauded.

There will be new technologies coming to which racing, and production cars, will need to adapt

Hybrid capabilities

Even Formula 1, the highest profile series using hybrid technology, has finally set its course for the medium-term future. The new regulations for 2026 have been agreed, and the engineers are now able to go ahead with their designs. F1 will continue with hybrid power, increasing the electrical element in order to produce the required lap time, and will continue to drive forward with sustainable fuel.

It is interesting to note how all these series are pushing the technical capabilities of hybrid power, making it a normality, rather than an emerging technology. Talk to the engineers in the paddock, though, and they all say hybrid and electric racing is a holding pattern, and that there will be new technologies coming.

As former president, Max Mosley, was sure that without increased safety manufacturers would not be able to continue their racing programmes, his successor, Jean Todt, was equally clear that manufacturers needed to have hybridisation in their racing arsenal to justify to their boards the budget required to compete. I wonder why more is not being made of hybrid in mainstream media. Coverage of these world championships rarely talks of hybrid, or the thermal efficiency of the engines, or the reduction in fuel economy. By 2026, for example, Formula 1 is planning to use half the amount of fuel per grand prix than in 2016.

There may be new technologies coming, and currently the focus appears to be heading towards hydrogen, but right now this hybrid technology must be recognised for what it is. It wasn't that long ago that 800V and 900V systems were the stuff of witchcraft. Now, they are commonplace in racing, and in the production car world.

Alternative thinking

Meanwhile, the other side of the coin is what is happening in the US, and in customer racing. NASCAR successfully introduced its Gen 7 car this year and, while there's still work to do on the car, having followed the story of the Gen 6, this will be an ongoing process. Once complete, it will be time for Gen 8! Stock Car's organising body also has plans to go hybrid, when the time is right, and its president, Steve Phelps, reckons that will be around 2024. Maybe.

IndyCar has pushed back on its plan to introduce hybrid technology. The parameters have been set and the targets are clear but, like NASCAR, is biding its time.

Next year will also see the introduction of new GT3 cars from Ferrari, Lamborghini and Porsche, which will set the tone for the forthcoming era. The Ferrari is particularly extreme, built to a set of technical regulations it has exploited to the maximum. Lamborghini, likewise, has built an engine with a throttle body for each of the car's 10 cylinders. Balancing that is going to be a challenge.

There is no hybrid rule set for GT3 racing, and there likely won't be. This is customer racing and, until hybridisation becomes even more commonplace, there doesn't seem to be a need, or a plan for it, in GT cars.

Looking forward, it will be fascinating to see whether or not electric racing will take off around the rest of the world. Or perhaps, a new technology will come soon. If it does, would politicians be willing to change their course, or is Europe so wedded to electrification that it will ignore even better solutions?

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