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November 2024 / Vol 34 No 11

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Alex Palou won the 2024 IndyCar title at the final race in Nashville, the first IndyCar title won with a hybrid system onboard

Joe Skibinski


MSD

Tricky trade off

How F1 teams are grappling with an impending regulation change

Next year will be the last for the current Formula 1 technical regulations, which were introduced in 2022. Their arrival marked a significant departure from what came before as F1 sought to reduce the huge downforce losses incurred by cars following each other closely in dirty air.

The 2022 shift prioritised downforce generation through ground effect and tidied up the extremely complex bargeboard areas. With the end of those regulations now in sight, teams are looking to the next technical framework that will shake things up again in 2026.

Having been the talk of the town, ground effect will have a lesser role as downforce and drag figures are cut back significantly. Cars will also be lighter, nimbler and utilise active aero devices at the front and rear, with DRS as an overtaking aid replaced by an electrical energy boost.

There are rules in place to ensure all teams start their 2026 car development on fair terms. The main one is they are not allowed to work on aerodynamics – besides permitted FIA studies – until January. That doesn't preclude teams from carrying out some investigations into mechanical layouts, and it will be important to lay the groundwork for an efficient start to aero testing, so there is some headway to be made even now.

Key conundrum

There is only a couple of months or so until aero work stars and preparations for 2026 take off. That isn't very far away and leads to a conundrum about how to approach the looming regulation change that all teams are grappling with. Do they ease off development of their 2025 cars to put more resources into creating a strong baseline concept in 2026? Or do they push on to the end of the current rules at the risk of harming their 2026 reference?

The start of the rules exposed how important it is to get things right from the outset. Red Bull perfected the art of generating huge levels of downforce through the underfloor while controlling the car platform, so it didn't suffer from intense oscillations, known as porpoising, that affected the rest of the field.

Mercedes, the dominant outfit before the 2022 change, spent a season investigating why it struggled so much with porpoising and then had to work out how to claw back lap time. As it did that, Red Bull charged to 38 grand prix wins and back-to-back title doubles with little threat.

Things are much closer now as the regulations have matured, and the likes of McLaren, Ferrari and Mercedes have all developed their way out of technical ruts.

With the 2026 technical regulations looming ever closer on the horizon, all the current Formula 1 teams are now having to decide which avenue of development to pursue

It has taken a lot of time for the gap to close as upgrades have been brought to the table. Surely, Red Bull's pursuers will have learned lessons from the 2021-'22 transition (even if the technical principles are now different) to give themselves a better starting point in 2026? If not, we could be in for a repeat of the last two and a half years, in which a team enjoys a period of dominance the others gradually chip away at, perhaps putting off some of the 'casual' viewers drawn in towards the end of the prior rules.

Any progress will tend to be gradual because the cost cap prevents teams from pouring money in to find and enact quick solutions.

Or, could the recent tightening of the front runners be an impetus for some teams to keep developing their 2025 cars deep into next year?

McLaren, for instance, has returned to winning ways. Its technical director of engineering told me in August that the team needs to be flexible next year as it balances projects for two different regulation sets. It is now leading Red Bull in the championship, so why should it ease off the gas? Equally, how should Red Bull respond? To fend off McLaren's charge, it may be forced to spend more time developing its 2025 concept than it might like.

Widespread impact

It's not just about the fight at the top either. Teams further down the grid are jostling for championship positions and the associated prize money. Though it's worth noting that the lower a team finishes in the standings, the more wind tunnel and CFD tests it will have for the first half of 2026.

'Imagine your 2025 car is nowhere,' said Haas team principal, Ayao Komatsu. 'You then have to make a tough decision of accepting to slow away this year to be in decent shape for 2026. Or are you going to have to sacrifice 2026 development? That decision can be made slightly better by having a good development this year for 2025.'

Teams are therefore keen to put their cars in a position where they don't need to make substantial changes throughout next season. This could shift the balance of focus next year to nailing the 2026 baseline, especially for those that felt they developed their 2021 cars for too long, at the expense of a better starting point when ground effect came in.

'I think everything is going to fall into place in the first few races, and I'm not sure we're going to see lots of upgrades after the summer,' predicted Mercedes team principal, Toto Wolff, at the Italian Grand Prix.

No F1 team is immune from the challenge, but the ability to strike the right balance, without too much compromise on either front, should have a significant bearing on who comes out of the gates fastest in 2026.

Could the recent tightening of the front runners be an impetus for some teams to keep developing their 2025 cars deep into next year?

Apex predator

Ford is preparing to contest the 2025 Dakar Rally with a version of its Raptor, developed in conjunction with M-Sport in the UK

By LAWRENCE BUTCHER

Ford is heading to the Dakar Rally in 2025 with a T1+ class entry in the form of its aggressive Raptor pick-up. Under the company's Ford Performance brand, the truck will mark the Blue Oval's first attempt for overall honours in the desert classic, with the majority of build and preparation work on the machine undertaken by M-Sport in Cumbria, UK.

Though Ford may not have a long history at the Dakar, it is no stranger to rallying and, with an ever greater portion of its global revenues stemming from truck and SUV sales, there is no more prestigious, or arduous, billboard for its products than the Dakar.

Mike Norton, manager for Ford Performance's motorsport activities in Europe, explains the thinking behind the programme: 'At a NASCAR race in Michigan, Mark Rushbrook [global director of Ford Performance] was talking to Jim Farley [Ford CEO] about various projects. With our quest to do more off-road, and the company moving towards trucks and SUVs, the conversation was along the lines of, "We should be in Dakar." This led to Mark texting me to ask what it would take to do Dakar. That's not a one word text back.'

Best match

That conversation took place two years ago and, with the idea firmly on the table, it was Norton's job to look at Ford's partners and find the best match for the project. It was quickly decided on M-Sport as the logical choice. 'They have a huge amount of off-road experience in rally, and that was how it was born. We wanted to present our off-road products in one of the toughest races on the planet,' says Norton.

Ford does already compete in Baja and King of the Hammers events in the US, but in the production-based classes, rather than the more extreme Trophy Trucks, which do have some similarities to Dakar machines.

'Baja is a completely different race in terms of how it's run, the navigation, the speed,' says Norton. 'FIA cross country is much more regulated, particularly in terms of speed and things like suspension travel. There are some similarities – sand, for one, though not like you find in the Empty Quarter of Saudi Arabia – and rough tracks, but the vehicles we have run are stock based, whereas the Dakar truck is a pure spaceframe prototype, built from scratch.

'However, if you know how to design suspension kinematics, it's not an art form, it's just science, and having a good base understanding of the concepts.'

'We wanted to present our off-road products in one of the toughest races on the planet'

Mike Norton, Ford Performance motorsport activities manager, Europe

‘We’re not looking for all the downforce - we want the slipperiest, smoothest, efficient, through-the-air vehicle we can manage’

Mike Norton

This meant that M-Sport, with its vast experience as a Ford rally car builder – and helped by the fact that the current T1+ rules concerning suspension travel and chassis construction are much closer to the FIA World Rally Championship than before – was unphased by the idea of tackling the Dakar.

Knowledge base

‘We had some good understanding of where we had to pay attention, and it worked very well using the knowledge base from both sides,’ notes Norton.

At the Raptor’s heart is a full tubular steel chassis, flanked by independent wishbone suspension at each corner and single coilover shocks (more on those later), with propulsion provided by the same Coyote V8 found in Ford’s Mustang GT3 car, mated to a Sadev six-speed sequential transmission and, of course, four-wheel drive.

M-Sport led the project, with overall input from Ford. However, all the aerodynamic and body design was handled by the latter, with its styling department heavily involved from the start. ‘We started out with something that looked very much like a Ranger Raptor,’ says Norton. ‘It looked like a pick-up, but when we started putting our resource into the simulations, looking at c of g, moving things like the fuel cell and the spare wheels, it started to evolve.’

For example, he points out that if one looks at the Toyota GR DKR Hilux, one of the older cars competing, both spare wheels sit under the cabin, whereas newer cars such as the Prodrive Hunter and Audi RS Q e-tron mount the wheels outboard.

‘We went through all of those exercises, using the tools we have to understand what we needed, and that drove us to the final shape we have today.’

The vehicle dynamics team at Ford worked hand in hand with M-Sport, and Ford’s engine team responsible for the GT3 motor took on the light re-work of the Coyote power unit. Where M-Sport lent its muscle was in design and construction of the spaceframe, in addition to areas such as the electronics system and, lauds Norton, ‘they are very accomplished at putting the whole thing together for us.’

From an aero performance standpoint, Norton says the Dakar is quite a different proposition to other series Ford races in, where downforce is often king.

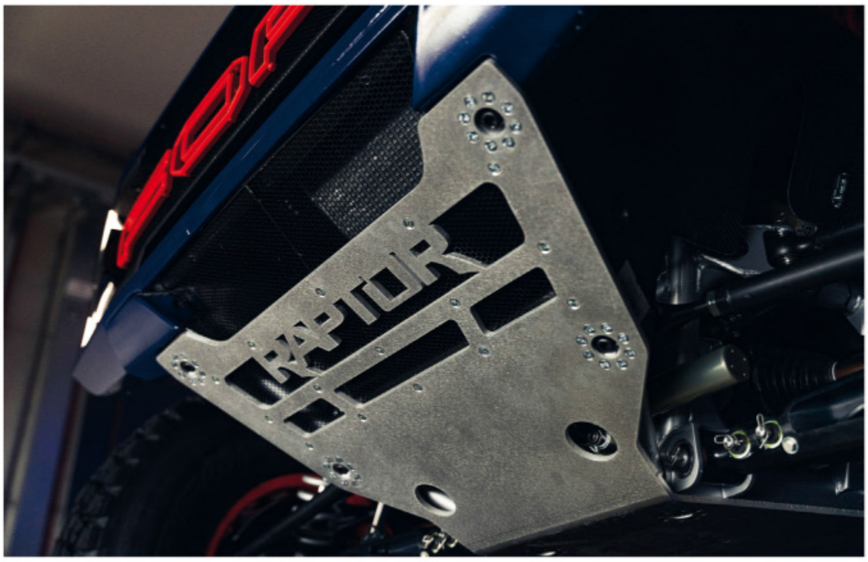
‘In Dakar, we’re limited to 170km/h, so the average speed of a Dakar event is relatively slow. What we want is efficiency. We’re not looking for all the downforce - we want the slipperiest, smoothest, efficient, through-the-air vehicle we can manage. The tools remain the same, and the team were exceptional in guiding us in various shapes and attributes that gave us what we were looking for.’

Comfort, stop

Survivability and durability also played a huge role in the design of the car. Here, input from drivers played a significant part: ‘We were sitting down for dinner with Carlos [Sainz snr] at Baja Spain in 2022 and discussing this.

T1+ rally-raid cars do not need to be homologated, only to run with a technical passport so, provided the technical regulations of the class are adhered to, design is largely free. It makes the class an exciting proposition

Being able to design the racing machine from scratch meant M-Sport could put the mass exactly where it wanted it



Truck features a tubular steel chassis with independent wishbone suspension and a single Fox damper at each corner

It's not about having the fastest car – don't get me wrong, you need a fast car to win – but if the driver can't drive for eight hours straight and concentrate, the car can be as fast as you like but they won't survive. So, the number one consideration is comfort.'

Comfort does not simply mean keeping the driver cosseted; the car needs to be ergonomic and fit for purpose.

'They need to be able to see, the vision angles up and down dunes,' continues Norton. 'If they can't see where they are going, they will need to lift and slow down. So, comfort was the number one priority, reliability two and performance three.'

To this end, considerable effort was expended to ensure ride comfort and cockpit comfort were to the drivers' expectation.

This brings us back to the dampers used on the truck. In 2025, the Raptor will be unique in the T1+ class in that respect because its Fox shocks – rather than Reigers, as run by the rest of the field – use only a single coilover and a second, bypass damper.

The choice to go with Fox appears surprising on the surface, particularly given M-Sport's long association with Reiger. However, Norton says the American company's product ended up matching its requirements more closely.

'We tested both, and we have a lot of experience in North America with our stock car racing and Raptor road car programmes with Fox. In terms of vertical stability, the Fox dampers are quite supreme in their ability to absorb the terrain. Reiger are fantastic, but it's a different discipline [to rally]; we wanted to be unique, and to support our trusted production car suppliers. Fox has some good technology that came to the fore, so the choice was purely down to performance.'

Seal with a KISS

Across the Raptor's development there has been something of a KISS philosophy (Keep It Simple…). The powertrain is a good example. Though the option of hybrid systems is now off the table, Ford had a choice of multiple turbocharged and naturally aspirated motors available, so why chose the Coyote?

The engine is very similar to the GT3 unit. Beyond a revised dry sump, inlet and exhaust system, the Coyote only really diverges in its calibration

'We went through the due diligence and opted for simplicity and robustness,' says Norton. 'We know the V8 is solid, and there isn't the pipework and other ancillaries you have with a turbo to worry about.'

The engine is very similar to the GT3 unit. Beyond a revised dry sump, inlet and exhaust system, the Coyote only really diverges in its calibration, designed to improve driveability at low rpm, and meet the FIA-mandated power curve and peak power of 261kW, which from '25 will be monitored by torque sensors.

The KISS approach was carried over to the transmission, too: 'We run a front, centre and rear differential with the Sadev [gearbox] everybody uses. It's reliable, it's robust and we took that option because there is no point complicating things,' says Norton. 'Choosing your ratios to match the power curve is the bit where we spent a lot of time modelling the different scenarios to see what works where.'

Notably, in T1+, the cars are not homologated. They simply run with a technical passport, so elements like gear ratios do not have to be homologated. 'Apart from the safety 'cage, you run under a technical passport. So long as you stick to the technical regulations, if you've got to modify something, weld something on, you can,' highlights Norton.

Racing hard

'If you can keep going the entire race without mechanical issues, you will be somewhere near the front come the end,' he adds. 'Then you can decide how to play it, but to race hard for those first 12-13 days is not easy. You can do a million miles of testing and still have a problem you have never seen before.'

This doesn't mean a car has to be able to run the full Dakar distance without issue. Unlike in other disciplines, there is plenty of scope to make repairs at the end of each day without penalty. Therefore, they need only to last the distance of the longest stage – around 900km – after which the vehicles can effectively be torn down.

Ford has tested all over the world to find conditions that mirror those of the Dakar, including the sand dunes of Morocco. There, Norton says they tried to simulate some of the more challenging scenarios: 'One thing that is hard to replicate is following another car, having sand and stones being thrown at you. So you try to do things like crash artificially hard into dunes, looking at how the sand behaves. Does it come out where you expect it to? How do the fans handle it?'

Even the simple act of driving in sand dunes places huge stress on the vehicle, particularly the cooling system, as drivers are in a low gear at high rpm for extended periods.

Safe hands

Having experienced drivers in the form of Sainz snr and Nani Roma paid dividends during the development phase.

'They have got an absolute wealth of experience on what we need to do, and how we need to do it,' says Norton. 'It's also the little details we are looking at. Are the jacks stable in the dunes? How easy is it to change the wheels? Carlos had 13 punctures in 2023 so the ability to change a wheel quickly, regardless of the state it is in, is crucial. You have to make that part foolproof. Even things like the drinks system, you don't want something like that to break, and the driver not be able to drink for several hours.'

At time of writing, Ford had completed over 13,000km of testing in the Raptor, as well as contesting the Baja Hungary event, with a further test in competitive conditions planned for Rallye du Maroc in October.

'Our goal was to do at least two Dakar distances in testing, and we've done way over that now,' confirms Norton. 'We want to get to Dakar and not have issues.' Adding cautiously, 'I don't want to say you can get match fit for Dakar, because it's an event by itself, but doing events gets us in race mode rather than testing mode, and that just prepares us more for Dakar.'

During testing, the team has had to be careful to ensure it created comparable conditions to those it will face in January 2025. For example, there is the temptation for the crews to nut and bolt check the car after every test loop. While this was fine early in the development process, now, 'the car has got to do 600km before anyone touches it,' explains Norton. 'It's having the discipline to make sure that everyone stands back, gets the feedback and does the debrief with the drivers.

'We've got our plan, we know what we want to test but we've got to be very rigorous when we do certain tests, making sure we are not making adjustments, or doing technical things, within a timespan you wouldn't be able to utilise while on the race.'

Ford's preparations are impressive, and the Raptor Dakar certainly looks the part. M-Sport's expertise and Ford's can-do attitude should stand it in good stead come January, but the Dakar will of course take no prisoners, and only time will tell if the team has found the optimal balance between comfort, reliability and pace. ®

Long-range logistics

The sheer scale of the Dakar Rally is intimidating. In 2023, competitors covered nearly 8000km of running, with 5000 of those on competitive stages. This means the logistics operation supporting the racers and vehicles must be as refined as the engineering behind them.

'That's where M-Sport comes into its own. Matthew Wilson has built a great team of young and very experienced engineers and technicians,' says Norton. 'It's more like old-school rally where you need a slightly different mindset because you are allowed to fix stuff. You need that balance of youthful enthusiasm and, dare I say, fitness, because it's a long, *long* race. But you also need experience to be able to think, yeah, I've seen that before, I know what's happening. I know some elements that I could do to fix it.'

It also helps that M-Sport is well versed in running from remote locations in the WRC, away from the usual niceties one finds at a purpose-built racetrack. The operation for Dakar is more substantial than WRC though. With four trucks running in the event, the logistics trail will be considerable.

'It is a huge undertaking, but M-Sport has an entire travel office that helps us with that, and we have a very experienced coordinator to liaise with the governing bodies or the organisers, wherever it is, in terms of getting us what we need and where we need to be. So logistically, yeah, it's complicated, but M-Sport are very in tune with how to make all that work for us.'

'Our goal was to do at least two Dakar distances in testing, and we've done way over that'

Mike Norton

Power comes from Ford's venerable Coyote V8, only mildly modified from GT3 spec, and is directed to all four wheels through the industry standard Sadev gearbox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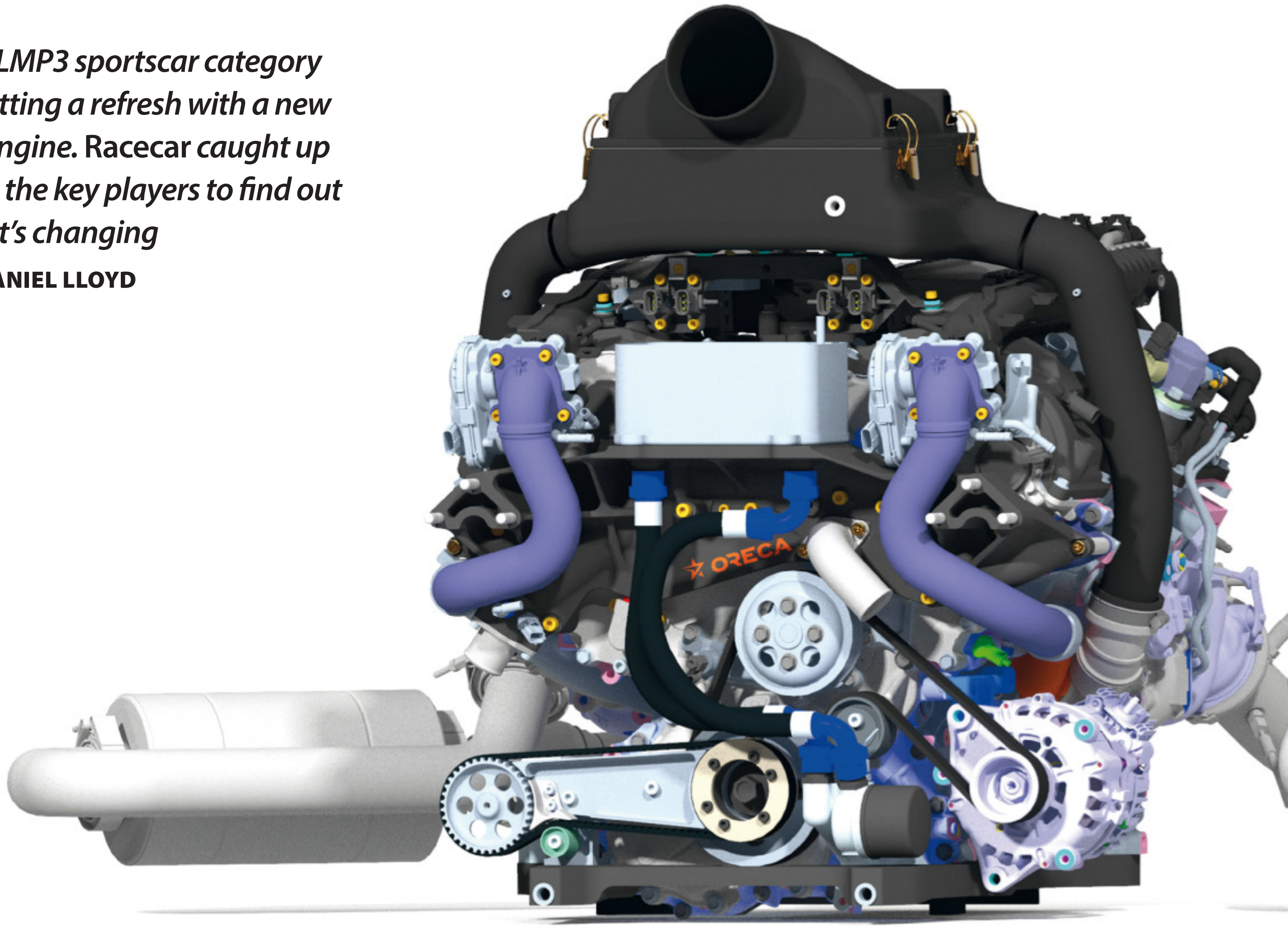
Turbo time

The LMP3 sportscar category is getting a refresh with a new V6 engine.* Racecar *caught up with the key players to find out what's changing

By DANIEL LLOYD



ORECA

The sound of the LMP3 cars will change as a new V6 ORECA-developed engine, with integrated oil cooler and exhaust manifold, will be introduced for the 2025 season

Anybody who has been to the 24 Hours of Le Mans, or attended a European Le Mans Series (ELMS) meeting, will be familiar with two distinct sounds. One is the swarming call of the Gibson GK428, the naturally aspirated V8 engine that powers all LMP2 runners. The other is the deep rumble of the Nissan VK56, another naturally aspirated V8 that is found in the back of every LMP3 machine. Those two have pervaded sportscar paddocks in recent years, filling the air as dozens of cars using either power unit stream past. However, from next year, the latter note will become much rarer (and paddock conversations will be significantly easier).

This is because LMP3 is undergoing a major technical refresh, the second since its inception, that will see the thunderous 5.6-litre Nissan V8 supplanted by a twin-turbocharged, 3.4-litre Toyota V6. With the Nissan unit going out of production, LMP3's governing body, the Automobile Club de l'Ouest (ACO), decided to introduce something new, with better fuel and sound efficiency, that was more in line with current road car technology. Two bidders went for the contract (with both offering turbo solutions) and ORECA, which already supplied the V8, was selected to continue into 2025.

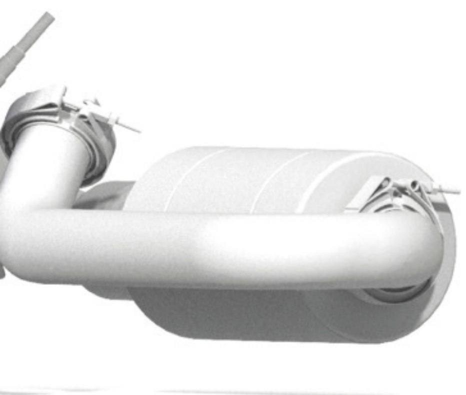
The new V6 engine's arrival will signal the beginning of the end for one of the most recognisable sounds in sportscars, but potentially also offers the glimmer of a fresh start for the car manufacturers hoping to generate new business.

Third division

LMP3 is approaching the end of its first decade. The junior prototype formula was launched in 2015 as the third tier in the ACO's endurance racing ladder, sitting below LMP2 and LMP1 (the latter has since been replaced by LMH and LMDh). Its mission has been to serve as a cheaper entry point for teams and drivers with fewer resources than those in LMP2. It has also occasionally been a springboard for careers. The exciting Danish talents of Mikkel Jensen and Malthe Jakobsen, both now part of the Peugeot LMH programme, were unearthed in LMP3. Similarly, several notable LMP2 teams, including United Autosports, Inter Europol Competition and Cool Racing first made their case in the third division before stepping up to the bigger league.

To prevent cost escalation, licensed LMP3 manufacturers from the start were required to use a spec engine and Xtrac gearbox. After a tentative first season with only a few cars on track, ELMS grid numbers exploded in 2016 and have remained strong. Interest was so high in fact that the ACO launched the Le

ORECA's racing version of the Toyota V35A engine, which stems from the Lexus LS 500 road car, produces 470bhp. This adds another 15bhp… though the introduction of the beefier turbo engine and associated cooling adjustments has been worth around 40kg



Mans Cup, which continues to serve as an overflow series and a proving ground for teams that want to enter ELMS.
It also enables LMP3s to compete in a support race at Le Mans.

The category has not been constrained to those ACO-run series, though. It has also been licensed to several independent competitions, many of them in Europe. In 2017, LMP3 was exported to North America, first appearing in a support series before being added to the main IMSA SportsCar Championship in 2021. However, after three seasons in which the non-professional LMP3 drivers swiftly gained a sour reputation for causing incidents, and with other categories growing, the class was squeezed back out to the support ranks. Still, LMP3 as a platform has largely been a success, with hundreds of cars produced to date.

The ACO initially approved six manufacturers to build LMP3 chassis: ADESS, Ave-Riley, Dome, Ginetta, Norma and Onroak. The Dome project failed to get off the ground, while the Ave-Riley didn't gain much traction. Norma became Duqueine following a buyout in 2017 and Onroak was re-branded to Ligier in 2018. Since then, ADESS, Ginetta, Ligier and Duqueine have been the four licensed constructors, and will continue into the upcoming 2025-'29 rule cycle.

Generation changes

The first generation of LMP3 ran from 2015 to 2019 and, to make readers feel old, those cars are now already cropping up in historic racing. The ACO updated the formula in 2020, replacing the original 5.0-litre Nissan VK50 with the 5.6-litre Nissan VK56, which added 35bhp and increased total output to 455bhp. ORECA continued to build, supply and service the branded engine and powertrain package.

Traction control was introduced to make the cars easier to drive for amateurs (there is no ABS), while Zylon anti-intrusion side panels were implemented for better safety. As part of the ACO's cost-cutting ethos for the category, teams could upgrade their first generation cars to second gen' specification for much less than the price of a new vehicle.

The 2025 technical refresh therefore marks more of an evolution, considering the same carbon monocoques from 2020 have been carried over and most of the front-end components are unchanged. ADESS wanted to bring a new monocoque but was outvoted.

More significantly, the switch to turbo power has brought some substantial side effects, such as major cooling system revisions and increased weight. ORECA's racing version of the Toyota V35A engine, which stems from the Lexus LS 500 road car, produces 470bhp. This adds another 15bhp on what the second gen' LMP3 engine produced, though the introduction of the beefier turbo engine and associated cooling adjustments has been worth around 40kg and required manufacturers to re-crash test.

'All the manufacturers will have an increase of minimum weight due to the cooling system, which is much more demanding compared to the V8,' says Duqueine Automotive CEO, Max Favard. 'We have had a shift in weight distribution, and we have worked on the aero package to make sure we can compensate for this.'

Ligier Automotive technical director, Nicolas Monteil, also notes that the weight

Marcel Wulf/DPPI

New cars will debut in ELMS and Le Mans Cup, including Road to Le Mans, next year before arriving in other series in 2026

distribution has shifted the car's c of g rearward slightly. 'There is a small influence, but this was known from the beginning and taken into account from the development of the aero,' he explains. 'In the end, on track, there is no big modification of the car's behaviour. Additionally, we are still in a very workable envelope for the tyres.'

Cooling system

The most significant change has been to the cooling. The new engine requires two water cooling systems. One cools down water that, in turn, cools the engine oil via a heat exchanger and keeps the V6 at a comfortable operating temperature. The other system regulates the intercooler, which is a new feature in this turbocharged era of LMP3. An intercooler is necessary to cool the compressed air coming from the turbocharger, before it enters the engine. The increased density that is a characteristic of this compressed air results in more potent combustion inside the cylinder, producing a more powerful and efficient engine with increased bottom end torque.

'The VK56 was naturally aspirated, so we had a regular water circuit for it,' says Monteil. 'On top of that, we had to deal with the thermal losses from the oil with a radiator of our design. With the Toyota V35A, it is quite different because the water for the engine oil cools down a heat exchanger, which is in the responsibility of ORECA. So, we don't control a specific radiator for oil, but we have to anticipate the heat through the water circuit.'

Monteil adds that thermal losses from the turbocharged V6 are 'considerably larger' than from the naturally aspirated V8.

'On top of that, because it's a turbo engine, you have the intercooler,' he continues. 'In some cars, this cooling is through an air-to-air heat exchanger. But here, we are using an air-to-water system from ORECA. We have to cool down this water with air, which requires an additional circuit.'

It has been up to each manufacturer how they handle the cooling system although, according to ORECA, there aren't too many ways of doing it. The more complex system has also led to changes on the surface.

'The new engine has quite a knock-on effect on the cooling system, and the cooling system has a knock-on effect on the external aero,' says ADESS CEO, Stéphane Chosse. 'We had to re-work the sidepods where we put the radiators. This was the main change.'

Priority reliability

Keeping the turbocharger cool to ensure its reliability for endurance races has been a priority. Many LMP3 series run to short distances, but ELMS contests are held over four hours. That is why the manufacturers have focused on testing in the heat of southern Europe this summer. Duqueine, for example, conducted a two-day test at Aragon in Spain where the temperatures reached 38degC ambient and 65degC on the track.

The ACO announced its switch to turbo power in July 2023 and confirmed the Toyota source of the engine a year later. Dyno testing started that September before ORECA sent the first batch of V35As to the manufacturers in April, with track testing due to commence shortly after. However, ORECA detected an issue during a shakedown with Ligier where gear shifts and engine behaviour under braking became inconsistent. It recalled the engines, which delayed further testing until July, once a software update had been distributed.

'The new engine has quite a knock-on effect on the cooling system, and the cooling system has a knock-on effect on the external aero'

Stéphane Chosse, CEO at ADESS

The V6 engine's internals were carried over from the production unit. However, because ORECA wanted to retain LMP3's existing gear ratios for the Xtrac gearbox, it needed to increase the power. To do this, it had to depart from the production turbo and worked with IHI to source one better suited to the task.

'We were a bit close to the limit of the turbocharger,' says ORECA design office chief, Frédéric Eymere. 'We made this change to be safe, reliable and closer to the VK56 curve.'

Commercial enterprise

Ligier is the dominant manufacturer in LMP3 and has sold 250 new cars since the category started in 2015. That impressive number doesn't include sales of kits to upgrade cars from first to second gen' either. Although it is an LMDh chassis constructor for Lamborghini, and an LMP2 manufacturer, the French company sees LMP3 as its 'flagship' project, according to its motorsport director, Franck Tiné, because it has become a highly successful commercial enterprise.

'The LMP3 category is really important for Ligier, he says. 'We are really proud of what we have achieved in the category, and what we hope to achieve in the new generation.'

Design work for the Ligier JS P325 started in the last quarter of 2023 and focused heavily

Duqueine Automotive

Engine control gremlins arose during early tests, slightly delaying manufacturer development programmes, but ORECA provided a fix and subsequent running has gone smoothly

Ligier Automotive

Ligier Automotive

Comparison of the second generation Ligier JS P320 (top) and the third generation Ligier JS P325 (bottom). The most obvious external changes have been made to the design of the sidepods

on CFD evaluations. The car's first shakedown at Magny-Cours occurred in late June this year. In three months, it racked up 3000km – more than any other constructor – and the number of test days reached double digits. Experienced Ligier-affiliated driver, Olivier Pla, completed most of the mileage.

'The main goal for Olivier was, first, to work on the reliability of the car, which is the case,' adds Tiné. '[Another was] to work on a car that is fast, but he also must keep in mind that it will be for gentleman drivers. This has always been the goal for us, and this is still the case with this new car.'

Visual clues

The JS P325 is visually distinct from its successful JS P320 predecessor in multiple areas. The distinct bowl-shaped nose remains the same, due to the monocoque being unchanged, but around it the air intakes have been positioned much further forward and lower down. The area where the intakes appeared on the JS P320 is now covered with a sloping surface that guides air around the cockpit, while the sidepods rise much earlier on the JS P325, smoothening the hump around the wheel of the 2020 car. This is mainly due to the cooling system packaging, but also helps to reduce drag while maintaining downforce.

'There was a lot of aero development in order to find the best compromise for the cooling, and also a lot of trials for various cooling arrangements,' recalls Monteil.

Ligier held off integrating customers into its test programme, instead preferring to keep them in the loop before delivering the final homologated product, however that approach wasn't universal. ADESS, for instance, opened the door for potential teams to try its AD25 before the car's homologation. In the same three-month timescale, the Portugal-based constructor racked up 2000km of testing, including outings at Portimão and Estoril.

'We initially wanted to complete the testing and develop the complete car, then invite the customers,' says Chosse, 'but there has been a timing issue [with engine delivery]. So, we have been inviting potential customers to test the car while it is still in the development phase. They can come to visit us and see how we are working on it.'

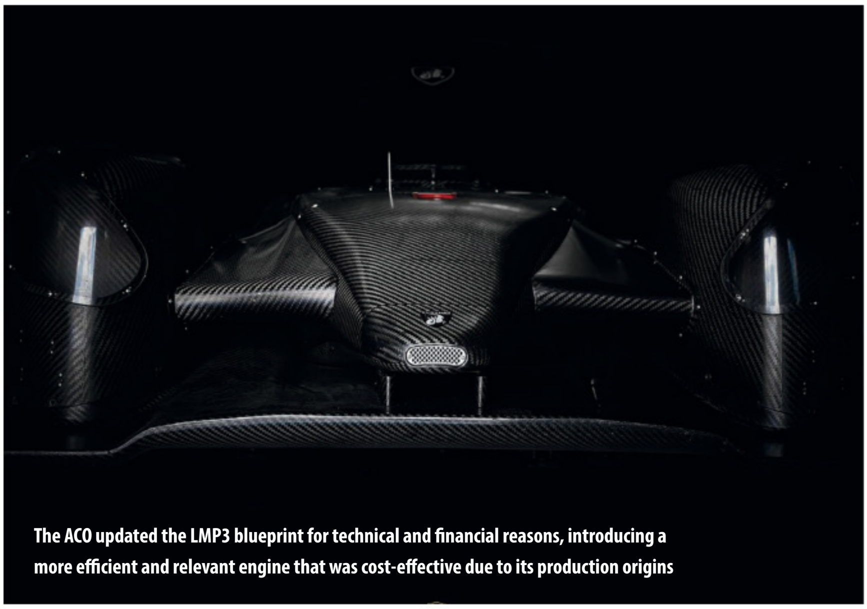
The ACO's manufacturer-limited model for LMP2 and LMP3 was introduced to keep costs down. However, eight years on, both categories are dominated by one car builder. ORECA supplies almost every LMP2 car in the series that run the class, while Ligier holds a commanding share of the LMP3 market: it had 87 per cent of this year's combined ELMS and Le Mans Cup grids, Duqueine the other 13 per cent. Ginetta and ADESS were absent from both series and have generally lagged behind the French constructors in sales.

Snowball effect

'It's like a snowball effect,' suggests Chosse. 'When you are small, you don't generate interest from the biggest teams who have more budget and test more. We were generating only interest from smaller teams that were really tight on budget. It's very difficult to compete.'

In a cost-controlled arena like LMP3, there are few areas in which the manufacturers can really stand out from the crowd.

Duqueine Automotive



The ACO updated the LMP3 blueprint for technical and financial reasons, introducing a more efficient and relevant engine that was cost-effective due to its production origins

'The challenges and tricks are in the sidepods with the radiators. We were spinning plates with two or three elements, but all were ultimately achieved under the standard silhouette'

Clive Seddon, technical director at Ginetta

Damper choice is one of those areas and ADESS is trying to bring new technology that it hopes will help to sway some Ligier customers. For the 2025 refresh, Ligier and Duqueine have both stuck with the same damper products, the Öhlins four-way TTX40 and the TTX36 respectively. ADESS, meanwhile, has switched from the TTX36 to KW Automotive four-way dampers with an adjustable anti-roll bar system. Ginetta has also updated its dampers, moving up to the four-way Öhlins product.

'There is more adjustability [with the KW dampers],' notes Chosse. 'In the previous generation, the other manufacturers were running Öhlins dampers, [but] a lower spec compared to the Ligier. Now, with this new spec, we chose another manufacturer. The car is more expensive, so we didn't want to come with the same dampers and bring a car [that is] more expensive for the same thing. I think it will be interesting to see what that brings. We are happy with what we have seen so far from the dampers.'

British bulldog

Ginetta was the first constructor to have cars racing in 2015 and is continuing to invest in LMP3 with its latest offering, the G61-LT-P3 Evo, which is based on the same monocoque as the original Ginetta-Juno. The British company has squeezed the new cooling apparatus into existing sidepods, so the car looks more like its predecessor in the rear third than the opposition.

'That created the challenge of cooling it with the amount of air we were grabbing originally,' says Clive Seddon, technical director at Ginetta. 'Everyone else had grabbed more air, and used that air to cool the car, but that potentially hurts aero. But we strived to achieve this using the air we were grabbing. The challenges and tricks are in the sidepods with the radiators. We were spinning plates with two or three elements, but all were achieved under the standard silhouette.'

Seddon adds that Ginetta's engineering team was surprised to see how much it could package into the G61 Evo's sidepods.

'If you think about the heat rejection numbers from the VK50 [first gen' engine], this is double. Our cooling package is about the same, in terms of air, but in terms of water and radiators, it couldn't be more different.'

Ginetta's second gen' car, the G61-LT-P3, struggled with being overweight, but this meant the weight increase in the third gen'

Ligier Automotive

Homologation is taking place this autumn and every car needs to crash test again due to the increased weight. Customer deliveries are expected to begin once that is finished

Stéphane Chosse says ADESS wants to be 'back in the game' after its second generation AD-03 Evo struggled to find sales

ADESS

gen' has not been a factor. Rather, Ginetta put its car on a diet, said to be worth around 15kg.

In mid-September, the Evo embarked on its first overseas test at Magny-Cours with a customer team. Up to that point, it had completed around 2000km at tracks in the UK such as Silverstone, Donington Park and the company's own Blyton Park facility.

'Everyone else has gained weight, getting big and bulky, whereas we've kept the same profile and packaged it well,' says Ginetta motorsport director, Mike Simpson. 'That should be to our advantage. Everything I've seen looks maybe more downforce and more drag, but we've got quite a nice nippy car.'

Ligier's prominence in LMP3 raises questions about what Ginetta sees in the category, considering it hasn't appeared in ELMS since 2016 and Le Mans Cup since 2018. According to Simpson, LMP3 is a 'halo project' while the company's real moneymaker is the spread of one-make GT series it runs. Servicing large numbers of LMP3s in the way Ligier does would detract from the core GT business, so Ginetta plans to build an initial run of four new turbo cars, plus two upgraded G61s (of which it built just over a dozen), and then react to further enquiries as and when.

Citizen Duqueine

Duqueine has come closest to challenging Ligier's dominant position in the market. Despite being outnumbered in ELMS and Le Mans Cup, the French manufacturer has enjoyed decent representation in IMSA and is currently doing well in Prototype Cup Germany. It has sold 55 examples of the second gen' D08 to date.

Moving into the third generation rules cycle, Duqueine wants to build on the strengths of its existing car. In the first three months of testing, the new D09 completed around 1800km. Experienced LMP3 driver, Laurents Hörr, carried out the first shakedown at the Alès circuit where Duqueine is based.

> **'Running costs per kilometre are still very low. You can do many races. Motorsport is not free, but you can buy two LMP3s for the cost of a GT3 right now'**
>
> *Jean-Karl Vernay, customer racing manager at Duqueine Automotive*

'We had a few drivers that know the Duqueine and Ligier cars,' adds Favard. 'One of them had driven all four cars already, so had very clear opinions. We had the good surprise of improved balance and driveability. Performance is easier to extract from the [D09] due to the balance shift we did, following the engine integration.'

The tricky part is on the commercial side, where Ligier has an advantage. Duqueine's target is to work closely with its existing teams, such as DKR Engineering and R-ace GP, to achieve strong results in the first year that persuade other teams to consider the D09.

'The only way we can inverse the fact that Ligier has more cars is to just be faster,' says Jean-Karl Vernay, customer racing manager at Duqueine. 'They are pretty strong, and aggressive, commercially. At the start, the D08 had a lack of top speed, reliability and, for gentleman drivers, wasn't easy to drive. I think we have improved all these points. That's why we are now ready to try [to gain more] customers. We are already talking to some Ligier teams to switch.'

LMP3 doesn't usually grab the headlines – unless for crash-related reasons – but the platform continues to move forward. Its popularity can be attributed to its pricing: a third generation LMP3 car will cost €299,000 (approx. $332,500), but customers can retrofit their second gen' cars with the new turbo engine for around €60,000 (approx. $66,700).

Accelerated interest

Although LMP3 won't take you to the major 24-hour races, it is significantly cheaper than an LMP2 car, which currently touches €500,000 (approx. $557,000). Furthermore, the growth of LMH and LMDh has certainly helped accelerate interest in sportscars for young drivers who would otherwise toil away on the F1 ladder for several years. LMP3 has the potential to tap into that interest.

'Running costs per kilometre are still very low,' notes Vernay. 'You can do many races. Motorsport is not free, but you can buy two LMP3s for the cost of a GT3 right now. You have so much fun in one too: they have some downforce and it's a cool car to drive. It might also be a door for young drivers. I was talking to some young guys in [FIA] Formula 3, and the new car there will [cost] 45 per cent [more to run]. To do the championship, it is going to be around two million euros. We are now close to many formula teams, as we have done with R-ace. This is a new target.'

LMP3 exists under the radar of the ACO's premier Hypercar class of the FIA World Endurance Championship, but clearly still plays an important role at the base of the sportscar pyramid. Although its popular V8 sound is fizzling out, the new turbocharged era of LMP3 will help to keep this important feeder category moving into the future.

'The TAG-510 provides the brains, but it is combined with an additional unit, called an EIU-510. That supplies specific I/O needed for combustion'

Josh Wesley, senior product manager at McLaren Applied

NASCAR used the same type of ECU for over a decade, but as car technology improved, so computing limitations were reached

Forward thinking

McLaren Applied has upgraded its operating system and produced a new series of ECUs ready for future technology advances

By ANDREW COTTON

On the face of it, there was nothing wrong with McLaren Applied's existing TAG-400N electronic control unit. It was introduced to NASCAR in 2012 and, since then, has serviced the normally aspirated V8s during the Gen 5, 6 and 7 regulations. The control unit is so good that some of the teams are still running the original ones, yet to be serviced by McLaren Applied since they were first installed into the cars, and still functioning perfectly well.

The 400 unit was something of a game changer in NASCAR when it was first introduced. Although it was initially more expensive than alternative ECUs, it led to more efficiency, not only in servicing time but also in fuel mileage, which improved by an estimated 25 per cent through better engine management, as well as advanced electronics elsewhere in the car.

New generation

However, the 2024 season has seen the British company roll out the first of a new generation of Series-500 ECUs. The first for engine control is named the TAG-510 and will be introduced into NASCAR next season for testing, with full-time competition starting in 2026.

Getty Images

The TAG-510 sees increased functionality that will shepherd NASCAR through the rest of this generation and into the next.

The Series-500 ECUs are already in use in Formula E, in the VCU-500 vehicle controller variant, where it has performed strongly during its debut season. The VCU-500 has also been running in the new E1 electric powerboat series which first hit the water at the start of this year.

This is the first in a series of upgrades the company will be introducing over the next two years, with the TAG-510 set to line up alongside the TAG-700 that will be introduced into Formula 1 in 2026 under the new rule set.

The move is all part of an internal upgrade for McLaren Applied as the motorsport world changes according to the political and technical landscape. The company has relied on the TAG-320 that was, and is, used by Formula 1 teams, and by sportscar manufacturers in the FIA World Endurance Championship. It also had the 400N for NASCAR, as previously mentioned, and the 400i that is currently in use in IndyCar.

Common architecture

The difference is all these units were designed for specific purposes within the racing series they operate in. There was little or no crossover of coding between them so, this time round, McLaren Applied has taken the opportunity to link them with a common modular computing architecture.

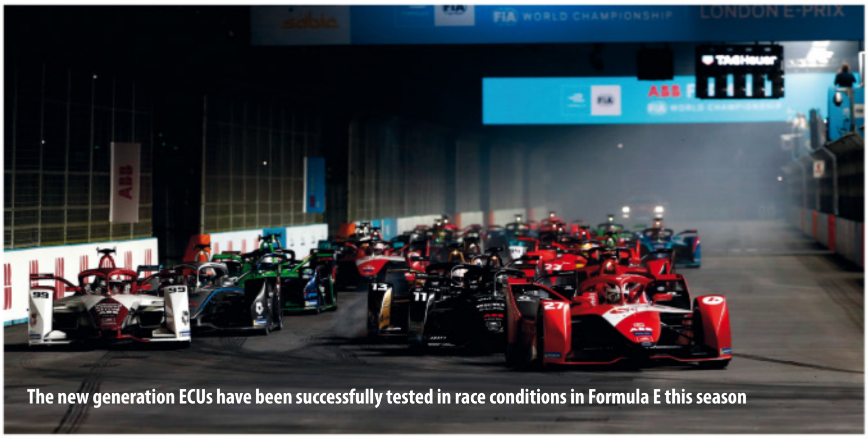
There is a clear need to do so, too. With Formula 1 and sportscar racing both having introduced hybrid systems in 2014, the demands on the ECU were very different in application to any other racing series at the time. However, with IndyCar introducing hybrid technology this year, there is a need to have some commonality in the ECU upgrades that will inevitably come.

NASCAR may have skirted around the issue of introducing hybrids into its series, and then abandoned the idea in favour of more environmentally-friendly fuels, which are currently under evaluation, but it is still first in line to receive the new TAG-510 ECU as an ICE control unit.

'Compared to the VCU-500, the TAG-510 is broadly the same unit, but with minor modifications to support combustion,' says senior product manager, Josh Wesley. 'There are some software changes that allow it to synchronise to an engine cycle and external interface unit, and modifications to the analogue inputs to deal with knock sensors.

'The TAG-510 provides the brains, but it is combined with an additional unit, called an EIU-510 [Engine Interface Unit]. That supplies specific I/O [inputs and outputs] needed for combustion, for example injector and ignition drivers, so instead of building one big unit that includes everything, we split it in two so that in EV applications, you are not carrying unnecessary components.'

The EIU-510 is an additional unit that supplies specific I/O for combustion engines. Separating this part reduces the amount of equipment carried in an EV application



The new generation ECUs have been successfully tested in race conditions in Formula E this season

NASCAR famously limits the amount of information teams can retrieve from their cars to control cost. There are only 16 telemetry channels that can be used to evaluate performance and put together sim' programmes, with a number of further data channels for use by the organisation only.

The TAG-400N unit has a total of 200 channels that are open to use, while the TAG-510 unit will have an available 2000. This looks like overkill, but McLaren Applied says it wants to give series more options for the future in terms of recording how a vehicle behaves, while also future-proofing it for possible regulation changes to come.

This increase in available channels will enable NASCAR to monitor more complicated systems, such as engine use and chassis control. It will also give the series some headroom in case it is forced to go in a different direction and introduce tools such as hybrid, or active aero (DRS) to improve fuel efficiency, or to adjust the style of racing. As yet, there are no plans to do so, but McLaren Applied has ensured its new generation ECU will be able to cope with such demands.

The TAG-400 series ECU had reached the end of its natural life after 12 years in service, with teams limited by logging performance, computing power and input and outputs (I/O) in terms of analogue and digital interfaces. The TAG-400 system could, says McLaren Applied, cope with a new bio or synthetic fuel, but dealing with direct injection, for example, is better suited for the new Series-500 ECU.

Ease of upgrade

While the new system will be able to channel more data from car to pit or race organisation, for McLaren Applied the new generation of ECUs will allow it to more easily upgrade from series to series, as all seem to be converging toward similar requirements.

'We were using an old manufacturer [of processor] in the 400N, but what we have tried to do with the new generation of units is to align the processor architecture, because that means we can roll out updates and efficiencies in the hardware if they are all based on the same platform,' says Wesley.

'Historically, from a cost and use-case perspective, our F1 customers are different to our NASCAR customers, so we made a unit for each. But if you have some quality of life improvements, such as the way you update the ECU, we have to do that twice, once in the F1 TAG-320 and once in the NASCAR 400N, and then again in other cells. Even though we

The brains of the operation is the TAG-510, which has significantly upgraded processing power and improved security architecture

want to replicate the functionality, you cannot just replicate the code because they are running different architecture underneath.'

Typically for McLaren Applied, there is an underlying control computer platform that has been labelled the MCP, or McLaren Compute Platform, which is a new processor architecture and supporting electronics that drives the new generation ECUs. This is already established and functioning well in Formula E, so McLaren Applied is confident of running it out into further race series.

The TAG-510 has increased processing power, up from 264MHz to 1.5GHz, has four times the logging memory and more than six times the data offload speed.

The new control system, thanks to increased I/O and processing, can cope with the demands of direct injection, high pressure fuel pumps, fly-by-wire throttle bodies and turbocharging. Another of its strengths is high-speed inputs to support knock / in-cylinder pressure placement and diagnostics.

The increased computing and logging performance better supports development and deployment of the advanced control strategies required to run more advanced engine configurations, including V6 engines that are expected to appear in NASCAR in the next few years.

The increased computing and logging performance better supports development and deployment of the advanced control strategies required to run more advanced engine configurations, including V6 engines

One of the other headline features in the next generation of McLaren Applied ECUs is their patented security architecture. This allows series organisers, manufacturers and teams to all work together on a single device, while controlling information flow and protecting their own IP.

Security layers

With more advanced engine architecture not only requiring more I/O, processing power and logging, the engines often come with additional political challenges and stakeholders.

The Series-500 ECUs all support multiple security layers and up to nine applications, allowing expansion of collaborators throughout a project, such as engine, gearbox and chassis suppliers or battery / hybrid suppliers.

The security benefits, twinned with MATLAB / Simulink support via the McLaren Control Toolbox, provides a very flexible and powerful control solution, resilient to changes in both technical and political architectures.

The EIU-510 itself is designed to integrate a turbocharged, hybrid powertrain of up to eight cylinders. With persistent rumours that Honda is looking at NASCAR with a V6, possibly based on the LMDh engine, this upgrade is thought to be highly relevant.

The system comes with eight transistorised ignition drives and 12 port or DI (Direct Injection) drives, which help to improve control over the engine and increase fuel efficiency even further. That would allow cars to start races lighter, or go further in a stint, further opening up strategic options for teams.

As demand for more information grows, and converges to similar requirements, McLaren Applied's new ECU and EIU look set to meet the expectations of several high-profile series over the coming years. R

TECH SPEC: TAG-510

- Rectangular cuboid shape
- Aluminium case (hard black anodised)
- Weight: 1400g
- Dimensions: 215 x 150 x 60mm
- Power supply inputs must be provided from an external system power regulator
- Unit supply input (7.5-18V) for internal circuitry
- Dual rail injection supply inputs (14V nominal and 60V or 80V nominal)
- Ignition supply input (48V nominal)
- Internal tri-axis accelerometer
- IP65 rated
- Splash resistant to standard motorsport fluids
- Lids sealed with o rings
- Maximum humidity: 100 per cent
- Minimum operating temperature: 0degC
- Internal temperature not to exceed 70degC as measured by internal diagnostic sensors
- Storage temperature: -25degC to +85degC
- Vibration: 100-1000Hz, all axes, 24 hours (vibration isolation is recommended)
- Integral, sealed, Deutsch AS motorsport connectors
- Connector A (16-way), B (66-way), C (21-way) and D (32-way)
- 12 configurable active-low injection open drain trigger inputs or active-high using TTL signals
- Eight active-low ignition trigger inputs (driven using open-drain drivers)
- Two configurable active-low high-pressure fuel pump trigger inputs or active-high using TTL signals
- Four K-type thermocouple inputs
- Two wideband lambda interfaces for Bosch LSU4.9 and NGK sensors
- One ignition switch input
- Force boot switch input
- 12 injector drivers in bridge configuration providing multi-stage current waveform control. Peak current: 25A max, hold current: 10A max
- Eight transistorised ignition drivers. Peak primary current: 40A, primary fly-back voltage: 500V max
- Two high-pressure fuel pump drivers
- Two 5A low-side drive stages – lambda heaters
- Four 8.5A H-bridge drive stages – electronic throttle bodies / wastegates
- Two user-configurable diagnostic oscilloscope outputs for viewing injector, ignition or fuel pump drivers

Circular economy

Formula E has a strong case for being considered the most road-relevant form of motorsport today

By GEMMA HATTON

For years, we have been told the story of technology transferring from racecar to roadcar. Though with automotive now a complex landscape of combustion, hybrid, electric and hydrogen powerplants, combined with the shift to autonomous and software defined vehicles, how much of a role does racing really play in the development of today's fleet? To find out, we investigate arguably motorsport's most relevant category to mainstream automotive – Formula E.

The championship marked a major milestone in the era of electrification as it was the first all-electric series to take to the track. It kicked off with the first (Gen1) Formula E car in 2014, which was raced by 10 teams, some backed by car manufacturers which then built powertrains for subsequent seasons. At the start, there were only 23 EV models available on the automotive market, whereas today there are close to 600.

Over the course of Gen2, which raced from 2018 to 2022, the number of powertrain manufacturers involved reached 10, while Gen3 so far has attracted seven, with a number of others waiting in the wings (for context, there were nine manufacturers in Hypercar at this year's 24 Hours of Le Mans).

'The reasons behind why a manufacturer chooses to be involved in Formula E varies for each manufacturer,' says Jeff Dodds, CEO of Formula E. 'Some are looking for pure R&D crossover, where the engineers at the racetrack go back to base and collaborate with other engineers, as well as with the commercial team. Others are involved because racing is part of their DNA, or they want to showcase their technology and benefit from the media exposure.

'Ultimately, if a manufacturer wants to race electric and demonstrate their expertise in an inclusive world championship, then Formula E is the platform for them.

'From a championship perspective, I think the optimum number of manufacturers in the series is between five and seven,' continues Dodds. 'We are allowed to have a maximum of 12 teams and 24 cars on the grid. Manufacturers usually want to capture data from two teams, so that's why we see most entering [both] a factory and a customer team. If they all follow that same model, it means a maximum of six differemt manufacturers but, with a bit of flexibility, five to seven feels like the right number.'

Unique challenge

It isn't just the powertrain that makes Formula E unique, but the intention behind the regulations, too. The series features a highly standardised package, which includes spec batteries, chassis, aerodynamics and tyres, while the motors, inverters, transmission and control systems are all open for development.

On track, the sporting regulations also limit the amount of energy teams have to complete the race. Each car starts with 20-55 per cent less energy (depending on the circuit) than they need to run flat out to the chequered flag, so they have to make up the deficit through regenerative braking and energy saving. This forces teams to focus their attention on energy efficiency technologies, as well as energy management strategies.

'The objective in Formula E is to maximise energy efficiency,' explains Tommaso Volpe, team principal at Nissan Formula E Team, which has been a manufacturer in the championship since 2018. 'This means ensuring as much of the electrical energy provided by the battery is converted into kinetic energy at the wheels as possible. In Formula E, we are now achieving energy efficiencies above 95 per cent, so less than five per cent of the energy is wasted through heat or noise, which is impressive.

Outwardly, Formula E racecars appear to bear little relevance to the latest generation of road cars, but under the skin it's a different story

'The software is directly transferable to automotive because it is less restricted by budget. You win or lose races based on how well you manage energy, so the energy management software we use in Formula E is extremely sophisticated'

Tommaso Volpe, team principal at Nissan Formula E Team

In Formula E, the motors, inverters, transmission and control systems are all open for development, while the rest of the car is spec. This is attractive for manufacturers who want R&D for their mainstream automotive business

'This is achieved through innovative design and use of materials, as well as complex software,' continues Volpe. 'The software is directly transferable to automotive because it is less restricted by budget. You win or lose races based on how well you manage energy, so the energy management software we use in Formula E is extremely sophisticated. It allows engineers to continuously optimise the energy targets for the driver, lap by lap, and react to scenarios during the race. This level of sophistication, along with all the other experiments we do in racing, are gold for the core business of road cars because in automotive, improving energy efficiency significantly increases the range of a vehicle.'

Market differences

Of course, there are substantial differences between the two industries. The budget per vehicle is much higher in motorsport than automotive, so some of the more expensive technologies are not feasible to scale up across thousands of production cars.

Reliability is another differentiator. A Formula E powertrain is built to last around 50,000km, while a road car needs to endure over one million kilometres, at the very least.

'The interesting thing about electrification, when compared to other technologies that transfer to road cars, is its flexibility,' highlights Volpe. 'The energy management software is as strong for a brand like Nissan whether we are building a sportscar, or a city car like the Leaf. Electrification is much more flexible than internal combustion technology, for example.

'The power output of an engine is typically optimised for a very narrow operational window, whereas the power output of a motor is dictated by the software. In essence, the same motor can be utilised for a sportscar or an SUV, it's just the software that changes how the energy is deployed. That's probably why there are more mainstream brands involved in Formula E than any other category of motorsport, because it is not just relevant for high performance cars, but other vehicles as well.'

Formula E may have found the right blend of standardised and open regulations to attract automotive manufacturers so far, but to ensure its championship remains a relevant testing ground for road car, it needs to stay ahead of the curve. This is proving somewhat tricky when the future direction of automotive continues to fluctuate between hybrid, electric, sustainable fuels, hydrogen ICE and hydrogen fuel cells.

Changing boundaries

'We have the manufacturer perimeter and the FIA perimeter,' explains Dodds. 'What are the manufacturers accountable for? The powertrain, software and components around the powertrain, so we can change that mix and add things into that manufacturer perimeter.

'So speculatively, if we thought that battery development was really important to manufacturers, or an area where they can differentiate, then we can put battery development into that perimeter. Where we have to be careful is cost. We want our championship to be a good return on investment for manufacturers, where they can learn a lot. The perimeter we've currently defined seems to be achieving that, but that might need to change in the future.'

Interestingly, many of the manufacturers would prefer to have a common battery, even though this appears to be such a crucial area of development in the automotive world.

'When you open up bespoke development of the battery, it will become super expensive to build a battery specifically for our Formula E programme,' adds Volpe. 'And it might not even be relevant to our core business because the regulations may force us into a direction that is different to our road car development.

'It's the same with opening up the aerodynamics package. This will take up a large chunk of our investment, but has zero relevance for automotive. You see this in prototype racing. Only when you get to GT level does the aerodynamics have some relevance to road cars.'

Supplier crossover

Alongside manufacturers, suppliers are also using Formula E for R&D, which they can then transfer to their clients from other industries. Materials science company, Dow, is a technical partner of Jaguar TCS Racing and supplies a variety of thermal, EMI shielding and anti-vibration adhesives.

'Over the course of the last four years that we have worked with Jaguar TCS Racing, we have implemented a number of our materials in different areas on the car,' says John McKeen, technical director of Dow. 'Our thermally conductive materials have been particularly effective in removing heat from powertrain and electronic components, which has helped improved the car's efficiency and reliability.'

When Dow first started collaborating with the engineers from Jaguar, one of the first tasks was analysing the thermal adhesives used in the inverter. It was discovered that the thermal conductivity quoted in the spec sheet was different to what was being achieved. 'That's when we suggested using our materials to deliver the thermal performance they required,' says McKeen. 'So, we were able to leverage our two decades of experience to specify the right thermal adhesive for the inverter straight away.

'Formula E is a great test bed for us to gain feedback on our materials in a demanding environment,' continues McKeen. 'Some are successful and stay on the car, while others have been really good learnings for us to internalise and feed back to the product development teams.'

Nissan was the first manufacturer to commit to Gen4, signing up until 2030. Like Formula 1, the new rule set will begin in 2026

> **'Formula E is a great test bed for us to gain feedback on our materials in a demanding environment. Some are successful… while others have been really good learnings for us to internalise and feed back to the product development teams'**
>
> *John McKeen, technical director at Dow*

Circular charge

However, this technology transfer is not all one-way traffic. ABB's Formula E Race Charger introduced for Gen3 originates from the chargers used on road cars.

'We took the charger we already have in the automotive field and adapted it to be more mobile and meet the necessary standards for Formula E,' explains Bas Berix, project manager at ABB. 'This required improving the packaging to make it smaller, lighter and easier to transport, but still robust.'

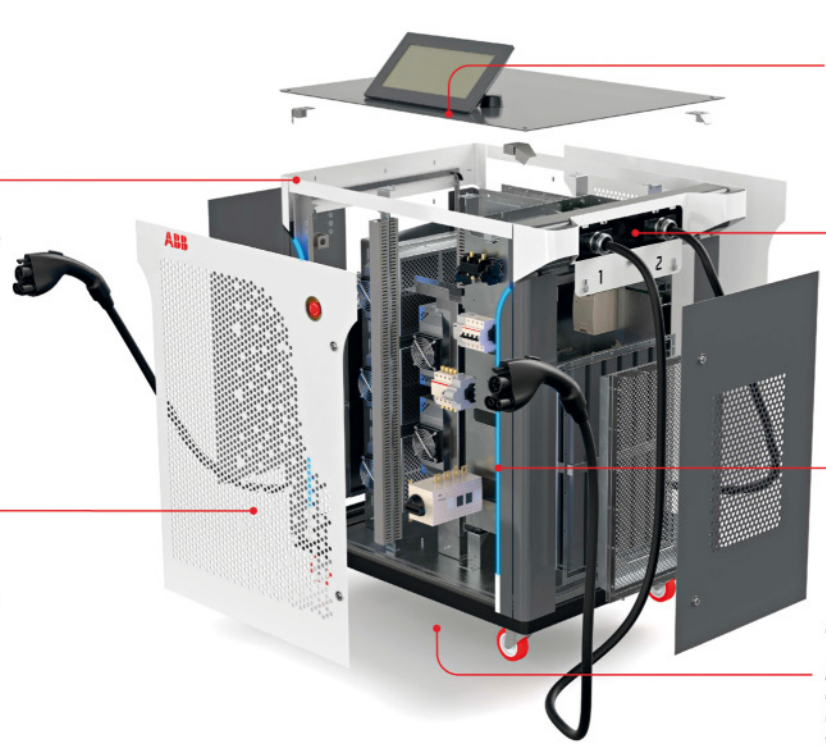
There are 14 ABB chargers in the Formula E pit lane during a race weekend, one for each team and two spare. Each charger delivers a maximum power of 160kW and can charge two vehicles at 80kW simultaneously from zero to 100 per cent State of Charge (SOC) in around 45 minutes. This double charging capacity avoids having one charger per car, saving space in the garage and, perhaps more crucially, in freight.

'We made sure teams can charge two cars at the same time, and also work on the car whilst it is charging,' continues Berix. 'This is a lot more flexible than in Gen2 when teams had to disconnect the wires from the battery, put a cable from the battery to the charger and not touch the car at all during charging. We have implemented safety systems so the charger is plug 'n' play, just like road cars. Engineers can also work on the car, as long as they don't disconnect the battery, or some of the critical sensors.'

With two seasons now completed in Gen3, ABB is already transferring R&D learnt from Formula E back into its road car products, completing the circle.

'The crossover of technology between automotive and Formula E is a two-way street, because each is operating at an extreme,' says Eric Ernst, VP of Technology at Formula E. 'Automotive is extreme in that it needs to produce thousands of reliable vehicles, while Formula E is extreme in terms of performance.

ABB's Formula E Race Charger has the capability to charge two cars simultaneously at 80kW each



Specifications
Pre-race mobile charger

CHARGING POWER	OUTPUT CONFIGURATIONS	DIMENSIONS	WEIGHT
Up to 160 kW from one outlet, or 80 kW per outlet when charging two vehicles	Up to 200A and 920V via a CCS2 connector	Height: 1300 mm Height: 1520 mm (with top screen) Width: 1150 mm Depth: 850 mm	450 kg

'In a funny way, we have almost come full circle with this Gen3 car,' smiles Ernst. 'In Gen1, the range of the battery meant the car could only do half a race, so drivers had to swap cars. Whereas the technology in Gen3 has come so far that this car can do half the race, and regenerate the rest of the energy it needs to reach the chequered flag.'

Future direction

Formula E's 11th season, which commences later this year, marks an evolutionary step in the championship with the introduction of the Gen3 Evo. This iteration of racer features an upgraded body kit, newly homologated powertrains, tyres with five to 10 per cent more grip, ultra-fast charging (originally planned for Gen3) and all-wheel drive, which teams can utilise during qualifying duels, race starts and attack mode. The result is the quickest accelerating FIA single seater, achieving 0-60mph in 1.82 seconds (0-100km/h in 1.86 seconds), a second faster than the Gen3 and 30 per cent faster than F1.

The next major technological leap is set for Gen4, which comes into force in 2026. This will see a host of new suppliers, with Podium Advanced Technologies providing the batteries, Marelli developing the front powertrain and Bridgestone the tyres.

The new battery will boost power output to 600kW, a significant step from the 350kW currently deployed in Gen3. Maximum regen' will hit 700kW, with 350kW split between the front and rear powertrains, while all-wheel drive will be available for every session.

'We, along with the other manufacturers, really pushed for all-wheel drive for Gen4,' says Volpe. 'It's a crucial technology for electric vehicles because it allows you to manage the torque and braking of each wheel independently. We already use this in automotive with our e-4ORCE all-wheel drive technology in our road car models such as the Nissan Ariya, and it's perfect for motorsport.

'So, in this case we are transferring our expertise from road to race, which we have partially started doing for Gen3 Evo, but for Gen4 this will be much more direct. We will then look to improve our e-4ORCE technology with the expertise we gain from the track.'

'The crossover of technology between automotive and Formula E is a two-way street, because each is operating at an extreme'

Eric Ernst, vice president of technology at Formula E

For Gen5, there are a number of exciting technologies on the horizon: 'If I were a betting man, I would expect solid state batteries to be introduced for Gen5, but we're not there yet,' highlights Dodds. 'The powertrain will also be larger and more powerful and we'll improve the amount of product that is being recycled.'

Solid state batteries use solid electrolytes made from ceramic or polymer materials, instead of liquid electrolytes found in typical lithium-ion batteries. This means more energy can be stored within the same space, achieving higher energy densities and therefore powering vehicles for longer without the need to recharge. This has been a development focus in automotive recently and will likely be another area where manufacturers can tap into the knowledge gained from road cars.

'Nissan is investing a lot of resources in solid state batteries for the future and we really believe in this technology,' says Volpe. 'If we were selfish, we would tender to be the sole supplier for the battery to accelerate the development of this technology but, when you look at it from a strategic standpoint, this isn't the right move.

'We don't welcome the situation that a manufacturer competing in the championship is also the sole supplier of a component so crucial to car performance, such as the battery, as is the case currently,' says Volpe. 'We believe it's better to have a common supplier outside the manufacturers fighting for the championships.'

Autonomous driving

Another potential technology on the cards for Gen5 is autonomy, which is already being investigated in automotive.

'The trends in automotive are not only to make mobility more sustainable, but also safer,' says Volpe. 'This can be achieved through autonomous drive features that can help to prevent accidents. At Nissan, we see autonomy as something that doesn't take the excitement out of driving, but actually enhances it. For example, it can be used to correct any driving defects, allowing you to get more from the car, as well as in scenarios that are not exciting to drive, such as in traffic.

'Let's say that 80 per cent of your journey is fun to drive, but the other 20 per cent is spent stuck in traffic. Autonomous driving can take over when you're in traffic, which means you're effectively making that 80 per cent of your journey the full 100 per cent driving experience.

'It would be interesting to transfer this approach to motorsport in the future,' concludes Volpe. 'For example, the cars could drive autonomously behind the safety car, keeping a specific gap to the car in front. This would not affect the excitement of the racing, but would be a good way for manufacturers to showcase their autonomous driving technologies. The strength of Formula E is its relevancy to automotive, so the next generations of racecar should continue this positioning of using motorsport to show what is happening in the mobility industry.'

The Gen3 Evo car will debut later this year in the 2024-'25 season. The all-wheel-drive racer will feature an upgraded body kit, more grip, ultra-fast charging and a claimed top speed of 200mph, with a 0-60mph time 30 per cent faster than a current Formula 1 car

Could autonomous driving be used in future generations of Formula E, in scenarios such as lapping behind a safety car?

So, it seems there is still a strong connection between the development of racecars and road cars, as motorsport remains a suitable testing ground for pushing the boundaries of technology. However, there has been a shift change. This transfer of technology, expertise and knowledge is no longer the one-way street from race to road that it used to be. Instead, it has evolved into a more circular economy.

Automotive's pursuit for electric mobility and autonomy has allowed it to make huge advances in some areas, which some sectors of motorsport are now capitalising on. Meanwhile, lessons learnt in the experimental and unforgiving laboratory of motorsport are being fed back to automotive, enhancing the performance and efficiency of the new breed of electric road cars.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Cup of plenty

The INEOS America's Cup team has built on its relationship with Mercedes Formula 1 engineers to develop the Britannia AC75

By ANDREW COTTON

The America's Cup yacht race has long been associated with advanced technology. For the 2021 edition in New Zealand, Britain's INEOS crew joined forces with engineers from the Mercedes Formula 1 team to help in its quest to win the title.

The relationship was developed late in the competition, when the INEOS team was struggling to achieve the desired results. That meant the engineers had only limited time to step in, but the outcome was undeniable. The team recovered form and, although it didn't advance to the final competition, it certainly felt the benefit of the relationship.

That, then, was the cue to continue into the 2024 edition together. Starting earlier this time, and more carefully allocating resources from the beginning, the development path of the team, the boat and the project was best described as extreme.

The design team of the 2024 boat moved close to Mercedes' F1 headquarters in Brackley, to an airfield with a hangar large enough to house the build of the vessel. That allowed the Britannia yacht designers to integrate fully with the F1 designers and engineers, making full use of the latter's available facilities.

Test boat

One of the decisions taken early, and as a result of this move, was to build a test boat, rather than adapt the previous competition boat, or work on an AC40-class yacht (a smaller version of the AC75 type that would go on to be used in the main competition).

Using the F1 team's expertise in producing prototypes to a tight schedule, and to a cost cap, played a key part in making that decision.

'The famous saying in sport is that you can be over budget, or behind on your timeline. Hitting both is pretty hard,' says Sir Ben Ainslie, the skipper of the crew, team principal and CEO of the INEOS America's Cup project. 'In sport, you *have* to make the timeline, because they are not going to postpone the start of the race for us.

'We had a big decision to make early on in the campaign, whether or not to build our own test boat. We could have had the same as the other teams, which is one design [the AC40] and bolt on your open foils and control systems. That's a much easier way of doing it.

'However, we made the decision that we wanted to design and build our own test boat, given the partnership with Mercedes, because a lot of the designers there had never done that. It was well worth the process to go through because it highlighted a number of areas we needed to improve on for the eventual race boat.'

Ian Roman / America's Cup

‘We learned a lot as an organisation from a technical point of view, and exercised a lot of the test rigs that we built using the F1 culture’

Geoff Willis, former F1 technical director and now technical director of the INEOS America’s Cup team

The AC75

First introduced in 2018, the purpose-built, 75ft, monohull boats are capable of reaching incredible speeds on the water. The hull is constructed of carbon composite material to save weight, while at the same time retaining the strength needed to deal with the impacts experienced with water.

The foils for the 2024 edition were made later to promote quicker lift and faster flight. Weight has been reduced, partly by hardware advances in electronics, hydraulics and software systems, but also by reducing the crew number from 11 to eight.

Some of the boat is spec, including the mast, rigging, foil cant arms and cant hydraulics, but much of the rest of the boat, including the control systems for these cant arms, as well as the design of their trailing edge, is free.

The yacht weighs 6.5 tonnes. Its mast is a massive 26.5m high and it is capable of top speeds in excess of 50kn in race conditions.

The test boat turned out to be more important than first realised. By the team's own admission there was a lot of over engineering in it, so the second version, that which competed in the 2024 competition, was revised and much more effective.

'Last time around [in the 36th edition of the Cup], we were supporting certain specific things, whether it was along the areas of controls, some specific engineering design and testing and some other software-related tools,' says Geoff Willis, a former technical director in F1 who now holds the same position on the INEOS America's Cup team. 'This time, it's been very much integrated.'

Skill alignment

Many of the F1 engineers that helped with the design and build of the Britannia AC75 have now returned to their regular jobs on the grand prix team. Before they did, though, they worked alongside the experienced yachting design team, assisting in CFD, cell design simulation, software, materials, composite design and powertrain.

'Clearly, there are experiences and skill sets that are different between the two groups, but I think it's worth rewinding a little bit and emphasising just how impressively overlapped the F1 world and the yacht world is,' says Willis. 'Consider that we've got carbon fibre composite structures, mechanical systems, transmission systems and hydraulic systems, with electro-hydraulic control pumps. We also have lots of aerodynamics and hydrodynamics; let's just call it fluid dynamics. It's pretty much the same.

'Mathematically, there's a couple of features that would be new to the F1 world, specifically hydrofoils with cavitation and ventilation. But for all the fluid analysis, all the aerodynamicists in the F1 world would have been well aware of that in their background, training and experience. So, you've got all these areas of technical expertise, which are amazingly well aligned.'

Cultural differences

Grand prix teams generally have a stable core that develop cars together and compete multiple times per year. To do this, they have teams of designers and engineers in the team HQ, but in the America's Cup there is a small group that generally competes every couple of years, in regattas building up to the main competition, and then the competition itself.

'A difference in culture is that the Formula 1 teams, for the main part, have had lots of continuity and stability,' confirms Willis. 'Decades of it, and this has allowed the teams to build up an enormous base of team-centred IP capability and technology. People do move between teams, but the team doesn't lose the stability.

'With the possible exception of Team New Zealand, [the America's Cup teams] are much more episodic. Come together, work together, work out how to do it. And then a certain

Ian Roman / America's Cup

‘It’s worth rewinding a little bit and emphasising just how impressively overlapped the F1 world and the yacht world is’

Geoff Willis

amount of that is dissolved at the end of the Cup cycle. Then the next one moves on.'

Using the stable core, the INEOS team started work early on its 2024 contender. The rules allow for one test boat and one competition vessel to be built, and that's the route they chose to take.

'The protocol allowed us to build three foils with the wings and flaps, with fundamentally the same design,' says Willis. 'You can have evolutions of them, but you can't have completely different concepts of 80 per cent of your foils. The 80 per cent of the foil that goes on the boat must be from common stock, what's called the immutable part. That got us asking, what are we going to do with the time we've got until we have to commit to design before manufacture, and until we go testing on the water?

Maximising opportunity

'There's clearly a lot of opportunity, so we wanted to make sure we best used that. We could either sail the old yacht, or there was the proposal for the AC40s – this small class of single design foiling yacht, built by Team New Zealand – or build a test yacht ourselves. Given some of the uncertainties at the time about when the AC40s would become available, and not knowing what sort of opportunity we'd have to experiment with them, we decided the best thing to do was to build a test platform, and use the knowledge we already had about the previous race boat.

'As it turned out, it also proved to be a very useful tool for testing the whole team as an organisation.

It wasn't all plain sailing though.

'We got a number of things wrong with it,' admits Willis. 'We were also late with it, and it was over complex. By the time we got some of the test systems in place on the boat, we pretty much already knew the direction we wanted to go, so it became sort of more confirmatory rather than exploratory.

'I don't think any of that made it any less useful though. To be able to say, 14 months out [from the competition], in early April, we were going to put the boat in the water and go sailing in a sensible way. We achieved that, and I don't think we would have been able to deliver on time, and with the level of reliability, had we not done the test boat in all its detail. We learned a lot as an organisation from a technical point of view, and exercised a lot of the test rigs that we built using the F1 culture.'

America's Cup rules do not allow boats to be tested in a wind tunnel, water tunnel or turning tank, so any aerodynamic testing can only be carried out in open spaces. However, for such things as foil arm control, loading rigs, actuators and other mechanical parts, there is no such limitation. This testing was done at the base on Turweston Aerodrome, where the boat was put together. It was even stress tested there, turning the hull upside down and applying weight. Failures here are significantly less stressful than on the water for the design engineers.

'We took the approach where nothing goes on a car [or boat in this case] unless it's been tested first,' says Willis.

Having built the two boats, the team developed its crew of data engineers to quickly and accurately analyse the huge amount of data coming from the competition boat. According to Ainslie, much of the development work is done between the start of the America's Cup – this year in Barcelona in August – and the main competition at the end of October.

With more than 700 sensors on the competition vessel and around 30,000 data channels, there's a huge amount of data coming from the boat that needs to be curated into information that can be analysed and properly used.

Typically, an F1 car produces a large amount of data per run, which needs to be downloaded, transmitted back to base and plugged into a simulator, so the testing can continue in a controlled environment. It's a similar story in America's Cup competition.

Support act

'We have what we call our Sailing Support Room, or SSR, similar to Formula 1,' explains Ainslie. 'We have an SSR at the base here in Barcelona and another one back in Brackley. The data that comes off the boat goes straight to Barcelona and Brackley. The analysis work starts immediately, in terms of, what are we seeing? If we are not hitting our numbers, why not? Then what can we do? It can be anything from basic straight-line performance to the manoeuvres, so that's incredibly useful in terms of our rate of learning and development.

'The concept is not totally new. We had something similar in 2017 in Bermuda when we had a data stream back to our base, which was then in Portsmouth, but it was not on the same scale, or at the same level of resource, we currently have at Mercedes.'

The current Formula 1 cost cap regulation means a number of engineers and team members have to be re-allocated to other programmes to stay within the limits. These could be other racing series, such as the FIA World Endurance Championship, or, in this case, working on high-performance yachting.

From an F1 engineer's point of view, there are several attractive traits of involvement in America's Cup competition, including more freedom to design, a different set of parameters that the boat faces, as well as interpreting data. Let's not forget that, like F1, these are incredibly competitive teams, for whom winning is the only goal.

Ricardo Pinto / America's Cup

America's Cup – the challenge

Two preliminary regattas were staged in 2023, using the single make AC40 design. A third regatta was then held in Barcelona this August with the senior AC75 monohulls, designed specifically for America's Cup competition.

After those regattas, teams competed for the right to challenge the defending champion team from New Zealand at the Louis Vuitton Cup. There were two round robin brackets, from which the four semi-finalists qualified. The winning boat of the round robin got the opportunity to select its opponent to race, and then, at the conclusion of the two semi-finals, the two victors met in the final. The LV Cup winner then earned the right to challenge the reigning America's Cup champion in a best-of-seven contest held in Barcelona.

'It allows you to take your Formula 1 designers out, give them a new challenge, and it's quite a mentally refreshing challenge… which might lead to a sort of reset on how you tackle problems in general'

Geoff Willis

One of the key challenges, then, is effectively managing the engineers in an unfamiliar environment. That's one of the crossovers from racing to yachting that the F1 team can help with. A grand prix team of the 1990s comprised tens of people, but today that number can be north of 1000. Scaling up is one thing, but to do it efficiently is another matter entirely.

Resource management

Although the America's Cup team is split roughly evenly between yachting engineers and the grand prix team, integrating the increased manpower into an effective unit was one of the hurdles to overcome.

'We certainly wouldn't do anything within the Cup programme that was materially beneficial to a Formula 1 design, but it does two things,' outlines Willis. 'It allows you to take your Formula 1 designers out, give them a new challenge, and it's quite a mentally refreshing challenge. People have to think through a different set of regulations, and that stimulates the [question of] how can I get around these rules? How can I explore these ones? It opens up new engineering problems, allows you to explore ways of dealing with them, maybe ways that you might not have thought of in a different environment, which might lead to a sort of reset on how you tackle problems in general.

'I think we found most of the people that worked, I wouldn't say 100 per cent of them, but the vast majority, probably 90 plus per cent, have found it a very positive experience. It's also a way of retaining really good skill when we're down to this cost cap, sort of micromanagement of the number of people we've been able to use, and to get them off the F1 books for a while.

'We've been able to flood the Cup programme with F1 people when we don't need them in F1, but desperately need them in the Cup, though not for the whole three years. So there's been a lot of use there, and that's clearly beneficial to the cost cap side.'

Platform stability

One of the big challenges the engineers face is accepting the difference between an F1 car that operates on a relatively stable platform, and a boat that does not. Sometimes the seas can be choppy due to wind, other times flat and calm, and each condition, each wind or wave profile, requires a different mechanical set-up to remain competitive.

'They're *very* difficult to sail,' says Willis. 'We've got an extremely noisy environment in which we're doing measurements. So, unlike lap times, where although you see variability due to track conditions, you can pretty much say, if I put this front wing assembly on it's predictably going to be a second a lap quicker. We just can't pick up the relative numbers like that at all on the sea. There's variability in current, waves and wind, which makes back-to-back tests extremely difficult.

'The combination of that, and the fact they're difficult [to sail], you need to build up a lot of statistical basis for your pulling [of] these relatively weak signals of performance improvement. What we've seen, though, is an underlying performance improvement, right from day one, when the boat has been on the water. More recently, that curve has taken quite a strong uptick.

'I think what you do is explore lots of parts, of the sort of operational performance space, and then you begin to learn where the gains are. You go through that routine of understanding, exploring, updating your models, and then updating the quality of the hardware, because you find where you've got a problem, and you fix that. There is clearly a positive feedback mechanism, both in absolute objective performance, but also your ability to extract that performance.'

Secret to success

'You feel you're not making a huge amount of progress at times,' Willis continues, 'but then it starts gathering pace. I'm imagining everybody will be making huge gains [in the run up to the final competition]. So, the same as in F1, the secret to success here is to ensure your development slope is greater than your competitors, because if it is, you'll get there.'

This attention to detail is one area Ainslie believes has been a big improvement compared to previous Cup campaigns.

'It's a lot harder with an America's Cup boat [than an F1 car] because it's much bigger,' says the four-time Olympic champion. 'The rules are effectively more open than they are in Formula 1 so you can't control it in the same way, but we have tried to do that and, in a lot of cases, it's really paid dividends for us. In other areas, though, there's a danger that it just complicates the whole thing, and we can't be doing that.

'The attention to detail, particularly in areas like fluid dynamics, are something we haven't been able to match in America's Cup to date, so that has been hugely instrumental.'

Having spent a great deal of time in the development phase of the yacht this year, the INEOS team is already working towards the next competition, possibly to be held in 2027. Wherever the event eventually takes place, the team has already learned so much in this most recent stage of the project that it is confident it can take even bigger strides in the future. Whether that will be enough to win the next America's Cup remains to be seen as it's well aware that others, including Red Bull, are also busy integrating their F1 expertise into this extraordinary engineering challenge.

'The attention to detail, particularly in areas like fluid dynamics, are something we haven't been able to match in America's Cup to date, so that has been hugely instrumental'

Sir Ben Ainslie, skipper, team principal and CEO of the INEOS America's Cup project

Toto legging it

Mercedes F1 team principal, Toto Wolff, pedalling hard on board Britannia as a cyclor

One of the big changes to the competition this year is that all the boats are using 'cyclors' to generate the energy needed to run the hydraulic power for the control systems for the sails. Cyclors are nothing new to the America's Cup – they replaced the old generators that were powered by human arms, before teams realised legs could produce more power. The target for today's boats is to generate 500kW of power in 20 minutes via the cyclors.

When the INEOS team took Mercedes F1 team principal, Toto Wolff, and driver, George Russell, out on the boat, they found that Wolff could generate an impressive amount of power on the bike. Not enough that they would consider him in competition, but still notable!

ISTOCK/NADIIA BOROVENKO

Super Formula is proud of its more open design philosophy, so what effect has the Japanese championship's switch to spec dampers had? Racecar *investigates*

By JAMIE KLEIN

The thinking behind the change to spec dampers is a familiar one: to reduce cost and level the playing field, but the move has thrown an engineering challenge at teams, and upset some drivers

Common land

Super Formula, Japan's top single-seater championship, has implemented a number of significant technical changes in recent years. The most obvious of these was the change to the SF23 aero package last year, with revised front and rear wings, sidepods, engine cover and floor aimed at decreasing downforce and improving the quality of the racing.

For the 2024 season, a less outwardly obvious, but arguably no less significant, change was made to the cars: the introduction of spec dampers.

Öhlins, which already supplied around half the field up until last year, was awarded the deal to supply the 21-car grid with new dampers, which Super Formula organiser, Japan Race Promotions (JRP), says are aimed at reducing costs and levelling the competitive playing field.

Whether either of those aims have been met with the change is certainly up for debate, but what is certain is that the switch to common dampers has presented teams with significant technical challenges to overcome, and has forced drivers to adapt to an extent as well.

Open damper development had always been an integral part of Super Formula and its predecessors, with the series historically taking pride in maintaining a relatively high degree of technical freedom, certainly when compared to other one-make series such as FIA Formula 2.

Step change

The shift to common dampers therefore marks a step change in philosophy for the championship, with the organisers' idea being to lessen what had been considered a major point of performance differentiation between teams and allow the drivers to make more of the difference.

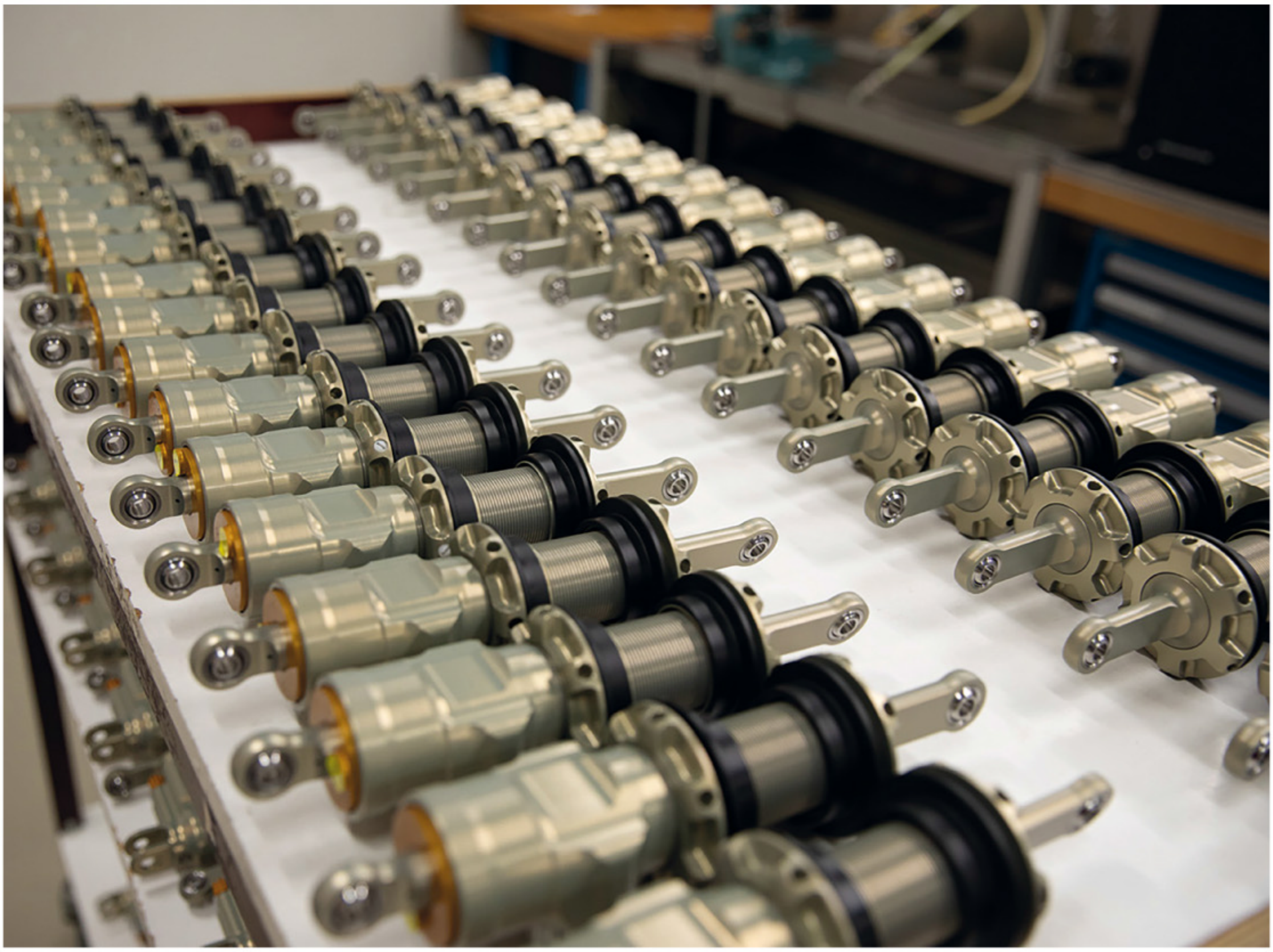
Previously, Öhlins and Sachs were the two main corner damper manufacturers supplying the series, with a limited number of teams also using Multimatic, though Honda team, Dandelion Racing, is rumoured to have manufactured its own bespoke parts. Now, everybody must use the product provided by Öhlins, which had been the supplier of choice for most of the Toyota-powered teams.

Indeed, paddock rumours strongly suggest that TOM'S, Team Impul and Rookie Racing were pushing the hardest for the change, believing it would help them to close the gap to leading Honda squad, Team Mugen, Super Formula's dominant force of recent times.

However, with half the current season gone at time of writing, the evidence that this has been the case is limited. Perhaps that's partly because Öhlins has made an effort to differentiate the new common dampers from those that were in use until last season, in accordance with managing body, JRP's, wishes.

'About half the grid was using Öhlins last year,' explains the damper manufacturer's acting general manager in Japan, Yoshiki Yamano, whose role includes inspecting the dampers used by every team at each race weekend to ensure they are functioning properly. 'But teams at the level of Super Formula have experience of using Sachs, Öhlins and Multimatic. So, even the teams that are racing with Öhlins for the first time this year already understood the capabilities of the Öhlins dampers.

'It doesn't appear that the teams that were using Sachs dampers last year, for example, are struggling. They are able to use the new ones normally.



Öhlins was already a major supplier into Super Formula, with over half the grid using its suspension products. Now, all teams have to buy new units as there is no continuation of the old dampers

'However, because JRP didn't want the teams already using Öhlins products to have an advantage, we have prepared dampers that are slightly different to the ones from last year. All teams are in the first year of using this particular model of damper, so there shouldn't be any teams at a particular advantage or disadvantage.

'Even then, the teams that were already using Öhlins have slightly more know-how, so in theory should have an advantage but, based on what we have seen up until now this season, it didn't appear to be that way.'

Same, but different

So, what exactly is different? The main change from last year's Öhlins products is that the front corner dampers, which have the type number DR30, now use both oil and gas pressure, whereas the previously used TTR30 used only oil. Öhlins claims this helps reduce cavitation (the formation of vapour bubbles) and internal friction.

The rear units, meanwhile, still only use oil, but the TTR30 type is used, instead of the TTR36 which was in action last year.

Tamper-proof stickers are placed on the reservoir caps to ensure teams cannot modify the internals of the damper to gain any kind of advantage, as was previously common practice.

The new dampers still leave plenty of scope for tuning, featuring four-way adjustability and the ability to create near endless damping graphs. Mastering the various possibilities therefore remains a key component of creating the car's set-up.

Rookie Racing engineering consultant, Ryan Dingle, is one of the few non-Japanese engineers involved in Super Formula. He previously worked for Mugen and returned to the paddock this year for selected races alongside his race engineer duties for Toyota's no.8 car in the FIA World Endurance Championship. He explains in more detail some of the challenges associated with trying to find the magic formula with the new Öhlins products: 'It's a bit simpler than before, I would say, but you still have a big selection of damping profiles to choose from, almost infinite.

> **'All teams are in the first year of using this particular model of damper, so there shouldn't be any teams at a particular advantage or disadvantage'**
>
> *Yoshiki Yamano, acting general manager for Öhlins in Japan*

'With Öhlins, you have 50-60 'clicks' in four ways – bump and rebound in both low speed and high speed. You can make all sorts of shapes with that but, as the valving in the damper is now the same for everybody, the effect of each click is more similar between all the dampers.

'You can't affect the properties of the damper itself now. If you want more low-speed damping, for example, you would think you just put the low-speed damping to maximum, but actually the low and high speeds bleed over on each other. So, you have to increase your high-speed damping and drag up this part of the graph as well.

'Likewise, if you just add low speed, you will increase the cut-off point of the high speed just because it bleeds over. So, they are not perfect four-way dampers.'

For some teams, particularly those, like Team Mugen, that were using Sachs

'Now that there are no inerters in the third damper, it has become much harder to manage the car's posture'

Yoshiki Yamano, acting general manager for Öhlins in Japan

Tamper-proof stickers will be placed on the reservoir caps to ensure teams are no longer able to modify the internals of the new dampers, though four-way adjustability means set-up will be key

dampers last year, four-way dampers could be viewed as a retrograde step, as their previous products boasted six-way adjustability, including so-called 'blow-off' functions for compression and rebound. This was a particular advantage at slower circuits like Motegi, where adjusting the damping profile at low speed over kerbs was a particular benefit.

'When you have a kerb strike, or a very fast movement with the damper, you can remove the damping, which can help with kerb riding,' explains Dingle, 'but that's not available any more, so you have to do the best you can to get the same shape of damping as you had before.'

Inerter ban

Another noteworthy change for 2024 is the ban on inerters, which has made it much harder for teams to maintain the same consistency with the tyre contact patch they were used to. Naturally, teams have adopted different approaches to try and make up for this loss.

'Now that there are no inerters in the third damper, it has become much harder to manage the car's posture,' says Yamano. 'It depends on each individual team's way of thinking when it comes to set-up, but there are some teams running the car extremely stiff [to compensate], and others that are running it less stiff and are trying to control the car with the aero.'

If teams were hoping the change of dampers would shake up the order, they will surely have been disappointed

The main difference is the new front units, type number DR30, use both oil and gas for control, whereas the old TTR30s used only oil

based on the evidence so far. Last year, the championship was fought between Team Mugen's two drivers, Tomoki Nojiri and Liam Lawson, as well as TOM'S man, Ritomo Miyata. The only other team to win a race all year was Dandelion Racing.

Small change

At time of writing, the only race winners this year have been Nojiri, Sho Tsuboi (who replaced an F2-bound Miyata at TOM'S) and Dandelion's Tadasuke Makino. *Plus ça change…*

Another noteworthy change for 2024 is the ban on inerters, which has made it much harder for teams to maintain the same consistency with the tyre contact patch they were used to

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With all teams grappling with the new dampers this season, testing became crucial. Shown is Atsushi Miyake of Three Bond Racing

'The biggest change is that your potential rises and falls a lot more than before. The level of inconsistency is much larger. I don't think it's possible to be as consistent as before, so it's tricky'

Tomoki Nojiri, driver at Team Mugen

'It doesn't look like the competitive order has changed all that much from last year,' observes Yamano. 'The fast teams are still able to set their cars up well and produce good lap times and, while this may seem something of a harsh way of saying it, it's clear some teams are still not able to put together their cars that well.'

In particular, Mugen looks to have lost virtually none of its strength from last year, even with Lawson making way for another member of the Red Bull junior stable, Ayumu Iwasa. While problems getting off the start line have severely hampered Iwasa's title aspirations this season, he and Nojiri have proven by far the most reliable drivers in qualifying. In terms of sheer consistency and reliable points scoring, no other team has come close to matching them.

Tomohiko Koike, the race engineer assigned to Lawson last year, who now oversees Iwasa's side of the Mugen garage, says that early efforts to try and recreate the behaviour of last year's dampers didn't pay off during pre-season testing, but that a change of approach ahead of the start of the season paid dividends as Nojiri won the season opener.

'In terms of the Suzuka test, we tried to adjust the damping of the new dampers to make it more similar to the old [Sachs] dampers, but it didn't work well,' admits Koike. 'After that, we changed our mind and tried to use different damping.

'The biggest difference is low-speed damping, especially the front corners. The maximum level of damping on the front and rear corners is limited by Öhlins, so the total level of damping [force] is less than last year, which creates a problem.'

Efforts to recreate the behaviour of last year's dampers proved unsuccessful, so teams had to adopt a clean sheet of paper approach

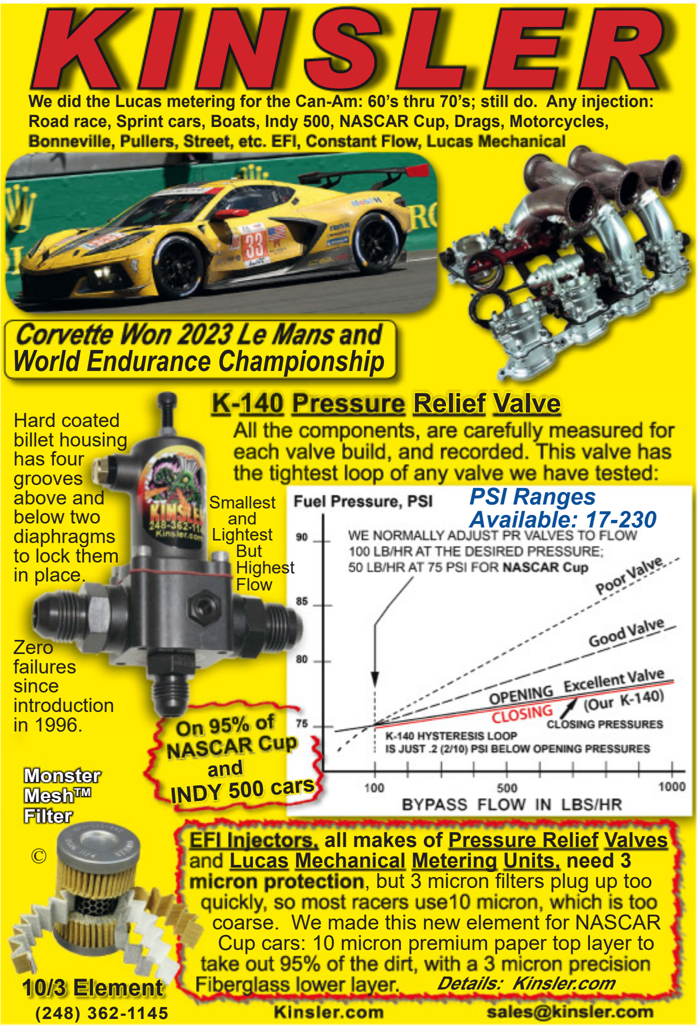
Koike isn't certain that Mugen's advantage will last, however: 'The current situation is that we have better damping than other teams, but I think it's just for now. Next year, the other teams will have more data and maybe they will adopt more similar damping.'

Driver opinion

The irony of Nojiri kicking off his quest for a third title in four years with a victory at Suzuka was that, pre-season, he was vocal regarding his dislike of the feeling of his Mugen mount with the new dampers. At the halfway point of the season, his views haven't changed: 'The feeling is still the same,' he says. 'Autopolis was a really hard race for me, partly for that reason, and it was the same in free practice at Sugo. The biggest change is that your potential rises and falls a lot more than before. The level of inconsistency is much larger. I don't think it's possible to be as consistent as before, so it's tricky.'

It used to be common practice in Super Formula for teams to take their supplied dampers apart and improve them in various ways but, as that's no longer possible, Dingle believes this is another reason why some drivers are experiencing car behaviour they are not used to.

'You are also limited in your ability to account for the friction in the damper,' he says, as a man who knows Nojiri well from his time serving as the ARTA Honda team's race engineer in Super GT from 2020-'22. 'In Super Formula, damping is used for body control a lot. You can get very different movements based on how the damper is put together, the oil used, the seal, and how many miles you've done. These parts were open before.



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'The problem you run into with the standard Öhlins dampers is they don't provide predictable enough damping in the very low-speed range, not with the seals and oils that are being used. You can see how drivers feel like the car is moving more.'

Stable performance

Nevertheless, even if the feeling inside the cockpit for some drivers has changed, the data so far in 2024 suggests the ultimate performance of the world's fastest single seaters outside F1 hasn't dropped significantly.

The switch to the SF23 aero package had a far larger effect, resulting in across the board lap time increases in qualifying of anything up to 1.5 seconds, depending on the circuit. This year, the increase has been less than half a second.

'Body control is the thing the drivers feel the most, but in terms of actual contact patch variation, load variation and ride height variation, you could come up with something that is giving you very similar performance, excluding the inerters,' continues Dingle. 'Because you can get something similar, from a non-driveability performance standpoint, you should have the car in a similar window. You can control ride height variation similarly. It's just down to the ability of the driver to extract the performance.

'You need to look at other aspects of the car to stop these movements, but these are difficult to stop elsewhere without impacting overall performance. By making the car stiffer, using the springs or bump rubbers, you will have other issues.'

Nojiri is one of the most perceptive, even bordering over-sensitive, drivers on the grid in terms of car feel and indeed this is part of the reason for his spectacular success over the past three seasons. For all his complaining, the numbers don't lie. Nojiri led the 2024 championship at time of writing, and Mugen remains the absolute benchmark team. That's due to a whole host of reasons, including its financial resources, its proximity to Honda, the fact it supplies engines to all the Honda-powered teams and its unrivalled depth in engineering talent. That vastly outweighs any disadvantages that have resulted from the switch to common dampers.

'Nojiri's driving has evolved, and he has a wider scope than he used to,' says Dingle. 'So he can cover what used to come from the damper. He will tell you the car feels like shit, but the performance is still there. It's not the main aspect that is driving the performance of the car.'

At what cost?

This might lead you to question whether Super Formula's switch to common dampers was really a good idea. While there is some

There are fears that common dampers will lead to a dumbing down of Super Formula, inhibiting the development of new engineers

evidence that the weakest teams on the grid are closing the gap to the top of the grid, this is more likely down to personnel changes and a concerted effort by these teams to focus on improving their engineering capabilities.

From a cost point of view, *every* team has had to invest in new dampers and, while in theory these costs should be amortised over time, it's unclear how long teams are expected to keep their current dampers, or if Öhlins has plans to update the specs.

In any case, the cost saving is minimal, and will surely be ploughed into other areas that will generate performance.

Perhaps more significantly, there are fears that common dampers will lead to a dumbing down of Super Formula, inhibiting the development of new engineers. When you consider that the knowledge of the engineers is ultimately passed on to the drivers, it could undermine Super Formula's reputation as a 'graduate school' for budding F1 and IndyCar drivers. The case continues.

Even if the feeling inside the cockpit for some drivers has changed, the data so far in 2024 suggests the ultimate performance of the world's fastest single seaters outside F1 hasn't dropped significantly

There are many in motorsport who argue that spec parts are not the answer, and the jury is still out on the new dampers' effectiveness in reducing cost or shaking up the order in Super Formula


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Magnetic appeal

Suspension testing specialist, LABA7, is shaking up the market with its electromagnetic damper test system

Lithuania is not the first country that springs to mind when you think about motorsport. Its most famous contribution is probably the Palanga 1006km, an unusual sportscar race held on a closed public highway that today features GT3 cars. However, dig a little deeper, and it becomes clear that the Baltic nation has quietly become home to a rising star in suspension testing: LABA7.

The company, based in the capital city, Vilnius, has already made a name for itself as a specialist in high quality suspension testing and servicing tools. Established in 2018 to develop and deliver high quality equipment such as Scotch-Yoke dynos, spring rate testers, corner weight scales and suspension bleeders, it is now disrupting the market further with its new electromagnetic-actuated damper test system, the EMA, which promises to raise the bar in terms of suspension testing technology. Combining cutting-edge technology, affordability, and a user-friendly design, the EMA delivers superior performance and value.

Each LABA7 electromagnetic damper test system comes with its own dedicated power supply unit

Precision testing

One of the EMA's most innovative features is the integration of its control unit and data logger into a single board. This design allows the system to sample test results at an impressive 20kHz, avoiding possible phase shifts and ensuring data accuracy. The EMA controls electromagnetic motors and records data with precision down to a nearly imperceptible 50nm, detecting even the smallest changes in damper performance.

For motorsport teams, where every millisecond counts, having a testing system that delivers precise, repeatable results is invaluable. LABA7's EMA is designed to do just that, offering exceptional accuracy and control.

Speed and power

Despite its meticulous precision, the EMA can also test dampers at extreme speeds and loads. It achieves a maximum velocity of 7m/s and can withstand an impressive acceleration of 40*g*.

LABA7 founder and CEO, Andrius Liškus

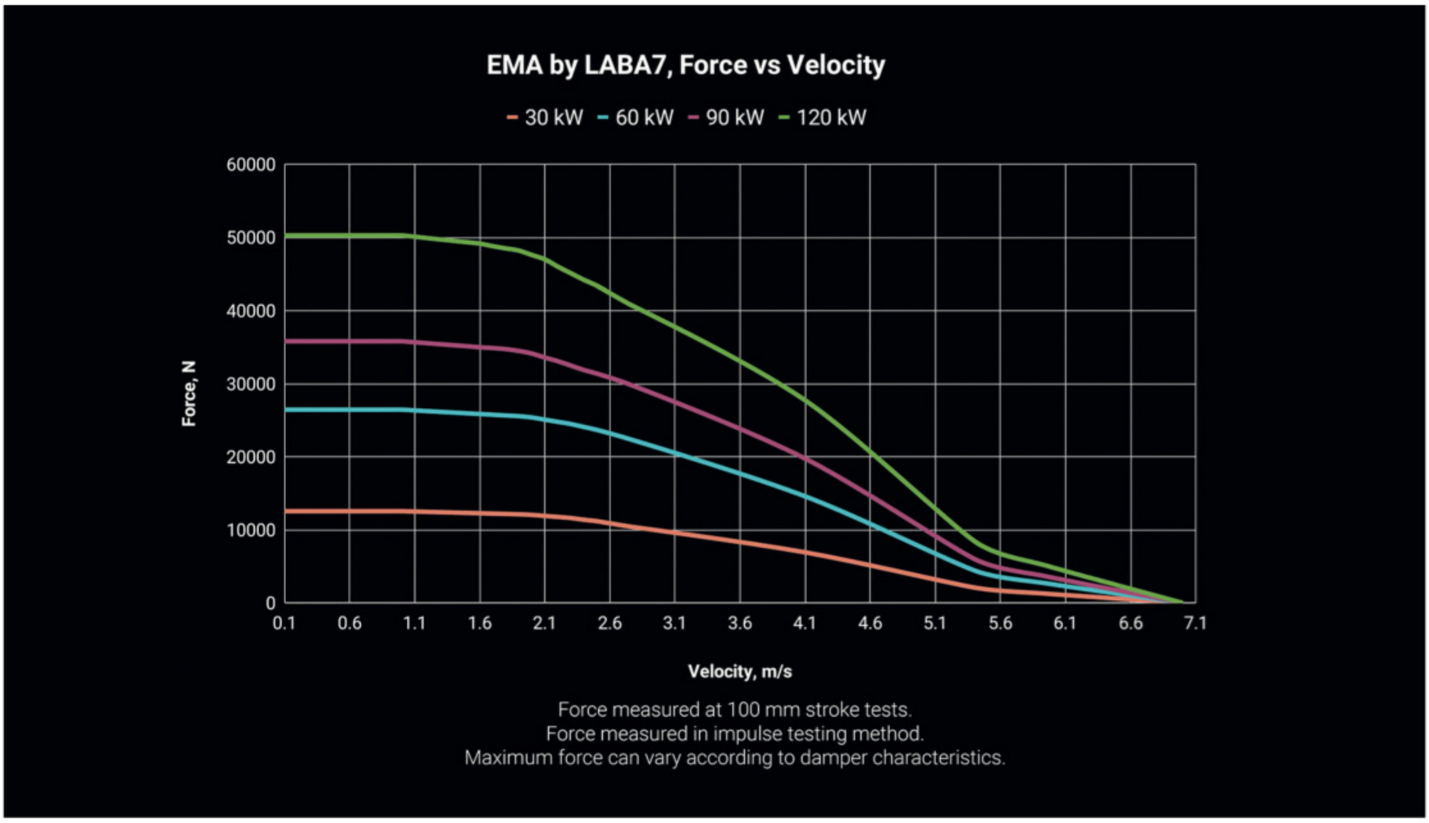
At the lower end of the spectrum, it can test dampers at just 1mm/s, essential for measuring seal drag and friction.

LABA7 offers the EMA in four models. The entry-level 30kW model delivers a peak force of 11.9kN at 2m/s, which is more than sufficient for most suspension systems. For those needing more power, the top-tier model produces a peak force of 45.4kN, ensuring robust testing capabilities across a range of applications.

Another standout feature of the EMA is its innovative power supply unit. Traditional electromagnetic shock dynos require high voltage and amperage inputs, often needing expensive and specialised infrastructure.

LABA7 solved this issue with a unique solution that stores energy in supercapacitors, releasing it only when the system is active during testing. As a result, EMA models can run on standard three-phase 380V / 8-16A inputs.

The top-tier model produces a peak force of 45.4kN, ensuring robust testing capabilities across a range of applications



Graph showing relative velocity and force capabilities of the four current EMA damper test system products, each one represented by a different colour curve

The smallest model can even be optimised to run from a standard 220 / 240V socket, making installation simple and cost effective.

Streamlined with software

LABA7 has designed the EMA's software for ease of use. While it may sound like a cliché, the focus on user experience has resulted in an intuitive and easy-to-navigate interface, significantly reducing the learning curve for the user.

Motorsport teams are likely to appreciate the ability to edit custom waveforms before testing. This feature allows the operator to easily trim track data after importing it from telemetry devices. Focus on specific segments of a course can be invaluable when testing damper performance for specific real-world racing scenarios. Due to its high accuracy, the EMA can test any shock absorber and replicate a wide range of conditions, exposing the tiniest discrepancies in damper performance across a wide range of standard waveforms such as sine, triangle, square and pulse.

After testing, the software facilitates in-depth analysis by allowing operators to overlay individual cycles and slide graphs, making it easy to pinpoint performance gains or losses. In addition, the system integrates seamlessly with external sensors and other testing equipment, allowing for a comprehensive evaluation of damper performance.

Another valuable feature introduced by LABA7 is a cloud-based shock dyno library. This service simplifies storage, sharing and analysis of data across multiple departments, and supports test data from both the EMA and Scotch-Yoke dynos.

The EMA's modular design and remote troubleshooting capabilities also make maintenance simple and cost effective. LABA7's Fast-Fix warranty further ensures quick resolution of any issues, with spare parts typically dispatched within a week, minimising the amount of disruption to motorsport teams' test and race schedules.

Unlike hydraulic shock dynos, which require frequent maintenance due to potential leaks and fluid replacements, the EMA's electromagnetic design involves fewer mechanical components that wear out over time. This not only reduces downtime but also slashes the overall cost of ownership.

Competitive edge

What truly sets the EMA system apart, though, is its affordability. Priced from €50,000 (approx. $55,170), it costs less than half compared to competitors' products. LABA7 says it has been able to keep the cost down by minimising reliance on third parties.

As motorsport continues to evolve, the demand for precision, efficiency and cost effectiveness in suspension testing is greater than ever. LABA7's EMA is a groundbreaking solution that meets these demands head on.

'The EMA system represents a new benchmark in damper testing,' says Andrius Liškus, founder and CEO of LABA7. 'We combined high precision, energy efficiency and user-friendly design to create a tool that not only enhances performance but also makes advanced suspension testing accessible to more motorsport teams.

> **'Our focus with the EMA system was to deliver cutting-edge technology without the high costs typically associated with advanced damper testing'**
>
> *Andrius Liškus, founder and CEO of LABA7*

'Our focus with the EMA system was to deliver cutting-edge technology without the high costs typically associated with advanced damper testing. By simplifying installation and reducing maintenance, we're giving motorsport teams the tools to push performance limits without breaking the bank.'

By offering unmatched accuracy, energy efficiency and ease of use, all at a highly competitive price, LABA7 is positioned to become a key player in the motorsport testing landscape.

For teams seeking to gain a competitive edge – and point out a team in any form of motorsport that isn't – the EMA range sets a new standard in damper testing, pushing the boundaries of what is possible on track. With these developments, LABA7 is helping to put Lithuanian engineering expertise on the map.

Shock to the system

How R53 Suspension, a relatively unknown British manufacturer, has been taking the fight to the big players in the high performance damper market

By MIKE BRESLIN

If there is a motorsport equivalent of the term 'by royal appointment', it might be 'as used by Gordon Murray', because the former Formula 1 designer, now hypercar builder, is famously picky when it comes to the parts he uses on his cars.

So, when he selected R53 coilover dampers for his T.50 road car, the world of high-performance engineering sat up and took notice. After all, there is no shortage of established damper manufacturers, so why opt for one most people had never heard of?

The answer is, of course, that R53's IL46 damper simply ticked all the Murray boxes. The same is true for companies and teams operating in many motorsport markets too, with R53 now supplying its products to rallycross, off-road, circuit racing – notably GT and Formula E – and a host of other categories besides. To be able to achieve all this from a standing start, in just over 15 years, against a host of established rivals with many decades of experience, meant bringing a whole new approach to damper design and manufacture.

Naming convention

It all started in 2008, when Roger Estrada and three others set up R53 in Royal Leamington Spa, Warwickshire, as a motorsport engineering concern – although it has been largely focused on suspension since 2015.

As to the intriguing name, this comes from Estrada's past in his native Spain: 'It's 53 because in the '90s I used to race stand-up jet skis,' he explains. 'I was a Spanish champion, and that was my race number. The R is for Roger, or maybe now racing.'

Estrada first developed an interest and expertise in dampers at university, where they were the subject of his dissertation. He then worked for high-end factory motorsport organisations like SEAT in Spain – where he designed the WRC Safari Rally spec for the Córdoba – before moving on to Mitsubishi and its WRC programme in the UK.

'I learned a lot about dampers in rallying, for sure,' Estrada says. 'At the time, I was fortunate to be able to work with great drivers [including Tommi Mäkinen] and great engineers. With rallying, you need a car that gives confidence to the driver, that can work in different conditions, and you cannot just have the optimum damping for a particular corner, or a particular stage. It needs to work everywhere.

'In rallying, I also learned how to translate what we see on the dyno, what we see on the data, what the drivers feel on the car, and then also what I can feel on the car. That is how we can reach a good solution.'

When Estrada says, 'what I can feel on the car', he means exactly that: 'At Mitsubishi, I would often ride along in the passenger seat,

Former Mitsubishi WRC engineer, Roger Estrada, set up R53 as a general motorsport engineering company in 2008, but it has focused on dampers since 2015

'I learned a lot about dampers in rallying, for sure… you cannot just have the optimum damping for a particular corner, or a particular stage. It needs to work everywhere'

Roger Estrada, managing director at R53 Suspension

Gordon Murray Automotive opted to use R53 dampers in its ultra high-performance T.50 road car, which was a massive coup for this little known suspension company based in Warwickshire, UK

'I will still go in the car as a passenger on the disciplines that we can do this, to evaluate the performance of the dampers. That's a big added value we can bring at R53, and it's something different'

Roger Estrada

R53 dampers have been proven in some of the toughest environments on earth, thanks to the company's involvement with South African Dakar buggy producer, Century Racing

R53's distinctive dampers can be found on an increasing number of rally, rallycross and off-road cars, but the company also supplies products to the circuit racing and high-performance road car markets

to see if I could feel what the dampers were doing,' he recalls. 'Now, I will still go in the car as a passenger on the disciplines that we can do this, to evaluate the performance of the dampers. That's a big added value we can bring at R53, and it's something different.'

Flow motion

Something different was exactly what was required to break into the highly competitive world of high-performance dampers.

'We knew the competition were at least 30 years ahead of us,' admits Estrada, 'but we cannot go back in time. We accepted we were 30 years behind, so we needed to do things differently to the others, because otherwise we're always going to be 30 years behind them.

'This also meant we had the freedom to start with a blank sheet of paper, and one of the main things we did was started designing using CFD, for the inside of the damper.'

While it's not unknown for a high-end damper company to use CFD to evaluate flows of oil and nitrogen within its products, R53 took things a step further.

'We pushed it further because we felt we had to,' says Estrada. 'There are now a lot more tools available, more powerful simulation tools. We started designing, doing a lot of CFD simulations and calculations, basically to try to catch up on the 30 years we were behind, to be able to understand quicker. By using this method, we have managed to reach the level of the other companies very quickly.'

With that in mind, it's no surprise to learn one of the key technologies at the heart of R53's dampers is called Optiflow, which is obviously derived from the CFD work, and is all about managing turbulent and laminar flows within the damper to achieve the optimal pressure distribution. Consequently, every internal part of an R53 damper is designed to optimise flow, especially the pistons, though using the right hydraulic oil is also a crucial part of the programme.

Optimum oil

'It was very important for us to have our own oil,' Estrada says. 'We wanted very specific characteristics, so we analysed what was on the market, and found a small-ish oil company whose base product was already near to what we needed, so we approached them.

'It's a synthetic oil,' Estrada continues, 'and they have a very good technology in the oil; it's a nanotechnology that helps reduce friction. That means we generate less heat, and we are more efficient.

'Their base oil was already good, but we asked for a few extra things, which for them were easy to add. I'm pretty confident we now have one of the best oils out there.'

Some of R53's dampers also feature its hydraulic adjustable bump stop technology, which it calls HBS. This replaces conventional hard bump stops with a hydraulic cushion, which can be tuned for 'load, engagement and progressivity', says Estrada.

R53's ST60 damper. Each unit is designed with CFD to optimise internal flows, while the company also uses a bespoke synthetic oil to reduce friction

While this technology has obvious benefits in off-road applications, so far it's not been used much on track.

'In circuit racing, they're not ready yet to see the benefits of this, but it's a huge benefit for sure,' says Estrada.

Materials used in the construction of R53's dampers include aluminium, aerospace steels, high tensile stainless steels and very little titanium, mainly because the latter is banned in most forms of motorsport. Meanwhile, the company is also developing a 3D-printed damper (see box out below).

The finished dampers contain between 150 and 200 individual parts, but what makes this particularly impressive is that each individual component, apart from the o rings, is made to R53's own design and specification, and that includes the springs.

Those springs come in a rather striking orange, which is no accident, as there's a strong design element evident at R53.

'We put a lot of effort into making our product aesthetically pleasing, because it's important for customers,' Estrada says. 'But also, it's very important that we have a distinctive branding. We want people to recognise that when you see a damper on a car with orange springs, it is an R53 damper. That is our trademarked orange. Other companies have their own colours, but we want to be known as the orange damper.'

That orange is now being seen on more and more cars, but no top team or manufacturer is going to choose a damper on the colour of the springs. The product needs to work, and work well, but R53 has already proven itself in this respect.

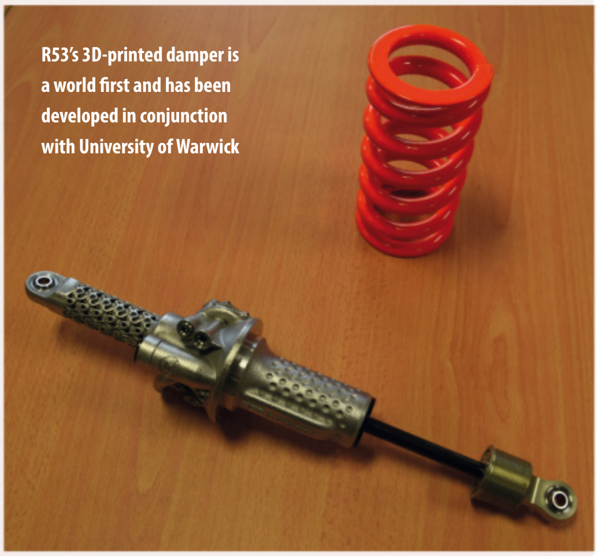
Key customers

Estrada believes there are some notable business relationships that have been crucial in bringing R53 up to speed as a successful damper concern: 'For somebody to make the leap to go to a new manufacturer for something like a damper, which they then have to homologate, it is a big step,' he says. 'So that was a big hurdle we knew we had to overcome. Fortunately, we found three companies willing to take that "risk".

'One is McLaren. We did a road car for them [the Artura], while in motorsport, there were two key customers. One is OMSE [Olsbergs MSE], run by Andreas Eriksson, the number one company in rallycross in the world. He stumbled upon us on a track where we were testing. Just by chance, he was there, and he saw what we were doing. Before that, he had never heard of us. He came and asked questions and it just so happened that we had some dampers that would fit their car in the van. He fitted them, straight out of the box without having done much work – we just did some quick calcs there and then and were lucky that they were the right lengths.

The company has gone to a great deal of effort to stand out from the crowd, both in internal and external design, and is helped from a visibility standpoint by its trademark bright orange coil springs. Pictured here is a unit in place on the Gordon Murray T.50

Another dimension



R53's 3D-printed damper is a world first and has been developed in conjunction with University of Warwick

Alongside its wide range of conventional metal-bodied dampers, R53 has also developed a 3D-printed damper.

'We are the first damper company in the world that has made a fully working damper using metal additive manufacturing,' notes Estrada. 'We worked with University of Warwick to develop our own process, and our own material selection, to be able to produce something that is as strong as aerospace aluminium but 30 per cent lighter and 40 per cent more efficient.

'Because it's additive manufacturing, we can integrate a lot of the components into one single piece. So you can incorporate components rather than having to build them into the damper. Also, it is a lot more efficient because of the shapes we can produce, some of which are simply not possible with traditional machining.'

Estrada believes this could be the future for some damper applications, and R53 is now looking at reducing printing times, which will also reduce costs. Meanwhile, the company, alongside the university, is experimenting with new technologies to further develop this exciting project.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'He did a back-to-back test and, on a 42-second track, driven twice – because the guy couldn't believe it – we were more than 1.2 seconds a lap faster than with the dampers he was previously using.'

Through its subsequent relationship with OMSE, R53's dampers are now used in various rallycross disciplines, including Nitrocross and RX2e, but they are also starting to build a reputation for themselves on the Dakar and off-road scene. This came about after R53 was contacted by Julien Hardy, the team manager at South African off-road car constructor, Century Racing.

'We were thinking of designing a damper for off-road and he said that when we had built it, they would test it for us,' says Estrada. 'That was incentive enough for us to go and design that damper, because it's difficult to get dampers tested and validated. We sent them to South Africa and – bear in mind this was a brand new design for us – he fitted them straight away and then called us later that same day, saying, word for word: "Are you guys for real? In the 20 years of my career, I never, *ever* had dampers come from DHL, put them on the car and they're ready to race."'

And race they did, the following weekend, winning the event and beating a number of factory teams in the process.

Estrada says these two companies, OMSE and Century, both now key customers, will always have a special place in the history of R53, 'because they were the ones that allowed us to show what we could do'.

However, we mustn't forget Gordon Murray.

'They didn't know about us, nothing at all,' admits Estrada. 'They told us their plans [for the T.50] and asked us to send a sample damper, which we did. They had several [suppliers] to choose from, because obviously everybody wanted their dampers on that car. And then one day they called us and said, "Gordon likes your dampers."'

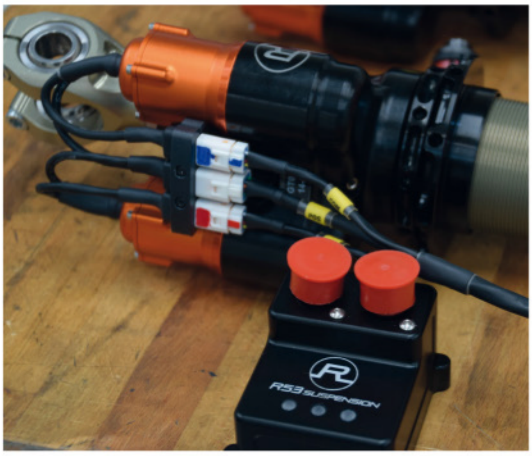
For a relatively unknown company to secure a contract to supply such a high profile vehicle with dampers was quite a coup, and it says a lot about the philosophy of the car that Murray went for what he considered to be the best, rather than a name that might look good on the spec sheet of the £2.8m vehicle.

Race ready

R53 now also has a presence on the circuits, including an involvement with the Revolution A-One sports prototype and also Formula E, the latter chiefly through its supply of throttle dampers (see box out on p69), which Estrada describes as 'F1 tech available to everybody.'

Naturally, F1-level technology comes at a price, and Estrada admits that R53 products are not the cheapest. They are priced for the market they are in, and a big selling point is the dampers come pretty much ready to use, which ultimately cuts costs for the user.

'When we deploy a damper, it's 90 per cent there,' says Estrada. 'So the customer, very nearly, doesn't have to do anything. It's difficult to convince somebody of this, though, because they're not used to it.



Electronically-controlled dampers are just one of R53's many products, all of which have gone through a stringent quality control process

There are between 150 and 200 components in an R53 damper, and pretty much every one of them is made to the company's own design and specification, and that includes the coil springs

Swedish rallycross powerhouse, OMSE, was an early convert to R53 dampers, and now Estrada's firm supplies a number of series in this discipline, including Nitrocross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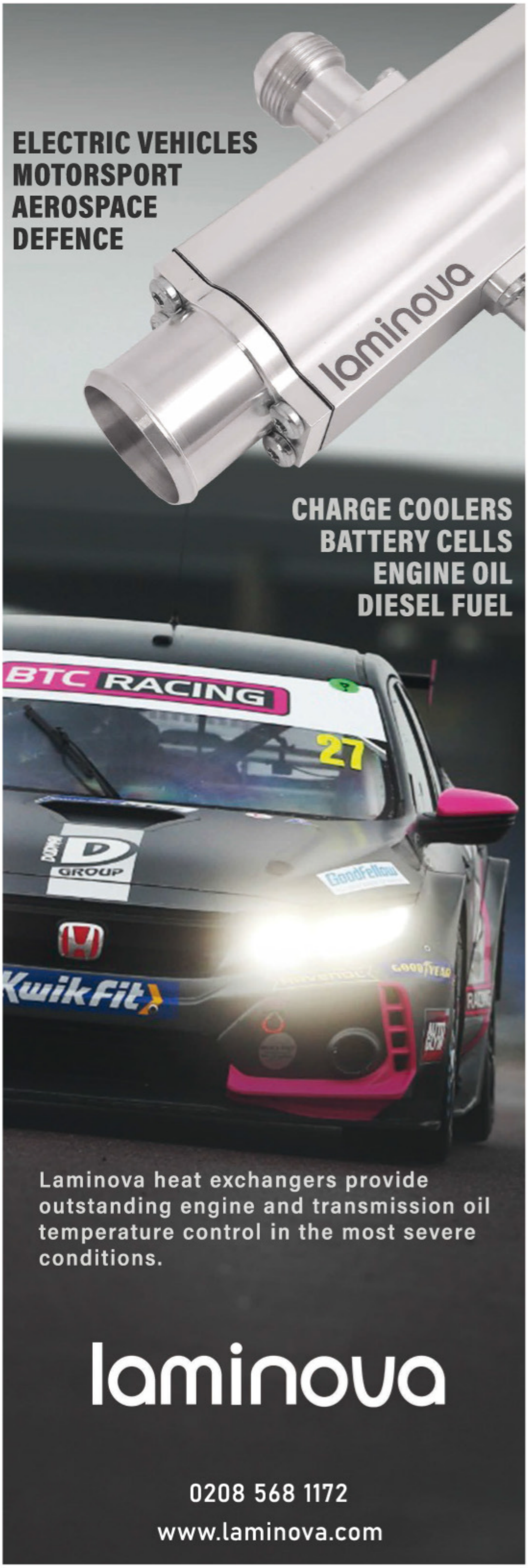
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They're used to buying a damper from our competitors that they then have to re-tune, to re-valve, but that costs money, and time. With ours, the process is a lot quicker.'

Currently, there are around 25 people producing these ready-to-race dampers at R53, and Estrada is keen to expand the workforce. To begin with, however, it was just three others working alongside Estrada, and these three still play a major role in the firm.

'There is head of engineering, Diego Lopez,' says Estrada. 'We have the head of R&D, which is Christian Bowman, and we have the guy that runs all the production in the workshop, Roger Smith.'

Quality control

At the factory, prototype dampers are produced from scratch by someone from the R&D side of the operation, but when they go into full production they are built up from sub-assemblies. Indeed, the facility itself is basically all about design and assembly, because all the machined parts are brought in from local CNC operators. This means that goods-inwards quality control is a vital part of the process.

'On the inwards side, obviously we only work with suppliers that we trust,' says Estrada. 'But we also put in quality controls at their production facilities, and they supply us with a huge quality control report. Even so, we still check all the parts when they arrive.

'Then, when we build a damper, we know from which batch a part came. It is all electronically controlled in terms of which quality report, which purchase order number, and so on. We know *exactly* which part is going on any one damper.

> **'We have the technology to do Formula 1. We have the capabilities to do it, and we are based 30 minutes away from six teams. The thing is, they don't know we exist'**
>
> *Roger Estrada*

'We also try to design and engineer the quality into the part, by making sure that we work *with* the supplier, so it is easier for them to achieve the required tolerances,' Estrada adds. 'We've involved a lot of the suppliers in our design process, and that's something I learned when I was at Mitsubishi, that you have to design the quality, not expect the supplier to make you the quality.'

That's not the only lesson Estrada has taken from his time working for, and with, larger car companies into R53, and it now works to an impressive collection of quality standards and processes, including ISO9001, APQP, FMEA, DFMEA, PFMEA and PPAP.

'We are using the processes of the large tier 1s, but adapted to low volume, and this is one of the reasons we are doing so well with high-performance road cars,' Estrada says. 'It means we can still be very reactive, like a motorsport company, but also use quality processes more usually found in tier 1 companies. We have adapted from the high volume to the low volume, so we can have the best of both worlds.'

Due diligence

'We can do the due diligence to give customers confidence that this has been done in the same way that it would have been done for a part that you make a thousand an hour, but adapted to the volume. That's the big differentiator.

'So, for example, the Gordon Murray car, all these low-volume cars, they need dampers, but they are sitting in a no man's land because they can get a motorsport company to make a few dampers as one offs, but then do they have the consistency, the quality, the batch control? Or you go to the other extreme. You have the large tier 1 suppliers of this world that supply all the big OEMs like Ford, Volkswagen and JLR [Jaguar Land Rover]. They do all this, but obviously it'll take two years and cost several million.'

Quality control does not stop with processes, of course, and every completed damper is also physically assessed on one of the firm's six test dynos. 'We have a five per cent tolerance plan, and basically the dampers need to fit inside this on every single speed,' Estrada explains. 'There's a curve, which is the centre, and then we create plus and minus either side. That's why it's so important for us to get our inwards quality control right. If you have 150 components, or more, all with their own tolerances, to be able to hit this five per cent tolerance for the completed damper is very, *very* difficult.'

Development dyno

As well as the test dynamometers, R53 also has a purpose-built, multi-frequency development dyno, which can do track replays and operates at five metres per second. This was a large investment for the firm, but is just the sort of thing that's needed if the company is to fulfil Estrada's ambition of supplying dampers to Formula 1.

'We have the technology to do F1,' Estrada says. 'We have the capabilities to do it, and we are based 30 minutes away from six Formula 1 teams. The thing is, they don't know we exist.

'We also have technologies that Formula 1 has never seen that we use in other disciplines that will help them immensely, especially in terms of control, because our dampers are very good in controlling the platform of the car. Which is everything in F1.'

The question is, then, with one Formula 1 great already persuaded when it comes to the efficacy of R53 dampers, how long before the current teams come knocking at the door?

Throttle control

Designed to give drivers more accelerator 'feel' in a world of fly-by-wire, R53's throttle damper is a little larger than a pen, and is an exquisite piece of engineering.

'Throttle dampers have been used for many years in F1 because while they do have a return spring on the throttle, a damper is needed to help modulate the power delivery,' says Estrada. 'A spring is position dependent: depending on which position you have, it gives more or less resistance. However, a damper is a speed-dependent device. So, depending on how fast you apply the throttle, you get a different feedback. If it's very slowly, you have just a spring. If it's fast, then you have more resistance, you have a different feel. That helps drivers to modulate the throttle.'

Formula 1 teams make their own throttle dampers, but Formula E required a cheaper approach and also something that was very robust.

'With an electric car, it is even more important, because of how you deliver the torque,' continues Estrada. 'So we looked into it, and then we made one, and it's been on every single Formula E car from the Gen2. All the cars have our throttle dampers.'

It's not just for FE, though. The R53 throttle damper is used in Nitrocross and is available for other cars and series, too.

'We also run it in off-road racing, but for a different purpose,' says Estrada. 'We configure it differently, because it's all configurable, so that it helps to reduce driver fatigue.

'We are probably the only damper company in the world that has a throttle damper available off the shelf. There are some other solutions out there, but they are often like the dampers on the boot of your car. Ours is a proper nitrogen-filled damper with shims, but then we are taking it to the ultimate level.'

R53's delightful little throttle damper is used by Formula E


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Druck

Sensors are important, but ensuring those sensors are calibrated and giving consistently accurate readings is just as vital

Pressure environment

Druck pressure sensors, temperature monitors and calibration tools continue to set the standard

Accurately measuring a racecar's vital functions and fluids helps to minimise the risk of serious failure and keeps the vehicle operating to its highest performance level at all times.

Pressure sensors are key to this, taking measurements and relaying the recorded information through an electronic output and display. Using the sensors and keeping them in good working order makes the racecar more predictable to set up and more likely to produce consistently quick lap times.

Druck, a Baker Hughes business, stands at the forefront of pressure and temperature sensor technology. Since its formation in 1972, the Leicester-based firm has developed, manufactured and delivered its innovative sensor solutions internationally to customers in a wide range of sectors, including aerospace, transportation and meteorology.

Since 1990, it has also been deeply involved in high-level motorsport, where many different aspects of the racecar need monitoring with absolute precision. Druck's motorsport pressure sensor and calibration portfolio has been used by front-running teams in major series and applied to a multitude of disciplines such as single seaters, sportscars, electric racing and off-road. The company's three and a half decades of motorsport experience mean it can adapt quickly to the demands of different vehicle properties, as well as various pressurised fluids such as coolants, fuels and oils.

Sensor technology

Modern racecars are covered in sensors. Motorsport is therefore a suitable high-stakes environment where sensor technology can be applied and showcased.

The racecar powertrain is a neat starting point and contains several sensors for different functions. An important one concerns engine oil, which lubricates the moving parts of the power unit to prevent friction that could cause performance-reducing wear. The oil is pumped under pressure into the cavity between the crankshaft and the bearings to stop them from grinding against each other. Pressurised oil also helps to regulate the engine's temperature, dissipating large amounts of heat. Sensors are therefore required to monitor both oil pressure and temperature. Druck's solutions are designed to function well in harsh environments such as high temperatures and high-vibration scenarios.

For example, Druck's PMP4400T serves as a combined pressure and temperature sensor, saving the weight and packaging of separate components. The 14.5mm diameter unit is made of stainless steel and can withstand temperatures up to 185degC.

The PMP4400T is also suited to monitoring the pressure and temperature of the fuel system, pneumatics, coolant and crankcase. Fuel pressure, for example, needs to be kept in a sustained 'Goldilocks' zone – not too low and not too high – to ensure the engine combustion chamber is not starved or overfed. Either causes a reduction in overall engine performance, so the sensor plays a vital role in making sure the system works to its full potential.

Turbocharged engines require a sensor to control boost level to optimise performance, and to adjust engine parameters depending on how much boost pressure is in the manifold. If the sensor records a pressure spike or drop, it will display a warning to the user, alerting to the prospect of an issue before damage is inflicted.

Keeping the car running well is one thing, but stopping it is equally important. Sensors can also be used to measure brake pressure; the right amount ensures adequate braking force to slow the car down without locking the wheels. Here, the PMP4400T can also be applied.

Data retrieved from the sensor gives clues as to how the brake balance is changing the car's characteristics and constantly monitors brake temperature.

While the PMP4400T is a two-in-one solution, Druck gives its customers the option of measuring pressure without temperature. This can be achieved with the PMP4200, the configurable PMP4300 or the most advanced pressure-only sensor in Druck's range, the PMP4400.

Electric application

The casing in which batteries for electric racecars are housed requires monitoring to ensure the integrity of the pack. To protect the batteries, a modular pressure controller, such as those in the Druck PACE range, can pressurise the casing to 3bar and inform the user if any leaks occur.

The internal pressure of the case can also be monitored using the Druck ADROIT6000 sensor. The PACE5000 controller has a single channel pressure controller chassis and a navigable, colour, touchscreen display.

The follow-up PACE6000 model features a dual channel pressure controller chassis, and can be used in single, auto ranging or simultaneous dual pressure control modes if fitted with two PACE CM control modules.

Since 1990, Druck has been deeply involved in high-level motorsport, where so many different aspects of the racecar need monitoring with absolute precision

Tyre pressure windows are a common feature in championships worldwide, with suppliers providing their own recommendations for safe maximum and minimum pressures at each track. To stay within these margins, a team might use a handheld sensor, such as the Druck DPI705E with its 0.025 per cent FS (full scale) accuracy, to check tyre pressures before sending the car out.

Sensors are clearly indispensable tools, but only when they are displaying accurate information. Testing and calibration equipment helps to ensure sensors maintain their accuracy and don't lead engineers down an incorrect set-up rabbit hole, or incur penalties for operating outside a stipulated pressure range.

In addition to its sensors, Druck manufactures a range of portable, hand-held calibration devices. Its products include the DPI610E, a pressure sensor calibrator with accuracy and stability up to 1000bar, and DPI620 GENii, which is an all-in-one calibration solution especially suited to engine monitoring due to its 0.0185 per cent of FS accuracy. This device can be used in tandem with the PV643 pressure generating base station.

Software package

Druck's sensor and calibration hardware is complemented by a software package called 4Sight2. This bespoke tool displays all the required information from the sensors and enables engineers to calibrate their equipment for lasting accuracy. Users can create a comprehensive asset and test equipment database, carry out uncertainty calculations and generate drift graphs for interval analysis.

A sensor is an indispensable feature of modern racecars that has a direct impact on set-up and performance. Whether it's sensors or the calibration tools that keep them ticking over, Druck is making sure all angles are covered.

Druck

Druck's pressure sensor products have been used across a wide range of motorsport disciplines where engineers demand the highest levels of accuracy, including circuit racing, off-road and bikes

Upwardly mobile

Unmanned Aerial Vehicles offer a zero-carbon alternative to city transport and, as an engineering challenge, are a lot closer to racecars than you might think

By GEMMA HATTON

The world's first internationally certified eVTOL from Volocopter completed a demonstration flight in August

Flying around cities in Unmanned Aerial Vehicles (UAVs) that look like they've come straight from a *Star Wars* movie is no longer a futuristic vision. The age of Urban Air Mobility (UAM) is upon us, with AutoFlight completing the first intercity air taxi flight in February this year, followed by Volocopter's demonstration flight of the world's first internationally certified eVTOL (electric Vertical Take Off and Landing) aircraft in August.

So, what are UAVs, why do we need them and how do they relate to racing? These aerial vehicles don't require a human pilot and are instead controlled remotely or by onboard computers. They fly at lower altitudes than conventional aircraft, offering a zero-carbon alternative to city transport, helping to reduce traffic, congestion and pollution.

New York and London are two of the busiest cities in the world, and recent traffic surveys suggest congestion is so bad, the average speed of cars is 4.9mph (7.9km/h) in central Manhattan and 7.1mph (11.4km/h) in central London. Meanwhile, studies show that an eVTOL could save around 20 minutes on journeys under 50km and 79 minutes on those under 300km, compared to cars.

Vertical thinking

One key to unlocking the potential of urban air mobility is VTOL. These relatively small aircraft are capable of carrying several people, or around 300kg of cargo. They combine a helicopter's vertical flight with an aeroplane's horizontal flight via a mixture of rotors, propellers and fixed wings. This vertical take-off and landing capability avoids the need for large runways and enables the aircraft to operate from rooftops.

There are many varieties of VTOL, depending on the propulsion and powertrain design. The simplest of these are multi-rotors, which use horizontal rotors to generate both lift and propulsion, similar to a typical drone. A good example is Volocopter's Volocity UAV, which features 18 rotors powered by an electric powertrain and can achieve a top speed of 68mph (110km/h) and has a range of around 22 miles (35km).

Although the introduction of electric powertrains has helped enable VTOL, battery range currently remains a limitation, just like in automotive. To solve this, fixed wings and vertical propellers can be combined with rotors, resulting in a 'lift and cruise' VTOL. These use vertical rotors to take off and land,

eVTOL prototypes developed by Joby Aviation, with a hydrogen-electric demonstrator in flight

As UAVs transition to hybrid and electric powertrains, the lessons learned in motorsport around motor efficiency, battery range, cooling and safety are boosting both the performance and potential of this type of aircraft

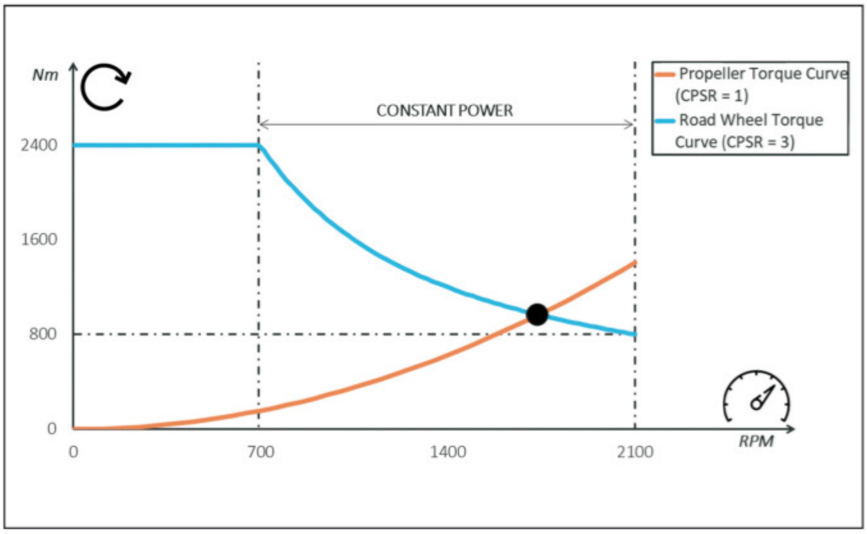


Figure 1: the Constant Power Speed Ratio (CPSR) of a UAV propeller vs the wheel of a racecar

whilst the wings and horizontal propellers generate lift and thrust for forward flight, demanding much less energy from the battery and increasing range.

However, due to the fact horizontal rotors can be a major source of drag and are pretty much redundant during horizontal flight, vectored thrust and tilt rotor UAVs have also been developed. These use the same type of rotors to provide lift during take-off and landing, but then rotate them to generate thrust during horizontal flight.

Over the last few decades, there has been many examples of tech that has crossed over from motorsport to aerospace and *vice versa*, although much of it has been primarily focused on aerodynamic efficiency and lightweight composites. The emergence of urban air mobility has accelerated this sharing of intelligence and, as UAVs transition to hybrid and electric powertrains, the lessons learned in motorsport around motor efficiency, battery range, cooling and safety are boosting both the performance and potential of this type of aircraft.

Power demands

'UAVs demand extremely high power during take-off and landing but, when cruising, this power demand drops considerably and can be around six times less for some aircraft,' says Nathan Bailey, managing director at AIE, a UAV powertrain component supplier. 'Therefore, the majority of the flight operates at a more stabilised and lower power level.

'Of course, this varies depending on the type of UAV. Once in the air, fixed-wing aircraft require much less power because they generate their own lift, whereas multi-rotor UAVs need power to keep the rotors spinning throughout the entire flight.'

This is very different from motorsport, where the power demand is much more dynamic and constantly varies according to the acceleration and deceleration phases of corners on a racetrack, along with the large changes in car speed.

'One way to understand the difference in power and torque requirement is to look at the Constant Power Speed Ratio [CPSR],' explains Andrew Cross, chief technical innovation officer at renowned motor supplier, Helix. 'This is the ratio of maximum speed to the 'base speed', where the base speed is the minimum speed an engine or motor can deliver its maximum power. An internal combustion engine typically has a very narrow maximum power band – in other words its CPSR is not much more than one – whereas the car or racecar demands maximum power over a much broader range, spanning, say, 100-300km/h, which would make the CPSR equal to three. The solution to broaden the range over which maximum power can be delivered is, of course, a multi-speed transmission, which every ICE car or racecar has.

'An electric motor, however, has such a broad speed range that car manufacturers have been able to remove the multi-speed transmission. Though, this then means the motor and inverter must deliver the CPSR demanded by the vehicle directly. Propulsors for a UAV on the other hand, need a CPSR of around one, because the load on the propeller, or fan, is highest when the rotational speed is highest.'

Optimised operation

Figure 1 on the previous page shows this distinction as the torque requirement vs speed for a propeller vs the road wheel of a racecar. The maximum speeds of the wheel and propeller might be similar, but the requirement for torque at low speed is very different. This, in turn, means the electric machine for a UAV can be optimised for a much narrower operating range and, ultimately, can be smaller for a given power.

The requirement to switch between high power for take-off and low power in cruise make a regular internal combustion engine alone an inefficient solution.

'If you mechanically couple an ICE to a propeller, delivering 30bhp during take-off and landing one minute, and then 4bhp for cruising the next, is a massive challenge,' confirms Bailey. 'Whereas, if you combine a generator with that engine, the engine can operate at a fixed power level, while the battery acts as a buffer, providing propulsion through electric motors, which can be more power dense than the engine. This easily achieves the required power differential, whilst allowing the engine and motor to operate efficiently, and the engine, or engines, to be downsized.

'Many new UAV and VTOL aircraft architectures being proposed are therefore looking to series hybrid solutions, such as a combustion engine coupled to an electric motor-generator and then distributed electric propulsion for lift and forward propulsion,' adds Cross.

Together, Helix and AIE have developed the highly compact and cost-effective 90kW generator / range-extender shown below.

Hybrid and electric

This transition to hybrid and electric power is one of the major technology disruptions currently happening within the UAV industry.

'The challenge is relatively similar between an electric UAV and an electric racecar,' explains Gerard Torres, COO at battery manufacturer, Bold. 'In both cases, you need to have high power density to accelerate the vehicle to either take off or race around a circuit, but you also need high energy density for the vehicle to travel from A to B. That's why we developed the BOLDhp battery module, which delivers high peak power and high energy density at the same time.'

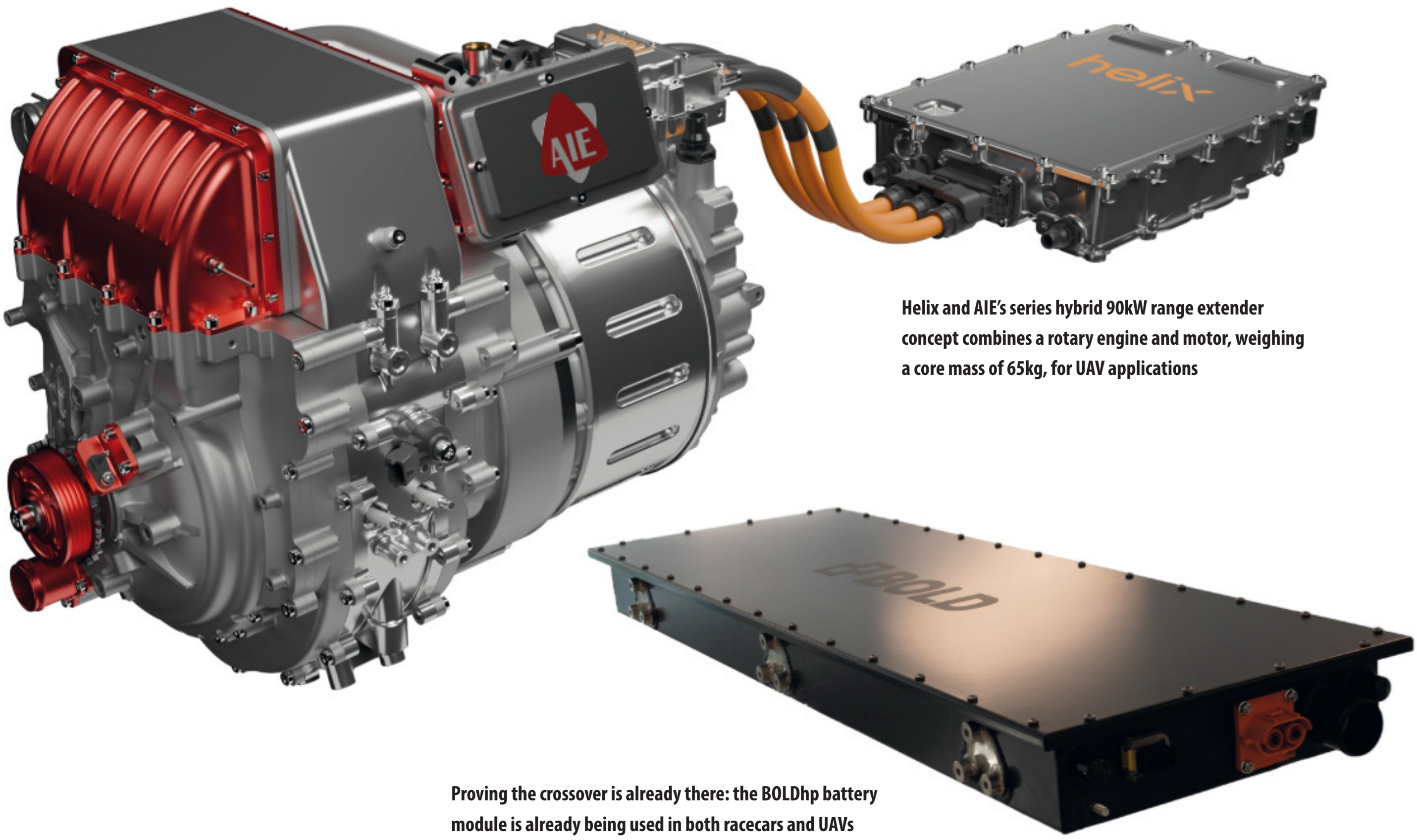
'The challenge is relatively similar between an electric UAV and an electric racecar. In both cases, you need to have high power density to accelerate the vehicle to either take off or race around a circuit, but you also need high energy density for the vehicle to travel from A to B'

Gerard Torres, COO at battery manufacturer, Bold

The BOLDhp has an energy density of 188Wh/kg in a pack that weighs 62kg. To boost the available power and energy, multiple units can be stacked on top of each other, making this unit suitable for both UAV aircraft and racecars.

'The module is just over one metre in length,' continues Torres, 'so sometimes we reduce the length for UAVs as typically they have even less space than racecars. Ultimately, it's exactly the same system.'

As well as battery technology, motor and inverter design are also crossing over from racecar to aircraft. Electric racecars and premium road cars typically run Surface



Helix and AIE's series hybrid 90kW range extender concept combines a rotary engine and motor, weighing a core mass of 65kg, for UAV applications

Proving the crossover is already there: the BOLDhp battery module is already being used in both racecars and UAVs

Permanent Magnet (SPM) motors, where the magnets are located on the outside of the rotor. Conversely, the Interior Permanent Magnet (IPM) motors used in most road cars position the magnets in different orientations on the inside of the rotor.

'The highest performing racecars usually use SPM motors, specifically Halbach array SPM motors, which we develop for our racing customers,' says Cross. 'This is essentially the most effective way of architecting an electric machine to maximise torque and power density. UAVs are now utilising this same fundamental architecture for their motors, as well as silicon carbide inverter technology, so there are strong similarities between the electric machines used in both industries, but there are also some key differences, such as the cooling systems used.'

> **'A UAV spans everything from a small drone you can fit in your hand to an aircraft that can carry half a tonne, so there are a wide variety of flight envelopes'**
>
> *Nathan Bailey, managing director at AIE*

Cooler air

At high altitudes, the air is thinner and cooler, so the powertrain components of UAVs tend to experience much lower minimum and maximum temperatures than a racecar.

'You can actually get situations where you over cool the powertrain,' explains Bailey. 'This can be a particular issue with air-cooled powertrains where you haven't got dynamic control over the cooling system.'

Unlike motorsport, which favours liquid cooling systems using water-glycol coolants and a separate heat exchanger to air, the preferred cooling system for most UAVs is air cooling. This is mainly because it is simpler, lighter and cheaper. From a serviceability and safety perspective, it also avoids handling potentially harmful liquid coolants in the field and leaks whilst airborne.

'There are certain UAV applications that suit the type of liquid cooling systems we see in racecars,' Bailey continues. 'Heavy, or multi-rotor, aircraft that spend a substantial amount of time hovering at low altitudes need to operate at high power levels and therefore require powertrains with high power densities. This leads to higher temperatures, which can be difficult to dissipate with air cooling alone. This is why using liquid cooling systems, which transfer heat from hard-to-reach places, becomes a more viable solution.

'Liquid cooling also gives you more control as you can adjust the coolant's temperature and speed through the system,' continues Bailey. 'It's a trade-off and very much depends on the application. A UAV spans everything from a small drone you can fit in your hand to an aircraft that can carry half a tonne, so there are a wide variety of flight envelopes.'

You may be surprised to learn weight plays an even more crucial role to performance in the UAV industry than motorsport. The heavier a component on a car, the more mass the powertrain must move, demanding more power, which in turn requires a stronger, more robust design, increasing weight. It's a similar cycle for a UAV.

'Mass is a major driver for a lot of technical decisions on an aircraft,' reveals Bailey. 'The heavier anything is, the more power you need to move the vehicle off the ground, and therefore the more wing you need. The efficiency of the powertrain comes into play as well. If you have an extremely lightweight, power dense engine that requires a lot of fuel, which has to be carried onboard, then you offset the mass advantage of that engine.

'Similar to motorsport, as you burn through that fuel, the vehicle becomes lighter, so the power demand drops,' explains Bailey. 'Batteries, on the other hand, don't get lighter as they run flat. If you take off with 20kg of batteries when they're full, you still have to carry those 20kg when the cells are empty.'

This pursuit of minimising mass is therefore another area where motorsport's mindset has helped UAV companies.

'Just like in racing, you need to develop UAVs with efficiency in mind right from the very start,' explains Cris Hiche, commercial director at UAV specialist, MGI Engineering, which is Mike Gascoyne's (former Caterham F1 technical chief) engineering company.

'It comes back to Mike's experience in Formula 1. As soon as you relax the weight targets, this quickly compounds and the car becomes a lot heavier further down the line,' continues Hiche. 'It's the same with UAVs. If you don't meet those mass targets, your wings then need to be more robust to cope with the higher loads and, all of a sudden, the weight of the entire vehicle goes up, which can push you into another category of drone.

'Due to regulations, we currently specialise in drones below 25kg. The moment we go over that threshold, regulatory requirements increase significantly as you've moved into a heavier category of vehicle.'

Safety requirements

Which neatly brings us to safety. Of course, safety is of paramount importance in motorsport, and over the years we have seen numerous safety devices introduced and lives saved. But when it comes to aircraft, safety requirements reach a whole new level.

It is not only the safety of the pilot and the passengers on board that needs to be considered, but also the potential loss of life if the vehicle crashes into others. Famously, this is why the flight path of helicopters over London follows the River Thames – to avoid hurting anyone else if one should crash.

Helix's range of SPX motors that are helping to electrify land, sea and air vehicles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'In aerospace, you try to eliminate single point failure modes,' highlights Bailey. 'If there's one of anything that's key to the operation of the vehicle then you try to either duplicate it, over engineer it to avoid failing, or design other systems to take over.

'This is why UAVs with multiple rotors are typically architected to satisfy the One Engine Inoperative [OEI] case where the aircraft needs to still be able to operate, even if one of its engines fail,' explains Cross. 'So, if a failure occurs in one of the rotors, the UAV needs to be able to shut down the other rotors on that same DC Bus and hover with the remaining rotors to land safely.

'Similarly, if a generator engine fails, the battery pack can still be used to land safely. If a battery fails, it's usual that a parallel battery pack, and even the generator engine directly, can deliver electrical power. This hybrid architecture can make achieving the safety goals of the aircraft easier than for either a solely combustion or fully electric powertrain.'

Overall, it would seem the requirements of a UAV are very similar to that of a racecar. The goal is to optimise the efficiency, performance and safety of the vehicle as an entire package, not just in one area.


MGI Engineering uses Formula 1 composite materials and 3D-printed parts in its MGI cargo eVTOL

'You can see the parallels with racing,' concludes Hiche. 'You have some cars that perform well in the straights, and others that perform well in the corners. The holy grail is finding the balance where the vehicle performs well everywhere.

'What makes racing teams unique is their ability to make decisions quickly. There is no 'analysis paralysis' because, ultimately, the worst decision is no decision at all. This mindset, combined with the hunger for performance and efficiency, as well as the understanding of the trade-offs required to optimise a vehicle is why we are seeing so much crossover between motorsport and the UAV industry.'

Similarity in simulation

As well as powertrain components, composites and aerodynamics, another area that shares similarities between UAVs and racecars is simulation.

'Our UAV dynamics library is based on all the same foundations and technologies as our motorsport library that is used by our NASCAR, IndyCar and Formula 1 customers,' says David Briant, senior project engineer at modelling and simulation specialist, Claytex. 'The only difference really is the application. That's the joy of system simulation – you can look at everything in isolation, so as long as it does the same thing, you don't have to reinvent the wheel just because it is connected to a UAV or a Formula 1 car. The only thing that changes is the data you provide and the accuracy you require.'

Consider an electric powertrain for a UAV vs a racecar. The modelling of the motors is the same for both; the differences only come when you look at what the motor is powering.

'In a racecar, an electric motor delivers power to the wheels through a transmission and differential,' explains Briant. 'Whereas a UAV goes through a single-speed transmission to a propeller. This may sound simple, but the amount of torque and the reaction of the propeller is dependent on aerodynamics, and that's when things start to become extremely complex.

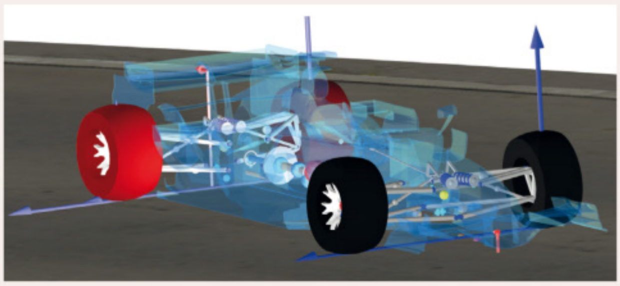
'The wash over the wing, the turbulence of the airflow, the resulting vibrations, the effect of the other rotors, the transition from horizontal to vertical flight... it all needs to be approximated to achieve accurate simulations. So, while aerodynamics is king in motorsport, for UAVs it really is everything.'

> **'While aerodynamics is king in motorsport, for UAVs it really is everything'**
> *David Briant, senior project engineer at Claytex*

To help streamline the endless modelling possibilities, as well as facilitate easier integration with other tools, Claytex has developed a suite of templates. These cover many types of UAVs from fixed wing to four, six or even eight-rotor aircraft, as well as tilt wing applications. The trick is finding the balance between standardising parameters to give engineers a good starting point, whilst also allowing them the freedom to adapt the models to suit their specific scenarios.

'Our templates provide the structure engineers need to then expand the models in whatever direction they want, but they can also start from scratch at any level,' says Briant. 'They can go into detail in the subsystems they care about, but then leave the rest, with the confidence that these have been developed with over 25 years' expertise.

'It's a never-ending problem of how much constraint you integrate into a model. To make a model user friendly and robust you need to lock everything down, which restricts how much of the model is open for adaptation. In doing that, you end up excluding people who want to investigate other areas. It's a difficult balance to get right, but that's what we strive towards.'


Claytex's UAV dynamic library is based on the same foundations as the motorsport library used by the company's customers in NASCAR, IndyCar and Formula 1

Pitch perfect

Using pitch data to better understand your aeromap

By DANNY NOWLAN

One of the most important articles I have ever written for this publication was how to figure out aeromaps from pitch data. In that article, I laid out some general principles about what to do when things don't correlate.

While that article has gone on to serve me and many readers very well, one of the things I now feel it lacked was a very focused example. So, while doing some Time Attack work recently, I had the opportunity to re-visit this subject, and the result proved to be a perfect example of how you can combine data analysis and simulation. This will be the focus of this article.

Before we start, though, it might be useful to refresh your memory on a few things. Firstly, when I talk about pitch data I'm discussing what happens when you combine the front dampers and the rear dampers together in one channel. I realise what I'm stating might be obvious to some, but let's define the front pitch and rear pitch as the following:

$$FrontPitch = \frac{FL\_Damp + FR\_Damp}{2}$$
$$RearPitch = \frac{RL\_Damp + RR\_Damp}{2} \qquad (1)$$

Where,

$FL\_Damp =$ front left damper
$FR\_Damp =$ front right damper
$RL\_Damp =$ rear left damper
$RR\_Damp =$ right rear damper

At this point I should make a small correction to my previous article. When I wrote that in 2013, I only had a nodding acquaintance with asymmetric formula. That is no longer the case. So, even with asymmetries, this is still very relevant. Admittedly, it's a bit challenging with higher roll centres under lateral *g* but it's not the end of the world.

The thing about these pitch channels is they eliminate the roll information, so are a brilliant tool for figuring out what's going on with the aero and the anti-dive and anti-squat.

The other refresher I will mention is that every spring / damper / bump rubber unit is a load cell. The force on the spring is calculated by that shown in **equation 2**.

$$F_S = (k(x_s) + c(\dot{x}_s)) \cdot MR \qquad (2)$$

Where,

F_S = force of the spring damper unit at the wheel
x_s and $\dot{x}_s$ = movement and velocity of the spring
k = spring rate or function
c = damper rate or damper function specified at the damper
MR = motion ratio of the spring expressed as damper / wheel movement

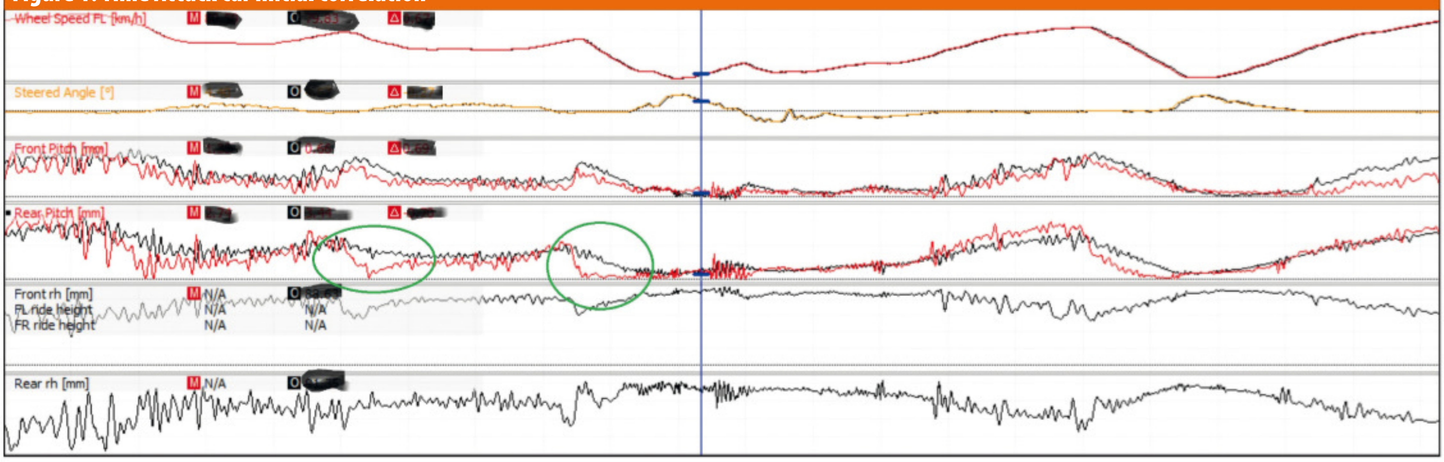
Note, it is assumed here that the zero of the spring function is when the car is on the ground. In most cases, the spring function k is a spring rate, though if bump rubbers are used the spring function k can be easily deduced by a look-up table. If you're fortunate enough to have strain gauges fitted to the car, then all the hard work in **equation 1** has been done for you.

Now the spring force has been worked out, we need to determine tyre deflection. In the absence of laser ride height sensors, this is given by that shown in **equation 3**.

$$w_m = \frac{F_S}{k_t} \qquad (3)$$

Here, k_t is the spring rate of the tyre. Now, this is where things can start to get tricky. As we know, tyre spring rate is a function of wheel speed, tyre pressure and camber. However, to get started I would suggest you use a single approximate figure.

Figure 1: Time Attack car initial correlation



When I talk about pitch data, I'm discussing what happens when you combine the front dampers and the rear dampers together in one channel

While not strictly accurate, you can add a more complex analysis later. Also, in my experience, if the appropriate value of k_t is chosen, this can actually get you very close.

Once the deflection of the tyre is known, the user can deduce how much the corner of the car compresses under this load.

This deflection can be deduced by **equation 4**.

$$d_i = \frac{x_{s_i}}{MR} + w_{m_i} \tag{4}$$

Where,

d_i = compression of corner of car for corner i

x_{si} = the spring deflection for corner i

w_{mi} = the wheel movement for corner i

The convention you use for the car corners is at the discretion of the user, but for the record I use one for the left front, two for the right front, three for the left rear and four for the right rear.

Once you have deduced the corner deflections, the front ride heights, rh_f, and rear ride heights, rh_r, can be calculated by **equation 5**.

$$\begin{aligned} rh_f &= rh_{f0} - \frac{d_1 + d_2}{2} \\ rh_r &= rh_{r0} - \frac{d_3 + d_4}{2} \end{aligned} \tag{5}$$

Where rh_{f0} and rh_{r0} are the initial ride heights.

I realise I've said this before, but **equations 2-5** will give you all the tools you'll ever need to calculate what's going on in the individual components of the aeromap.

So, all that being said, let's now return to the example at hand, which was the aforementioned Time Attack car. **Figure 1** shows the first cut of the aeromap and the correlation I was getting when I did some initial testing on the car.

This was actual data, and the simulated data was created using the ChassisSim track replay feature with a curvature and bump profile generated from the actual data. As always, actual is coloured, simulated is black.

The first trace is speed, the second is steer angle, the third and fourth traces are front and rear pitch, while the last two traces are the simulated ride heights. I've left that in for a purpose that we'll return to shortly. Also, because this is live race data, all scalings and numbers have been redacted.

Cliffhanger

The big standout with the correlation is highlighted by the green ovals for the rear ride heights. The problem was the actual data under brakes fell off like a cliff, whereas the first cut of the model didn't have that. My initial thoughts were that there was something in the spring / damper package I must had overlooked. So, just for grins, I modelled a hysteresis bump rubber with the forces in rebound halved. **Figure 2** shows where that landed.

The coloured is with the standard set-up, the black is with the hysteresis halved. Looking at the rear pitch channel, it's addressed by 5-6mm. That's a step in the right direction, but nowhere near where it needs to be.

Now remember, whenever you are confronted with a situation like this, hand calculations are your best friend.

So, let's just say for the purpose of the exercise we've had a drop of 30mm under brakes with a car that weighs 1200kg, has a c of g height of 0.45m and a wheelbase of 3m. Also, the rear spring rate is 1000ft.lbs and I'll assume unity motion ratios. Given all this, under 1.5*g* of braking, the load transfer reduction at the rear will be that shown by **equation 6**.

$$\begin{aligned} LT &= \frac{m_t a_x \cdot h}{wb} \\ &= \frac{1200 \cdot 1.5 \cdot 9.8 \cdot 0.45}{3} \\ &= 2646N \end{aligned} \tag{6}$$

Working that through, the total load transfer from the rear is 2646N. Let's now take a look at the load that has been lost at the rear total. This is deduced simply by multiplying spring rate by spring movement. Also, because this is pitch data, we need to multiply by two. The total load lost at the rear is therefore that shown by **equation 7**.

$$\begin{aligned} \delta L_{rear} &= 2 \cdot k_r \cdot \delta x_{rear} \\ &= 2 \cdot 175.126 \cdot 30 \\ &= 10507.56N \end{aligned} \tag{7}$$

As you can clearly see, the load loss at the wheel dwarfs the load transfer. I've obviously exaggerated the numbers here to make a point but, when you see a differential like that pop up, it's telling you that you have to deal with something in the aeromap, which is exactly what was happening in **figure 1**.

Given all this, we now return to where we were, displaying the ride heights in **figure 1**.

Figure 2: Effects of the hysteresis halved in rebound

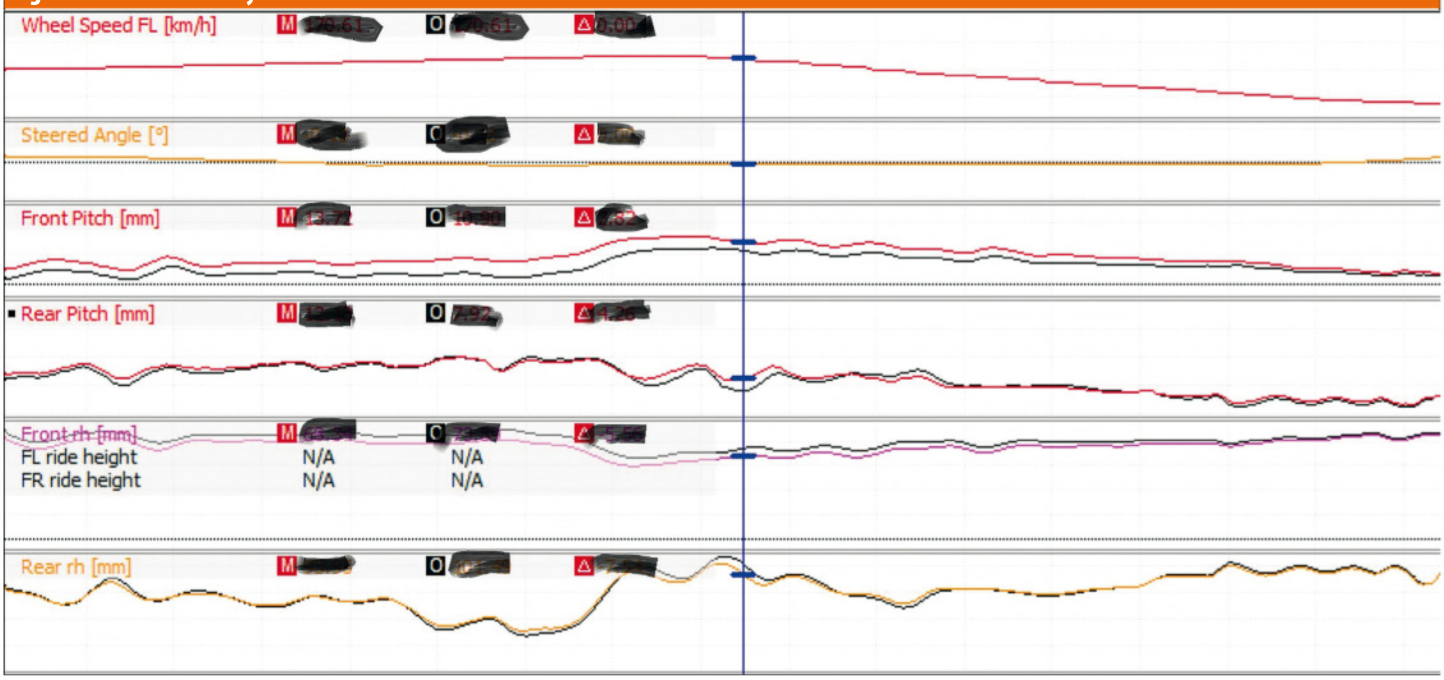
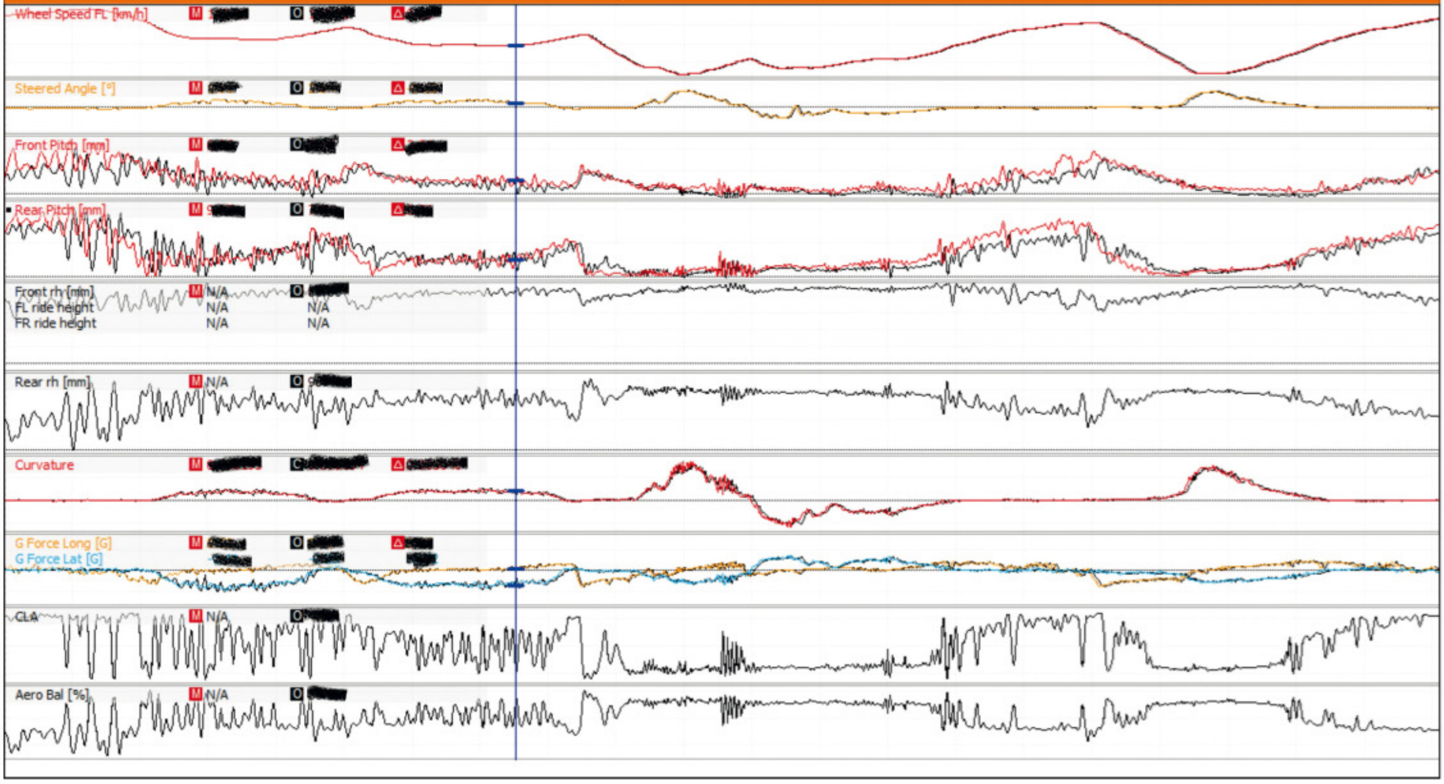


Figure 3: Final incarnation of the aeromap from the track replay simulation



What was particularly curious about the running of this car at this circuit was we weren't going fast enough to fully exploit the aero on offer in the car. Consequently, this showed a hole in the aeromap.

The takeaway from this is that when you are displaying simulated ride heights with actual data and see the sort of discrepancy we saw in **figure 1**, you take the simulated ride height and add double the spring movement of the actual data (normalised to a motion ratio of one). The reason for doing that is that with medium to high downforce cars, for every millimetre of spring movement, that's what the tyre is moving (that comes out in the wash with **equations 3-5**). More importantly, this tells you what to change in the aeromap and where to change it. It won't give you an exact answer, but it puts you in the ballpark.

Applying that knowledge proved critical to resolving the aeromap in this case, and the end results are shown in **figure 3**.

As we can see, we are now significantly closer with the front and rear pitch channels, particularly under braking. There is still a discrepancy in the last part of the lap, but that is down to me not fine tuning the last bits of the aeromap.

However, one trace I will point out is the bottom two traces that show the CLA and aero balance logged from ChassisSim. When you are fine tuning an aeromap, these two channels, paired with the pitch data, are a critical tool to see what is going on with the car. In this job, they proved invaluable.

In closing, using pitch data is a vital tool for correlation, particularly when it comes to both suspension geometry and aero. Combine this knowledge with good old hand calculations and it will tell you where you need to look. Learn that lesson and it will open you up to a much larger world.

Recent analysis of a Time Attack car provided the perfect opportunity to revisit the principles of pitch data. Apply that knowledge to your aeromap and you'll soon be winning

CTS24 to be biggest show to date

The eagerly anticipated MIA CTS24 trade-only show takes place on 16 and 17 October at The Silverstone Wing. Now in its third year, the show is set to be bigger and better, featuring more exhibitors than ever before.

Over 100 businesses, including those featured here plus Dassault Systèmes, Alcon, Lifeline Fire & Safety Systems, M-Sport, AVL and Cosworth will showcase their latest products with innovative displays, offering visitors a unique chance to explore cutting-edge technology and trends.

The UK's leading motorsport engineering and technology show is free to attend. It offers those in the motorsport and the high-performance engineering industry, as well as adjacent sectors, a unique chance to get together and meet new and existing customers, suppliers and buyers ahead of 2025.

CTS24 is conveniently located at the heart of Motorsport Valley, with direct and easy road access from both the M40 and M1 via the A43. Free parking is available at the Hilton Garden Inn Hotel, which is linked to The Silverstone Wing via a new pedestrian bridge that spans the Hamilton Straight.

Don't miss out, register now for your FREE entry pass.

For more information visit: the-mia.com/event/MIACTS24

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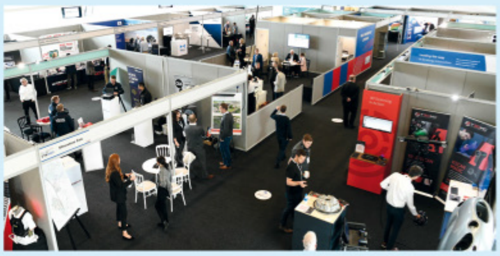

CTS24 takes place at The Silverstone Wing, right in the heart of Motorsport Valley

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Micrometric has experience in handling a wide range of common and exotic materials

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Druck has been involved in motorsport since 1990 and is a leader in pressure sensor technology

Xtrac embracing period of transition

As Xtrac enters its fifth decade in business, transitioning from pioneer and innovator of racecar transmission engineering to leader in the field of roadgoing hypercar gearbox design, the company finds itself at the forefront of a once-in-a-lifetime automotive technology shift.

The seismic move from internal combustion engine through hybrid to electric vehicles in motorsport needed a transmission partner prepared to accept the challenge. Not only was Xtrac ready, but it was ahead of the game, already providing its customers with efficient, reliable and durable products that left the competition in its wake.

With the advent of Xtrac's recently formed Mechatronics division – designing, developing and manufacturing integrated control system solutions in-house – much of the laborious R&D work has been lifted from the shoulders of race teams and high-performance automotive manufacturers. This, in effect, provides a one-stop engineering facility, able to deliver the complete drivetrain, including all the actuation electronics.

Xtrac turned 40 this year, but is not slowing down as it scaled up its high-performance automotive and mechatronics activities

None of this would have been possible without the company's intelligent and loyal workforce, many of whom are under 30 years of age, creating the future leaders in motorsport and high-performance automotive solutions, evidenced by Xtrac winning the Princess Royal Training Award in 2024, the third time it has collected the accolade.

Scanivalve unveils new smart pressure scanner

Scanivalve, the global leader in high-density pressure and temperature measurement technology, is proud to announce the launch of its latest innovation, the MPS4216 16-channel miniature ethernet pressure scanner.

This state-of-the-art device is designed to revolutionise aerodynamic testing and industrial applications with its compact size, accuracy and speed.

Key features of the new 16-channel pressure scanner include:

- Compact design: the miniature scanner ensures seamless integration into any testing environment without sacrificing performance.
- High accuracy: the scanner delivers reliable and accurate pressure data, crucial for critical analysis and informed decision-making. Using the same individual ADC technology already deployed in the MPS4232, the 4216 is also fully synchronous
- Versatile application: ideal for use in wind tunnel testing, flight testing, and various industrial pressure monitoring tasks.

Compactness, high accuracy and speed are at the heart of Scanivalve's new pressure scanner

- Easy integration: the scanner is compatible with existing data acquisition systems, simplifying the upgrade process.

'The new 16-channel miniature pressure scanner not only meets, but exceeds industry standards, providing our clients with the quality and reliability they expect from Scanivalve,' says Paul Crowhurst, managing director at Evolution Measurement. 'This innovation is testament to our commitment to advancing precision measurement technology.'

The 16-channel miniature pressure scanner is set to enhance testing capabilities across a range of industries, offering unprecedented levels of accuracy, together with ease of use.

Reis Insurance has racers covered

If you're involved in motorsport and need insurance, as one of the most well-known and respected names in the industry, Reis Motorsport Insurance has a deep understanding of the vehicles, people, teams and businesses involved in making it happen.

The Reis team of motorsport enthusiasts speak and understand your language, providing expert guidance and unmatched knowledge to cover competitors, teams and motorsport businesses at all levels, from amateurs through to professional.

With this specialised industry knowledge and detailed product know how, Reis Motorsport Insurance tailors cover to meet your individual needs.

JEP

Reis covers a broad spectrum, including commercial, on-track accident and promoter insurance

Fresh approach to sportscar refuelling

Using wireless technology, the E-POD system from EEC Performance Systems will transform fuelling for top-level endurance racing teams.

The E-POD wireless endurance fuel rig system is the result of extensive research and development to produce a superior product ensuring fuelling is simple, accurate and safe. It features semi-automatic logging at the touch of a button, with a wall-mounted base station featuring a colour touch screen. The system takes inputs from wireless modules monitoring fuel weight, fuel temperature, ambient air temperature, dead-man's handle position, fuel time and more. The screen displays current levels, last fuel stop data and records all necessary data during the active stop.

Modular construction gives the option to buy modules separately as required. The E-POD's unique, proven Automatic Track Compensation (ATC) system automatically compensates for any weight variation, whichever circuit the team is racing at worldwide. Additionally, all information can be viewed remotely on the race engineer's laptop.

Prodrive has adopted the E-POD system for its support of Aston Martin Racing's FIA World Endurance Championship customer teams to good effect, recently winning the LMGT3 class race at Circuit of The Americas.

Aston Martin GT3 teams are using EEC's wireless endurance fuel rig system

Competition power steering that strikes the perfect balance

DC Electronics has recently launched its EPAS500 Competition electric power steering system, which aims to strike the perfect balance for motorsport users looking for a cost-effective EPAS solution, without necessarily requiring the CAN Bus connectivity of the DC Electronics Ultra EPAS system.

Steering maps for DC Electronics' new power steering system are available via a free software package

Following an extensive process of refinement, involving many miles of on-the-road testing, DC Electronics managing director, David Cunliffe, is understandably delighted with the final product.

'We were keen to develop a system that provides motorsport users with the ability to tune the steering maps themselves, yet without the complexity of our Ultra system,' he explains. 'The result is an incredibly flexible, versatile system, which has the added benefit of being extremely attractive to cost-conscious manufacturers and teams.'

Designed for motorsport, the system is IP66 rated with built-in anti-vibration mounts, making it ideally suited to the harshest of environments, including open cockpit vehicles and even powerboats. The EPAS500 Competition system is easy to install (having only three wires to connect), with the steering maps tuneable via the free software available on the DC Electronics website. For full system details, visit dcemotorsport.com/epas500-competition-system/

Hyundai commits to WEC

South Korean car maker, Hyundai, has confirmed it will build an LMDh car for an FIA World Endurance Championship programme. Under the guise of its Genesis luxury vehicle brand, the car is set to be developed by an expanded Hyundai World Rally Team, but not at the expense of the WRC effort.

In a statement, the company said: 'Genesis is actively exploring programmes to strengthen its high-performance image and, after a thorough evaluation of various options, LMDh emerged as the most strategic choice for us at this time.'

The car development team will likely be based in France and will select ORECA as its base chassis. Chip Ganassi Racing is currently in the frame to run the car in races.

As many as four brands could join Hypercar in the next couple of years. Aston Martin will enter next year with the Valkyrie, while Honda is rumoured to be looking at a global programme with the ARX-06 and may commit in 2026.

Others known to be interested include Bentley, which has yearned for a Le Mans return since its 2003 win, and McLaren, which has stated its intention to join and holds two spots on the LMGT3 grid. One other possibility is Mercedes, which wants to bring its new GT3 car to the world championship for the first time, but has not run a prototype since 1999.

Meanwhile, Lamborghini is known to be considering a withdrawal from one of its two LMDh programmes. The Iron Lynx team fields a single SC63 in both IMSA and WEC but has not found success in either. The WEC will next year force manufacturer teams to run two cars, which may prompt Lamborghini to focus on the North American series.

Hyundai is preparing for its WEC debut with a Genesis-badged LMDh, while its WRC effort is expected to continue

FIA launches new generation F3 at Monza

The latest FIA Formula 3 car has broken cover, with a few major revisions compared to the previous version, and to the Formula 2 car that made its debut this year.

The new F3 model features improved safety standards, built into the one-make Dallara design.

The car will be powered by a 3.4-litre Mecachrome engine that produces 380bhp at 8000rpm. Power is delivered to the 16-inch wheels via a 3MO longitudinal gearbox, rather than the Hewland unit found in the Formula 2 car.

Marelli supplies the paddle shift system, which is electro-hydraulic, and the vehicle control unit, which is carried over from Formula 2.

This version of the Formula 3 car is set to run on 100 per cent sustainable fuel from Aramco, forming part of the F1 group's target to be net zero by 2030, and three compounds of tyre will be made available for teams to choose from.

New features include improved safety, a 3MO gearbox and a more accommodating cockpit

After a shakedown at Varano, the car completed 2000kms of testing ahead of its unveiling at the Italian Grand Prix in late August. Deliveries are expected to take place before the end of the year.

'The 2025 car has been designed to provide exciting racing, with a lot of overtaking opportunities,' says FIA F3 CEO, Bruno Michel.

'We have also worked to ensure the new car fits all types of drivers, taking into account FIA requirements regarding steering effort.'

As previously reported, the car will not race at the Macau Grand Prix, which has switched to the Formula Regional rule set, replacing the Formula 3 cars that have raced there since 1983.

IN BRIEF

Ferrari has appointed **Loïc Serra** as its chassis technical director. The French engineer will start with the team on 1 October and will report to team principal, **Fred Vasseur**. **Enrico Gualtieri** continues in his role as power unit technical director.

Pirelli and **Bosch** have partnered to create the Pirelli Cyber Tyre, which features in-tyre sensors that collect, process and transmit real-time tyre data. The new product offers greater safety and tailored driving conditions.

The **Pioneer 25**, which will form the grid of the Extreme H series, has passed its mandatory FIA crash tests, the first hydrogen car to do so. The hydrogen pressure systems were fitted for the tests, but the tanks and batteries were not. Delivery is scheduled before the year ends. Meanwhile, Extreme E put the rest of its 2024 season on hold as Extreme H work continues.

The **Callum Skye** project won the Nick Carpenter Innovation Award at the Cenex Expo.The award recognises outstanding niche vehicle R&D projects that accelerate the transition to zero emission forms of transportation. Callum won the award for its lightweight, all-electric ATV. Of particular note was the use of sustainable materials to produce the bodywork, and the vehicle's ultra-fast charging battery.

Formula 1 is considering an option to run sprint races using rookie drivers in 2025. The idea has been discussed in the F1 Commission and the results of that meeting look promising. Senior team principals said it would be a good way of judging drivers against each other on equal tyres and fuel loads.

'It's going to be a strain on the team because we have another day,' said Mercedes' Toto Wolff, 'but we are in the entertainment industry and that's the best idea so far we have come up with to give them more driving time.'

The FIA has declared that **Honda** and **Alpine** were in procedural breach of F1's power unit manufacturers' cost cap this year, although neither exceeded the cost cap level.

Aston lands the biggest fish

Adrian Newey, the decorated Formula 1 designer, will switched to Aston Martin in March 2025 after 19 years with Red Bull.

The 65-year old had previously courted interest from Ferrari, McLaren, Alpine and Williams, but chose Aston Martin, which has invested heavily in a new facility and wind tunnel next door to Silverstone circuit in the UK.

The outfit has also secured a factory Honda engine deal for 2026, when all-new technical regulations arrive, bringing more hybrid power.

In his 30-year career in Formula 1, Newey has worked for March, Williams and McLaren, before joining Red Bull and helping to elevate the team to champion status. In total, he has been central to 13 Drivers' and 12 Constructors' world titles.

'It's the biggest story since the Aston Martin name returned to the sport, and another demonstration of our ambition to build a Formula 1 team capable of fighting for world championships,' said team owner, Lawrence Stroll. 'As soon as Adrian became available, we knew we had to make it happen.

'When he saw what we have built at Silverstone – our incredible AMR Technology Campus, the talented group of people we have assembled and the latest wind tunnel in the sport – he quickly understood what we are trying to achieve.'

Aston also recently signed Andy Cowell, formerly of Mercedes HPP, to be its F1 team CEO, plus ex-Ferrari chassis chief, Enrico Cardile. Newey's former Red Bull colleague, Dan Fallows, is Aston's technical director.

Aston Martin F1

After 19 years with Red Bull, Newey is leaving the gardening gloves on the shelf and taking up a new F1 challenge as managing technical partner of Aston Martin, which is keen to climb the grid

Williams' young engineering talent search

Williams Racing and its principal partner, Komatsu, have launched the Komatsu-Williams Engineering Academy, a global initiative designed to cultivate the next generation of engineering talent. The programme will select 10 STEM students and provide them with mentorship and support throughout their educational journey.

The Academy's first group of students will be selected in collaboration with F1 in Schools, a non-profit organisation dedicated to promoting STEM education. Students aged 16 and above attending the 2024 F1 in Schools World Final in Saudi Arabia this November will be invited to apply for a place in the Academy assessment centre, where Williams and Komatsu will jointly narrow applicants down.

Students at this year's F1 in Schools final will have the opportunity to apply. 10 will be selected

Those chosen for the Academy will have access to a range of benefits designed to support their growth and career development, including:

- Early career opportunities: access to work experience internships, apprenticeships and graduate roles across Komatsu and Williams.
- Williams employee mentorship: quarterly sessions with a Williams engineer, offering personalised guidance and industry insights.
- Online learning platform: access to educational modules and tasks related to Formula 1, providing a solid foundation for engineering principles.
- Exclusive experiences: a comprehensive programme focused on community building, learning and networking opportunities across both Williams and Komatsu.

The Komatsu-Williams Engineering Academy experience will be individually tailored based on the educational level at entry, ensuring each student receives support that aligns with their academic journey.

Advanced Engineering gearing up for October

The Advanced Engineering Show takes place on 30-31 October at the NEC in Birmingham, UK, and will feature the usual wide array of technologies for which the show is internationally famous.

Central Scanning will showcase two hand-held Artec 3D scanners, which bring a brand new, highly accurate, metrology-grade 3D scanner to market that's compact, portable and flexible, making it ideal for use in tight spaces such as manufacturing, engineering and healthcare. The scanners reach high levels of precision, up to 0.02mm in 3D resolution.

Broder Metals Group Ltd will also be exhibiting at the show. The company is a stockist and distributor of high-specification steels, alloys and super alloys to the UK, European and worldwide markets, including the motorsport arena.

Broder Metals Group also offers a diverse range of metal powders and alloys for additive manufacturing and hot isostatic pressing, along with next-generation alloy development.

Elsewhere at the show, Innovatest will present its range of advanced testing machines, including models designed for high precision, automation and ease of use in various industrial applications. The exhibition will highlight solutions for such industries as aerospace, automotive, energy and manufacturing.

Airtech will also be on hand to demonstrate its latest closed-loop motorsport tooling project. This repurposes carbon-fibre moulds from the 2022 Pikes Peak International Hill Climb into 3D-printed moulds, which not only contributed to Brumos Racing's class record-setting run in 2023, but also diverted more than 300lb of material from landfills, reducing the demand for new polymer production.

Airtech recycled, 3D-printed, composite mould tool

Zircotec leads ceramic research

British coatings company, Zircotec, has secured government funding to develop market-ready ceramic coating solutions that meet the new demands of electric vehicles.

Zircotec has been involved in heat management for more than 30 years, and is set to develop a single, proprietary ceramic coating that will unlock the use of lightweight materials, including aluminium and plastic composites, across EV battery enclosures and cooling plates. Currently, almost all EV battery enclosures are manufactured from heavy duty steel.

The government-supported CeraBEV (Ceramics for BEV) project, which forms part of the government's work to ensure the UK remains at the cutting edge of battery technology, will last for 12 months. Zircotec has been installed as the lead partner, while Cranfield University is the project partner responsible for coating testing and evaluation.

'The Advanced Propulsion Centre 'CeraBEV advanced route to market demonstrator' project allows our engineers to develop world-first, all-in-one, dielectric and flameproof ceramic coatings that will address and overcome the significant thermal management and electrical insulation challenges associated with the lightweight materials OEMs want to use on their vehicles,' says Dominic Graham, Zircotec engineering director.

Toyota commits to Australian Supercars

Toyota has confirmed it will contest the 2026 Australian Supercars Championship with the GR Supra that will be run by current Ford team, Walkinshaw Andretti United, with Chaz Mostert and Ryan Wood as the named drivers.

The Japanese manufacturer has committed to the series for a minimum of five years, and will line up under the Gen3 regulation set, alongside Ford and Chevrolet.

Toyota Australia has already begun design work on the GR Supra Supercar at its Altona base. The car will be powered by a development of the company's 23UR-GSE all-aluminium V8 engine.

'It's testament to the immense popularity and international appeal of our sport that a powerhouse like Toyota has chosen to join our grid,' says Supercars CEO, Shane Howard. 'We congratulate Toyota on its commitment to Supercars and are proud to be in such esteemed company as it continues its global motorsport legacy.'

Toyota already supports its one-make Toyota Gazoo Racing Australia Scholarship Series and GR Cup, alongside the TGRA Rally team, while its racing activities outside Australia extend to world championship rallying, endurance racing and NASCAR.

Supercars has been a two-manufacturer championship since 2020, but that will change with the arrival of Toyota and the GR Supra

Performance review

PMW is Europe's premier motorsport and high-performance automotive event

13-14 November 2024
Cologne, Germany

After an incredibly busy 2023 event, the Professional MotorSport World Expo team is gearing up for what will be another very impressive show this year. The event is expected to attract 200 exhibitors and launch new products and technologies, including high-performance, cost-effective turbocharger solutions for motorsport applications, torque measurement with fibre optic sensors and high-performance cast and machining solutions – to name just a few of the technologies that will be on show.

Following the success of last year's extremely well-attended exhibitor presentations, the PMW team has added two brand-new forums to the agenda for this year. Visitors will be able to join free-to-attend presentations at the exhibitor showcase, such as the new Advanced Powertrain Technology Forum, which will take place on the first day, and the AM for High Performance Automotive Symposium on day two.

Additionally, the exhibitor showcase will provide an opportunity for businesses to present their cutting-edge solutions. Visitors will uncover the latest developments across racing, high-performance automotive, powertrain and additive manufacturing.

Discover the latest developments and technologies across motorsport, high-performance automotive, powertrain and additive manufacturing at PMW

Highlights in the exhibitor presentation line up include: Tom Brown, head of motorsport programmes at Cosworth; Chris Blockley, head of high performance mechatronics at Xtrac; Stuart Cooper, market head of motorsport at Ricardo; and Prof Andrea Genovese, CEO at VESevo.

Speaker highlights at the Advanced Powertrain Technology Forum include: Selin Tur, technical director at Williams Grand Prix Technologies; Pierre-Jean Tardy, chief hydrogen engineer at Alpine; Julien Jehanne, site director at Ligier Automotive; and PMW Expo's headline sponsor, McLaren Applied's head of motorsport electrification, Neil Palmer. And that's just naming a few of those who will be present!

Whether you are looking to discover the latest developments in energy management strategies, learn how to harness design for AM in your engineering workflow or understand the role of cloud computing resources in democratising advanced simulation, the PMW Expo will provide your answers.

For more details on speakers and the full agenda, please visit the event website at www.pmw-expo.com

Lola leads with McCool appointment

Lola Cars has appointed Peter McCool as its technical director as it seeks to find its way in the marketplace. McCool was part of the Lola team between 2009 and 2012, has held senior F1 design roles at McLaren and Super Aguri and, more recently, was head of design for Mercedes when it won a brace of Formula E titles.

McCool will play a leading role in Lola's development of broader motorsport technologies, including expanding its motorsport and technological capabilities in key areas such as hydrogen, electrification and sustainable fuels and materials.

Former technical director, Mark Tatham, will remain with Lola as a technical consultant. Tatham is credited with building Lola's technical team to date, and has been instrumental in leading the company's development of the Gen3 Evo Formula E programme, which will bring Lola back to top-level motorsport this year.

McCool joins Lola from Alpine R&D Lab, the applied engineering division of the F1 team

New Bicester base for YASA

Electric drive company, YASA, has broken ground with a new headquarters in Bicester, UK. The new building will total 90,000ft.sq, and is expected to be completed in the summer of 2025, with YASA's fit out to follow.

YASA, which is wholly owned by the Mercedes-Benz Group, includes teams in the areas of innovation, engineering, prototyping, operations and business support functions. In January 2026, many of these teams will relocate to the new Bicester Motion premises.

The construction project is targeted to include eight apprenticeships, work experience opportunities, volunteering, career events, school engagement and site tours.


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Subscriptions
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Europe (12 issues) £100/€120
ROW (12 issues) £120/USD$165
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Tel +44 (0) 20 7429 4000
Fax +44 (0) 20 7429 4001
Email info@seymour.co.uk

Racecar Engineering (ISSN No: 0961-1096, USPS No: 463) is published monthly by The Chelsea Magazine Company Limited, and distributed in the USA by Asendia USA, 701 Ashland Ave, Folcroft PA. POSTMASTER: send address changes to Racecar Engineering, 701 Ashland Ave, Folcroft, PA. 19032.

Printed by Walstead Roche Ltd
Printed in England
ISSN No 0961-1096
USPS No 007-969

THE CHELSEA MAGAZINE COMPANY LTD

TELEGRAPH MEDIA GROUP

www.racecar-engineering.com

Ideology vs reality

One step forward might force a century of forward steps backwards

The newly appointed United Kingdom government is considering the possibility of restoring the ban on sale of internal combustion engine cars in 2030, just over five years away, as part of its pledge to reduce carbon emissions. This date was originally floated by the former government before being pushed back to 2035, in line with the European Union, which now looks set to consider pushing it further back still, to 2040. I believe the UK government is mixing up two arguments into one, and in doing so is making a mistake.

One argument is that electric vehicles are better for the environment; the other is that we have to reduce carbon emissions. These two statements are entirely separate.

Early in September, the Cenex Expo, a low carbon vehicle conference, took place at Millbrook Proving Ground, and was a wonderful example of how technology can help the government to achieve its zero emission target. Hydrogen was, of course, high on the agenda, as a combustion fuel with the emission at the tailpipe being almost zero (a negligible amount due to oils and other materials), and as a power source for electric motors.

As a combustion fuel, which seems to be where the market is heading at the moment, including in racing, it appears this option will be taken off the table in the UK if the government does, indeed, go ahead with this blanket ban. I have to put in a caveat here, because current reporting says a ban on the sale of ICEs, but also mentions petrol and diesel, and there is no distinction between the fuels, yet. If it is *all* ICEs, then the development path of more than a century would be put in the bin.

Bygone era

The other big event this month was the Goodwood Revival, which celebrates cars from a bygone era. Every car that races there now does so on sustainable fuel, regardless of their age and original design. That technology, too, will be in danger if the government gets its way as *all* fuel will become too expensive, or too scarce, to buy.

Yet electric cars are not sustainable in their current form. They have worse range, are heavier, use more damaging materials than an ICE car to keep the weight down, and currently are only cheaper to run because of big government incentives. They will get better, but the investment needed from all areas is still significant to make the technology work on a global scale.

At the Cenex Expo, there were EVs on display, but very few of them were designed for long-distance driving. For example, Prodrive presented its 'Last Mile' delivery van, a masterpiece of engineering. Simple, effective and built for purpose, it will indeed clean up the air in towns and cities where it is most needed. And in factories and warehouses.

Flailing around

Electric infrastructure needs investment before it becomes viable for the majority of the population, rather than just the noisy minority it currently serves, and the government should be looking at *all* alternatives to reach net zero. Happily, there was a government booth at Millbrook and I hope the representatives there feed back well to head office. Even if they do, this flailing around is causing mischief for the industry. Should anyone train on ICEs in the UK or not? Should anyone invest in the equipment, or future greener fuels, or not? One possibility is that companies will move abroad and develop technologies there.

The government should be looking at *all* alternatives to reach net zero

My last point on this matter is that EVs are already expensive and, if they become the only option in 2030, are unlikely to drop much in price. That will push the majority towards a secondhand market, which rather defeats the government's intention.

Better, I think, is to invoke the philosophy of Ulrich Baretzky, formerly head of powertrain at Audi Sport. If the government obtained cross-party support and announced that in 10 years the price of fuel would be, say, ten times today's price, it would invoke a change in buying habits. Most people would choose lighter, smaller, more efficient cars, knowing a big one would lose them money in the long term. The added benefit is that when biofuels, synthetic fuels or hydrogen is introduced, it will be cheaper still.

That would drive rapid change for the better, and help the government in its quest. Lighter cars do less damage to the roads, smaller cars leave more room for cyclists, and are invariably more efficient. As Steve Sapsford wrote for us a few years ago, a human emits 15g/km of CO_2. Asking a car to do better than that is the current target, but is it realistic?

History has proven time and time again that banning technology is never the solution. Investing in technology, and going with the best available solution, is the better choice. Unfortunately, the UK looks as though it could be about to take a giant step backwards on the global stage.

ANDREW COTTON Editor

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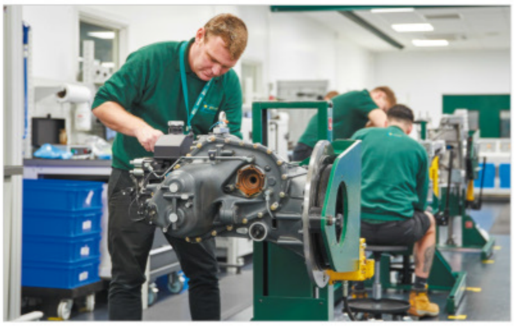

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