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The 2026 season will welcome a new electronic control platform from McLaren Applied.

The 2024 season marks the 13th of McLaren Applied's involvement with the series. NASCAR has been using the TAG-400N Engine Control Unit since introducing electronic fuel injection in 2012. The device has completed over **4 million miles** without any race failures.

Skylar Stamey, McLaren Applied VP of Motorsport, North America:
"Being the sole supplier to the NASCAR Cup Series is both an honor and a challenge. For over 12 years, we've continuously improved our products and services, staying committed to the local motorsport community."

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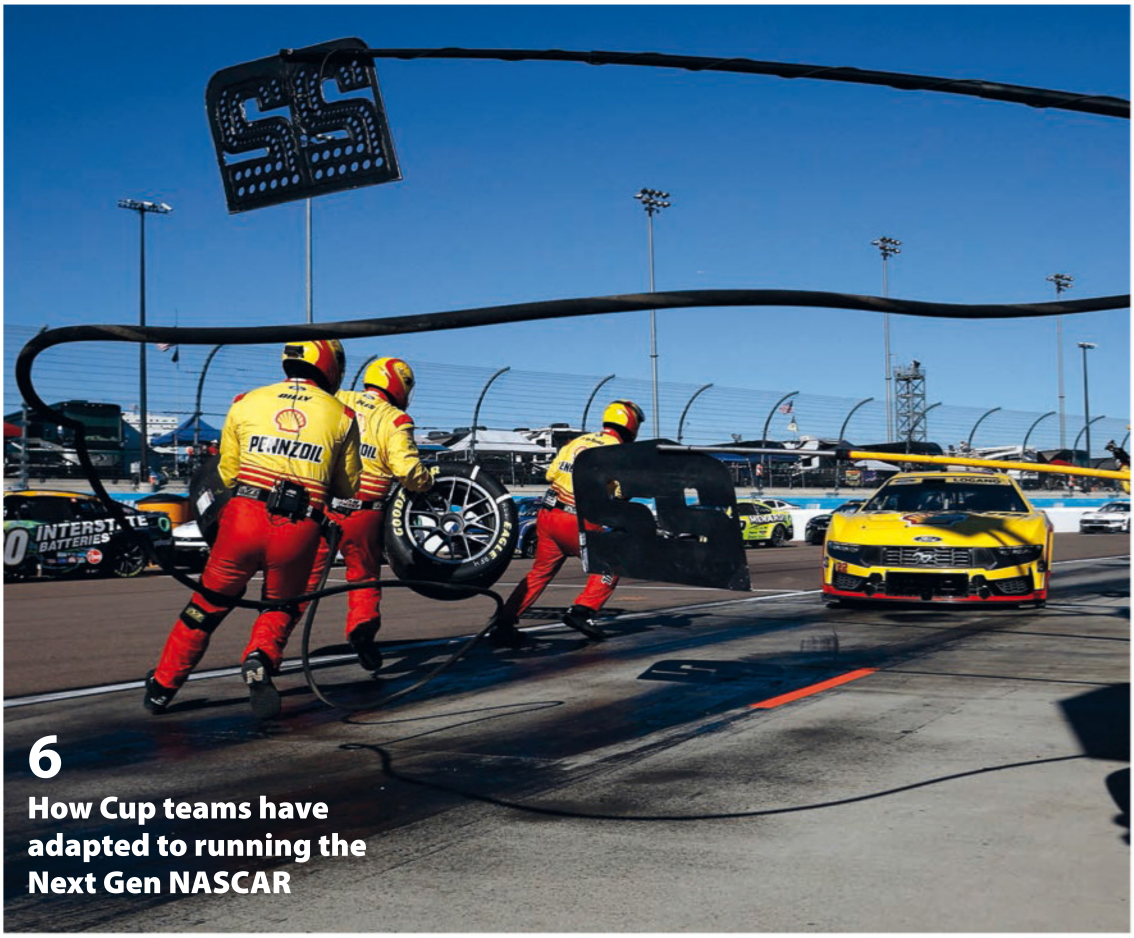

Getty Images

New world order

NASCAR is looking to open the door to alternative engine configurations, but will that be enough to bring new manufacturers into the Cup Series?

By Andrew Cotton

All across the motorsport spectrum, there is a push for new manufacturers to join top racing series. NASCAR is no exception, and has a long-term plan to introduce a new engine formula that will use lessons learned from sportscar racing to increase diversity on the grid.

The premier NASCAR Cup Series currently only has three manufacturers – Chevrolet, Ford and Toyota – and feels its V8 formula is not attracting enough attention from others. It has looked at other fuels, including efuels and the bio-fuels being used in sportscars, and may yet introduce them. Indeed, NASCAR's Garage 56 Le Mans entry in 2023 gave valuable information on this to the series, and to Hendrick Motorsports, which developed the power unit for the race.

In the meantime, a change in engine formula is being prepared, and new dynos will shortly be delivered to the NASCAR R&D Center near Charlotte, North Carolina, where work has already started on the new era of powertrains.

Broad reach

NASCAR owns IMSA, the American sportscar racing sanctioning body. This gives it instant access to the research and learnings developed collaboratively by engineers at the FIA, ACO and IMSA.

Right now in sportscar racing, the top-level cars have their power output monitored by torque sensors mounted on the driveshaft. *Racecar Engineering* published a feature on MagCanica, the California-based company that produces the sensors and modifies the driveshafts, in our Le Mans supplement, available on www.racecar-engineering.com.

Using torque sensors changes the way the cars operate, and are operated. As well as monitoring engine output, they account for power losses through the gearbox and differential, before the torque produced by the engine reaches the driven wheels.

What that means in practice is that everything north of the torque sensor is largely irrelevant. As the only thing that matters in a performance-balanced formula is the power at the wheels, *any* power unit can be used, and *any* fuel. A power curve is configured by the series' organisers for a particular engine, and the task of the engineers is then to get as close to that curve, and to keep the car as close to it for as much of the time it is on track as possible. Any percentage below the prescribed curve is performance lost.

> ‘The only thing that matters in a performance-balanced formula is the power at the wheels’

On paper, it should be easier to introduce torque sensors into NASCAR than sportscars. The latter discipline runs exclusively on road courses, normally taking kerbs, which can disrupt the accuracy of the sensors. On an oval, it should be simpler to manage such variances but, as NASCAR found out when it ran a torque sensor test at Richmond, it's not straightforward.

Further tests will be conducted throughout 2025, with a view to running torque sensors across all cars in all races during 2026, creating a benchmark for power delivery. That will make for an interesting season. As it should be the last with the current generation V8 engines, there will be no reason for teams to hide performance. Assuming the tests of the torque sensors in race conditions are successful, that will open up a whole new world for the sport of stock car racing.

It has been a long time since anything other than a V8 raced in NASCAR. Of course, there were V6s in the 1950s, and they ran in the second-tier series until recently when they were replaced by the V8 configuration. However, in today's world, motorsport needs to demonstrate visible progress, so other powertrain variations are certainly on the agenda.

Manufacturers are looking for efficiency rather than volume. That said, pole position at Le Mans was set by a V8-powered Porsche prototype. It narrowly beat a Cadillac, also fitted with a V8.

Six of the best

So, who are the manufacturers that might take an interest under a new engine formula? The obvious one is Honda. Although, officially, the Japanese manufacturer backs IndyCar to the hilt, involvement in NASCAR does make sense. The company produced a jewel of a V6 engine for sportscar racing, and a single-seater variant, only to have it rejected by IndyCar so, understandably, Honda Racing Corporation (HRC) is looking for other applications for it. Publicly, HRC says it is evaluating all options, but a new engine formula for NASCAR would surely be very welcome.

Anyone else with a plan, or desire, to break into the North American market might also have a good look at NASCAR with a new formula. The fan base, and the marketing possibilities that come with it, are enormous. This could present one of the biggest opportunities in the series' long and illustrious history. ●

Next Gen brought a new look, fundamental changes to the aerodynamics, tyres and major mechanical components that put teams back to square one when it came to development

Seven up

The Next Gen cars brought a completely different concept to Gen 6, forcing teams and drivers to adapt to a new style of racing

By Andrew Cotton

Getty Image

> Larger wheels allowed for bigger brakes, but required lower profile tyres that had a completely different set of characteristics

NASCAR's Next Gen rule set not only brought about a completely different car, both conceptually and technically, but it also led to a different style of racing. Teams have had to adapt to a new way of working with the cars, and drivers have learned an entirely new way of controlling them, aided by their strategists, as they seek to move up through the field.

The Next Gen, or seventh-generation, regulations were introduced for the 2022 NASCAR Cup Series season, and brought a new, Dallara designed, coupé-style body shape to the track that, unlike Gen 6, is symmetrical at the rear. It also introduced 18in wheels, low profile Goodyear tyres, standardised brakes from AP Racing, revised suspension and a manual sequential gearbox.

These were the headline changes, but there were plenty of others, such as using standard gear ratios throughout the field, and changing the way teams can adjust the aerodynamics, including banning race tape from the front of the cars. This, in turn, led to a completely different engine set up and settings in the differential.

All this has helped close up the field, but making up places through slipstreaming has become more difficult.

New approach

Consequently, the arrival of the Next Gen cars changed the way teams approached races. The larger wheels allowed for bigger brakes, but required lower profile tyres that had a completely different set of characteristics, compared to those used in Gen 6.

'What's been a very interesting difference for us is the aspect ratio of the tyre,' says Cliff Daniels, crew chief of Kyle Larson's Hendrick Motorsports Chevrolet. 'It's a lot wider contact patch area for a lot shorter sidewall. Early in the Next Gen era, Goodyear was struggling with sidewall blowout failures from over deflection and under inflation. With a 3400lb [1542kg] stock car, the more tyre deflection we can get, the more grip we can achieve, and a more comfortable feel for the drivers.'

The change in tyre pressures led to a change in camber settings, and teams had to create whole new set-up sheets which, after three years of running, are now routine.

One of the main aims of the redesign was to close up the field from Gen 6 (shown here in 2015) and, while the new car achieved that, it has made slipstreaming and passing more difficult

Getty Image

The new, coupé body shape behaves very differently to the Gen 6 car, but the aero modifications made underneath mean drivers in the pack struggle to reel in cars running in clean air at the front

However, the larger wheel, compared to the Gen 6 car, had an unexpected side effect, as Daniels explains: 'The wheels seem to pump a lot more air than what our old steel wheels would do with very small close outs. The available brake cooling from these wheels, and the lack of tyre temperature increase – our tyre temperatures seem to build to a certain point and then kind of stabilise – really has to do with the amount of air the wheels are moving.'

Braking performance

The new braking system from AP Racing, detailed on pp40-45, has also presented a different way of working for the established teams. Teams now run a single caliper package throughout the season, with just the choice between heavy and light-duty discs, and some minor pedal box adjustability. This lack of brake set-up options is another big change from Gen 6 and, after three years of getting used to it, teams through the field say they have settled on settings that work for their drivers' preferences.

One of the biggest differences in braking performance comes on the ovals. The Gen 6 cars had a shut-off valve on the right rear corner, which meant a driver could choose to reduce brake pressure there to improve stability under brakes. That valve was removed under the new rule set, so teams adapted by running different brake pad material side to side, which is still a free choice, to bring about the same effect.

> “It's become this kind of chess game. If I just stay behind for a little longer, he'll burn up his right rear tyre and then I can pass him and have more towards the end of the run”
>
> *JR Houston, strategy and analytics engineer for 23XI Racing Toyota*

Cooling the Cup Series car also became a very different game. With Gen 6, teams would regularly use race tape around the front of their cars to close vents and improve airflow over the top. This caused power units to run hotter, but the engine builders worked around that. But race tape is now banned for this use, and bonnet vents are standardised.

'In Gen 6, we could basically tape the nose off, and we would control how much cooling went into the engine,' says JR Houston, strategy and analytics engineer for 23XI Racing Toyota. 'More tape was more downforce and less drag. If you added a piece of tape to the front of the car, it was basically free speed.

'A lot of the engine manufacturers migrated towards being able to manage extremely hot running temperatures because the couple of horsepower you'd lose by running that hot, you gained by the tape on the nose. With this car, the cooling goes straight through the hood and over the car.'

Aero perspective

Clearly, from an aerodynamic perspective, the Next Gen cars were completely new. The move to a coupé-style body shape was deemed more in keeping with what the Cup Series manufacturers are selling from their road car production lines. However, airflow over and under the car has fundamentally changed the racing. Pushing air out through the spec louvres in the bonnet has led to a larger wake, which makes it more difficult for a following car to effect a change of position.

Further changes to the car between generations included adding an underwing, which essentially raises the take-off speed, changing the front splitter function and introducing a more powerful diffuser at the rear. This has led to cars running nose high,

Getty Image

The Gen 7 cars are said to be most aero susceptible at high speeds, mid-corner, where the lead car benefits from more frontal downforce than a following car that gets looser when trying to pass

in an attempt to generate strong airflow under the car to the diffuser, rather than over the top of it. That, coupled with a drop in downforce, has fundamentally changed how teams, and their drivers, go racing.

'I would say the biggest change was they put stuffers, so it's roughly three quarters of an inch tall by an inch and a half long pieces that come just inboard of a portion of the splitter, to literally dam the air,' explains Daniels. 'That's why we run the cars at such an awkward pitch angle, with the nose of the car pretty high and the back quite low.

'Really, you're trying to get above the wake the stuffers create to continue to use the airstream underneath the car to power the diffuser, to try and make as much downforce as we can at the diffuser. If it wasn't for the stuffers, we'd be able to run a more even pitch [angle].'

Running nose high works fine in clear air, so hasn't been a problem for drivers at the front of the pack, but those behind have struggled in traffic. Starved of airflow under the car, they run into understeer issues, due to their diffuser being less effective, while the airflow over the top of the car exiting from the bonnet louvres creates a turbulent wake behind. All of this adds to a greater difficulty of progressing up through the grid.

'You end up with very heavy understeer, because we're lacking so much front downforce just trying to keep the splitter area from stalling,' says Daniels. 'The car feels like it's driving more on edge because you are at the understeer limit quite a bit. Then, as you get into oversteer, the car gets loose, and you don't have all the side force contribution, all the tightening yaw moment we used to have on the old car due to the tail offset.'

Houston agrees: 'Where the car is most aero susceptible is at high speeds, 170mph mid-corner speeds. The lead car has all the air, so it has the most front downforce. The second car has less front downforce, so that car is a bit looser. It's built to have a little more oversteer, because it needs it for that aerodynamic situation, but the second that car takes the lead it becomes loose, with tons of oversteer, so it heats up the right rear tyre and can't then pull away from the car behind.

'So, it's become this kind of chess game – if I just stay behind for a little longer, he'll burn up his right rear tyre and then I can pass him and have more towards the end of the run.

> Airflow over and under the car has fundamentally changed the racing

'Now, a lot of the places where you might want to run nose high for perfect steady-state qualifying, you lose [any advantage] the second you get in traffic. The cars are so aerodynamically tight that you have to build them mechanically loose.'

Pit stop strategy

That fundamental aerodynamic difference has changed the teams' approach to racing, and to pit stops. Where before a team might have made a set-up change during a stop, now the time lost in doing so, putting their car further back in the pack in the process, exacerbates the problem of making up time, and positions, out on track.

'You don't know what you're going to end up with at any moment,' says Houston. 'If you come in on a pit stop from the lead, and you have a bad stop and come out 10th, your car's built tight, but you're now in traffic and it's awful, so that's a really tough one.

'Say you wanted to make a mid-race change, your pit stop is going to be a little bit longer, which means you're going to lose some positions. If you have a tight car and need to loosen it up, well, now you probably have to double down on the adjustment, because you're going to be even further back than you were before when you get back out on track.'

The difficulty of passing in the pack has led to a change in pit stop strategies. Now the aim is to get the car in and out again as quickly as possible, rather than making set-up changes mid-race

Another significant change between the Gen 6 car and Next Gen is ride height. While the Gen 6 car was able to run low, with skirts that created downforce through efficient airflow, the Next Gen car has a minimum static ride height at tech and control dampers that limit what the teams can do at speed.

Teams have therefore been trying to find a balance between ride control on the springs and running as low as possible and close to the bump stop limit. Non-linear springs have been banned from the Cup Series under the Next Gen rules, but are still allowed in the feeder Xfinity and Truck championships.

'Everything's a linear spring,' corrects Houston. 'It's anything from a 200lb spring to a 4000lb spring. There's so much nuance in the characteristics of the racetrack. If you had a perfectly smooth track, you'd run a really heavy rate spring so the car doesn't move much between high aero load and low aero load. If it's a bouncy track, though, or a very rough track, you need a softer spring rate just for grip. But then the car is rising as the pace slows down because of that soft spring, which means you're up off the [bump] stops and making less downforce, even though the car is technically set up for more grip.'

Modular chassis

The Dallara tube-frame chassis has also been something of a novelty under the Next Gen rule set. The Italian manufacturer introduced the concept of a modular chassis, with front and rear frames attached to a main structure to make accident repair faster, cheaper and more efficient. Significantly, teams no longer prepare their own chassis, instead purchasing the base product from NASCAR.

'There's a lot of ingenuity and innovation behind our approach, from a chassis, mechanical, body and aerodynamic standpoint, because it is basically a spec-type car now,' says Daniels. 'It's really become a game of quality control, of understanding

> “There's a lot of ingenuity and innovation behind our approach, from a chassis, mechanical, body and aerodynamic standpoint, because it is basically a spec-type car now”
>
> *Cliff Daniels, crew chief of Kyle Larson's Hendrick Motorsports Chevrolet*

the parts and pieces you have, the finer points of their measurements, their fitment, and how you assemble your puzzle from the pieces that are given to you.'

Race shops, in particular, have felt the pinch here, being notably much quieter than they were during the Gen 6 era. Teams are estimated to have trimmed their workforces down by 10-30 per cent as they no longer need to construct multiple chassis and engines, and development restrictions bite.

That's not to say the Next Gen cars are a finished product. Teams have been working hard over the last three years to unlock the secrets of the concept. For some, such as 23XI Racing, which was always set up to buy in components, the change to Next Gen has not been such a big one. Where before they would buy from Joe Gibbs Racing, now they buy direct from NASCAR. For teams that built their own cars, though, the switch has been more significant.

'A lot of the really big teams, say Joe Gibbs Racing for example, have entire design departments, whole fabrication departments, that are now halving in size, because what is there to design?' says Houston. 'Even the Xfinity Series, they're slowly going to run into the same issue as all the parts, or at least most of the parts they're using, were coming from old Cup cars. As the old Cup cars aren't being built any more, those teams are soon going to run out of parts, unless they also get a spec car. So that's probably coming down the line.'

> “I think [fixed gearbox ratios] helped to bridge the gap with a lot of the stock car-specific drivers when we go to road courses”
>
> *Cliff Daniels, crew chief of Kyle Larson's Hendrick Motorsports Chevrolet*

Retained advantage

The shift to a sequential Xtrac gearbox and fixed gear ratios was also a step into the future for NASCAR, although race engineers we spoke to confirm that drivers who were already good on the brakes have retained that advantage with the new transmission.

The ramp angle on the differential is now locked in, although teams can play with diff' pressure. However, teams have lost some of the adjustability they enjoyed with Gen 6 cars.

'Obviously, everybody's in the same boat now,' says Houston. 'So, if somebody is accelerating better than somebody else, it's just motor. We used to do pit road rolls pre-race for pit road speed. Some cars would be in first gear, others would be in second gear – you could easily hear the difference – and you'd mark down if a competitor was using first gear because you knew it must be their transmission settings.'

'I think it's helped to bridge the gap with a lot of the stock car-specific drivers when we go to road courses,' adds Daniels. 'How they're able to manage corner entry and downshifts getting into the corner vs the car of old. It's been a good bit different.'

The change from Gen 6 to 7 was always going to be a major shift, but few could have imagined the effect it would have on all aspects of the race meeting. Teams have adapted well to the changing landscape, and will continue to work with NASCAR to address issues on track to ensure the Next Gen cars continue to provide classic NASCAR racing.

Getty Image

The knock-on effect of the introduction of Next Gen has yet to be realised in the Xfinity series, which traditionally used parts from old Cup cars, the supply of which will slowly start to dry up

Graduation day

Those involved in the aero development of the NASCAR Next Gen racecar saw it not so much as the birth of a new era, more the completion of a study course

By Dr Eric Jacuzzi

> A once-in-a-lifetime project for most of us involved, who may never see another project quite as revolutionary to an ecosystem as this

The NASCAR Next Gen car platform took to the track in earnest in late 2021, for the final team tests undertaken prior to its debut at the Clash at the Los Angeles Memorial Coliseum, an exhibition race to kick off the 2022 season.

The car's development spanned several years, consuming thousands of hours of design and testing work, involving numerous suppliers and a global pandemic. What follows here is a small part of the story of Next Gen's development from an aerodynamic standpoint, as told by the managing director of aerodynamics for NASCAR.

The sanctioning body's outgoing vehicle, the Gen 6, was introduced in 2013. With its forward emphasis on manufacturer identity, it was a breakthrough for the sport. It was the first time in many years that the entirety of the vehicle, from nose to tail, was unique to each manufacturer (within certain parameters),

> Perhaps the greatest departure of the Next Gen vehicle from the Gen 6 was the move to a coupé-like roofline, and the symmetry of the rear of the vehicle

The evocative, 'retro' styling of popular cars like GM's Camaro and Ford's Mustang don't lend themselves to the traditional three-box NASCAR silhouette, so the Next Gen body moved more towards a coupé appearance

The new body style, and change to a symmetrical shape, meant all the aero development done to ensure the Gen 6 cars remain on the ground in yaw on high-speed ovals had to be revisited

harking back to the fiercely competitive manufacturer racing days of old. After eight years of racing, though, it was deemed time to update the look of NASCAR's headlining Cup Series so the cars more closely resembled their roadgoing counterparts, which too had evolved over that time period.

Evocative coupés

Perhaps the greatest departure of the Next Gen vehicle from the Gen 6 was the move to a coupé-like roofline, and the symmetry at the rear of the vehicle. The Gen 6 was designed around a sedan greenhouse profile, which at the time was more relevant to the manufacturers' vehicle mix. However, the re-introduction of evocative coupés such as the Ford Mustang and Chevrolet Camaro meant fitting the production body style onto that sedan greenhouse would be a challenge.

The side profile of the Next Gen car was therefore a blend of the lines of the Camaro, Mustang and Toyota Camry, featuring a lower roof line and swooping back glass design that worked well for all three cars. With the greenhouse decided, the next step was to move to another stylistic sore point, the tail.

The Gen 6 vehicle was optimised to race on left-turning, high-banked ovals, generating stability in yaw via a large rear overhang and a 2.5in offset to the right. This offset generated rear side force, resulting in a restorative, positive yawing moment to the car. It also allowed the car to 'correct' itself when the driver overstepped the boundaries of traction at the rear.

The lower roof line and swooping rear window suits all three of the main manufacturer models, as does the much shorter rear deck section. The result is all three retain a strong brand identity

However, achieving all that presented significant aesthetic challenges for both the manufacturers and NASCAR, since car designs not only had to be stretched at the rear, but also required different shapes on the left and right sides. This led to various interpretations of what was acceptable, and often lengthy lists of revisions from NASCAR in terms of qualitative styling, as compared to the production vehicle.

Introducing a symmetrical body eliminated most of these issues and presented a car that was a near spitting image of its street counterparts. Another factor in moving towards a symmetric body was the evolution of the NASCAR racing calendar. The introduction of more road courses and short tracks reduced the need for the car's design to focus on high-speed ovals, and more towards a shape that could comfortably do it all.

Spoiler alert

Speaking of the tail, another key feature of NASCAR machinery is the spoiler. It's a blunt instrument, but a historical element that completes the stock car look. It is also a very effective device from a sanctioning body perspective for controlling top speeds, which is critical for both fan and driver safety due to the proximity of both to the walls and fencing at most of the oval tracks.

Another element that influenced vehicle styling was the decision to duct cooling air out of the car once it passed through the radiator. This concept is not new to vehicles in general but, for all previous NASCAR designs, the radiator simply emptied into the under-bonnet (hood) region like a production car. The counter incentive this created was less radiator cooling flow, which resulted in more front downforce and less drag, all of which added up to very hot engine temperatures.

NASCAR previously investigated ducting radiator air out of the engine bay area of the cars at the 2019 All-Star Race at Charlotte Motor Speedway, and it was decided to implement this feature on the Next Gen cars in an effort to promote longer engine lifespans and reduce in-car temperatures. Two zones were opened up for OEMs to place their radiator exits, with the majority of the underlying radiator ducting made common. Either louvred or open designs were permitted, based on the styling desires of the manufacturers, which is apparent when comparing the three vehicles.

Cowl induction at the base of the windscreen has been a mainstay of NASCAR competition cars for decades, but is not compatible with heated radiator air exiting out of the bonnet just ahead of that zone. It was therefore decided to take the engine air from the front side of the radiator core, rather than create an additional opening in the front fascia for stylistic reasons.

One development was ducting hot air from the engine bay to prolong engine life. This had a knock-on effect with air induction paths

With these elements settled, the OEM aero teams and design studios went to work on what would become their 2022 challengers.

Carbon underbody

One of the largest departures of the Next Gen car, aerodynamically speaking, was the lack of side skirts. While skirts are effective at generating downforce in a simple manner, they give the appearance of the cars being sealed to the track, along with the inevitable – and undesirable – wrinkling and deformation they experience during competition.

The Next Gen car became the first NASCAR vehicle to feature a full carbon fibre, aerodynamically-driven underbody. That said, the Gen 6 cars had become substantially developed to take advantage of the high-speed undercar flows. The difference is that one was purposefully built; the other had to 'pretend' to be for other reasons.

> 'The process was primarily undertaken in CFD, with over 2000 runs dedicated to underwing development for both performance and lift-off safety testing'

Development of the underwing was done in parallel with the common elements on the car body. The process was primarily undertaken in CFD, with over 2000 runs dedicated to underwing development for both performance and lift-off safety testing.

Side skirts were removed, and the Next Gen cars have a full-length, aerodynamically-driven, carbon fibre underbody, plus 18in rims

"Bandage" for Racing Components

Most racing components are designed to be as light and compact as possible. Unfortunately, metal components can sometimes fail due to oil starvation or metal fatigue, and racing teams often lack the time to redesign and retest before the next race or cannot modify the parts due to regulations.

WPC Metal Surface Treatment

WPC Treatment is a surface treatment process that enhances oil retention and fatigue strength in metal components. This micro shot peening process creates high residual compressive stress beneath the surface, alters the crystal structure of the metal, and leaves fine dimples that serve as oil retention pools, helping to prevent oil starvation. WPC does not alter the dimensions of the parts, so clearances remain unchanged.

This treatment improves performance and reduces wear by minimizing friction, while also enhancing the durability and reliability of metal components. WPC treatment helps prevent cracking, breakage, chipping, pitting, fretting, galling, seizing, and overheating caused by friction.

WPC can be applied to any disassembled metal components, including pistons, piston pins, piston rings, valves, valve springs, valve spring retainers, lifters, rocker arms, camshafts, cam caps, crankshafts, transmission gears and shafts, shift shafts, shift forks, synchronizer rings, hubs and sleeves, dog rings, final gears, differential gears, drive shafts, washers, collars, and various bearings, such as transmission bearings, hub bearings, and CV joints. WPC treatment can even be applied to softer materials, such as plain engine bearings.

Clutch plates, limited-slip differential plates, automatic transmission clutch plates and one-way clutch sprags and races are excellent candidates for WPC treatment, as it makes engagement smoother and reduces chattering, which can otherwise impose impact loads on other components.

Finish the Race with WPC Treatment

While WPC cannot repair damaged parts, it can serve as a temporary "bandage" for racing components. Although it may not be a long-term solution, it can provide an interim fix to help complete a race or even a race season.

The turnaround time for WPC metal surface treatment is typically quick, usually within four business days. The WPC Treatment Company also offers an expedited processing service by appointment for "Emergency Care," which can be completed the same day.

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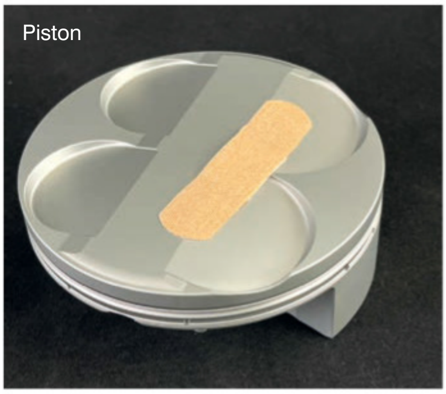

Piston

Since the introduction of Next Gen was originally slated for 2021, it was decided that the only viable path to making the timeline was to go from CFD straight to full-scale testing. Scale model options were evaluated as well, but with confidence in the simulation work and world class local wind tunnel facilities, it was decided to move ahead and target only four development tests of 20 hours each to finalise the underwing.

NASCAR has always placed a premium on safety for both drivers and fans in all instances, so it was important to establish early in the process that no design decisions would adversely affect the lift-off speed of the car. It was also decided to use a 14-point CFD ride height map, which included front and rear ride height, yaw and pitch sweeps to characterise as fully as possible the performance of the vehicle and any impacts that changes brought. This map was later used in wind tunnel testing at Windshear's wind tunnel in Concord, North Carolina.

Aero goals

Early in the process, the goal was to match the relative aero performance of the Gen 6 vehicle, primarily in terms of total downforce and balance. Because the Gen 6 car had a restorative yawing moment due to the rear asymmetry, teams were able to run very high front downforce percentages, often exceeding 50 per cent. It was understood early on that the reduction of rear side force due to body symmetry would impact the useable aero balance, but initially it was something of a guessing game, although not entirely without value. Early aero development therefore focused on matching the evenly distributed downforce number.

The thing about aero development in general is that it's much easier to make front downforce than it is to generate rear downforce. Minor improvements in shapes, fit and finish yield greater results at the front of the car, where the highest energy air is found. As that air loses energy towards the rear of the car, it becomes much more difficult to generate downforce. Add in the fact that the ability of the rear of a car to generate downforce is hampered by the mass in front of it means, basically, that the front of any car has the first choice on making downforce.

After reviewing ride height data from early tests and determining where the drivers felt comfortable after the car was adjusted, it was easy to identify that it correlated with a downforce distribution of approximately 30 per cent front. This meant moving the downforce balance rearward by 12-14 per cent, which was a significant departure from the existing Gen 6 architecture. This is where the front downforce-generating exercise paid dividends – by knowing what could reverse the front downforce gains.

In achieving the goal of matching the downforce and aero balance of the outgoing Gen 6 car, the front splitter played a crucial part

At the front of the car, one of the most substantial downforce-generating characteristics, aside from ground effect, was the outwash of the front splitter in front of the tyres. The outward sweep of the splitter footplate – which is a wear-limiting device for track contact – proved to be a very significant generator of downforce. Reducing the balance required reversing this original development. One of the advantages of this was that the change funnelled some of the previously ejected high energy air towards the rear of the car.

Diffuser evolution

At the rear of the car, the diffuser underwent an evolution at the same time as the front splitter when the balance change was being implemented. The original diffuser was relatively simple in its design, so wind tunnel testing could begin and provide an early opportunity for validation against the CFD model. With confidence in the CFD predictions and a need to attain more rear downforce, a multi-week CFD study began to refine the diffuser for the Next Gen car. It was decided to keep its kick line (the most forward edge) as far towards the centre of the car as possible.

It was also evident that the outer tunnels were ingesting the front tyre wakes. In an effort to draw in higher energy air from the outside of the floor, the rear of the rocker boxes was ramped upward and the diffuser outer tunnels were given a double hump design. This pushed the initial outer tunnel ramp forward and outward. To accommodate the maximum suspension droop, these outer tunnels would move back downwards before resuming an upward trajectory.

Rear downforce performance was largely constant over a range of ride heights, and floor pressures are very consistent across a range of ride heights.

> ‘Early in the process, the goal was to match the relative aero performance of the Gen 6 vehicle, primarily in terms of total downforce and balance’

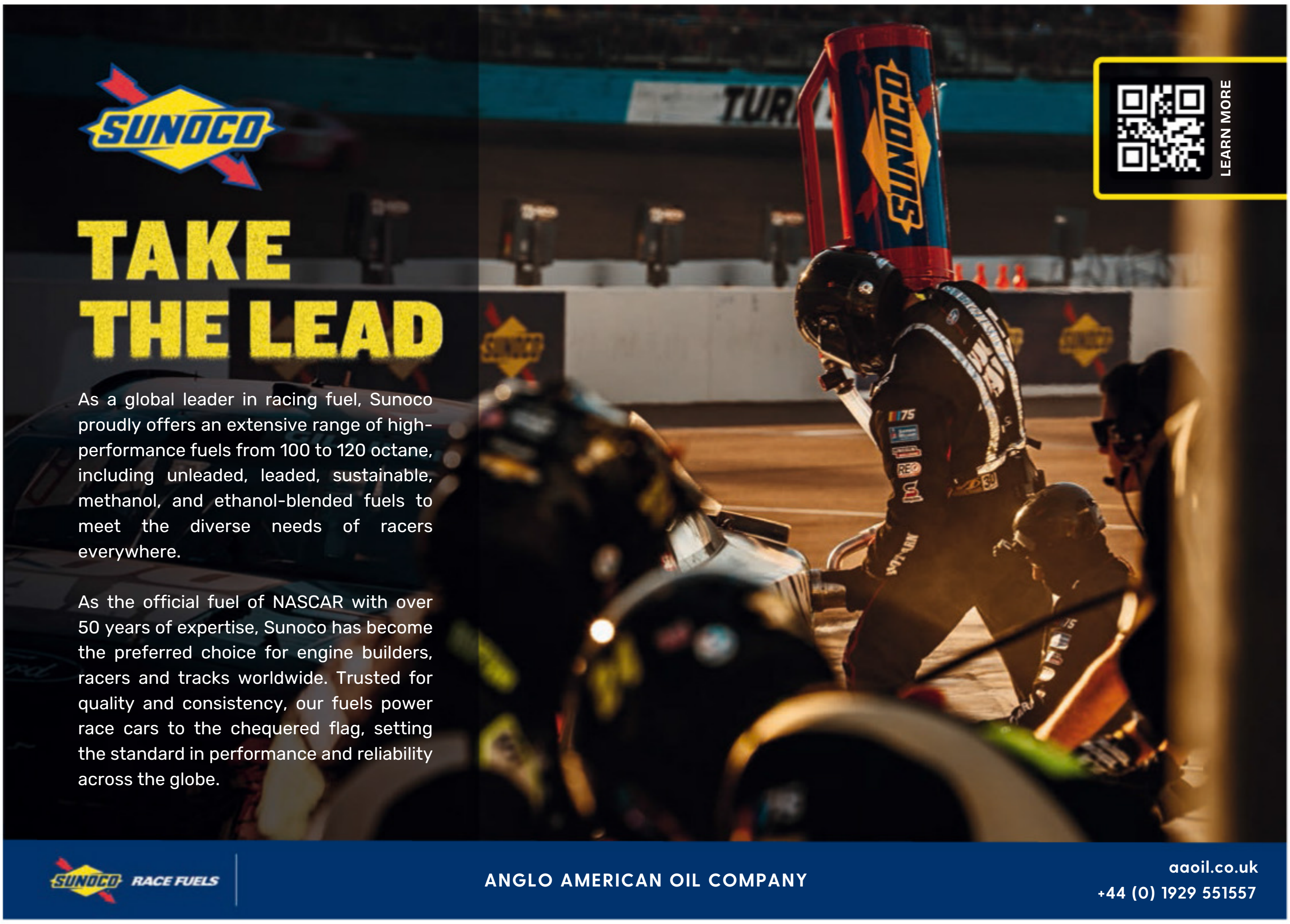
Lift-off safety

On the lift-off safety front, NASCAR evaluated the vehicle in CFD before testing at the Automotive Center for Excellence (ACE) in Oshawa, Canada and the Chrysler Technical Center's aero acoustic wind tunnel in Auburn Hills, Michigan. The Next Gen features the passively deployed bonnet (hood) and roof flaps used in all of NASCAR's vehicles, but the diffuser presented an opportunity to add another safety device by way of a diffuser flap.

This was held in place at the centre of the diffuser and, when deployed, released downward to block the central tunnel of the diffuser. This created low pressure behind the flap and increased the lift-off speed of the car when nearly backward by 10-20 per cent. The flap was originally designed to operate via a pressure-based deployment system, but it was found to be more effective to deploy it via a mechanical release connected to the right-side roof flap by a cable.

Overall, the path of development for the underwing was aggressive but successful, thanks largely to the correlation between CFD and wind tunnel data.

After nearly nine months of private development testing, all three OEMs submitted their finished vehicles in August 2020 for three gruelling days at the Aerodyn wind tunnel in Mooresville, North Carolina.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The advent of a new vehicle allowed NASCAR and the OEM aero teams to further refine the already tight submission process.

Aside from qualitative and quantitative CAD reviews, the wind tunnel performance of the body is the most critical component. To ensure the most accurate and repeatable testing environment possible, NASCAR uses a dedicated submission vehicle capable of having different OEM body panels mounted to it. Because of the enormous time demands of three manufacturers doing wind tunnel tests in the same period, three clones of the submission vehicle were produced for the OEMs to use in their private testing efforts.

The submission process itself consists of two distinct components. The test opens with NASCAR setting the performance targets using its generic body, with several repeated runs at the start of the test. The OEM vehicle(s) must pass the first gate with no radiator flow, which must be worse in lift and drag than the generic body. With the radiator flow open, the OEM body must have a radiator velocity ratio (VR) within +/- 0.005 of the NASCAR generic body, which also occupies the centre of a lift / drag box with tolerances in each direction. The body must fall within this box, or the test is considered a failure.

Configuration changes

OEMs are allowed up to five different design attempts per shift though, practically speaking, it is difficult to get through more than three configurations. The submitted OEM bodies are scanned in the wind tunnel and compared to the submitted CAD for each design, with strict tolerances enforced to ensure each test article is representative of the design intent. Testament to all three of the manufacturer aero teams is they all passed their submission tests on the first attempt.

With the bodies submitted and approved, work began on converting the bodies into composite components. The body uses flanges and a common mounting system to attach to the chassis, with adjustment built in of up to 0.15in in each direction to accommodate manufacturing tolerances.

Body inspection at the track is still conducted by NASCAR's Optical Scanning Station, which compares a rapid photo scan of the car to the approved CAD surface of the vehicle. This scan is located off targets on the chassis and has a tolerance of +/- 0.15in for the body, which presents challenges to the teams to build to that tolerance but also keeps the competition on a level playing field.

Production parts began to arrive in early 2021 and the first major test of team cars occurred at Daytona International Speedway. Over two hot and humid days, it became apparent the production cars were getting much hotter than the NASCAR test cars.

Early on-track testing showed unacceptable heat ingress into the cockpits, so a raft of changes were made to improve driver cooling

Some of this was attributable to inadequate insulation and material changes in production, but a great deal was due to the ingestion of hot radiator air into the cockpit, and inadequate evacuation of that air.

These issues had not arisen during single vehicle testing, due to some seemingly minor design differences between the prototype vehicles and production. One example was the use of Kevlar composites to form the seals between the exhaust and the cockpit, which appeared to result in greater conduction into the steel chassis of the car since no heat is dissipated from the composite surfaces. Another was at the rear of the car, where the production wheel tubs further closed off the rear of the boot [trunk] area, sealing in hot air from the transaxle cooler.

Thermal modelling

After Daytona, the NASCAR R&D aerodynamics team embarked on a month-long extensive study of the problem, thermally modelling the entire vehicle in much more detail than it had previously.

This resulted in a laundry list of changes that were implemented at the Charlotte Roval test in mid-September, which included windscreen driver cooling ducts, slotted rear glass, a full right-side door window, the elimination of left-side NACA ducts into the cockpit, a NACA duct in the floor and opening up the rear to evacuate the transaxle heat. These changes yielded substantial gains in the instrumented cars at the test.

> ‘While there were the expected teething issues… the Next Gen car has proved itself a worthy platform for the sport of NASCAR in the 21st century’

Overall, the Next Gen car proved a once-in-a-lifetime project for most of us involved, who may never see another project quite as revolutionary to an ecosystem as this. Its significance to the sport cannot be understated, and its promise yielded immediate gains, increasing team charter values and bringing a new team into the fray.

While there were the expected teething issues as teams adapted and learned at different rates, the Next Gen car has proved itself a worthy platform for the sport of NASCAR in the 21st century.

For the men and women of NASCAR R&D, Dallara, and all the industries involved in making the Next Gen car a reality, its first regular season in competition was treated not so much as the birth of a new era, but more like a college graduation; a well-prepared student entering a world of possibility and excitement, with a proud group of invested parents standing behind it, wishing it every success for the future. ●

Design guru

NASCAR called upon Dallara to design the Next Gen platform but, as a stock car racing newcomer, the experienced Italian company had a lot to learn

By Daniel Lloyd

NASCAR's move to a spec chassis required the organisation to find an experienced partner to do the design work. Step forward Dallara

Dallara had done virtually nothing in American stock car racing before receiving the call to help NASCAR develop its milestone Next Gen car. The Italian engineering powerhouse is well known for its design and manufacturing of top-level single seaters and sportscars, but this very different type of motorsport had barely crossed its radar.

Before Next Gen, which made its race debut in 2022, the extent of Dallara's NASCAR involvement had been setting up a drive simulator for the Richard Childress Racing (RCR) team. The link was created by Dallara supplying the chassis for Team Menard during its title-winning IRL IndyCar stint in the 1990s. The team owner's son, Paul Menard, then went on to race for RCR in the Cup Series. That was about as far as Dallara's attachment to stock car racing had gone, until recently.

It is why the call from NASCAR's technical leadership in 2018 felt like it came 'out of the blue', according to Dallara NASCAR programme manager, Luca Pignacca. The reason for the call was the sanctioning body wanted to enlist Dallara's help in designing the Next Gen racer. This marked a shift in philosophy. Previously, NASCAR teams designed and built their own cars to a set of technical regulations, even coming up with individual car packages for different tracks. NASCAR sought to bring those activities into its own wheelhouse with Next Gen, providing teams with a complete car package incorporating over 100 spec components.

However, the sanctioning body wasn't in a position to develop this common vehicle on its own. It had a few designers it could call upon, but no dedicated design office capable of handling such a mammoth task. NASCAR needed to partner with a company that already knew what it would take to produce a common chassis, upon which the various manufacturers could mount their engines and brand-specific bodywork.

Brand affinity

Dallara had built up some affinity with the NASCAR organisation through its sportscar involvement. The company designed and built the Cadillac DPi, a successful IMSA SportsCar Championship prototype that won the 24 Hours of Daytona four times. The Action Express Racing team that fielded a Cadillac DPi for six years – and now runs the Dallara-based Cadillac V-Series.R LMDh – also happens to be owned by NASCAR chairman, Jim France. Then there's the fact that NASCAR owns IMSA.

So, despite NASCAR's call to Dallara feeling like a bolt from the blue for the latter, it was certainly no stab in the dark from the former.

'We had been working a lot with the IMSA guys and Cadillac,' recalls Pignacca. 'Jim France is pretty involved in one of the teams. At one point, he said to his people, "Dallara did a good job with Cadillac. If you are looking for someone to help in designing the new car, you can try Dallara." This is how it [happened].'

Once NASCAR and Dallara finalised their working agreement, Next Gen design work started in the spring of 2019, only about six months before the first prototype track test. It was a transatlantic operation, functioning between Dallara's global headquarters in Varano, Italy, and its North American motorsport hub in Indianapolis, which was established in 2012 for its supply of the spec IndyCar chassis. All the lines then converged on NASCAR's headquarters in North Carolina.

> Next Gen design work started in the spring of 2019, only about six months before the first prototype track test

> We were the design office, but the aerodynamics of the car were developed 100 per cent by NASCAR
>
> *Luca Pignacca, NASCAR programme manager at Dallara*

Chris Graythen / Getty Images

Dallara

Ready-made design office facilities, built up over years of racecar construction experience, made Dallara in Italy a key target for NASCAR in its pursuit of a safe and reliable Next Gen stock car

The company's role as chassis provider for Cadillac's successful sports prototype programme gave the NASCAR figures involved a taste of what Dallara could bring to their series

'For NASCAR, it was quite convenient because they had a [Dallara] design office basically working on one and a half shifts every day,' recalls Pignacca. 'We started when it was night time in the US, and they finished when it was night time in Italy. That also meant when Covid hit, we were already using a teleconferencing system to meet [virtually] with the Indianapolis office.

'For quite a long period, I've been working in three offices: one in Italy, one in Indianapolis and one in Charlotte. We were connected all the time, with multiple meetings per day.'

Lean on me

The partnership worked like this: NASCAR provided design briefs to Dallara, which executed those designs using computer modelling, and notified the governing body of any anomalies or potential improvements. Pignacca likens it to a manufacturer's technical director (NASCAR) delegating tasks to their design team (Dallara) and taking onboard their feedback.

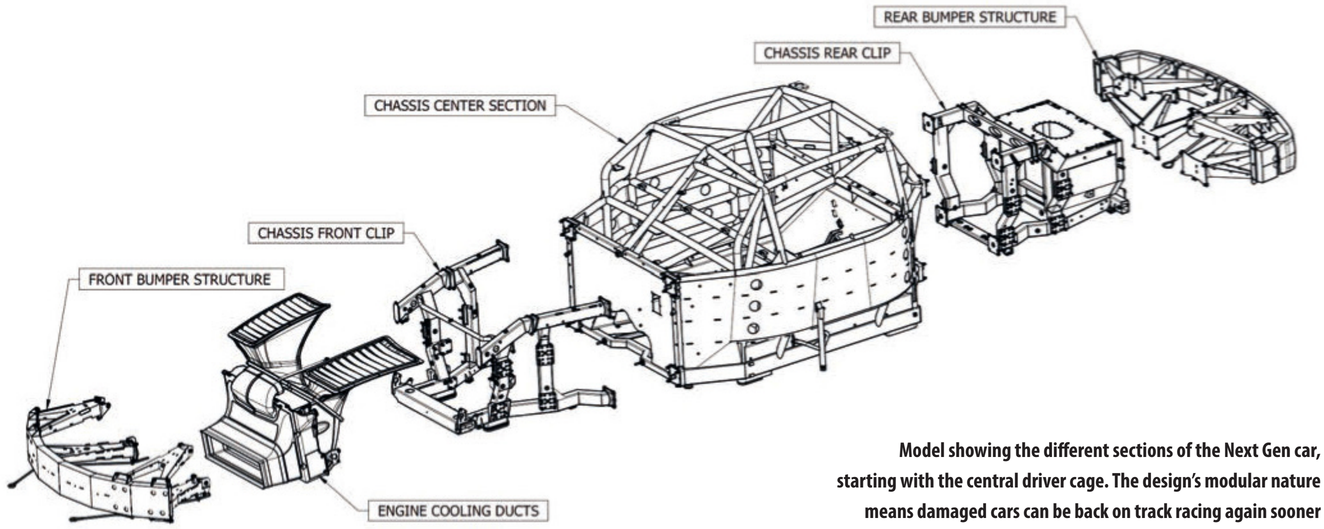
'The design office, with its experience, helps the technical director to make the best decisions within the boundary conditions you have,' he explains. 'We were the design office, but the aerodynamics of the car were developed 100 per cent by NASCAR. In this case, they gave us the final surfaces of the car – floor and body – and we engineered the bodywork so it could be manufactured. But NASCAR did the actual shape definition.'

For all its experience designing cars for other series like IndyCar and FIA Formula 2, Dallara approached the NASCAR job in a prudent manner. Most of its current projects focus on carbon fibre composite tubs, but the NASCAR chassis, constructed by North Carolina-based Technique, is a more traditional steel spaceframe. Therefore, it wasn't simply a case of the sanctioning body leaning on Dallara for its wisdom. Both sides had plenty to learn from each other.

'We applied the processes we used for all the other racecars, in the design of the new car, such as the way we do 3D modelling, vehicle dynamics and structural analysis,' says Pignacca, who has been with Dallara for three decades. 'We used the experience we have accumulated over the years doing other cars. But the NASCAR car is so different from any other categories [we work in], so we were very honest, saying, "We know nothing about the NASCAR car."

'We had to work together, and they had to explain everything as if it was all new. It is a completely different way of thinking. For me, having designed so many other cars, it was nice to have a completely new experience.'

NASCAR also helped Dallara to understand what had come before it, in terms of the previous technology deployed in the Gen 6 stock car. Broadly, the goal was to improve the Gen 6 in every aspect, but especially safety. Next Gen introduced several features that make it the most advanced NASCAR machine to date in that respect, such as incorporating crash structures into the design, introducing energy-absorbing foam bumpers and mounting a new flap to the



Model showing the different sections of the Next Gen car, starting with the central driver cage. The design's modular nature means damaged cars can be back on track racing again sooner

Dallara NASCAR

diffuser to further reduce the likelihood of a disturbed car becoming airborne.

Dallara's finite element analysis (FEA) of the chassis structure helped define the geometries deemed most suitable for NASCAR's requirements.

Real-world testing

Ensuring the safety of drivers in the Next Gen car was high on NASCAR's list of priorities and formed a key part of Dallara's design brief. The first of many track tests with the prototype vehicle took place at Richmond in October 2019. Two years later, the vehicle was ready to be trialled by a group of teams at the Charlotte Motor Speedway Roval, marking its first collective test session. In the first 20 minutes of that 11-hour test, the RCR car driven by Austin Dillon hit the outside wall at Turn 2. With Dillon uninjured and, after a scan of the car's condition, the golden opportunity emerged to see how quickly a Next Gen machine, with its modular structure, could be put back into action after a hit.

'With such significant damage, the Gen6 car would have been repaired in approximately two weeks,' notes Pignacca. 'The RCR guys loaded their Next Gen car on the truck and took it to their workshop in Welcome, 50 miles away. Rather than fixing the car, they just replaced the damaged parts – almost the entire front end – and, just a few hours later, before the end of the afternoon session, the car came back to the racetrack and was able to set good lap times. This is exactly what the NASCAR management had in mind when they gave us the brief to design the Next Gen car.'

Next Gen's safety features entered the spotlight again in 2022 when details emerged of NASCAR holding a live, autonomous crash test into a trackside barrier the previous year. NASCAR enlisted crash testing specialist, AB Dynamics, to integrate its autonomous driving software into the car for the occassion.

> 'Dallara's finite element analysis (FEA) of the chassis structure helped define the geometries deemed most suitable for NASCAR's requirements'

Naturally, a dummy was used instead of a human driver when the car was propelled at 209km/h (129mph) down the pit lane and into a right-frontal impact with the regulation SAFER barrier.

'It was incredible,' recalls Pignacca. 'We did it twice. After the first one with a prototype car, we weren't exactly where they wanted to be. And so there was quite an intense period to redesign some components. There was a panel of gurus, super experts and doctors who used to work with NFL players who had concussions. They would say whether the crash behaviour was good enough or not. Eventually, we made them happy.'

Constant evaluation

The work didn't stop there, though, nor did it cease after the opening Next Gen race at Los Angeles Memorial Coliseum in February 2022. Dallara continued to advise NASCAR on refining the package, rapidly rolling out any necessary updates in accordance with the Cup Series' brutal season schedule.

For all the extensive real world and simulated crash testing that had been conducted, actual racing scenarios exposed more reasons to keep pushing on the safety front. One example from the first season of Next Gen was an accident for Kurt Busch in qualifying at Pocono. The 2004 Cup Series champion lost control of his 23XI Racing Toyota going through a turn and slid rearwards into the SAFER barrier.

The impact left Busch with a concussion and he announced his retirement from racing a few months later. During its incident investigation process, NASCAR asked Dallara to model some modifications that would enhance driver safety in a similar impact.

'We had to make the rear of the car softer, or weaker,' says Pignacca, 'but at the same time we had to keep it strong enough. It was a trade-off between crashing at a certain speed, crashing at a low speed, manoeuvre loads and so on. With NASCAR, we brainstormed to see what we could do to achieve this and picked the best solutions.'

Considering the size of the Cup Series field (there are 36 full-time cars this year) and the packed race calendar, there was a limit on how drastic the changes could be. 'You cannot just decide to make a brand new rear clip, for example,' continues Pignacca. 'You have to do something that can be retro-fitted to the new cars. Otherwise, it's too expensive and it takes too long to be implemented.'

So, what was the solution?

'We changed the geometry of some of the tubing to make it more prone to buckling, to fold when you have a shunt. Or place some, what we call, 'triggers', so that you initiate the buckling of the tube where you want, and [dictate] where the best place is to absorb more energy. You have to be smart to find efficient ways to achieve results without redesigning the entire rear or front clip.'

Side impacts

Dallara and NASCAR have continued to optimise Next Gen safety, looking further at the front clip, as well as the rear.

Side impacts, which are common when an errant car crosses back onto the track after an impact, have also been extensively studied. The Next Gen chassis does not incorporate a side impact structure in the way that modern single seaters do. Instead, the side of the chassis is built for pure strength,

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while energy from an impact is absorbed by the deforming front / rear clip of the other car involved, or the SAFER barrier.

'There is nothing on the side of the car that is dedicated to absorbing energy in a side crash,' confirms Pignacca. 'The side of the 'H' in the centre section of the chassis needs to be strong.'

That strength was tested during last year's 500-mile race at Talladega, a flat-out speedway where constant speeds of 180mph (321.8km/h) are the norm. A kerfuffle caused Kyle Larson's Hendrick Motorsports Chevrolet to spin onto the grass apron, but it then came back, out of control, onto the banking and into the path of the three-wide pack. Larson's car was T-boned in the non-driver side by the helpless Stewart-Haas Racing Ford of Ryan Preece. Neither driver was hurt in the incident, although both cars sustained extensive damage, especially the side of Larson's Chevrolet.

'We had to make the right-hand side, the passenger side, even stronger,' says Pignacca regarding Dallara and NASCAR's response to that incident. 'Because, in this case, we had a T-bone crash at very high speed and the car didn't behave as NASCAR wanted. We realised we could do some modifications to make the car safer in that regard.

'Together with NASCAR, we designed a solution, and the reaction time they had was incredible. They were able to make quite difficult steel parts and retro-fit them to all the cars in a phenomenally short time. It was amazing, and a real big effort from the design, manufacturing and logistics teams.'

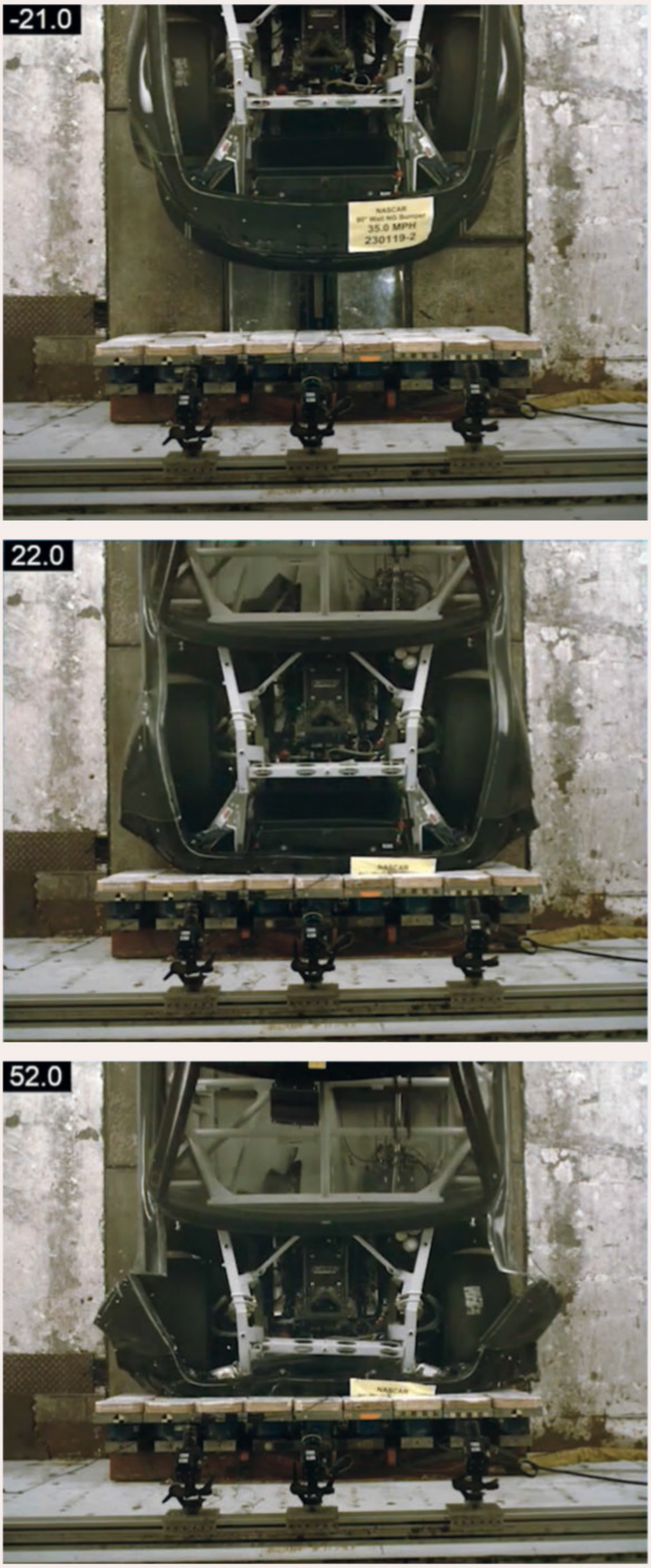
Side hustle

Dallara's involvement in the Next Gen car doesn't end with its overarching design consultation role. It is also on the long list of spec parts suppliers, making carbon fibre composite radiator cooling duct inlets and outlets that are sold to all Cup Series teams.

'We wanted to do something manufacturing-wise for NASCAR,' says Pignacca. 'We sent our quote, they accepted it, and we started making parts for them. [It is only] a few items, but that's a lot of parts, because NASCAR is huge.

Dallara only manufactures parts for the engine radiator system, so it does not cover the separate exhaust and brake cooling ducts. The engine radiator is positioned in front of the engine, ahead of the front axle. Air passes through an opening on the front of the car and cools the liquid coolant in the radiator that has been heated up during its time inside the engine.

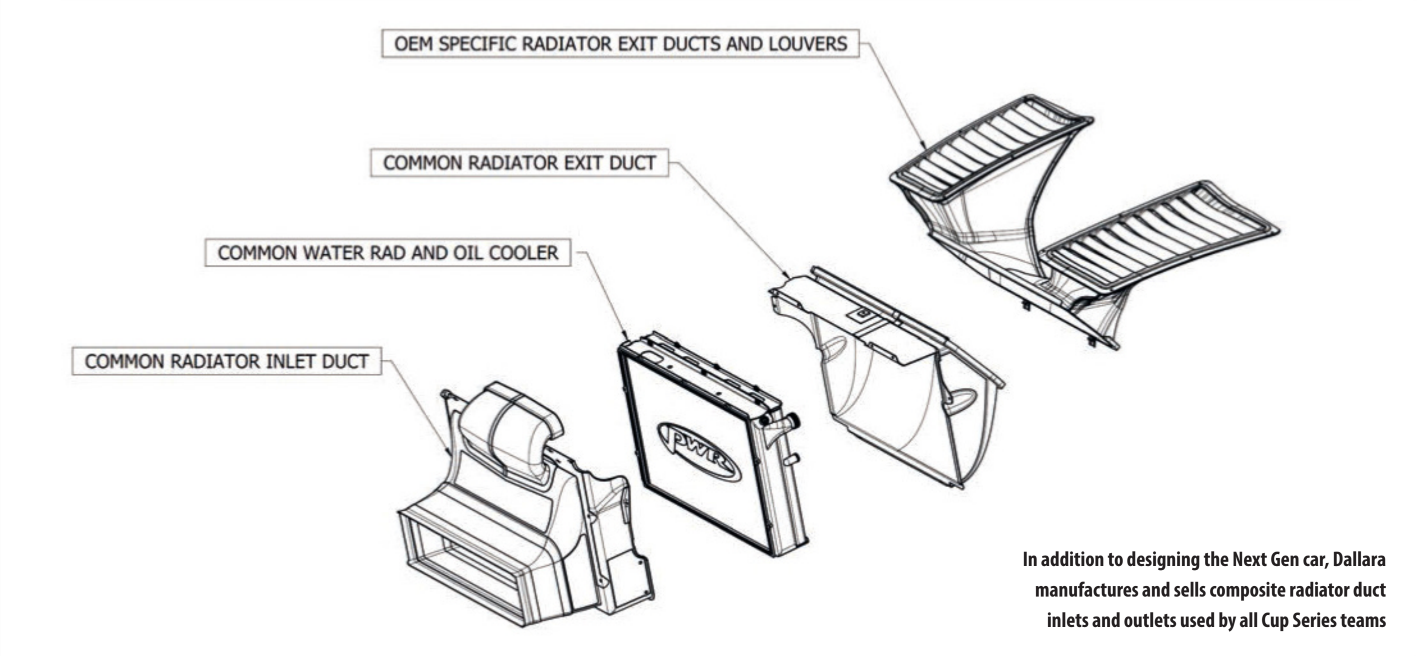
The engine cooling system itself is very similar to the Gen 6 layout. As mentioned in the Next Gen feature elsewhere in this issue, the main difference between the two is that, on the new car, cooling air is ducted through



NASCAR

After Preece and Larson's crash at Talladega in 2023, NASCAR called upon Dallara to make some modifications to both the main cage and front clip, removing crossmembers between the upright mounts to 'soften' the overall structure and reduce deceleration forces on the driver

Dallara NASCAR



In addition to designing the Next Gen car, Dallara manufactures and sells composite radiator duct inlets and outlets used by all Cup Series teams

openings in the bonnet and over the top of the car, rather than being kept under the bodywork. Incidentally, the composite openings are also made by Dallara.

'On the front fascia, you have an opening, as on normal cars,' explains Pignacca. 'These are different from manufacturer to manufacturer. Just behind this opening, you have the interface to the common inlet – the inlet duct – which must be the same for all.

'The initial part of the outlet is also common for all manufacturers. Then, we do the 'pants', where the outlet splits in two and comes out of the hood [on each side]. We make these parts for each manufacturer.'

The prevalence of frontal impacts in the Cup Series means Dallara has a ready market for these inlet ducts, generating consistent business throughout the season. A car won't be fitted with new ducts for every race, but replacing them is a fairly routine practice.

Since the start of Next Gen, Dallara's manufacturing of these parts had taken place in both Italy and Indianapolis, before being transported to North Carolina for distribution to teams. It expects all spare parts production to become US-based at some point next year.

Special projects

NASCAR's partnership with Dallara has shown no signs of slowing down since the race debut of Next Gen over two years ago. The collaboration has also extended to the Garage 56 Le Mans and electric NASCAR special projects, which are detailed elsewhere in this issue. And there could well be more work on the horizon.

'We are very happy and proud to be NASCAR partners,' says Pignacca. 'The relationship so far has been really good. We're looking forward to seeing what new projects they will have for us.'

The question is, when might work begin on the eighth generation of NASCAR, and will Dallara be involved in the design again?

'I have a feeling that the Next Gen car will be a very long-life car,' Pignacca suggests. 'I hope they will want to try the same concepts beyond Next Gen, to the other series that they have. I think it will come eventually, but I don't know yet.

'The good thing with NASCAR is that they are always looking for something new. For example, the electric car. I'm sure something else interesting and fun will come.'

Dallara is clearly prepared for a long-term presence in NASCAR, having learnt a great deal about stock car racing since its relatively recent induction. Its involvement has added another string to the bow of a versatile engineering company and has helped NASCAR fulfil its technical targets to ensure the sport has a bright future. ●

Dallara

Dallara's regional headquarters in Indianapolis serves the company's NASCAR, IndyCar and IMSA interests

> I have a feeling that the Next Gen car will be a very long-life car. I hope they will want to try the same concepts beyond Next Gen, to the other series that they have
>
> *Luca Pignacca*

Nerve Center

The R&D Center in Concord is more than just a place where research takes place, it's the multi-functional hub of NASCAR's operations

By Eric Jacuzzi

The NASCAR Research & Development (R&D) Center sits across from Concord-Padgett Regional Airport in Concord, North Carolina. Originally born to address growing needs in safety, competition and cost containment in the sport, the Center has grown to include an engineering staff of aerodynamicists, safety engineers, powertrain experts and competition officials.

The ability of the sanctioning body to conduct its own research has been crucial in driving safety, efficiencies and performance changes over the years. Obviously, requesting feedback from competitors is a key component of successfully operating as a sanctioning body, but expecting engineering assistance or in-depth study from race teams is just not practical. It is simply a case of misaligned priorities. The teams want to win the races, while NASCAR wants to have the safest and best racing possible. Any time teams, or manufacturers, spend on things that don't make their car faster is essentially outside their focus. In this sense, NASCAR acts as a leader to the industry on these topics.

Advanced engineering

The R&D Center officially opened in January 2003. Concord was a logical choice as most of the teams competing in NASCAR were, and remain, in this region of North Carolina.

The 60,000sq.ft facility was the first research and development hub owned and operated by any major motorsport series and has been the catalyst for many advances in the sport, including changes to the safety of driver restraints, vehicles and tracks. These include the introduction of SAFER barriers at every racetrack, mandatory head and neck restraint (HANS) devices, and the Incident Data Recorders (IDR) that are a feature of every car on the grid.

The Center has evolved tremendously in its nearly 24 years of service to the sport. It is not only a place for original research, but also functions as a technical nerve centre for the industry, with numerous meetings held there every year across a wide range of technical and business purposes. Engineering staff are always available to answer team questions, and the majority of the competition group that officiates at race weekends is present during the week. As such, the Center functions internally as an important crossroads between what happens at the track and the engineers behind the cars.

Here, we'll aim to cover some of the key functions that occur at the R&D Center.

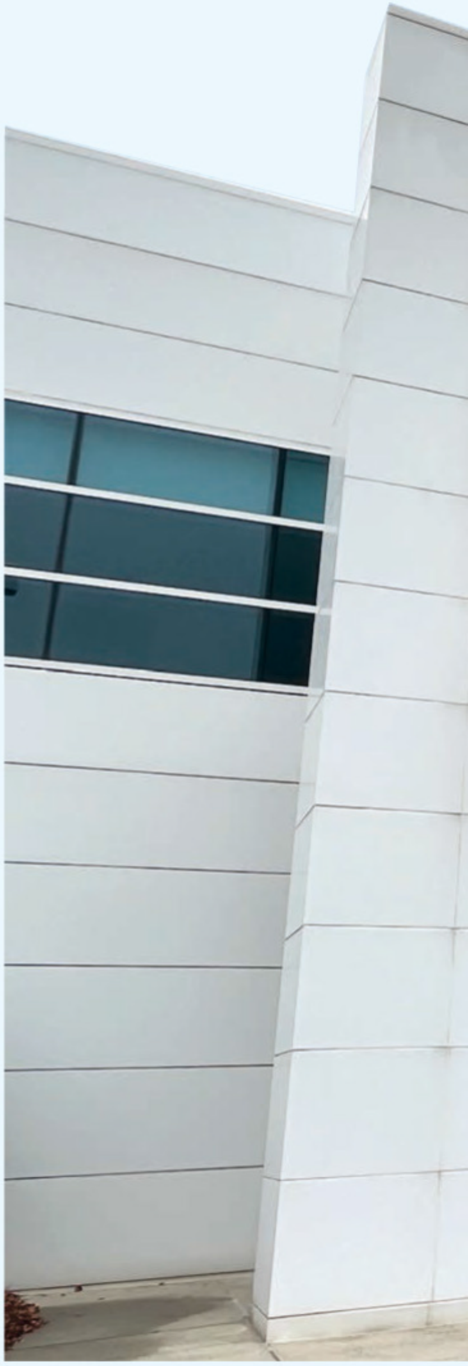
Additive manufacturing

NASCAR recently signed a partnership with Stratasys, a leader in the additive manufacturing (AM) field, to make the NASCAR R&D Center a showcase for its equipment. NASCAR began using additive manufacturing nearly a decade ago in its aerodynamics department, producing wind tunnel components and mock ups. This has grown steadily since and now extends to printed components on the racecars, which include a NACA floor duct made of high-temperature Ultem and the driver cooling duct visible in the windscreen of the car.

Aerodynamics

NASCAR's aerodynamics team maintains its fleet of both R&D wind tunnel test vehicles and those used for the body homologation process at the R&D Center.

> The first research and development hub owned and operated by any major motorsports series and… the catalyst for many advances in the sport



NASCAR's recent partnership with Stratasys has led to the creation of the DeBusk 3D printing laboratory at the R&D Center

> The Center functions internally as an important crossroads between what happens at the track and the engineers behind the cars

Josh Hamilton

The race-used Garage 56 car from Le Mans 2023 spends most of its time at the R&D Center, with occasional trips out to strategic events

Much of the work that takes place at the R&D Center is about improving safety. Shown here is the safety department's quasi-static testing rig, which is used for assessing anchorages, seat deformation and more. Full-scale vehicle crash testing and sled testing is conducted off-site

Next Gen chassis and tubs for the Cup Series are built over the road from the R&D Center at Technique, but all are inspected at the Center prior to going to teams

NASCAR R&D's current inertia engine dyno, which is soon to be replaced by a state-of-the-art AVL transient dyno

We cover the Optical Scanning Station in detail elsewhere in this issue, but a permanent OSS and Underbody Scanning Station (USS) is kept at NASCAR R&D and can be used by teams that don't have their own

> An AVL transient dyno… will be installed in the near future for use on the next generation of engine architectures, and investigations into electrification

With Windshear around the corner and the Aerodyn wind tunnel just a 30-minute drive away in Mooresville, NC, there was no need to have an on-site wind tunnel. However, there are several bays that can be concealed for secretive work, or to impound vehicles from the racetrack for post-race inspection.

Chassis certification

All Cup and Xfinity Series chassis are brought to the R&D Center to be certified, ensuring they are within specification and constructed using the correct materials.

The Next Gen chassis and clips for the Cup Series are produced across the road from the R&D Center at Technique, while Xfinity Series chassis are built by the competing teams. In either case, both the chassis and clips are inspected and certified for three years in Cup and two years in Xfinity. In the event of significant damage, or repairs, chassis may be returned and re-certified.

Body and underbody Inspection

NASCAR R&D maintains a permanent Optical Scanning Station (OSS), identical to that used at the track, to ensure bodies are within the approved assembly tolerances. The presence of an OSS at the R&D Center means teams that do not own the technology can schedule appointments to measure their cars. Likewise, the laser-based Underbody Scanning System (USS) is available for Cup Series teams to ensure their cars comply prior to arriving in the inspection line.

Safety testing

The safety group at R&D conducts LS-DYNA simulations, as well as static and quasi-static testing of components in-house. Hydraulic rams and a drop tower are used to evaluate head surround foams, composite anchorage strength and to characterise materials for simulations. Empirical full-scale vehicle crash testing and sled testing take place off-site.

Engine dynamometers

NASCAR does not currently prescribe power levels for its approved engines, but rather specifies the materials permitted in such a way that parity is ensured. To keep tabs on this, the organising body regularly tests engines straight from the racetrack in all three of its major national series.

Currently, there are two dynamometers in use at R&D: a Revolution Inertia dyno, which is mainly used for IMSA homologation work, and a SuperFlow water brake dyno primarily used for testing stock car engines. Next on the list is an AVL transient dyno, which will be installed in the near future for use on the next generation of engine architectures, and investigations into electrification.

Post-race inspection

A key function of the R&D Center has been the post-race teardown of racecars from the track. Currently, first and second place cars are usually inspected while still at the track to ensure the race result stands but, typically, a number of random cars are also selected to be taken back to the R&D Center for a more comprehensive review. This can include mechanical, body and engine measurements and inspections.

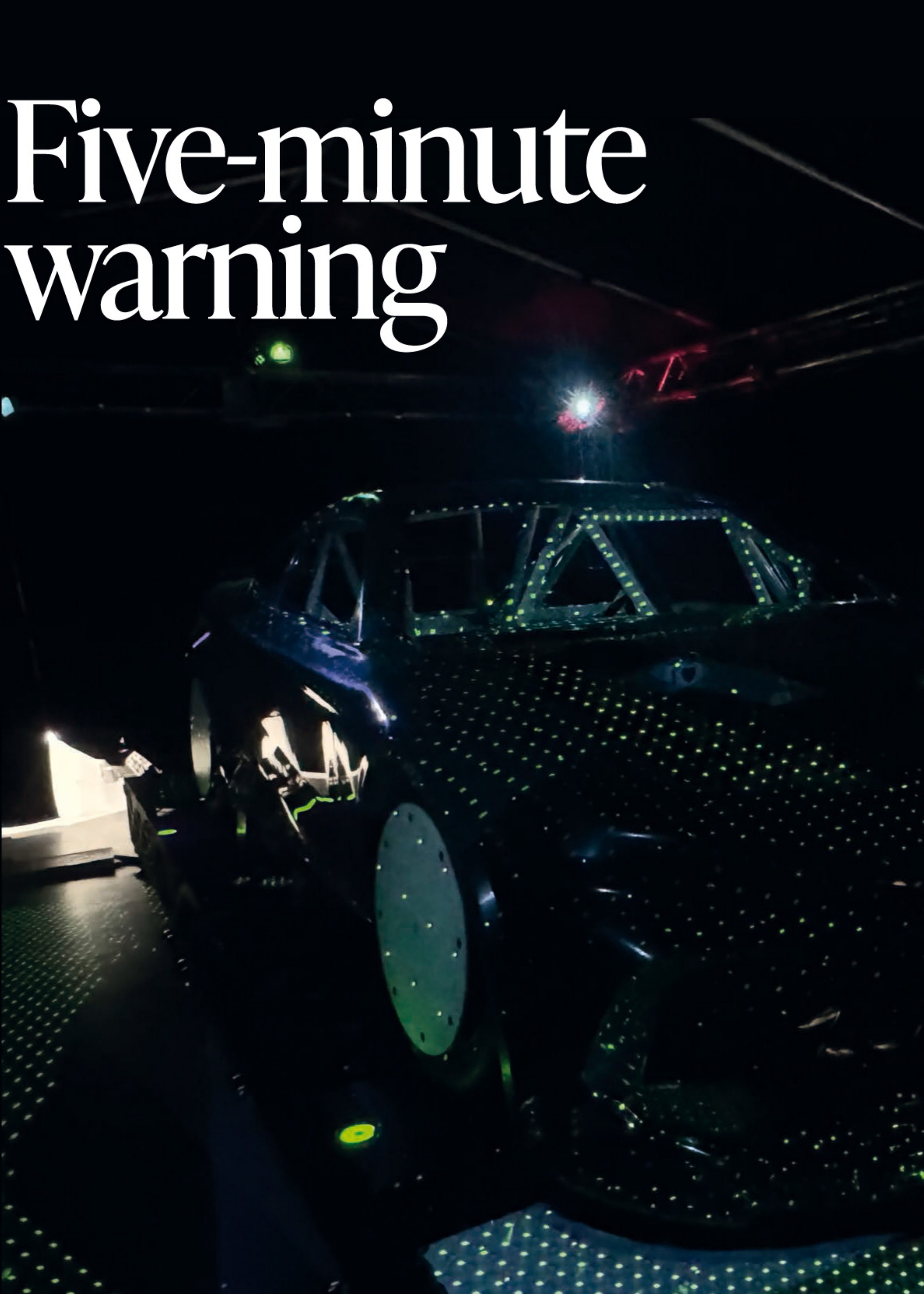
Production facility

In January 2024, a new $53 million addition was made to the neighbourhood around the R&D Center in the form of the NASCAR Productions facility. Housing almost 140 employees in nearly 60,000ft.sq of space from NASCAR Productions, NASCAR Studios and MRN Radio, the state-of-the-art facility replaces the current Charlotte studios.

In addition to the obvious media uses, the new facility also includes a remote race control room that is planned to augment at-track officiating. While still in its infancy, NASCAR has been evaluating SBC Race Watch throughout this year with a view to fully implementing the system in 2025 to combine all camera feeds and provide specific play-by-play reviews.

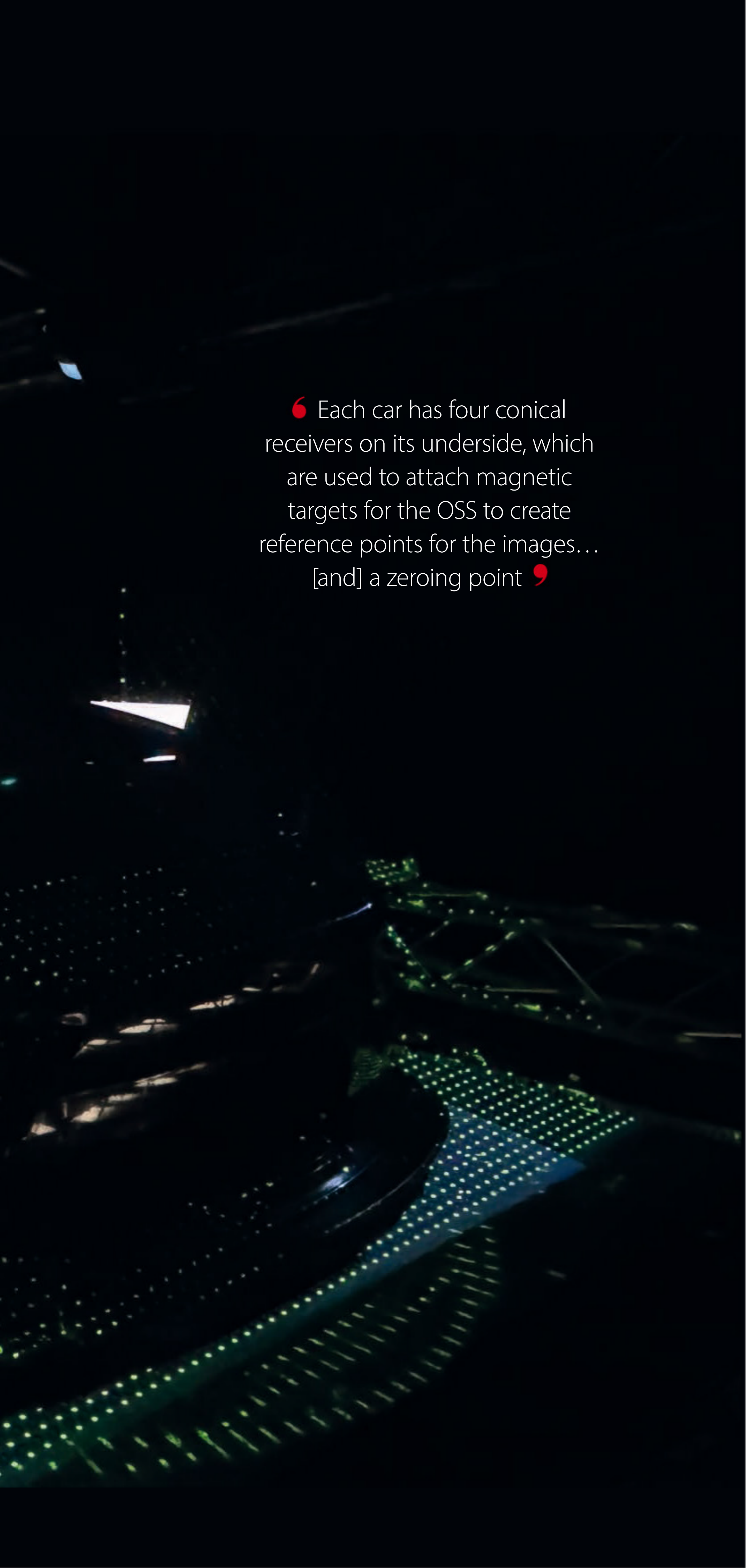
NASCAR's R&D Center will remain a fixture of the industry and continues to evolve in its scope and purpose. Alongside the new NASCAR Productions building, the Concord campus is well situated for the sport's future, whatever it may bring.

Five-minute warning



Three hundred seconds is how long it takes NASCAR to digitally scan a car in its Optical Scanning Station, using technology developed by an innovative company in the UK

By Bozi Tatarevic



> Each car has four conical receivers on its underside, which are used to attach magnetic targets for the OSS to create reference points for the images… [and] a zeroing point

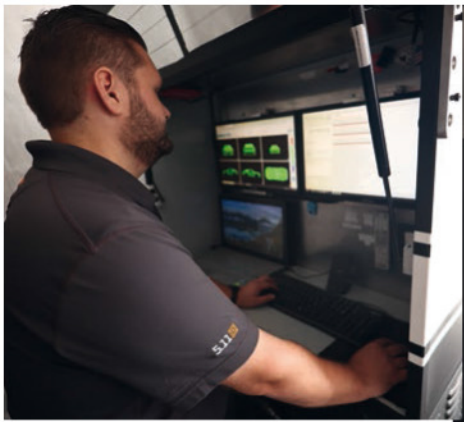
NASCAR needed a more efficient scrutineering solution as it sought to clamp down on aerodynamic tricks being employed by teams so, in 2017, the governing body put out a request for product (RFP) to replace the aluminium body templates it was using at the time. Hampshire, UK-based Hawk-Eye Innovations ended up winning the bid with a product that can be built up and torn down efficiently for 36 or more race weekends per year, while still maintaining calibration. Curiously, the company is perhaps best known for its tennis line calling system, but is also involved in other sports such as cricket and baseball.

Racecar spoke with Dan Reeves, research and development inspection technician for NASCAR who leads the Optical Scanning Station at NASCAR's R&D Center, about how the Hawk-Eye system turned from a concept to a prototype being tested and calibrated in the field, all within a single NASCAR season.

Going live

Once validated, the system went live for the NASCAR Cup Series and NASCAR Xfinity Series at the start of the 2018 season, each having its own Optical Scanning Station (OSS) unit at the track. Splitting the two series had the obvious advantage of efficiency, as each one can have up to 40 cars entered per race weekend, but it also allowed them to configure the system specifically for the coordinates of the car type that runs through its OSS. This was an important factor as the Next Gen car was introduced into the Cup Series in 2022.

Each car has four conical receivers on its underside, which are used to attach magnetic targets for the OSS to create reference points for the images. On the Xfinity car, these are



Engineers monitor results at a converted pit lane cart that serves as the control and communications centre

It takes roughly 12 hours to set up and calibrate the 20 x 60ft OSS at the track, much of which is done prior to the teams' arrival

1.125in metal bungs welded to the bottom of the chassis at specific coordinates, while on a Cup car the conicals are integrated into the metal skid blocks that protrude through the carbon floor of the central tub section. Each car also has a zeroing point. On the Xfinity car, it is a bung on the truck bar crossmember; on the Cup car it is positioned in the leading edge of the front splitter.

While each system is configured for the individual car type, switching between them is as simple as swapping the metal targets and choosing the correct car type in the software. Again, this was important because the NASCAR schedule requires each OSS system to be on the road constantly from February until November and the governing body wanted to be able to swap it between car types quickly in case one of the systems should go down at the track. A single system is also occasionally used when infield space is at a premium, for example at Martinsville Speedway in Virginia.

At the track, it takes about 12 hours to build up an OSS inside a 20 x 60ft, aluminium-framed tent. A large portion of that work is completed prior to the NASCAR inspection field team becoming involved as it employs Champion Tire & Wheel (which also moves wheels, tyres and pit boxes between tracks for teams) to transport and build up the tents and platforms for the OSS. The field team then comes in after that to mount the projectors, cameras and wiring within the tent.

Movie theatre

The Optical Scanning Station comprises eight high-resolution projectors and 16 high-resolution cameras. The projectors are commercially available Sony VPL series units, commonly found in conference centres and small movie theatres. They are capable of displaying a 60ft image, but NASCAR configures them to run the smallest possible lens image distance to work on a car sitting only a few feet away. Using widely available projectors allows NASCAR to easily source parts as they age, or need replacement.

Allied Vision supplies the monochrome machine vision cameras used around the car in the OSS. These are similar to those used in a fulfilment warehouse or manufacturing setting and are designed to capture things like bar codes at extremely high speeds. The OSS needs at least three cameras pointed at any given spot on the car to triangulate a single point of data but, for redundancy, a minimum of four are used, with up to six at complex portions of the bodywork.

All the control equipment is packaged inside a customised pit lane tool cart that sits just outside the scanning station and connects to the camera and projector wiring harness. A single server controls the entire station and communicates with the rest of the infrastructure via switches. One of those switches connects the primary server to four Intel NUC small board computers that control the light show for the eight projectors.

The primary server commands the NUCs and then each of them communicates with two projectors through HDBaseT, which allows for an HDMI signal of the light show to be sent over Cat6 ethernet cable. This ensures reliable runs to cameras on the other side of the tent and allows for easy repair, or replacement, of cable in the field if necessary.

> While each system is configured for the individual car type, switching between them is as simple as swapping the metal targets and choosing the correct car type in the software

A second switch connects to the 16 cameras, which employ Power over Ethernet (PoE) that adds to the efficiency of the wiring.

In addition to being the command centre for the system electronics, the tool cart also serves as storage for all the calibration and reference pieces the OSS uses, including wheel plates and the conical targets.

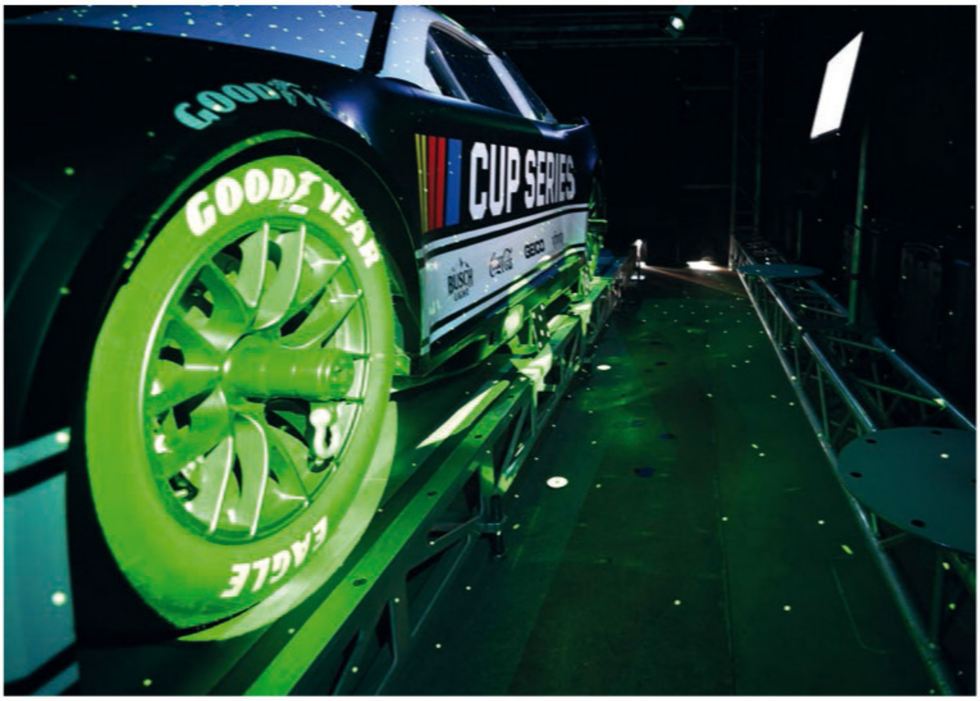
System goals

One goal of the system was to use innovative packaging so it can easily travel and be maintained at even the most remote racetrack that might not be near an electronics vendor. Once the OSS is broken down, it all fits onto the bottom floor of a single transport trailer, while the top floor of that trailer is taken up by the underbody scanner and some additional equipment NASCAR officials use to measure car heights and weights out in the field.

Once the tent is set up, mounting the projectors and cameras and calibrating them takes around three to four hours of the 12-hour window, with initial calibration done with frame stand-offs that mimic the targets that attach to the conicals of each car. Each of the four conicals has a dedicated target plate with a unique constellation that the cameras can identify and feed into the software to ensure correct calibration. These mimic the frame height and coordinates of the actual car that will be sitting in the three-dimensional space, allowing the software to verify the calibration.

In addition to the frames, NASCAR has also recently started bringing an entire car as an

> Roughly a minute after crew members have pushed the car onto the platform, they can see whether the bodywork is in spec



The light show employs various different projection patterns, along with a dot matrix point cloud, to collect 157,000 points of data

additional calibration point for the Cup Series. Known as the Rules Reference Vehicle (RRV), it can be rolled through the OSS to perform an additional verification of the calibration, and is also used to help calibrate a second inspection station, which contains an underbody scanner.

The measuring process

Once a car is pushed up on the platform in the OSS tent, it takes around 30 seconds for the projector light show to complete. This starts by projecting alternating horizontal and vertical lines across the car and completes with a dot matrix point cloud. During the light show, 157,000 points of data are collected and then used to calculate body and suspension measurements. The system is similar to the structured light scanning process used by companies like Zeiss, but employed on a much larger scale. The biggest difference to such commercially available systems is that the dot matrix cluster used in the OSS is an array of three-by-three dots.

NASCAR chooses to collect this many points of data at each scan for efficiency, but the system has the ability to turn that figure up to 1.5 million data points, should the inspectors wish to see additional details. This capability is occasionally used in post-race inspection, and increases scan time from 30 seconds to around five minutes.

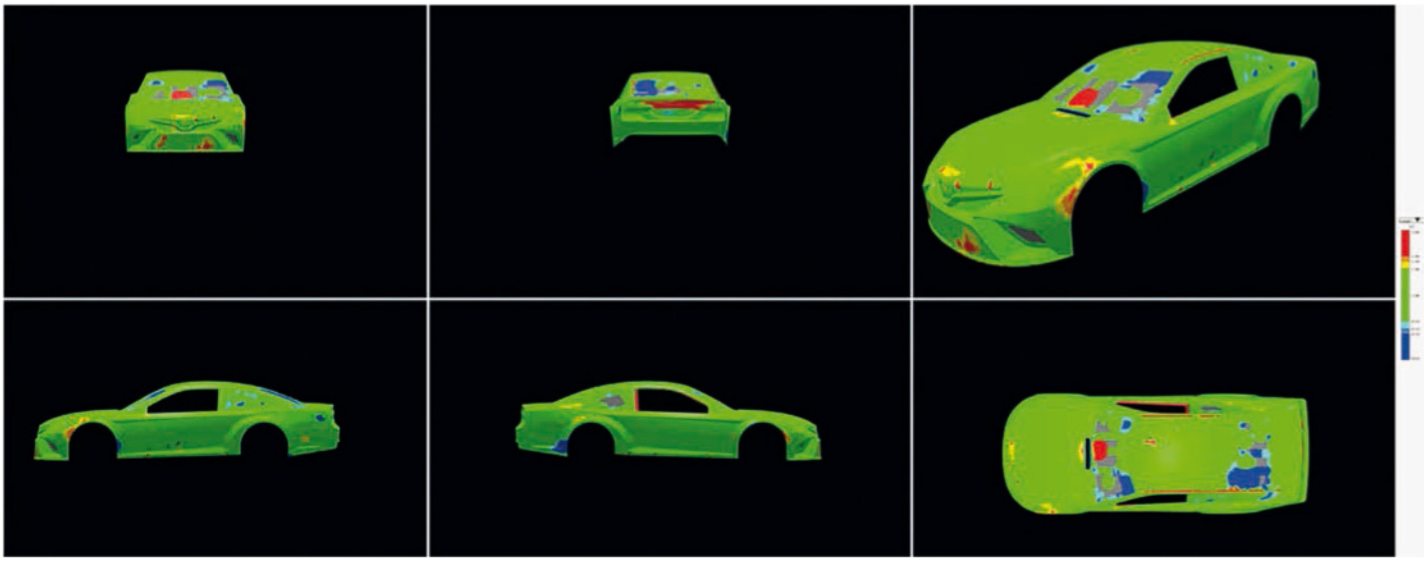
After a scan is completed, the software ingests the raw points cloud and compares it against a CAD file for that specific vehicle body. This takes around 30 seconds. Once the process is completed, the screen outside the tent displays a heat map of the entire car. Areas shown in green are in spec, areas in red are too tall and areas in blue are too short. NASCAR allows a tolerance of +/- 0.150in for the body during this scan.

So, roughly a minute after crew members have pushed the car onto the platform, they can see whether the bodywork is in spec.

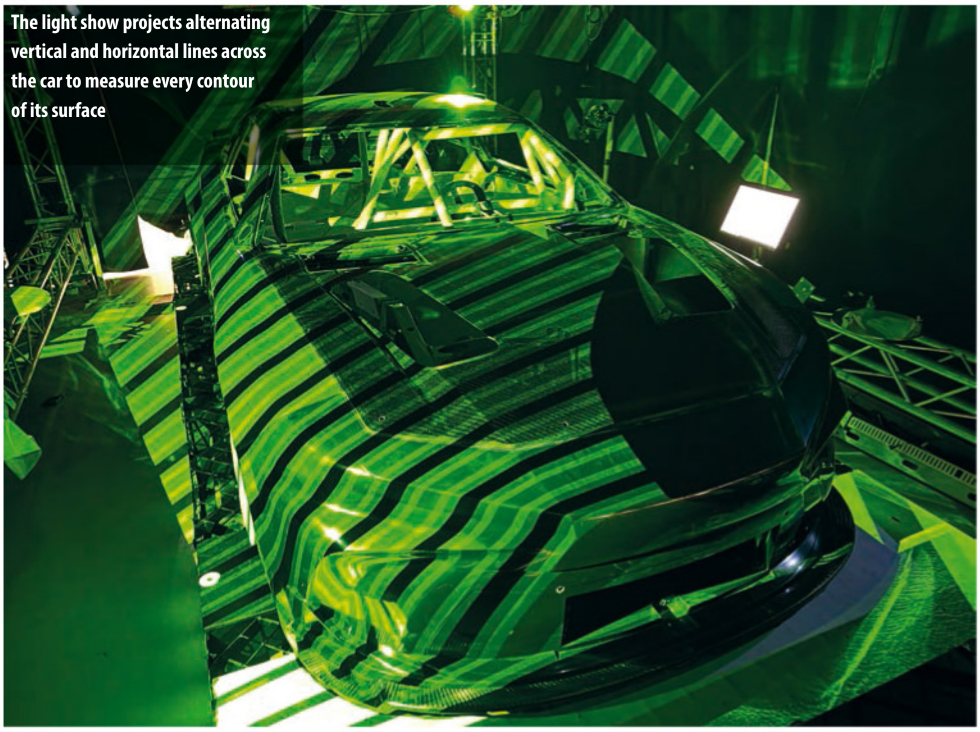
While team members review the heat map, a NASCAR official will go back inside the tent and complete a sweep with the steering wheel so the OSS can record suspension measurements. These are based on round wheel plate targets mounted to each of the four wheels and referenced against the targets on the conicals to establish a centre line for the car.

The targets for the Next Gen car attach to the centre-lock wheel nuts of its 18in aluminium wheels with magnets and centre on the wheels using stand-offs that sit on the wheel lip. The targets for the Xfinity Series cars have magnets on the stand-offs to attach to the 15in steel wheels used in that series. Each wheel plate has eight holes that are used by the OSS software to create a plane of reference, along with the XYZ values from the four conical targets. From these, the system software uses mathematics to calculate measurements like wheelbase, wheel offset, camber, toe and more.

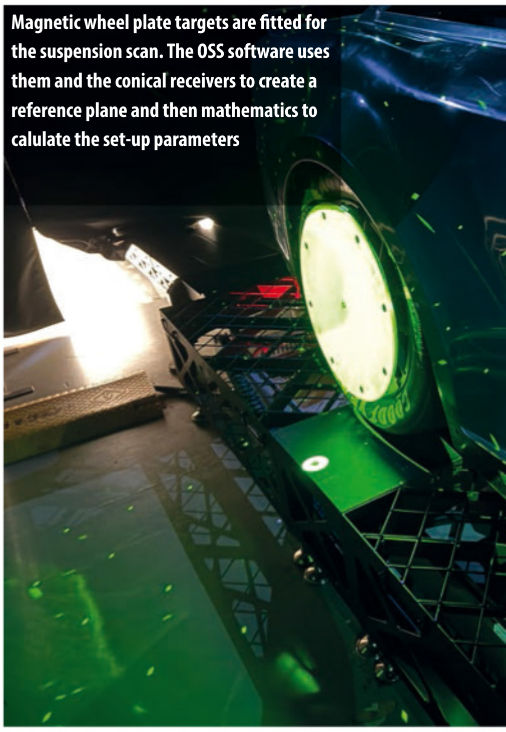
Further small, 3D-printed plastic pieces slide onto the edges of the rear spoiler to provide additional reference points for spoiler location relative to the rest of the car body.



The results of the scan are used to create a heat map of the car. Areas within spec are green, areas in red are too tall and areas in blue too short. The map must be all green for the car to pass



The light show projects alternating vertical and horizontal lines across the car to measure every contour of its surface



Magnetic wheel plate targets are fitted for the suspension scan. The OSS software uses them and the conical receivers to create a reference plane and then mathematics to calulate the set-up parameters

With so many cars to scan, efficiency is key, so each vehicle spends less than three minutes in the OSS, in which time the crew will have seen the body scan results and walk away with a suspension results print out.

Each scan collects around 400 gigabytes of data but, once it is processed, a heat map of the body is reduced to less than one megabyte, which is then digitally shared with teams. The suspension results are placed in the same digital folder, but a printed copy is also given to the mechanics as they leave so they have an immediate reference in case they need to return to the pit and make any adjustments to car set-up.

Having the ability to move cars through the station quickly, and with accuracy, is important as NASCAR teams build their cars to the extreme edge of the allowed tolerances. On an average race weekend, around half of the cars will fail on the first attempt through the OSS, while at tracks like Daytona or Talladega, where aerodynamics is even more significant, up to 80 per cent of cars will fail their first attempt as teams try to push the limits.

Far from being annoyed by this, NASCAR expects teams to chase these advantages, which is why the scanning process had to be so efficient, and capable of scanning 40 cars multiple times per day.

Additional testing

One of the reasons teams can tweak their cars to be so close to the edge of the OSS specs is that the governing body decided to let Hawk-Eye sell the system to teams, once it was implemented in NASCAR. So far, 14 OSS units have been sold to private entities, all exact replicas of the units NASCAR operates.

Teams that can't afford a $350,000 (approx. £270,185) OSS of their own have the option of scheduling time at the NASCAR R&D Center to use the unit available there. This is identical to the two OSS that travel to each racetrack and Reeves allows teams to schedule time in one-hour blocks every week from Tuesday to Thursday.

The environment is set up to replicate what teams encounter at the track, with a workshop for engineers to make adjustments before rolling the car back through the OSS until they see a passing score.

Reeves also schedules special sessions on Mondays or Friday for smaller teams, or those that operate part time, so they can set their cars up to pass the OSS process at the track. Occasionally, even larger teams with their own OSS will book time at the R&D Center to validate their own in-house measurements.

The reason NASCAR is so inclusive on how the OSS is assembled and calibrated is that the goal is for everyone to have access to the same data, so teams can show up to the track prepared to go through inspection quickly. To this end, Reeves will share any changes made to the OSS unit at R&D, or the systems used at the track, in a bulletin to the teams so they can bring their systems up to the same spec.

> ‘Teams have learned that light wave physics can be used to their advantage in certain cases, and some now employ dedicated engineers to study how the projectors interact with various colours on their car’

Clever tricks

Allowing teams to acquire their own units has improved efficiency at the track as most teams now typically show up with cars close to the required measurements. However, this being NASCAR, it also opened up an opportunity for teams to find loopholes…

Teams have learned that light wave physics can be used to their advantage in certain cases, and some now employ dedicated engineers to study how the projectors interact with various colours on their car. The increased appearance of gloss black in NASCAR liveries over the last few years is the direct result of these studies, because they've learned the cameras pick up less data from such a surface finish. When the OSS is unable to pick up a single data point, it will default to building an average of that area, which might offer a competitive advantage in certain areas of the car.

NASCAR quickly picked up on some of these tricks, and its response was to use an opaque developer spray on the surface to make it clearer for the scanner. These sprays are typically used in aircraft assembly and maintenance as they make it easier to spot leaks or cracks in glossy black surfaces. It is simply wiped off when the scan is complete.

In addition to physical prevention with the developer spray, the inspection team also shares what they've learned with the group that approves liveries so they can set rules for where certain colours may appear.

The underbody scanner uses six lasers mounted on carbon fibre tubes that measure the downforce-generating flat floor. Acceptable tolerance here is just +/- 0.100in from spec

Clear surfaces like the windscreen obviously posed a challenge for scans since the projected light goes through and hits surfaces behind. To counteract this, NASCAR started out with two large white vinyl dots that reflected the projected light but recently changed that method when it became apparent teams were exploiting the average measurement process by maximising the aerodynamic properties of the windscreen in the areas not covered by the inspection dots. Now, teams must adhere a specific vinyl cover to their car's windscreen before it enters the OSS tent so the complete area can be captured by the cameras.

While this adds an additional task for the teams, the process is still around four minutes quicker than the previous system of aluminium body templates. That may not seem like a huge amount, but it is significant when you're 36th in line waiting to be scanned.

Thermal shutdown

The nature of the racing schedule has allowed NASCAR to put the OSS through a variety of environmental conditions, which has seen the projectors operate at as low as 32degF (0degC) during a snowy weekend at Martinsville and at over 100degF (38degC) at some of the summer races. When things did go outside those temperature extremes, the projectors were found to go into thermal shutdown, so a 12-ton HVAC unit was added to the system, which pipes air into the tents to maintain an ambient temperature of around 75degF (24degC).

With the introduction of a completely flat underbody on the Next Gen car, and the most significant portion of its downforce being produced by the new rear diffuser, NASCAR also had to make sure it could capture measurements for that, so an underbody scanner was introduced that teams visit prior to rolling up to the OSS.

> ‘The [underbody] scanners are set to collect 3.2 million points of data in 15 seconds, and the computer takes around 90 seconds to process that data and generate a heat map’

The first variant of the system was a static laser scanner mounted under the height and weights platform, which collected data as the car was rolled across it. This system was reasonably accurate but again, teams quickly found ways to exploit it based on the speed and technique of how they rolled their car onto the platform.

NASCAR therefore decided to introduce a motorised system at the start of the 2023 season, which increased accuracy significantly and prevented crew members having any involvement in the process. The latest variant of this system relies on carbon fibre tubes with billet aluminium end caps with a run out of just 0.01in over the 20ft span.

The scanner is a long tray with six laser scanners from Photoneo that ride on the tube and can each produce up to 16 million points of data. The unit was developed as a collaboration between NASCAR and BOLT6, a company founded in 2021 by former development team members from Hawk-Eye.

Setting up and calibrating the underbody scanner is a fairly simple process and can typically be done in less than three hours at the racetrack. The calibration process lasts roughly 15 minutes and requires carbon fibre boards be placed on the platform at 90 degrees at various distances to set the calibrated baseline values.

Tight tolerance

The scanners are set to collect 3.2 million points of data in 15 seconds, and the computer takes around 90 seconds to process that data and generate a heat map of the underbody. The underbody has a tighter tolerance than the overbody, as the floor is only allowed to deviate +/- 0.100in from the measurements listed in the rule book.

Once scanned, an inspection technician views the heat map and approves it at that point. Again, the team is given a digital copy of the result in their cloud folder.

Since the underbody scan happens prior to the OSS, inspection technicians will typically discuss the underbody results with a car chief or crew chief while their car is completing an OSS scan to make best use of the time available. The whole process between the two scanning stations can typically be completed in less than five minutes per car, which fits with the tight track schedules in the days leading up to a race. It also lets teams know if they've passed post-race technical inspection immediately after a race and offers NASCAR the flexibility to pull a large portion of the field into post-race inspection during important parts of the season like the playoffs. ●

Where before teams had multiple different brake packages, the Next Gen racecar uses the same six-piston front caliper at all tracks. It is only the disc (rotor) that is changed

Brake dance

The decision to move to a single supplier for the braking system on the Next Gen car led AP Racing to a novel approach with its design

By Andrew Cotton

Likewise, at the rear. A single four-piston caliper is the only option available, though teams can choose between a light-duty and heavy-duty disc. Both use AP's innovative direct drive fitment

There was a clear goal for the Next Gen car when it was under design: reduce cost, without compromising quality. To achieve that, NASCAR moved towards a single supplier in some areas of the car, including the braking system. The target was to reduce the cost of the complete system by around 50 per cent, compared to the previous Gen 6 regulations, and a tender process was initiated to find the chosen supplier. UK-based AP Racing exceeded that target relatively comfortably, and won the tender.

From an engineering perspective, it was no easy task to bring down the cost, while at the same time retaining the performance level seen on the previous car generation. However, AP Racing was helped in several areas by the regulations, which included an increase in wheel size from 15 to 18in diameter, which offered more space to fit a physically larger, more robust brake package.

The Gen 6 cars were extreme in that they had bespoke brake packages per driver, per car and sometimes per race. Naturally, competition in the area of brake systems was fierce, and expensive, with multiple disc and pad configurations, different caliper designs and perhaps more than 100 bell designs to house the various braking systems. With very low production runs, costs ran out of control, so saving money should have been easy. The hard part was ensuring the drivers, and teams, were not disappointed by a new system that they all had to use.

There is certainly no shortage of experience at AP Racing. The Coventry-based company has supplied NASCAR since 1987, with 13 title-winning cars using its products, before it won the tender to become sole supplier for the Next Gen era.

Rules of the game

As with all single-supplier deals, the rules of the game change slightly. Outright performance and development are replaced by lower cost and easier to manage systems, which is just what NASCAR was looking for.

‘[AP Racing] designed and developed an all-new caliper, a single design that would accommodate a larger brake disc in two configurations – thicker for the heavy braking courses, thinner for circuits such as superspeedways’

Braking requirements vary enormously at the different tracks on the NASCAR calendar, so to develop a single package that worked across all of them was no mean feat

AP Racing set about the task by looking first of all at how to bring down the number of options, considering both the racecars and the circuits on which they compete.

The cars run on speedways of varying size, short tracks and road courses, plus there was a specific set up just for Martinsville. Accommodating all these different braking needs was not going to be easy but, against rival brake suppliers, AP Racing believes it hit upon an elegant solution, and ultimately one that NASCAR chose to adopt.

‘What we looked at was how to drive the cost as low as possible, while also making the braking system effective,’ says Steve Hood, technical sales manager at AP. ‘The system had to be very robust, because NASCAR wanted to make sure the life of the components was acceptable.’

Combined package

‘I was looking at what we had on the old car. They had four distinct packages: road course, superspeedway, intermediate and short tracks. I was looking at all those and thinking, how can we combine and reduce the number of options there? And then I thought, could we do this in one caliper and just offer two different disc options?

‘I asked the engineering team to start looking at it, and they said, “Yes, I think we can do this.” The bigger challenge, though, is that we had to be able to offer a complete package because, if you’re a single supplier and have a brake problem, you’re going to have it on 40 cars.’

The company therefore designed and developed an all-new caliper, a single design that would accommodate a larger brake disc in two different configurations – thicker for the heavy braking courses, thinner for circuits such as superspeedways. Cup series teams now use the same six-piston monobloc brake calipers at the front, and the same four-piston design at the rear at every race on the schedule.

Designing adjustability into the caliper so it would accept the different disc solutions was also not straightforward but, since it has achieved that, AP Racing is now rolling out similar designs to other areas of the sport.

Double duty

‘The heavy-duty disc is 380 x 40mm at the front, and with the same caliper we can run the light-duty disc, which is 380 x 36mm. That takes mass out of the disc, and weight, which is quite important because you don’t really want a 23lb (10.43kg) disc going 200mph at Daytona,’ says Hood. ‘We did the same study at the rear, so we have a heavy and light-duty spec there as well, and we managed to do it with only three different mounting bells, which are forged, so we have driven the price down as low as we can.’

Similarly, using the same caliper(s) for the whole season means production costs have been driven down by increased parts volume.

The introduction of the larger 18in wheel not only allowed the use of a bigger brake

❛ Teams now use the same six-piston monobloc brake calipers at the front, and the same four-piston design at the rear at every race on the schedule ❜

package, but also better cooling options, so the materials are less stressed now than the smaller brakes in the old 15in wheel. On superspeedways, heavy braking in the Gen 6 car from 200mph down to the pit lane speed limit occasionally led to cracked discs due to thermal shock. The larger disc and caliper arrangement has therefore been beneficial on many levels.

Although component lifespan was an important consideration, the use of steel brake discs means life of the brake is limited anyway, so extending this was another challenge faced by AP Racing.

NASCAR also recently amended the rules so teams can no longer change brakes during a weekend. If they make the wrong choice at a particular circuit, that decision must be carried through the whole meeting. When there were multiple braking packages available, this was an area of concern for teams. Now, having reduced choices not only makes this a more straightforward process, it also means the teams order parts in larger quantities for their sub-assembly shops, which will prepare brake packages for their cars up to two weeks in advance of a race.

For the less well-funded teams, extending the life of a smaller number of brake sets is critical to keeping costs under control. The Martinsville short track, for example, takes the life out of a single set for all teams due to its very heavy workload but, for other tracks, some teams will use the same system for multiple weekends.

'On the intermediate and superspeedway tracks, you can definitely get multiple races out of the same disc,' confirms Hood. 'The thing that has really changed [recently] is that you are not allowed to change [the brakes] during a race weekend. So, whatever disc you turn up with, you practice, qualify and race on.'

> “There were a lot of discussions with NASCAR when we did the original design about how much they wanted to have spec, and in what areas they wanted the teams to have a little bit of flexibility. One of those was piston retraction”
>
> *Steve Hood, technical sales manager at AP Racing*

Aerodynamic focus

Clearly, brakes have a role to play in the aerodynamics of the car, too. Minimising drag while also retaining performance over a stint has been a major focus for teams in all forms of oval racing, with some extreme solutions displayed, particularly in IndyCar. In NASCAR, though, there is a standard system, and AP Racing had to ensure the new brake package had enough adjustment, while also meeting NASCAR's brief on costs.

'There were a lot of discussions with NASCAR when we did the original design about how much they wanted to have spec, and in what areas they wanted the teams to have a little bit of flexibility,' says Hood. 'One of those was piston retraction. All our calipers have standard retraction, which is just about enough to take the pressure off the pad, but you can still have a little bit of interference between pad and disc.

'One of the things we have been doing for a while now is to look at the seal. There are two ways you can pull back from the disc – one is the seal groove that dictates exactly how far the piston is retracted. You have three angles on a seal groove, including the leading angle. You can put a different angle on the seal groove but then that means you have different calipers. Or you can put an angle on the seal, which is the approach we took.'

Rather than have the seal sit 90 degrees to the disc, there is an eight degree angle to it, which equates to around double the retraction from the disc. The downside of that, of course, is that there is more pedal travel with greater retraction.

Teams are clearly looking for the minimum drag on the disc on the high-speed superspeedways and ovals, and so many choose the shaped solution for these races as stopping only really happens when the cars are dropping to pit lane speed before a service, and even then, only some of the stops are made under green flags.

'That's one of the things the teams can actually control,' notes Hood.

The opposite end of the scale is Martinsville, where the ability to use the brakes to their maximum throughout the race means different cooling packages are required. AP learned from the 2023 race there that teams were running out of brakes, so worked on different cooling packages for the event in November 2024, which was run successfully. Teams now look likely to use this revised package at other heavy braking circuits, including Watkins Glen.

With such minimal use on some tracks, it helps to have the pads bedded into the brake disc before it's all fitted to the car, and this is a critical part of the whole braking package. The process is handled prior to delivery by Essex Parts Services, a company that beds in the discs ahead of shipping at the teams' request. It's an optional service, but one AP Racing has found to be beneficial to teams, not least because different brake pad suppliers use slightly different properties, so bedding them in correctly is crucial to obtaining maximum performance.

As well as pad choice, teams can control brake performance with the the type of brake fluid used and the size of the master cylinder to ensure the driver has their own preferred feel to the pedal. This ensures teams have the ability to tune their braking packages, within NASCAR's remit.

'We run a pull type centre valve master cylinder, but with 10 different bore sizes that the team can choose from to get their balance right. It goes from a 14.9mm effective bore up to 25.4mm, so there's quite a range there for them to get the feel right,' continues Hood.

Adjustable slug

'There's also an adjustable slug in the brake pedal, so there are five different ratios available at the pedal. We built as much adjustability – if you want to call it that – as we could into the pedal box, because one of the big hurdles was going from the old car, where everything was designed by the teams and manufactured bespoke for each driver, to a spec package they would all be happy with.'

Three years into the deal, teams have mastered the delivery of balance and feel to their drivers, and AP Racing says it has had no complaints about how the system works. If anything, they work too well.

Whereas before drivers might have to baby the brakes a little, particularly on the heavy-duty cycle road courses, now they are able to lean on them harder, and for longer, through the event. That characteristic has shortened braking distances and reduced overtaking opportunities. Consequently, if there was to be an update, there's a chance the brake performance might actually be reduced slightly to help retain the spectacle for which NASCAR is famous.

The spec brake package has been a resounding success, reducing cost to teams while still providing a tunable, fit-for-purpose package. If there's any problem with it, it's too effective!

AP's Next Gen pedal box offers five different pedal ratios and a choice of 10 bore sizes on the brake cylinder so teams can tune their brake system

Direct drive

AP Racing introduced a new design of brake disc for the Next Gen car, one that improves the mounting process, while also reducing cost.

'Before, most of our brake discs used a bobbin drive,' notes AP's Steve Hood, 'so you'd have flanges on the disc with a bobbin in. The problem with that kind of system is it does give a little bit more weakness in the disc itself. So, over the years, we've developed a direct drive system with tabs on the disc that fit into slots in the back of the bell.

'The big benefit of this is it really reduces the stress in the disc. On the old disc they had 12 bobbins whereas now we've got 20 tabs.

'It took us a long time to develop that because one of the key things in the direct drive system is the tolerance, the gap between the lug on the disc and the slot in the bell. If you get it too tight then, as soon as the disc starts to heat up, it binds and you lose the float. You've got to have float on this but, if you make it too big, the lugs bounce around in the slots and that starts to beat the bell, because the bell is just aluminium. So getting that gap between the two right took a long time, because it's the most critical thing on it.

'It's also more cost effective because it's simpler. You've got a bell, you've got the disc, and then we have a steel band that goes around the inside with bolts. Before, we had somewhere between 12 and 15 different bobbins to give different levels of float, and the teams would have to buy all of those. Then we had instances where the team had put the wrong bobbin in, so the disc would lock up or it would be bouncing around. The new system eliminates that entirely.

'So, it's simplified the system, but it's a far from simple from a technical perspective. It's just a much better system.'

The Eagle spreads its wings

Goodyear has been by NASCAR's side for decades, and continues to support the series as it looks to introduce more tyre options into the Next Gen era

By Daniel Lloyd

Chris Graythen Getty Images

Goodyear has been the sole tyre supplier to the NASCAR Cup Series since 1997. This stands out as one of the longest continuous single supply arrangements in top-level motorsport, comparable to Firestone's supply of IndyCar since 1999 and Dunlop's provision of tyres to Australian Supercars since 2002.

Before it became a class of one, Goodyear had been heavily involved in stock car racing since the 1950s, jostling for grid space with other tyre manufacturers. Its milestones during that time of competition included introducing the slick tyre in 1972 and bringing the first radial tyre in 1989, which proved more robust and reliable than the previous bias-ply construction.

It was perhaps no surprise then that, having been closely involved in previous iterations of NASCAR machinery, Goodyear was entrusted with the development of rubber for the Next Gen package, which arrived in 2022. As in other areas of the car, the development of that product has been a continuous process, including the upscaling of wet and option tyre usage this year.

Scale of operation

In addition to the Cup Series field, Goodyear supplies all cars in the supporting Xfinity and Truck Series, requiring the production of around 100,000 tyres each year. It is, therefore, intrinsically linked with the NASCAR structure.

There are 36 points-paying races on the Cup schedule, plus two non-championship events, but the logistical demand of each meeting differs depending on what is racing on the undercard. If it's a three-series weekend where the Cup Series, Xfinity and Trucks are all in action (meaning approximately 100 cars combined), Goodyear will need to bring an army of around 60 personnel, covering the tyre fitters who put the rubber on the wheels for collection by the team mechanics, as well as the engineers who work with the teams to ensure their tyre pressures are safe and legal. The number also includes sales and logistical staff.

Goodyear implemented wet tyres on a Cup Series oval for the first time this year, and also made progress on its tyre compound options

It's a much larger operation than Goodyear's main international tyre supply gig for the LMGT3 class of the FIA World Endurance Championship, where it has just 18 cars to equip. It also isn't far off what the company would bring to the 24 Hours of Le Mans, where this year it had a field of 39 cars to cater for.

'Where it gets complex for us is if Cup is racing at one venue, Xfinity is at another venue and Truck at another,' says Goodyear global race tyre operations manager, Justin Fantozzi. 'Then, the scale gets a little bit bigger, [but] not magnitudes. That's really when the system is taxed.'

Collaborative approach

Goodyear's NASCAR programme is based in Akron, Ohio, which is also the location of the company's global headquarters. It means the motorsport and road tyre departments are situated close to each other, streamlining any collaboration where necessary.

'We can go back and forth,' explains Fantozzi. 'We take track to street, as well as street to track, because the line of where those two products are for true ultra high-performance consumer tyres, and a slick racing tyre, is really getting close. You see that across the industry.'

The move from Gen 6 to Next Gen came with entirely new tyre requirements. Not least because wheel diameter increased from 15 to 18in, whereas the tyre diameter remained the same. This meant there was a reduction in the tyre's volume. When taking a side view, the amount of rubber between the wheel rim and the outer surface of the tyre has been reduced by about 38mm (1.5in). So, although the Next Gen car weighs the same as its Gen 6 predecessor, the sidewall of the tyre is subjected to greater loads than before.

'It's a complete rebuild from the ground up,' says Fantozzi. 'Not only the interaction between tyre and vehicle, but the vehicle itself, and how that changes relative to motor and aero, as we've changed regulations, what that box looks like and what we're asked to deliver from a tyre standpoint.

'If you take all the miles done in testing and learning, the pause we had for Covid, and then the implementation, there was a lot of knowledge going into the first season,' he continues. 'But then you start to learn. If you're not going forwards in motorsport, you're going backwards.'

In Fantozzi's view, the Cup Series teams have progressed well in their understanding of how to best use the Next Gen tyre product. 'There's no doubt about it,' he states confidently. 'We would see that, race over race at the same venue. If we went to Kansas Speedway, for example, the learning for the interaction was very large, but by the time you got done racing the first [time there], everybody had done everything different. Therefore, when you went back the second time, you had your notebook built up.

'It's been a very steep learning curve, [but teams have] adapted well to that steepness. They have then been able to provide a show to the fans to make sure they keep coming back and keep watching on television.'

Tyre intrigue

There have been plenty of intriguing Next Gen races from a tyre standpoint, and 2024 has been no exception. For example, the Cup Series held two meetings at Bristol, a half-mile oval in Tennessee, with one taking place in March and the other in September. The March contest produced one of the more exciting short track races of the Next Gen era so far as drivers struggled with rapid tyre wear. NASCAR officials were quick to heap praise on this outcome, noting that such a scenario is exactly what produces an exciting show.

However, when the Cup Series returned to Bristol for its autumn race, tyre wear was quite obviously significantly lower, and there were fewer passes for the lead than in the spring. This caused something of a conundrum for all involved, as Goodyear brought the exact same specification of tyre that was used in the spring event. Speaking on the SiriusXM NASCAR radio channel afterwards, NASCAR senior vice president of competition, Elton Sawyer, admitted the organisation was 'baffled' at what occurred.

Goodyear

Goodyear has been involved in stock car racing since the 1950s, and its NASCAR sole supply deal goes back 27 years, making it one of the longest-standing arrangements of its kind in motorsport

Goodyear

Goodyear's NASCAR operations are based in Akron, Ohio, the same location as its global company headquarters. This close proximity between road and race departments streamlines the business

'We felt like we had a recipe there from the spring that gave us what we're looking for in our short track racing, putting the tyre management back in the drivers' hands,' he said. 'We've seen some great racing throughout the year – Richmond, Watkins Glen come to mind – with great tyre fall-off. The anticipation as we rolled into Bristol was that we would see something very similar.'

Unlike the spring event, the September meeting included Trucks and Xfinity cars on the support bill, giving the track a layer of rubber prior to the Cup Series cars coming out. Towards the end of the Xfinity contest, it was clear a high racing line was being favoured. NASCAR consequently called a meeting with Goodyear, a selection of drivers and Bristol Motor Speedway representatives, and the outcome was a decision to pad the inside line with a layer of PJ1 TrackBite, a synthetic resin that increases grip and would encourage drivers to also use the lower line.

'We did have multiple grooves,' added Sawyer. 'What we didn't have was tyre wear.'

He went on to defend Goodyear's record in other short track and road course races that resulted in higher wear, saying the tyre 'contributed a great deal to that.'

Goodyear reckons several factors caused the tyre wear disparity at Bristol, including other series laying down rubber, changes to how the track surface was prepared, and how teams set up their cars. Additionally, track temperatures at the autumn race were more than 10degC higher than the spring race.

'This drove the worn tread rubber into the surface,' says Fantozzi. 'Once the surface filled with tread rubber, tyre wear was minimal.'

Racing in the rain

Goodyear produced a wet weather tyre for Next Gen in time for the car's debut in 2022, although NASCAR only allowed it to be run at road courses. The organiser then extended its usage to short oval tracks in 2023.

Seven of the tracks on this year's Cup Series schedule, including non-championship round venues, are designated short tracks: Bristol (two events); Iowa; Los Angeles Memorial Coliseum; Martinsville (two events); Loudon; North Wilkesboro and Richmond (two events). One of Goodyear's priorities, then, was to ensure the wet tyre option would be durable on a short oval track that is drying out.

> "We want to have one [wet tyre] product that does both road courses and ovals"
>
> *Justin Fantozzi, global race tyre operations manager at Goodyear*

Typically, NASCAR prefers to wait until the rain has stopped falling before resuming play, especially at an oval venue.

'That was the first concern,' says Fantozzi, 'because the vehicle dynamics and handling are completely different when you're at that sustained circle vs being on a road course when you're [turning] both ways. We were able to adjust and come up with one solution that's used for the vehicle, both on the ovals and on the road courses, given the box that we're asked to play in currently.'

The adjustment did not mean introducing a new tyre product. The carcass and tread pattern were kept the same, as well as the unique 'D-number', which designates the mould, shape and construction.

'You always have air pressure in your back pocket to help adjust,' adds Fantozzi. 'Then you have changes on the vehicle. The request was: work with the car, work with your air pressure but leave the material number alone, because we want to have one product that does both road courses and ovals. To work around it, you use those variables you can change, keep the others constant and give the best performance you can.'

However, the tyre pressure requirements for a short track are vastly different to a road course, and this had to be factored in when instructing teams on how to use the wet tyre.

'If we just talk slicks, if we go to places like Martinsville, you'll see teams choose to run in single digits,' says Fantozzi. 'It's probably seven tenths of a bar, maybe three quarters of a bar, in the left-side tyres, which is wildly low, all the way up to three and three quarters bar - around 55psi - on the right-side tyres, depending on where we're at, and the sustained load needed to get through the corner. The vehicle is heavy, relatively speaking, [and it is] sustaining that load lap after lap, corner after corner.'

The visit to Richmond in April marked the first time a points-paying Cup Series oval race had been held in the wet. Wet tyres were used for the first 30 laps, at which point a caution was thrown, allowing cars to adopt slicks. The wets then returned to action at Loudon in June. The 322-mile race started on slicks before the heavens opened, and play was stopped for a couple of hours until the track turned damp. With 82 laps to go, racing resumed with wets and the ensuing spectacle was largely deemed a success. Cars used multiple lanes and had entertaining battles, even if NASCAR enforced non-competitive pit stops when tyre changes were carried out.

Treaded roadmap

The implementation of wet tyres on short tracks is part of a joint roadmap plotted between Goodyear and NASCAR. Its success at Loudon this year raises the question of whether treaded rubber could also be utilised at larger, and faster, ovals.

'I know that, if you try to go to the moon, that's as far as you go,' says Fantozzi. 'If you try to go to Mars, you'd better have a plan to get there. We have a plan. If we're asked to bring something to perform, that's our job and that's what we plan on doing.'

The first indications of the path NASCAR and Goodyear are treading were seen in late October, when the series tried out wet tyres on the 'intermediate' oval at Homestead-Miami. All three car brands – Chevrolet, Ford and Toyota – were represented and different wet tyre options were trialled. Although it wasn't a superspeedway, the outing at the 2.414km (1.5-mile) oval was a step towards ensuring more tracks are covered by a suitable treaded rubber option, reducing the likelihood of major weather-related delays.

In 2020, Xfinity Series drivers were given a taste of racing on banking in the wet at the Charlotte Roval, which uses only part of the venue's banking. It went down as a classic. One of the biggest challenges drivers faced was spray from the car in front causing low visibility. Consequently, if wet tyres are extended to larger, complete oval tracks in the Cup Series, Goodyear's main concern would be to try and minimise spray levels.

'That may be what shuts everything down,' Fantozzi suggests. 'You can't ask a human to go into that situation and perform at that level but not be able to see where they're going. The industry as a whole will work on that and see how far we can push.'

Compound interest

As the taming of damp tracks has continued, the other big tyre topic of the year has circled around compounds. Tyre strategy options increased this year with the introduction of a second, softer product for certain races. Whereas Goodyear's philosophy in the WEC is to use a single compound at each race, the company's NASCAR partnership is moving towards giving more choice to the competitors. This comes as the sanctioning body explores ways of spicing up the racing on short tracks, aside from the aerodynamic updates to the Next Gen platform discussed on pp78-83.

'We take a range of products to a tyre test,' explains Fantozzi. 'From that, we pick one, because that's what the industry has asked us to do. We have different solutions. When the industry sat down and said, "We want to try this and see if two different options is the right path, can you do that?" Yeah, we said, we can do that. So we tried it.'

James Gilbert Getty Images

The 2024 All-Star Race at North Wilkesboro was the first time Next Gen teams had the opportunity to race with the two Goodyear slick tyre options. Teams were given two sets of both the prime and softer option tyres in the hope it would improve the racing spectacle

> It has not been a blanket rollout of different compounds at every race. Instead, it has been a cautious and measured introduction to determine what the option [tyre] brings to the racing

Although the option tyre's usage in the Cup Series has drawn attention this year, it's not the first time teams have been given a choice. For the 2017 All-Star Race at Charlotte Motor Speedway, NASCAR permitted a softer tyre that would offer enhanced grip and faster lap times than the standard 'prime' tyre, but with the drawback of losing its performance credentials quicker. The non-championship status of the All-Star race enables NASCAR to trial some of its more radical sporting ideas in a race setting, although in the case of the option tyre it was a one and done thing, for seven years at least.

The experiment at Charlotte on the Gen 6 car garnered mixed reactions from drivers. After that event, Goodyear's director of race tyre sales told *Autoweek* that the supplier had envisioned the option tyre to be 0.3-0.5 seconds quicker than the prime. However, the cooler night time conditions for the race meant the gap was reduced, and the impact of the different tyres on race strategy was smaller than hoped. Although the softer compound was cast aside for a while, it remained in Goodyear's locker until the Next Gen car arrived on the scene.

'The knowledge of that gap [in performance between prime and option] was truly needed,' explains Fantozzi. 'Whether it was done in the laboratory as materials, by us, or in the laboratory as finished tyres, or done on the racetrack itself, all those three things need to happen and build off each other.

'There is a lot of time spent by us in the laboratory, for materials and finished tyres. Simulation work and the electronic side of things is the precursor to any of that but, eventually, you've got to put it on the track and see what it's going to do.'

Option in action

The All-Star Race at North Wilkesboro in 2024 marked the first time Next Gen cars had raced with the two tyre options available. It was then applied in a points-paying scenario at Richmond in August.

At the All-Star Race, each car had two sets of each tyre compound for the 125-mile contest, whereas at Richmond teams had two softer sets and seven prime sets to use over 300 miles. Goodyear envisaged the option tyre at Richmond would be 0.5 seconds per lap quicker, and this prediction was realised during the daytime portion of the race, when track temperatures were higher. The gap closed as temperatures dropped after sunset, mirroring the scenario at Charlotte a few years prior, but Sawyer still hailed the race a success, pointing to how Daniel Suárez and Michael McDowell charged through the field after switching to the softer option tyre early.

Looking to the future of tyre choice in the Cup Series, NASCAR and Goodyear are taking a similar approach to the wets. It has not been a blanket rollout of different compounds at every race. Instead, it has been a cautious and measured introduction to determine what the option brings to the racing.

'I think you're seeing the pattern, which is [to] start on a short course or short oval, and then let's have a bigger discussion around it,' says Fantozzi. 'You want to walk before you run, because you always want to make sure you're making forward progress.'

Ultimately, Goodyear needs to be flexible enough to accommodate NASCAR's demands so it facilities the exciting racing that puts people in the grandstands and gets others tuning in. Such an approach has served this partnership well for almost 30 years. ●

Mr Fuel Pump

How a former GT racer has found a winning formula for developing high-end motorsport fuel pumps and systems

By Mike Breslin

Bresmedia

While Rob Schirle is more at home in a lab coat than Nomex these days, the products his Protec concern manufacture see action in a very wide range of racecars and disciplines, including NASCAR's Next Gen rule set

Many involved in motorsport will be familiar with the name Rob Schirle. For quite a while, he was more than a decent driver, competing successfully in karting and then excelling in one-make championships in the UK in the early 1990s, before graduating to international GT racing and even the 24 Hours of Le Mans. He was also a well-known team boss, his Cirtek Motorsport outfit being at the forefront of GT competition for a number of years.

These days, you will not see his name so often in the pages of the motorsport press, yet Schirle is probably more involved now than he's ever been.

Indeed, name any top line motorsport discipline and the chances are that Schirle's Protec Fuel Pumps concern has had some involvement with it. Its products are found in NASCAR, WRC, IndyCar, WEC, F2, F3 and Formula 1 (where they have been chiefly employed in pumping fuel from the cars), while the company is a supplier to the majority of fuel cell / system manufacturers. It has also worked with some of the top motorsport departments, including at Porsche, VAG, Hyundai and Subaru. Then there's the high-performance road cars, such as Aston Martin, as well as powerboats, drag bikes and even tractor pulling applications where the Protec name has appeared.

> "What did I think could be done better… what hasn't changed on a racecar for many years, at that time?"
>
> *Rob Schirle, Director at Protec Fuel Systems*

XPB

Before he became a market leader in fuel pump technology, Schirle was a successful racer, seen here in a Lister Storm shared with Ian Donaldson and Gregor Fisken at the 2004 24 Hours of Spa

So, how does someone go from being a high-profile racer and team boss to a businessman and engineer, developing and marketing fuel pumps and systems?

'Running the team meant I had plenty of contacts within the industry, and also plenty of experience working and running systems, so that was a really good grounding for what I'm doing now,' Schirle says. 'But how Protec came about was that I lost my father [Hans Schirle] and I just took a year out and thought about what I was going to do.

'It started with a clean sheet of paper. What did I think could be done better, looking back on all my experience with the team? I started from the front of the car and worked back, and I seemed to keep coming back to the fuel system, especially the fuel pump.

'I then asked myself, what hasn't changed on a racecar for many years, at that time? I also asked Adrian Newey, because Adrian and I were both racing in historics then, and he said the same thing – the fuel pump.

'The Bosch 044 pump had been around for a long time, and nobody had improved on it. I thought, well, I'm onto something here. At the time, I didn't really understand how the pump worked. I didn't understand how to design a pump. I just thought, we've got to be able to make something better if it hadn't been improved in all that time. So that was my first task, and it proved to be quite an interesting experience.'

In essence, a fuel pump's job is a simple one – to take the fuel from the cell and send it to the fuel metering system. However, it has to be delivered at exactly the right pressure for the whole gamut of engine speeds and loadings, while the car's attitudes under cornering, accelerating and braking also need to be considered. It then needs to do all this without leaks in the system and without allowing air in, while always keeping the fuel at the required temperature. Given all that, it is easy to see how designing and manufacturing a fuel pump is a complex undertaking.

The fuel challenge

It has become more of a challenge in recent times too, with the introduction of biofuels, which have created a range of new problems for fuel pump manufacturers to address. For example, ethanol can eat away at the metal parts of a fuel pump's motor, and can play havoc with seals and flexible parts. With the increased use of biofuels in motorsport already looming on the horizon when Schirle set up the company in 2010, it was clear that addressing this issue was a priority.

'I started to look into the change of fuels and the demands that the use of EFI [electronic fuel injection] and everything else were requiring, and I saw there was a massive hole in the market,' Schirle continues. 'The way the modern fuels were going, I could see the gradual movement towards ethanol-based fuels, and an increase in toluene and benzene coming into fuels, so we concentrated on brushless motor technology to begin with, as this is a way to counter the issues the newer fuels can cause.

'Brushless motors have other advantages, too. They are more efficient, they are lighter, and you generally get more bang for your buck. You've also got no brushes to wear out.'

Protec's first work was with NASCAR, during the series' switch from carburettors to EFI in 2012. Schirle helped design the system, alongside NHRA fuel pump guru, Sid Waterman, and after that launched the 340 pump into the wider market.

'That was our first big break,' says Schirle. 'We designed the 340 as a replacement for the Walbro 255, and we've now sold well over 100,000 of these pumps. It's turned out to be one of the biggest sellers [that fuel system provider] Aeromotive has ever had. It's still a core product now, and basically it just completely changed the marketplace, literally within a year. So that put us on the map, because it gave us funds to develop our brushless range. Within the market, at least, we suddenly became well known.'

Clean room

From there, Protec has gone from strength to strength and now supplies products into just about every major motorsport category. Building on its early work with NASCAR, the company was approved as a supplier to the Next Gen rule set introduced in 2022. Yet, despite all the success, Protec is not based in a smoked glass atrium packed with art installations. Rather, it's run from a nondescript unit on an industrial estate in Burton upon Trent, UK, usefully close to Donington Park race circuit.

> We concentrated on brushless motor technology to begin with, as this is a way to counter the issues the newer fuels can cause

Bresmedia

Protec's Cobra pump is the Burton upon Trent firm's flagship product

Bresmedia

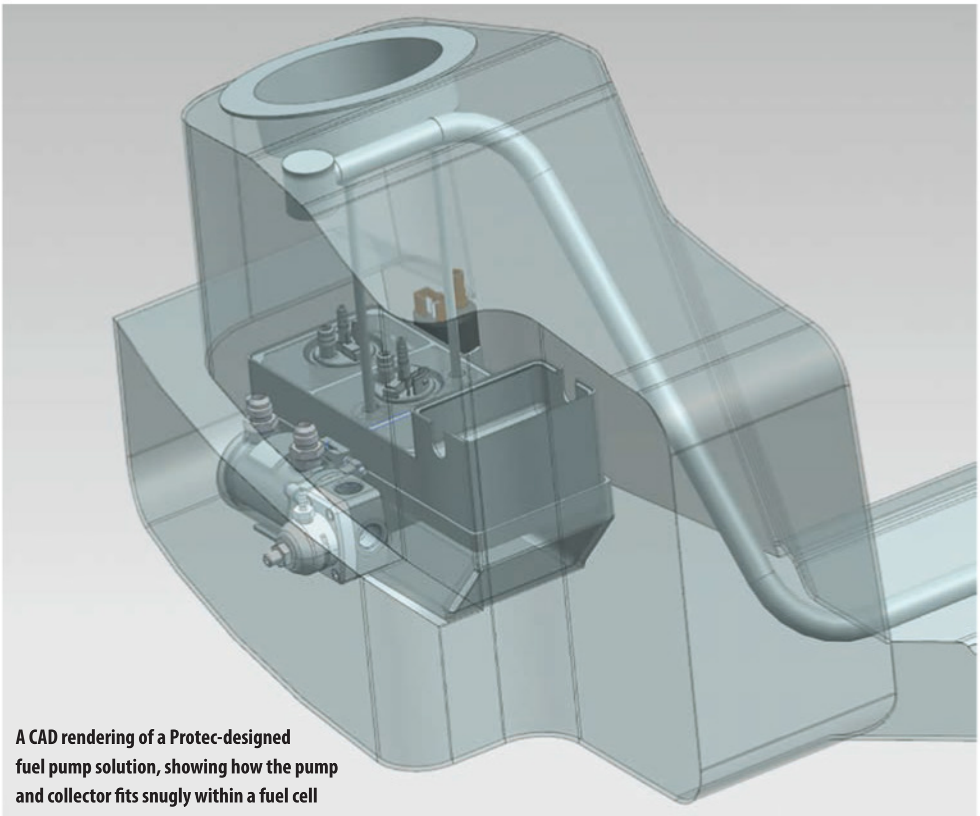
These delightful little screw pumps, which Schirle describes as 'mini superchargers', are at the heart of the Cobra pump

What's more, there are no production lines, just a clean room-type space that looks more laboratory than factory, where the pumps and pump assemblies are expertly built by a key member of staff, Mark Heaton, the assembly builder, who came to Protec after some 20 years with Premier Fuel Systems (a company the firm still works closely with).

Heaton pieces together components made offsite by trusted suppliers, or 3D printed in-house, mostly assembling pump systems that will typically include a power source, level sensor, filter and regulator, all designed to fit snugly into a fuel cell.

Other members of the team at Protec include Andy Green, who designs the products on CAD, and Liza Wong, who runs the office and the shipping operation, while there are a couple of other people involved in packing and the like, as well as motorsport engineering students. Schirle's wife, Mandy, is very much involved in the business, too.

It's a small team, but Schirle would have it no other way: 'It's almost fighting expansion, in a way,' he says. 'We don't want to expand, we want to stay niche and focused.'



Protec

A CAD rendering of a Protec-designed fuel pump solution, showing how the pump and collector fits snugly within a fuel cell

Quality control

This is partly down to keeping a firm grip on the quality of its products, but another reason is that Schirle feels very comfortable with the size of the business, and enjoys both the location and the sector he is working in.

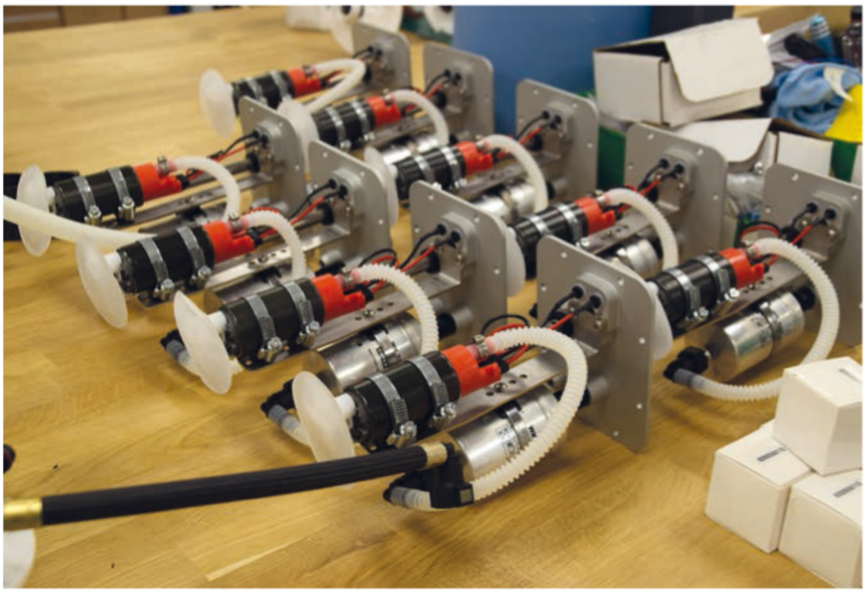
'I think this is what Great Britain does the best, motorsport in particular. We have a huge pool of small firms like this. It is very much a specialist industry, that's for sure,' he says.

It's also very much a specialist product, as Schirle admits, though he insists there is much more to pumps than people sometimes realise: 'What I find strange is, when you say, I do fuel pumps, people think it's quite a boring little thing. But when you get into it, it's not boring at all, and with some of the stuff we're doing here we're really pushing the boundaries of what's possible, and we always want to do that.'

The main way in which Protec continues to push the boundaries is by embracing game-changing technology, which has partly arisen from another groundbreaking approach the firm took from the very beginning, and that's supplying individual components when required. By doing that, if a customer has a problem, or needs a replacement part, they don't have to buy a complete fuel pump system. Now, with additive manufacturing being a major tool in the company's armoury, this approach has progressed a step further.

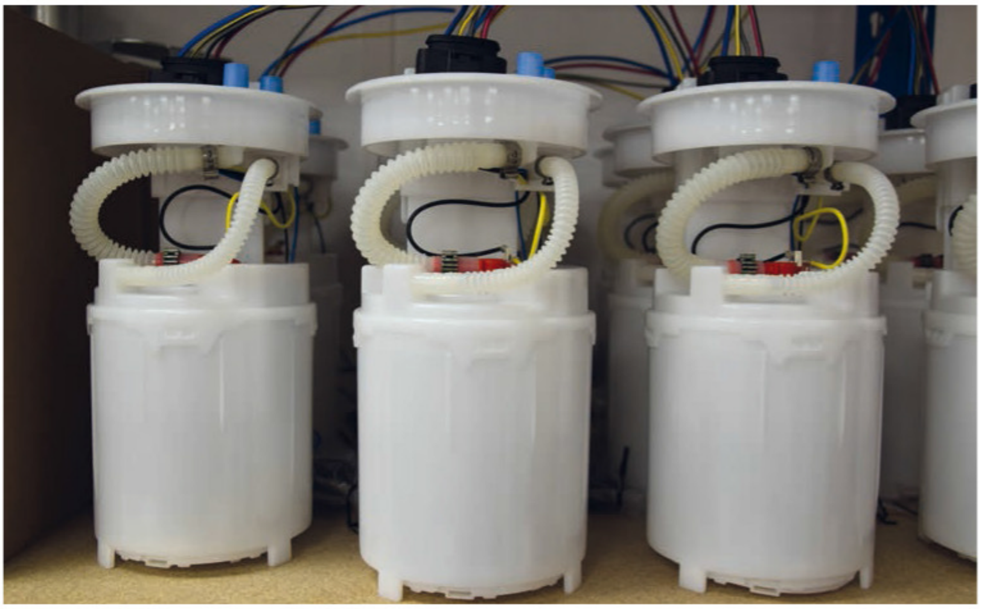
'We were the first company to launch, commercially, 3D printing into the fuel market,' says Schirle. 'We've partnered with Spanish company, BCN3D, to do it, and one of the reasons for partnering up with a printer manufacturer is because with 3D printing for these parts, the G code [the commands for the printer], the slicing and the material have to be 100 per cent right. We've also partnered with Italian firm, Filoalfa, which supplies the filament used in printing.'

In the corner of the workshop, there now sits an Epsilon W27, one of 12



Though it is undoubtedly its core market, the company is not just about motorsport. These pump assemblies were produced for the Aston Martin (and Brough Superior) AMB 001 limited edition motorcycle project

Assembly builder, Mark Heaton, is responsible for meticulously piecing together the various Protec pumps and systems



An array of completed fuel pump assemblies ready to be delivered to another successful UK motorsport business, Radical Sportscars

Protec has produced an eight bar screw pump for the Hypercar class WEC cars, including the new Valkyrie

Epsilon W27 3D printing machine. Additive manufacturing technology is revolutionising the way Protec can service its customers and design its products

> “It's all about efficiency; reducing the heat to make the system efficient”

3D printing machines that Protec has invested in over the past few years.

'It means we've got the ability to just print what we want for a specific application, but it is also changing the way we look at the design of fuel systems,' says Schirle. 'I think what we're doing on the 3D printing side could get quite big quite quickly. Manufacturing can work out cheaper, too.

'Whereas it used to cost us x to make an aluminium bush sleeve, for example, we can now do it in-house and it costs a fraction of what the aluminium did, but it still does the same job. And you're only printing the material you use, so there's no waste.'

Proof of concept

However, there are limitations, as Schirle explains: 'It's that understanding of what you can print, because you can't print everything. Safety is obviously paramount to us, and at the moment I don't see having 3D printing on the pressure side of this, but maybe that will come in the future. I think injection moulding for an aluminium part, at the moment, is a better solution.

'Again, though, the design advantages of this mean we can, for instance, print things out just to get us proof of concept, and that's a good thing. We may print something and then think, actually, it's good, but we're going to make it in billet.'

The principles behind designing a fuel pump remain the same, even with 3D printing to help. 'It's all about efficiency; reducing the heat to make the system efficient,' says Schirle. 'Often, the first thing we talk through with a customer is the pressures. Because pressures vs flow, there's a massive difference. As the pressure goes up, the flow will come down. And in some instances, you'll get pressures up to 10 and 11bar, which is really quite high.

'I think that's where our pumps score. In fact, we're confident our brushless Cobra pumps give the most amount of output for flow with the least amount of amperage, for higher pressures.'

System knowledge

It's also important to remember that however good the pump is, it will only be as good at the system it is a part of.

'You can put the best pump in the world into a bad system and, if the filter isn't rated accordingly, or if the regulator is not rated accordingly, you can create massive problems. Some of these pumps flow so much fuel that if you haven't got a filter or regulator man enough to bypass, or to flow what it needs, all you're going to do is create a lot of amp draw. Then the pump head pressure will go up dramatically, and the rest of the system won't be able to cope with it. It's that understanding of the flow and the volumes involved that is vitally important.'

To ensure the quality control is always there, all pumps are tested on Protec's array of flow rigs using Flowrite fluid (a product of leading fuel injector supplier ASNU, another company Protec works closely with). 'Flowrite gives us the same specific gravity as fuel, without the flammability,' explains Schirle. 'Every single pump we make is tested here before it leaves the factory, and that's something we're very rigid with.'

There are quality checks on the aesthetics of the products too, even if the part concerned might spend its life tucked away out of sight in a fuel cell. It's certainly true that some of the Protec pumps are very neat looking devices indeed, in terms of the engineering intricacies and the smart finish, especially the delightful little screw pumps that form the core of Protec's highly successful Cobra product.

'I want people, when they pick something up of ours, whatever that product is, to think that somebody's really thought about it, about how it looks. I think that's important,' says Schirle.

This approach probably comes from all those years running racecars but, even before he reached the car stage of his racing career, Schirle believes he learnt many things that are still of use today: 'I find it amazing that things I learned when I was building kart engines, those fundamental basics, are still applied here today. When balancing the motors that go in the Cobra pumps, for example, I still use a knife edge, and we do still balance the motors, every one of them, because we understand the benefits. We can see that if you balance a motor really finely, it will run smoother. And those fundamentals are core to everything we design.'

Yet for all the motorsport background, and the undoubted benefits this brings, much of the development at Protec today is about seeing what's currently available in OEM, and then adapting it for motorsport and performance applications. It's an approach that has been a feature of fuel pump development in motorsport for some time.

Siphon technology

A great example of this method involves the siphon jet Protec has developed. To explain, one of the toughest tasks a fuel system faces is dealing with surge – that is when the fuel sloshes around in the cell during hard cornering, acceleration or braking. This can easily move the fuel away from the pick-up, meaning the pump will suck in air instead. Scavenge pumps are often used to counter this, but Protec's siphon technology, which works a little like a drinking straw, albeit with much more advanced fluid dynamics, has proved itself in motorsport applications, doing away with the need for lots of scavenge pumps.

'Basically, we've taken the best OEM system and made it useable for motorsport,' says Schirle. 'It collects fuel from one side

> “Basically, we've taken the best OEM system and made it useable for motorsport”

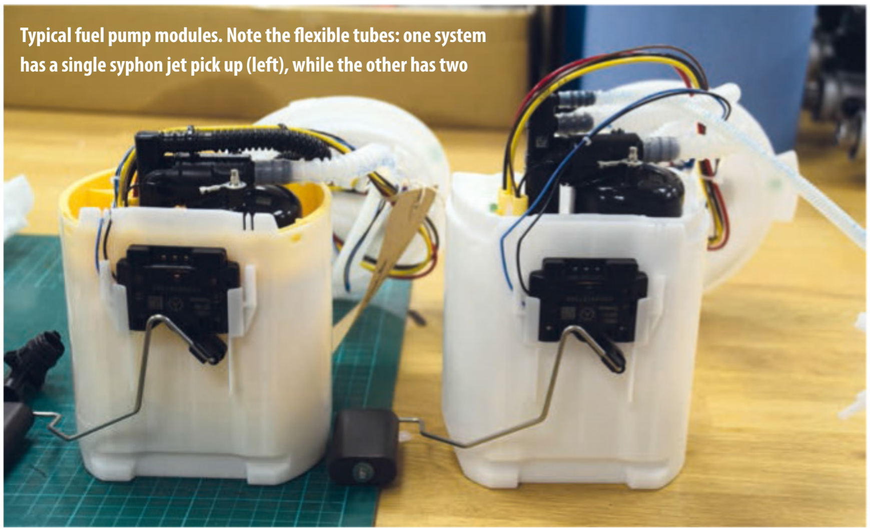
of the cell, or from a corner, and moves it to the collector area. It's a very efficient way of keeping the fuel in one area, making sure the fuel is always where you want it, and that's key in a fuel system.

'It means there's not such a need for additional lift pumps, while it also doesn't need electric power, as it pulls the fuel without power [at 300 litres per hour]. It's very simple and very clever, with the fuel passing through a Bernoulli system, which creates a negative pressure that then sucks more fuel in.'

Keeping ahead

Fuel pump assemblies incorporating siphon jets are just one product among many that Protec supplies. As well as offering complete fuel systems, the company also sells fuel cells and all the paraphernalia associated with fuel in an automotive application, such as filter socks, brackets, valves and couplings, though pumps still remain the number one focus.

The evolution of an in-tank fuel collector, from cardboard prototype through iterations of 3D printed versions to the final design on the right



Typical fuel pump modules. Note the flexible tubes: one system has a single syphon jet pick up (left), while the other has two

'The number of pumps we make each year just seems to increase all the time,' says Schirle. 'We supply a lot of different companies, but we're pulling back a little bit from having other company names on our product now. Now Protec is a stronger brand, we want to have our name on it, not a customer's.'

New technology bearing that brand name includes controllers that are CAN bus, so fully integrated, that accept pulse width modulation (PWM), which helps keep the amperage low in brushless motors. 'They've now got diagnostics built in, too,' adds Schirle. 'It's just staying ahead, and watching out for little changes.'

What about the big changes, though? What will a fuel pump company do in a world of electric cars and electric racing? 'They still need to cool the battery packs,' says Schirle, 'and, when you think about it, we've got a pump that would only draw about one and a half to two amps. With an electric vehicle, if you've got a heavy amperage motor, or pump, or heater, or anything, it's taking from that core source of energy. So, if you've got a pump that can move the coolant around but only use one and a half amps, it's a better solution than a pump that uses five or 10 amps.

'There will always be ways for us to supply our technology, because our brushless motors don't care what they drive: it could be an impeller for a water pump, it could be an impeller for a dyno pump, or for a 1000bhp car. If it uses less power, it's better. It's more efficient.'

Of course, the future is not just electric, and it seems likely that synthetic fuels will also play a large part in motorsport.

Synthetic fuel

'That's certainly something we keep at the forefront of our minds,' says Schirle. 'We're in constant discussions with synthetic fuel companies. We know who's developing it and we want to be able to test it, and do material tests, both for our own benefit with the pump, but also with Premier Fuel Systems. They want to test for the material for the bladders, because it has a knock-on effect for not just the pump, but everything you use: the hose, the regulators, the diaphragms, everything in a fuel system can be affected by a new type of fuel.'

Clearly, fuel pump manufacture is anything but boring, especially in today's evolving powertrain landscape. It's all about keeping ahead of the competition, and abreast of the technology and changes in regulations. Which, when you think about it, is exactly what Rob Schirle was doing when he was a race driver and a team boss. Maybe things haven't changed so much, after all?

> 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 its computing limitations were reached

Getty Images

Forward thinking

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

By Andrew Cotton

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

On the face of it, there was nothing wrong with McLaren Applied's TAG-400N electronic control unit (ECU). The device was introduced to NASCAR in 2012 and, since then, has serviced the normally aspirated V8s during the Gen 5, 6 and 7 (Next Gen) regulations. The control unit is so good that some teams are still running their original ones, yet to be serviced by the British company, and still functioning perfectly well.

The series-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 McLaren Applied 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, and into full-time competition from 2026.

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

The series-500 family of ECUs is already in use in Formula E, where the VCU-500 vehicle controller variant has performed strongly during its debut season.

> This is the first in a series of upgrades McLaren Applied will introduce 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 brains of the operation is the TAG-510, which has significantly upgraded processing power and improved security architecture

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

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

The VCU-500 has also been running in the new E1 electric powerboat series which hit the water at the start of this year.

This is the first in a series of upgrades McLaren Applied will introduce 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 in 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 F1 and sportscars having introduced hybrid systems in 2014, the demands on the ECU were very different 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 upcoming ECU upgrades.

NASCAR may have skirted around the issue of introducing hybrids to the Cup 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 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’

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 simulation programmes, with a number of further data channels for use by the organiser 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.

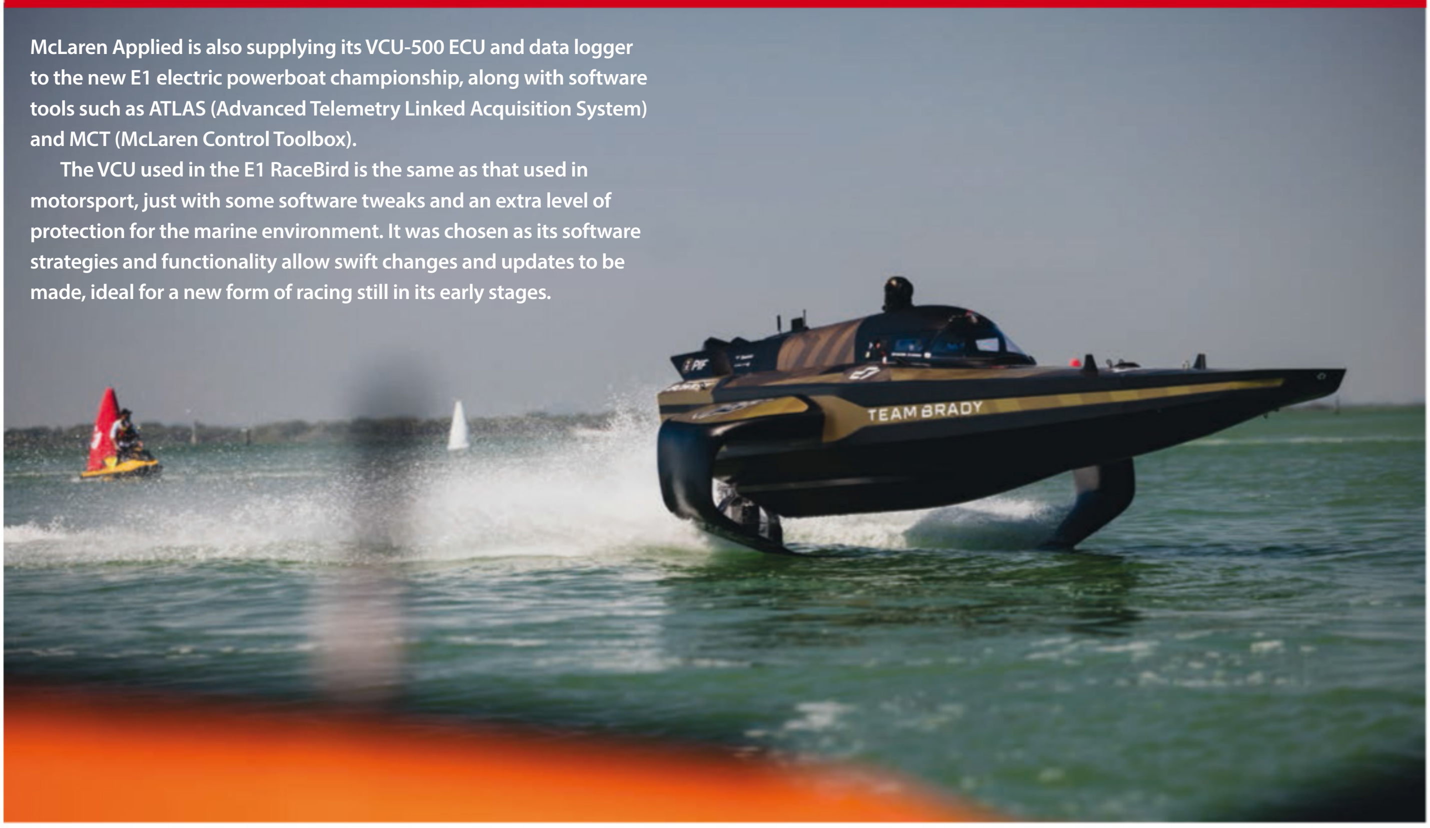
This increase in available channels will enable NASCAR to monitor more complicated systems, such as engine use and chassis control. It will also give the series some headroom in case it is forced to go in a different direction and introduce tools such as hybrid, or active aero (DRS) to improve fuel efficiency, 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 easily be able to cope with such demands.

The TAG-400 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.

Alternative application

McLaren Applied is also supplying its VCU-500 ECU and data logger to the new E1 electric powerboat championship, along with software tools such as ATLAS (Advanced Telemetry Linked Acquisition System) and MCT (McLaren Control Toolbox).

The VCU used in the E1 RaceBird is the same as that used in motorsport, just with some software tweaks and an extra level of protection for the marine environment. It was chosen as its software strategies and functionality allow swift changes and updates to be made, ideal for a new form of racing still in its early stages.



Spacesuit Media

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 Formula 1 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 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 rolling it out into further race series.

The TAG-510 has increased processing power, up from 264MHz to 1.5GHz, 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.

Security layers

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

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 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 ❜

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 its 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 the 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. ●

With the successful introduction of its new generation ECUs into Formula E, along with its MCP processor architecture, McLaren is confident the system is suitable for use in many other race series

Courtesy of Hendrick Motorsports

Row upon row of engines wait in the state-of-the-art engine shop at the massive North Carolina facility. The annual output of power units makes Hendrick Motorsports one of the most prolific engine builders working in racing today

Motor city

Hendrick Motorsports produces over 600 NASCAR engines per year and is bidding to reach 600 pro race wins

By Andrew Cotton

Anyone who has been to Hendrick Motorsports' campus cannot fail to be impressed. Housed on 140 acres in Charlotte, North Carolina, the facility runs up Papa Joe Hendrick Boulevard to a series of factories that has steadily grown in size from 5000ft.sq in 1984 to an incredible 430,000ft.sq today.

On site is a full race shop for Hendrick's teams competing in various NASCAR-sanctioned series, a museum that celebrates its 40-year history, and a state-of-the-art engine facility that produces one of the highest numbers of bespoke power units per season in global motorsport.

Since April 1984, when Geoff Bodine won the Cup Series race at Martinsville, products of Hendrick's engine shop have powered winners every year, bar 1985. At Darlington last year, Hendrick driver, Kyle Larson, racked up the 500th win for the company's power units across the Cup, Xfinity and Truck Series. They had been taken by a combination of customer teams and the in-house Hendrick Motorsports squad which has won more than 300 times in Cup alone. The next goal, then, is to for Hendrick engines to hit 600 victories.

Scott Maxim, director of powertrain at Hendrick Motorsports, is a man on a mission – one of consistency and quality

In the Cup Series alone, Hendrick fields eight engines, covering its own drivers Larson, Chase Elliott, William Byron and Alex Bowman of Hendrick Motorsports, as well as those of Spire Motorsports and JTG Daugherty Racing. Keeping up with this demand requires huge resources.

In 2024, engines built in the main shop have finished every race bar one, and that anomaly still grates with Scott Maxim, director of powertrain at Hendrick Motorsports: 'We had a broken valve spring on the no.48 car in New Hampshire,' he laments of the mechanical issue that stopped Bowman in that race. 'We had 29 events with eight cars, so we ran 232 Cup races, and that one out of the 232 still hurts!'

Reliability run

It's a long way from where engine reliability used to be. Even 20 years ago, it wasn't uncommon to see cars retiring from races due to engine failures, but power reductions from around 850bhp at their peak to a maximum of 670bhp today on street courses, short tracks and ovals, coupled with intensive development of the engine shops across the sport, mean such things are now a rarity.

Hendrick's race shop is one of the most prolific in racing, producing around 600 engines per year for competition in various series, each of them built from scratch by a team of around 100 highly skilled personnel, who also develop, test and maintain the engines over the course of the season.

The scale of the operation is staggering. Even sourcing the materials to create the engines, having the machinery and the workflow to produce them – to a schedule that is tightly controlled by NASCAR – and then to have them produce the same horsepower is a mammoth challenge.

Maxim says that to build eight engines for the Daytona 500, that are all within one bhp of each other, is not only extraordinary to achieve, but also to measure. The company uses its own dynos to test its engines' output before anything is strapped into a racecar to ensure parity across the units.

Resource management

The engine blocks are bought from GM as raw castings, then machined on site – main line, cylinder bores, lifter sleeves and main decks – using the latest CNC machines from Grob.

Even that is more difficult than it used to be. The Next Gen car was developed through Covid, and many of the manufacturers involved in racing, and road cars, found themselves struggling to source materials. Meanwhile, the war in Ukraine continues to consume resource that might otherwise be used for racecars, and Hendrick has had to find workarounds to maintain output.

'Dealing with supply chain issues is more of a challenge than it was five years ago,' admits Maxim. 'We always want to be a good partner to our vendors and, in that respect, they certainly have challenges when it comes to raw materials and production planning. So, we have to try to be good stewards of purchasing in that regard, and to work with our vendors to do the best we can.'

Despite the high output, NASCAR rules mean that the majority of races during the season have to be contested with engines that have raced previously. Out of 38 Cup race weekends, 20 must be run with refurbished, or pre-raced engines. Not only does that reduce the cost to the customer teams, it also slows the rate of development, as any new components have to be introduced to all the engines supplied, whether they are used by Hendrick's team or its customers.

Teams do have freedom to choose when those 20 engines can be run, but there are some limitations. The season-opening Clash at the Coliseum for example – in truth more of a showcase than true competition – has to be contested with a sealed engine that was raced the previous season. A sealed engine is mandated for the All-Star race too, while in

> “[This year] we had 29 events with eight cars, so we ran 232 Cup races, and that one [engine failure] out of the 232 still hurts!”
>
> *Scott Maxim, director of powertrain at Hendrick Motorsports*

With engine regulation so tightly controlled by NASCAR, not only do all the power units for the various series have to be built on time, they have to produce exactly the prescribed power output

"Our current engine builds are capable of running 1500 miles with reasonable level of confidence, and the average mileage that an engine gets is in the 1000-mile range"

Scott Maxim

Gavin Baker / NKP

the playoffs (the last four races of the series that decide the champion) cars must use sealed engines that have raced previously.

Power play

The strict regulations around engine use also mean Hendrick needs to ensure its engines do not lose large amounts of power over the course of their lifespan. That said, a fairly extensive rebuild can be undertaken without disturbing the seals around the engine that are mandated by NASCAR.

'We just ran about 600 laps around Bristol so, technically, that's just under 300 miles, but that's a little 0.533-mile [track] that we're running at an average of 7400rpm,' says Maxim. 'So, you are through a lot of cycles in a hurry there. That's a tough 300 miles, but one thing we've seen with respect to engine longevity is we're working with NASCAR as engine suppliers on this.

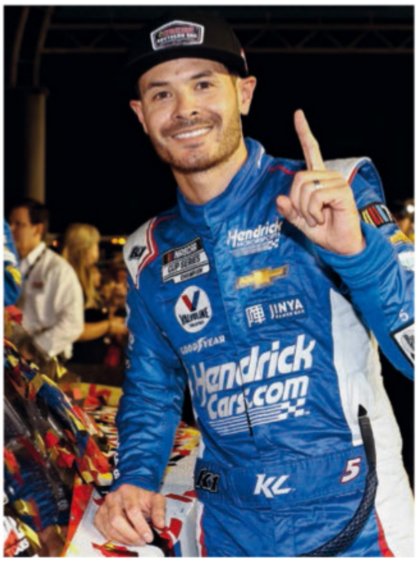
'Our current engine builds are capable of running 1500 miles with a reasonable level of confidence, and the average mileage an engine gets is in the 1000-mile range. The discrepancy there is because NASCAR is a contact sport. It's not a sterile form of racing, and what impacts our average [engine] mileage is wrecks, broken radiators, oil coolers and the like, that then lead to overheating. All things that are just a result of the type of racing we're in.

'That will take an engine that is half-life, or less, and relegate it to a full rebuild. There's just no way around that.

William Byron's win at the Daytona 500 (left) was of particular note for Hendrick Motorsports as it marked 40 years to the day that the company made its NASCAR Cup Series debut

Gavin Baker / NKP

Kyle Larson's victory at Darlington in September 2023 (below) marked the 500th win for a Hendrick Motorsports engine in national stock car racing



James Gilbert / Getty Images

'We also get spins where the car is going backwards and, with the short exhaust pipes, you can easily get debris from the exhaust pipe outlet make its way up through the engine. It's a rough environment our cars live in, and our engines.'

Seal the deal

The engine shop therefore has to select the races where it thinks the engines are going to have the least wear and prepare them for others later in the season. The amount that is done during a rebuild – bearing in mind these are considered sealed units – is impressive.

'The first time it runs a race, we arrive at the racetrack with a fresh engine build,' says Maxim. 'We have to install proprietary seals from NASCAR that seal the cylinder heads, both the even and odd heads, so left and right, and the oil pan to the block. The camshaft also has a retention seal that does not allow it to be removed from the engine, and those seals must stay on.

'So after you one run one race, that engine is re-installed in a racecar, and that's essentially a sealed engine from the previous race. We've got to run 18 points-scoring events with a sealed engine, and then we've got the two additional races that are mandated to run a sealed engine in addition to that, for a total of 20.

'The one caveat is that, if you are fortunate enough to be in the Final Four at the championship race, those four engines have to be sealed units from a previous race. So, for those four teams, they've got to run a minimum of 21 sealed engines out of 38 events.

'We get those back to the shop and, in those situations where the engine is going to run again, we go through a comprehensive checklist: we clean the engine completely; change valve springs; inspect the valvetrain; run oil analysis; look for wear metals, or lack thereof.'

Oil analysis

'The oil analysis will confirm that our wear levels for iron, aluminium, titanium, lead, indium and copper are consistent, and as we'd expect with an engine. If it's okay, the engine will go through its final peripheral systems checks and then go on the dyno. There, we run through all the vitals of pressures, temperatures, fluid flows, power output, crankcase depression and so on. Pending all of that being successful, and within range, the engine is signed off and ready to be delivered to a race team.'

Hendrick supplies eight full time cars in the Cup, so must have at least eight fresh engines for 18 races in the year. At each race, it also has a further eight fresh engines in the support truck, in case any are required.

Such attention to detail may seem common across the NASCAR landscape, but Hendrick has a particular claim to fame. During the 2024 season, it racked up its 520th race win in national motorsport, and the engine department is aiming to hit the 600 victories mark as soon as it can.

'I think what helped get us there is a commitment across our entire shop for process, procedure and discipline,' says Maxim, 'and holding ourselves accountable to a high degree. It always has been. I think every race engine shop has that to some degree; you've got to have it to be successful.

'We've been blessed through the years to be able to put our engines in cars and race teams of the highest quality, and that is an honour. It's also a lot of pressure, though, to live up to those needs and expectations.

Starting from raw block castings bought in from General Motors, all machining tasks are done in-house for tight quality control

> "We always strive to be a positive influence, and a contributor – our entire workforce does – to all the women and men out there racing. We're all driven by that"
>
> *Scott Maxim*

Because we have many teams every week that are capable of outstanding performances, capable of winning, we need to be a positive part of that, not hindering them and not holding them back.

'We always strive to be a positive influence, and a contributor – our entire workforce does – to all the women and men out there racing. We're all driven by that.'

Control updates

Despite all the regulations, there is always something to develop for the engine, and next year will see the new McLaren Applied TAG-510 ECU out track testing, with tentative plans in place for its race introduction in 2026. This will feature a more accurate digital signal than the current analogue system, offering benefits for both teams and engine builders.

'It's certainly more modern and capable, so there's much higher capabilities with respect to sensors, as well as throughput and telemetry, both in the vehicle and off-vehicle data transmission, be it via telemetry or wire,' says Maxim.

'Those capabilities, if there's future engine changes, or other manufacturers coming in, in addition to Chevy, Ford or Toyota, whatever options we have for engine architecture down the road, this ECU will be capable of managing those engines.

'It also offers the capability to provide for a safer and more robust racecar, which is something we always continue to strive for.

'In theory, I think it will be able to offer us higher quality data that we will be able to download in reasonable time. Right now, the data we can log is limited, and one of the reasons for that is having inefficient data offloads and transfers. With the more modern data transfer capabilities of the [McLaren] ECU, we will be able to download much larger amounts of data more efficiently.'

Mission statement

A walk around the Hendrick race shop is a humbling experience. The size and quality of the machines building the engines is almost dwarfed by the number of power units that sit in the shop ready to go. Pride of place is given to the engine that secured the company's 500th professional race win, mounted on a plinth to remind all the staff that their work has translated into success.

'Our mission is consistency and quality, and we have that in our machines, our quality control, our metrology, our processes and our people,' says Maxim. 'Those are all areas we will continue to work on, to improve our infrastructure, our measuring and our testing capabilities, because we're getting to a point where that's the limiting factor.'

Maxim is clearly proud of the facility, and the team working in it, to produce such a high volume of powerful, reliable NASCAR engines. It speaks volumes that both customer outfits and the in-house Hendrick race team have won with these power units, the former taking over 200 wins and the latter just over 300. It's now only a matter of time before they hit the current goal of 600 victories for Hendrick Motorsports engines.

Time is money

Before even entering a wind tunnel, teams and manufacturers can spend months in preparation. Racecar investigates

By Bozi Tatarevic

Nestled in the green landscape around Concord-Padgett Regional Airport in North Carolina is one of the most advanced, commercially available, rolling road wind tunnel facilities in the world

The tunnel's 6.7m carbon fibre fan is powered by a 5100bhp motor that can generate wind speed in excess of 180mph

The facility's FlatTrac rolling road is a delicate, precision instrument that floats on a cushion of compressed air and can be angled up to eight degrees to simulate a car running on banking

A power station situated just outside the facility ensures the wind tunnel never runs out of puff

Left: Windshear, the airstrip and, just out of shot on the other side of the airstrip, the NASCAR R&D facility

Loading bay with huge area of hard standing makes it easy for multiple rigs to offload vehicles for testing into the sectioned-off preparation areas

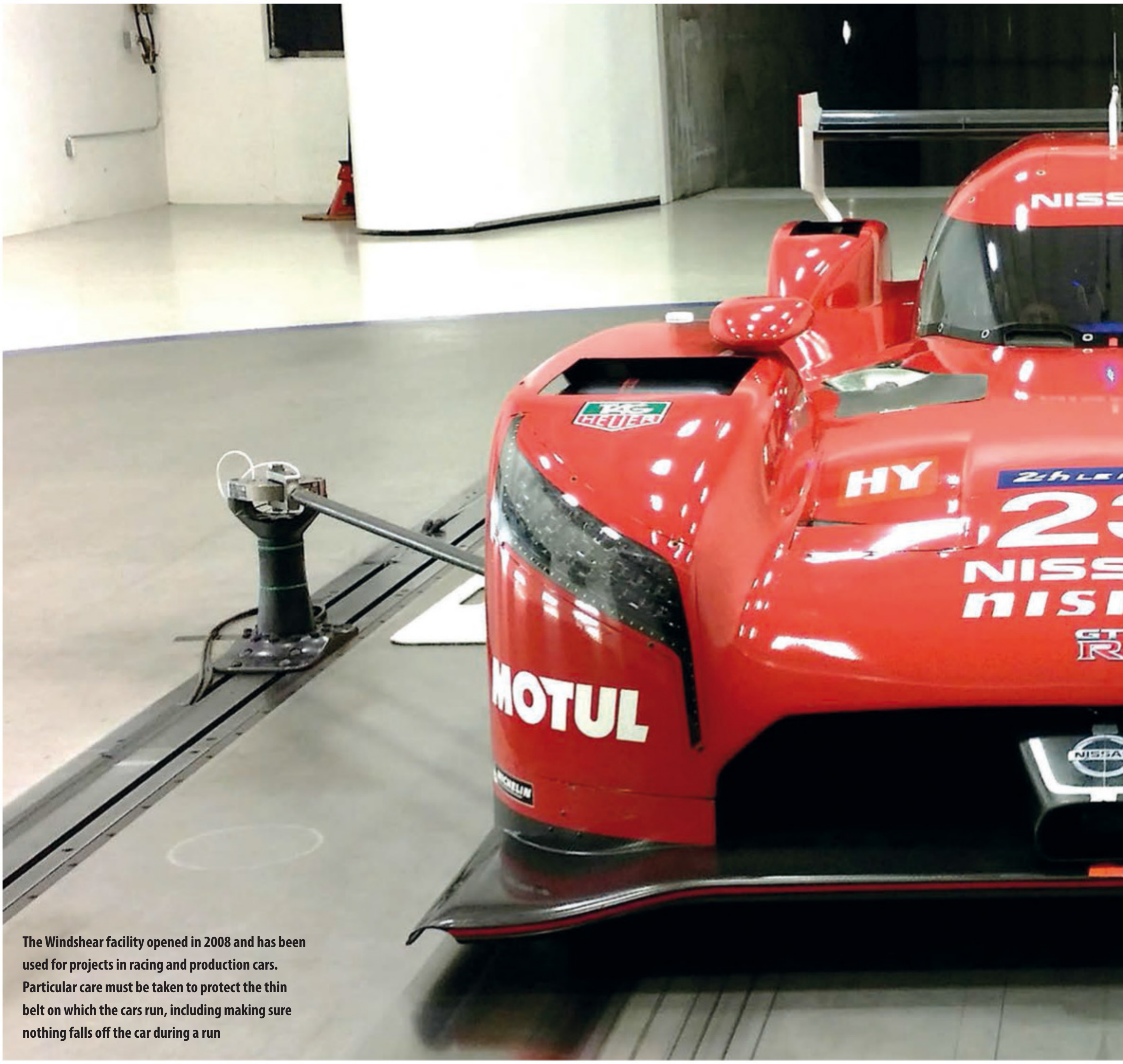
The Windshear Rolling Road Wind Tunnel sits in the shadows of Concord-Padgett Regional Airport in North Carolina, just down the road from trucking repair and rental firms. While their neighbours might deal with the dust and debris that comes from the freight industry, Windshear operates in what borders on a clean room environment as the staff that work there protect the thin stainless steel belt that is the centrepiece of their rolling road wind tunnel.

Windshear is one of the most advanced wind tunnel facilities in the world, and one of only a few that is commercially available for customer use. Since its launch in 2008, it has hosted teams from series such as NASCAR, Formula 1, IndyCar, IMSA and many more, along with visits from a number of production car manufacturers.

The single belt, FlatTrac rolling road from MTS Systems employed at Windshear measures 9m in length and just over 3m in width, yet it is only 1mm thick. That delicate track surface floats on a cushion of compressed air and moves on that air cushion using air bearings, which keep it rotating and also offer the opportunity to create up to eight degrees of banking using built-in air nozzles. This operation is supported by two Atlas Copco ZT250 air-cooled compressors, with a further ZT315 VSD compressor filling in when there are fluctuations in load.

Drag and drop

The tunnel's 6.7m carbon fibre fan is powered by a 5100bhp motor that can generate wind speed in excess of 180mph inside the tunnel. The amount of downforce created by blowing that much air onto a car is measured by multiple pressure sensors installed below the belt that are accurate to within a quarter of a pound (0.002psi). The same sensors can also calculate drag in certain types of tests.



The Windshear facility opened in 2008 and has been used for projects in racing and production cars. Particular care must be taken to protect the thin belt on which the cars run, including making sure nothing falls off the car during a run

We spoke with Kyle McClenathen, director of aerodynamics for Joe Gibbs Racing, to find out how his team prepares for a visit to a facility like Windshear. McClenathen explained how preparation often starts months in advance because teams (and OEMs) want to maximise their time spent in the tunnel. Generally, though, it takes a couple of weeks to prepare a new build car for a wind tunnel test, or a couple of days for one that has run there before.

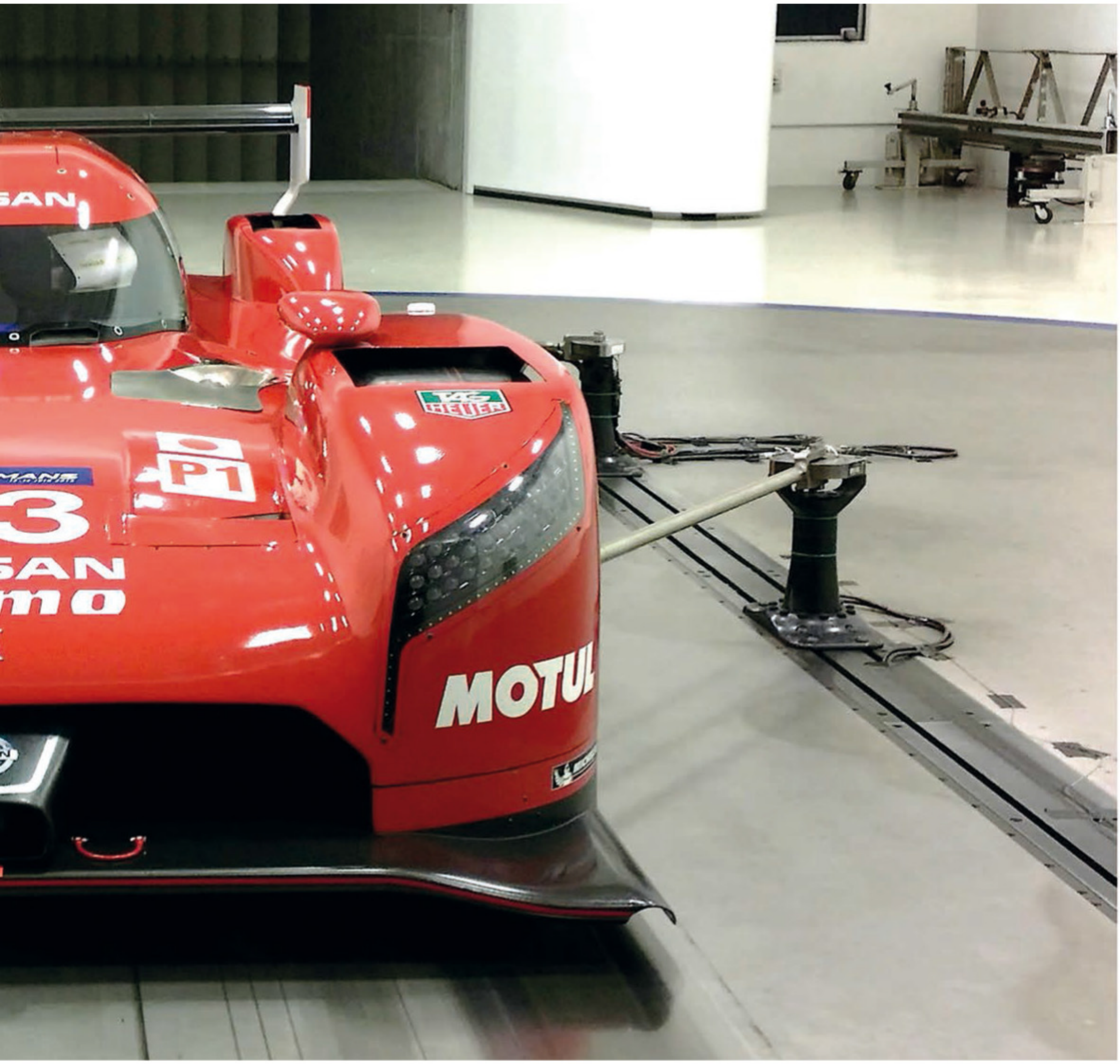
In NASCAR, each manufacturer is allotted 125 hours of wind tunnel testing per year, so staff at Windshear have to work together with them and their teams to map out that time effectively. The key is for all involved to be as prepared as possible before arriving at Windshear because having to make changes, or fixes, while the clock is running burns up expensive tunnel time and cuts into the NASCAR-regulated allocation.

We also checked in with Tommy Joseph, a motorsport aerodynamics supervisor at Ford Motor Company, who has a great deal of experience of testing in a variety of wind tunnels due to his time spent at the Red Bull, Sauber and Williams Formula 1 teams. Joseph concurred that the preparation process will often start a month or more before a visit, with the teams undertaking CFD analysis of designs to validate the shapes they want to test before producing the components and trial fitting them on the car to be as prepared as possible on the day.

Both McClenathen and Joseph agreed that a significant amount of the programme time is spent preparing and testing parts prior to a visit, so they can quickly be swapped or installed when a car is on the belt. Ideally, it is a process of addition only, in order to make best use of their time.

Pre-test checks

Once a test car arrives at Windshear, an entire day is spent just preparing and measuring the vehicle before any air is blown over it. According to Joseph, the most significant part of the set-up day is checking clearances using the Windshear motion system. This involves looking at wheel-to-body clearances, ground clearance and various other parameters.



Typically, engineers will run through the motions in a slow-stepped manner to ensure there is no interference around the parameters they will be testing. These preliminary tests serve two purposes. The first is obvious, to make sure the data being collected is accurate, but the second is to make sure the tests will not impact the stainless steel belt, and that no debris from the car can fall onto it.

This extreme care extends to the technicians, and any tools they might use for making changes to the vehicle.

'Dropping a tool from even a moderate height can require replacing the belt,' warns McClenathen. 'Additionally, the car must be thoroughly inspected before each test to ensure there are no loose fixings or parts. Running over even a small part, such as a bolt or fixing, can also necessitate a belt replacement. Very minor damage to the belt can be repaired, but specialists need to be hired to fix any dents.'

> "Dropping a tool from even a moderate height can require replacing the belt"
>
> *Kyle McClenathen, director of aerodynamics for Joe Gibbs Racing*

Cars that have been used in race conditions require even more thorough prep as they must be carefully cleaned as well. Joseph remembers the difficulties in taking raced rally cars to Windshear, and how careful they had to be to remove any debris, due to the potential for damage to the tunnel's infrastructure from errant gravel or rubber.

It's not just the cars that need to be meticulously cleaned. Walking into the facility, guests must tread on a sticky surface, intended to remove any debris from their shoes, again to minimise the potential for damage to the belt.

The stainless steel belt itself has a special coating to minimise friction, but customers also prepare the tyres on their vehicles using materials like Teflon, to further reduce friction.

Ford was so convinced by the Windshear technology that it developed its own rolling road wind tunnel, which is helpful in the development of electric vehicles, as well as combustion cars

In addition to the coating, tyres are often inflated to higher than normal pressures to minimise friction and lateral grip, so the car and belt do not move sideways.

According to Joseph, one of the dangers of working around the steel belt is that it moves very quietly, and with minimal deflection. As the belt features no visual indicators, it can be hard to tell when it is moving, so technicians working around a vehicle must be very careful to verify it is static before stepping onto it.

Temperature window

The job of keeping the belt clean, and in a safe operating zone, falls to the Windshear technicians, who monitor a variety of environmental variables including the temperature of the air bearings and the ambient temperature in the tunnel. If any of these measurements move outside what is a very small optimal window, a cool-down period may be required. Similarly, a warm-up period might be needed to prepare the tunnel for a day of testing.

Both McClenathen and Joseph agreed that running a programme at the Windshear tunnel requires extreme care and discipline if a team is to make best use of its allocated hours, and not cause any damage to the facility in the process of a test.

> ‘ As the performance of racecars becomes ever closer in many series… chasing incremental aero gains becomes ever more significant ’

Outside of racecars, Windshear sees a variety of other vehicles pass through its tunnel, including regular production cars, sports cars and, increasingly, electric vehicles. A rolling road wind tunnel is particularly useful for the latter as manufacturers seek to improve efficiency, and therefore range, by reducing drag as much as possible. The ability to recreate realistic ride heights and scenarios makes time spent in a rolling road wind tunnel extremely valuable.

So much so, some manufacturers have taken the technology in house. Ford, for example, recently launched its own rolling road wind tunnel facility in Michigan, and used it to develop the most recent generation of Mustang road car, as well as testing, validating and correlating its motorsport activities against results from Windshear. Ford involved a lot of the same vendors that were used at Windshear to create a flexible system that can interchange between a single belt and five belt moving ground plane.

Joseph shared that Ford will continue to use a variety of wind tunnel facilities in the future because the manufacturer competes in over 15 different racing series that often have different aerodynamic requirements and testing restrictions. He recalled his time in F1 and how quickly things changed in the mid-2000s when Williams and Sauber went to aerospace companies for advice on upgrading their wind tunnels.

Windshear used this same strategy as it employed Jacobs Technology and MTS in the construction of its tunnel, which attracts race teams from all over the world. F1 eventually put restrictions on testing, but Windshear still regularly hosts overseas customers. Australian Supercars, for example, shipped a Chevrolet Camaro and Ford Mustang over last winter to obtain an accurate aerodynamic comparison of the two Gen3 machines.

As the performance of racecars becomes ever closer in many series due to spec parts and performance balancing, chasing incremental aero gains becomes increasingly significant. It's no surprise then that Windshear has a full schedule, and looks likely to stay that way because of its commercial availability to a wide variety of customers. ●

ACE Climatic Aerodynamic Wind Tunnel

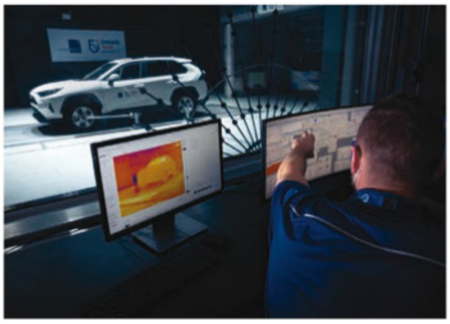
To find out more, scan the QR code or visit:
www.ace.ontariotechu.ca

ACE's "Plug and Play" Climatic Aerodynamic Wind Tunnel

ACE offers a unique 'Plug-and-Play' swap between the dynamometer and the Moving Ground Plane, making this testing chamber truly a climatic and aerodynamic wind tunnel

ACE (Automotive Centre of Excellence) is a core research facility at Ontario Tech University in Oshawa, Ontario, dedicated to advancing automotive technology. Specializing in automotive research and development, ACE utilizes state-of-the-art motorsport advancement technology to promote vehicle performance and environmental sustainability. Its five unique testing chambers provide capabilities for testing vehicle performance under various conditions, such as extreme temperatures, weather, and road simulations. This enables advanced aerodynamics, thermodynamics, carbon emissions, and electric vehicle technology research. Four of the five chambers are climatic and can create temperatures of -40°C to +60°C (-40°F to +140°F) with five to 95% relative humidity control. The Climatic Aerodynamic Wind Tunnel (CAWT) is the facility's most advanced chamber. It can generate various types of precipitation, such as rain, freezing rain, and snow while achieving wind speeds of up to 280 km/h. Additionally, the CAWT features a dynamic solar simulation system and an in-chamber 350 kW DC fast charger, making it an ideal hub for aerodynamic and thermodynamic testing.

The CAWT features a seven-meter Moving Ground Plane (MGP). This cutting-edge equipment replicates real-world driving conditions as it simulates the motion of the road on the belt under the vehicle. The MGP creates a realistic airflow surrounding the vehicle, allowing for accurate lift and drag measurements. With the tires and belt moving in unison, engineers can obtain crucial data to improve the design of vehicles for enhanced performance, efficiency, and stability. The MGP provides motorsports and original equipment manufacturers the tools they require to conduct research in a high-tech environment, create new energy-efficient products, maximize energy efficiency, and reduce carbon emissions.



ACE features a distinctive 'Plug-and-Play' system that allows for swapping between the dynamometer and the MGP, setting it apart from other wind tunnels worldwide. By utilizing the same airflow for both full powertrain and thermal development on the dynamometer, as well as world-class aerodynamic measurements with the MGP, the CAWT stands out as a truly integrated climatic and aerodynamic wind tunnel. The MGP uses a single belt wheel hub vehicle force measurement and restraint system to collect extensive data on the vehicle's wheels while driving in various conditions. Prior to testing at ACE, wheel hub adapters are fabricated and ready in advance of the testing. There are two options to prepare for testing: static ride height or dynamic ride height. The MGP can reach wind speeds of 210 km/h (130mph) with a yaw capability of +- 30° and a 13m² nozzle, making the facility exceptionally versatile for comprehensive aerodynamic testing.

The CAWT was engineered to optimize under-body flow for drag, aero-acoustic noise generation and heat rejection. Recent upgrades at ACE have improved the flow quality, reduced reverberation, and supports the measurements of aerodynamic forces. Enhancements in the CAWT include a honeycomb, secondary boundary layer removal system, primary collector, and acoustic panels. The honeycomb improves airflow by correcting angularity and uniformity while eliminating lateral and vertical flow velocities. Additionally, it dampens crossflow turbulence, enhancing the overall flow quality. The secondary boundary layer removal system and collector coordinate to reduce axial static pressure gradient and pulsation at high wind speeds. The acoustic panels cover the test section to significantly reduce background noise levels, as an acoustic array can identify precise noise locations on the test vehicle.

ACE's team of skilled engineers and technicians has successfully completed over 3,000 tests, emphasizing precision, innovation, and collaboration to provide effective testing results tailored to each client's unique requirements. Utilizing advanced technologies, ACE aims to partner with industry leaders and academics to enhance vehicle performance and development while promoting environmentally responsible practices.

How NASCAR approached the ongoing development of its Next Gen car for short track and road course races

By Dr Eric Jacuzzi

Short change

With the birth of the Next Gen car for the start of the 2022 season, NASCAR embarked on one of its most ambitious resets of the sport, and industry, in decades. With teams no longer constructing their own chassis and components, the aim was to help them financially, while ensuring on-track competition would reach heights never seen before. The goal is that on any given weekend, every team has a chance to win.

With its dramatic design departure from the Gen 6 vehicle, the hope was that the Next Gen would increase competition across the schedule. That largely held true, with the 2023 season, for example, featuring 15 different winners, and over 150,000 passes within the top 15 positions.

NASCAR diligently reviews every race, both from a technical perspective and from quantitative and qualitative feedback. In general, at large and fast tracks, the new car performed admirably in the eyes of series followers, with races trending above average in terms of fan scoring. Short ovals and road courses, however, have been more challenging, albeit with notable exceptions.

That, therefore, is where development was focused for year two of Next Gen. But improving the racing at these more demanding courses is not a one-dimensional concept, and solving it took effort in all areas of the car, beyond just the aerodynamics.

Short tracks under one mile have always been an integral part of NASCAR, going back to the inaugural 1949 season. While lacking a strict definition, oval tracks under one mile are typically considered short. However, there is a great diversity in their characteristics, even with the limitation on length.

Getty Images

Getty Images

Short tracks are not necessarily flat ones. Bristol's highly banked half-mile oval is well known for putting the greatest suspension loading on the cars of all the tracks on the Cup Series calendar

For example, the season-opening Clash at the Los Angeles Memorial Coliseum is a flat, 0.25-mile affair. Contrast this with Bristol's highly banked half mile, which sees the greatest loading on suspension of any track on the calendar, and one can see how diverse a challenge short tracks present.

Apex speeds vary greatly as well, from 40 to 130mph. As such, aerodynamics plays a varying role in its contribution to the racing product – at some places it accounts for very little in terms of car performance, but its importance increases as the speeds rise.

Short tracks are also known for close, door-to-door racing, and the drama and excitement that come with that are critical to what makes NASCAR.

The short challenge

The initial short track and road course races in early 2022 were generally below average in terms of fan ratings and the quantifiable metrics that NASCAR monitors week to week. This was also apparent to the sanctioning body from a qualitative standpoint. At the end of the day, we are all race fans and want to be entertained by what we see.

It quickly became clear that enhancing tyre size, therefore increasing mechanical grip, created a much more stable platform, so much so that drivers could no longer succeed at the 'bump and run'. This technique is integral to short track racing, wherein the only way to pass a car in front is to upset the lead car on corner entry or apex to move them off the preferred racing line. This, of course, leads to high emotions in the cockpit, but happy fans in the grandstand.

Continuing with the mechanical topics, adding larger brakes (arguably appropriately sized, compared to the previous car) greatly improved stopping performance, shortening the braking zones at road courses.

> ‘Short tracks are known for close, door-to-door racing, and the drama and excitement that come with that are critical to what makes NASCAR’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Phoenix Raceway in Arizona was the location chosen to test the new, reduced downforce ST / RC package that was run in 2023

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Road courses use a similar aerodynamic set-up to the Intermediate package, but with a shorter spoiler and three strakes removed from the diffuser, reducing overall downforce by 40 per cent

Compared to the current Next Gen car, the previous Gen 6 design had many features that made it less than optimal for road courses and short tracks, starting with the solid axle, trailing arm-type rear suspension. While great on an oval, the solid axle presented a challenging platform to manage under braking, leading to many mistakes by drivers asking too much of their cars.

The smaller, 15in diameter wheels and tyres also had two effects. The first was to limit the brake size dramatically, which reduced overall braking capability. The other was that the larger, more compliant sidewall and narrower tread reduced mechanical grip.

On the powertrain side, the move to a sequential, five-speed transaxle with multiple close ratios in the operating range for the engine offers much better acceleration than the previous four-speed unit. As with the previous generation of gearboxes, NASCAR mandated the final drive ratio in fourth gear and was able to limit shifting down to third gear at most tracks. Why does this matter? That bump and run technique again.

> The Short Track / Road Course configuration… is run at 10 of the 29 different tracks NASCAR visits in its 38-race schedule

With the ability to downshift to a useable gear in the meat of the engine's power band, a 'bumped' driver can recover quickly from any disruptions they receive from the following car attempting to pass. With the previous gearbox, the unsettled lead car would pay the price with a slower run down the straight heading for the next corner, typically leading to an overtake.

Durable body

Finally, the Next Gen car is the first Cup Series vehicle to use all-composite bodywork. Manufactured by Fibreworks Composites, Five Star Bodies and Roush Composites, the Next Gen platform features the most durable bodywork the series has ever had.

In the Gen 6 era, noses, tails and bonnets [hoods] were composite, with the remainder being hand-formed sheet metal. The metal parts, particularly on the wheel band areas, often sustained damage and could even lead to tyre failure if they came into contact. At minimum, the aerodynamic properties of the car were severely jeopardised.

NASCAR specifies the car configurations each team must use, depending on the track type. These are currently split into three separate packages: Intermediate, Superspeedway, and Short Track / Road Course (ST / RC). The Intermediate race package is run at the majority of tracks, consisting of a specified set of splitter stuffers, engine panel strakes, a four-inch spoiler and a full set of strakes in the diffuser. The power level for the Intermediate package is approximately 700bhp.

The Superspeedway package, run at Daytona, Talladega and Atlanta, features higher downforce and drag via shortened splitter stuffers, a seven-inch spoiler and horsepower reduced to around 520bhp.

Finally, the Short Track / Road Course configuration uses the same splitter stuffers as the Intermediate package, but a 2¼in spoiler and the three central strakes removed from the diffuser. Power is the same as the Intermediate package, but downforce is down by approximately 40 per cent. This set up is run at 10 of the 29 different tracks that NASCAR visits in its 38-race schedule.

Test programme

NASCAR engaged in an extensive testing programme, starting in early 2023, to work on all the elements of the ST / RC package. Phoenix Raceway in Avondale, Arizona was the site of the first test, and the sport's sanctioning body evaluated a reduced downforce package, with some positive feedback leading to the creation of the updated ST / RC package which was raced throughout the 2023 season.

The solution to improving fan engagement with the racing on NASCAR's short tracks and road courses is the so-called up / down splitter, seen here installed on the aero test car at Windshear

In the meantime, rubber manufacturer, Goodyear, continued to develop its Next Gen tyres to be softer with increased degradation (known as falloff in NASCAR parlance).

Round two of the test programme occurred in late July 2023, with a two-day test following the Richmond race. Originally scheduled for the much faster New Hampshire Motor Speedway, that date was scrubbed due to adverse weather conditions. In the period between the Phoenix and Richmond tests, the aero group at NASCAR R&D worked diligently on developing an aerodynamic package that lost less downforce when in traffic, with the dreaded aero push considered a contributing factor.

Ultimate solution

Computational Fluid Dynamics (CFD) was used to study both single car and drafting scenarios. The ultimate solution, dubbed the up / down splitter, featured a lift-generating centre section and downforce-generating outer sections. The idea being that the central wake behind a lead car near the ground would diminish the lifting section and generate downforce.

Goodyear also brought a multitude of tyre options to the second test with the goal of enhancing tyre degradation. Ultimately, thicker tread gauge tyres were found to be a dramatic gain for the test drivers to move around each other and make passes.

In CFD, the results were dramatic, and showed a 90 per cent improvement in aerodynamic loss, but the results on track were less convincing. Drivers commented that they couldn't really tell a difference, which was baffling initially, but a comprehensive post-test review revealed several reasons why this may have been the case.

The first is that Richmond has some of the slowest apex speeds of any NASCAR track, with mid-corner speeds in the 80mph range (this would not have been an issue at the original target location of the much faster New Hampshire Motor Speedway).

The next factor believed to have influenced the result is that Richmond is a very abrasive track, making tyre condition a critical factor, even after a single lap, which is not an ideal test bed for evaluating changes, but lesson learned.

Finally, driver behaviour at tests was identified through video as a contributing factor. Drivers naturally tend to be more courteous at tests than in a race environment, where points and money are on the line. This leads to drivers leaving room for their peers and not blocking the trailing car as they normally would. This better explains why the benefits touted by CFD for a trailing car were rarely, if ever, seen during the test since, as you would expect, the majority of the benefit occurs when the trailing car is directly in line with the lead car.

> The current iteration [of the up / down splitter] offers a massive 96 per cent improvement in total downforce loss, resulting in single digit losses in the worst positions for the trailing car

After Richmond, NASCAR went back to the drawing board and studied the aerodynamics of the up / down splitter even further, finding enhanced single car and traffic gains. The current iteration offers a massive 96 per cent improvement in total downforce loss, resulting in single digit losses in the worst positions for the trailing car.

The aero team also focused on the diffuser, and whether its performance could be similarly improved. A greatly simplified

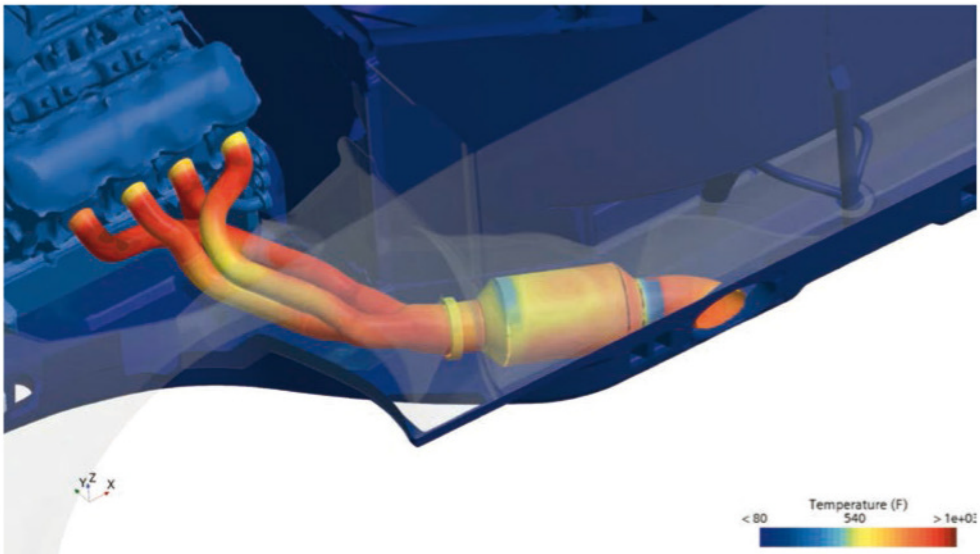
Next Gen development car undergoing testing at Windshear. Observant readers will note this is also the Le Mans Garage 56 test vehicle

NASCAR runs in the wet with a package that includes wipers, rain lights and flaps, along with appropriate Goodyear tyres. This became available for 2023, on some ovals as well as road courses

version with improved traffic performance was tested and shown to eliminate the benefit of running the car with a high nose and low diffuser height. That, in turn, led to teams chasing to run the rear of their cars as low as possible, and to the rather expensive diffusers being sacrificed in nearly every race.

The revised aero package was evaluated at Windshear's wind tunnel in late October 2023, with the results correlating well to CFD.

With a packed test schedule, continuing with a two-day track test of six cars at Phoenix during the first week of December, teams had the opportunity to evaluate aerodynamic, tyre, gear ratio, brake and suspension changes in an effort to further improve the short track package.



Thermal CFD simulation of the revised LA / Chicago silencer that will improve cockpit conditions for drivers at those tracks

Sounds of silence

One additional item that was tested at Phoenix was a revised, quieter silencer [muffler] that was slated to be used at the Clash at the LA Memorial Coliseum and the Chicago Street Race. The new unit, built by Next Gen supplier, ProFab, features a shorter design that utilises the normal forward exhaust exit position. During the 2023 season, though, this silencer proved too long to use on the front exhaust exit, which forced a return to the rear exit that was initially used in early Next Gen development.

However, this created adverse conditions in the cockpit due to conduction through the steel tube frame chassis. To its credit, ProFab was able to match the decibel reduction of the much longer unit with its revised design, with a minimal impact on power output.

On the aero side, the revised silencer presented an opportunity to revisit our thermal CFD modelling and upgrade it to include conduction and radiation, as these were believed to be much greater contributors to the resulting cockpit conditions (previously, only convection had been modelled).

Improvements to the cooling of the header and silencer area, along with revised close-out panels to accommodate the larger diameter unit, were tried in an effort to eliminate the temperature increase observed.

In closing, it was a busy off season between 2023 and 2024 for NASCAR R&D and the teams. The results of the Phoenix test informed the direction NASCAR is heading with the Short Track / Road Course package, which yielded positive directions to follow in all the areas being investigated.

Though much of this intensive, and ongoing, development work goes unnoticed, one thing is certain: NASCAR will continue to work hard to make *every* race event at *all* the tracks on the calendar as good as it can be for the drivers, teams and the fans in the grandstands and across the world watching the series on television. ●

Euro fighters

Japo Santos

The NASCAR Euro Series was founded in 2008 by Jérôme and Anne Galpin of Team FJ, and has become a staple of European racing

Flying the flag for NASCAR across the pond, the well-established Euro Series aims to prepare drivers for the big leagues

By Daniel Lloyd

There's a popular internet meme where a child asks his mother if they can have a certain fast food for dinner and she replies, 'we have that at home', accompanied by a photo of a sorry-looking microwaved burger. A motorsport version might go something like, 'Mum, can we have NASCAR?', to which she replies: 'We have NASCAR at home', accompanied by a shot of a Euro Series first-corner pile up.

Admittedly, that was the uninformed, and perhaps rather unfair, impression this author had of Europe's FIA-sanctioned stock car series before attending a round in the UK, held at the Brands Hatch Indy circuit as part of the popular American SpeedFest event.

The NASCAR Euro Series is a highly competitive championship and 2024 marked its 16th season. Far from being a poor relation to its American cousin, it has its own identity and sees well-drilled teams vying for the title.

The V8-powered cars are loud, brash and require skill behind the wheel because they can be a handful through the corners. At Brands Hatch, drivers take different angles through Clark Curve and feather their way onto the Brabham Straight without the luxury of traction control to aid them.

Circuit challenge

The European grid is a burst of colour and sound. Close to 30 brightly liveried cars, powered by a thunderous spec engine, pound around at different cornering angles in spectacular fashion. Whilst many of the parts are tightly controlled by the series to prevent cost escalation, there are still opportunities for teams to engineer their way to success. The variety of circuits on the schedule, owing to Europe's paucity of ovals large enough for this kind of car, adds to the set-up challenge.

There has long been an appetite for American-style stock car racing in Europe. ASCAR operated in the 2000s, mainly using the defunct Rockingham Motor Speedway in the UK, but for well over a decade the pinnacle has been the Euro Series.

Founded by Jérôme and Anne Galpin in 2008 as the Racecar Series, it was brought under the NASCAR umbrella in 2012, making it one of four licensed NASCAR international series, the others being in Canada, Mexico and Brazil. Each has slightly different technical specifications and suppliers.

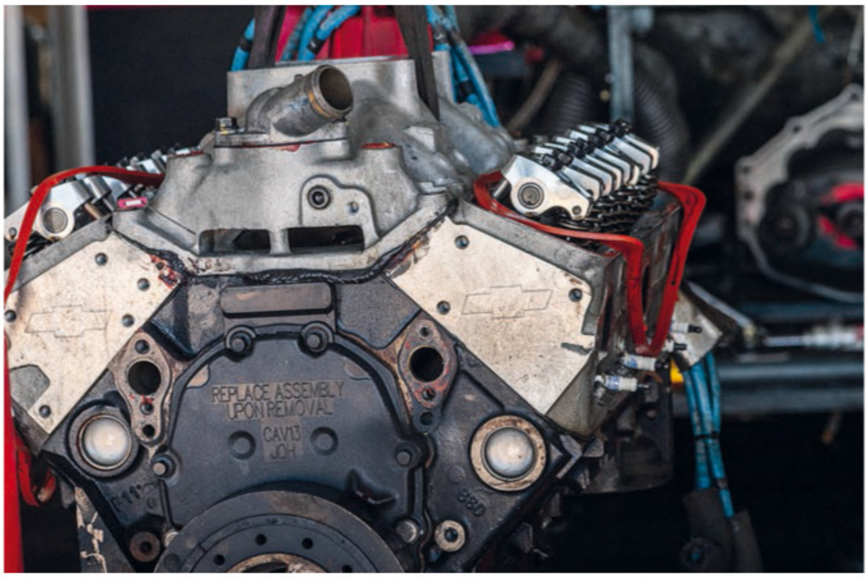
In Europe, the beating heart is a 5.7-litre, 604 crate V8 from GM Performance, a unit which is used widely in US late model racing. The rear-wheel-drive cars produce around 400bhp and weigh 1225kg without driver, with a roughly 60 / 40 weight distribution in favour of the front, where the engine is sited.

Power reaches the wheels through a four-speed, dog-leg manual gearbox from G-Force, although a new sequential unit is being introduced for the 2025 season.

The chassis is a steel tube frame design that can trace its lineage to a chassis developed by McColl Racing for the Canadian NASCAR series. The blueprint of that chassis was then picked up by the Galpins' company, Team FJ. The Blois-based firm established the Euro Series and co-runs it with NASCAR, whilst also being responsible for assembling the cars that are purchased by the teams.

> ‘Whilst many of the parts are tightly controlled by the series to prevent cost escalation, there are still opportunities for teams to engineer their way to success’

Japo Santos



All cars use a GM Performance 604 crate engine, an off-the-shelf V8 package that makes 550Nm of torque at 4600rpm

> Our philosophy is to maintain control of the teams and let teams have equal purchasing power of those parts. They don't have to pay for extra manpower, software or simulators to compete at a higher level in this championship
>
> *Joe Balash, NASCAR Euro Series sporting and technical director*

'It had to go through a whole approval process here in Europe, to make sure the FIA standards were applied to it,' says NASCAR Euro Series sporting and technical director, Joe Balash. 'It's a fully homologated car to FIA standard. A number of updates were brought in because of that. For example, we use a crash box in the front of the car, and we've got some extra reinforcement in the rollcage.'

Budget conscious

Cost control is key here. The standard brake package from Brembo consists of four-piston, monobloc calipers and 330mm vented discs. Suspension parts are also standardised and come from the French supplier, ALP Racing.

The chassis is shrouded in glass fibre bodywork, which differs depending on the car brand teams wish to represent. Ford Mustangs, Chevrolet Camaros and Toyota Camrys make up the current grid, in keeping with popular model lines in the US.

'We want teams to be able to come to this series with a reasonable budget and not have to outspend somebody to win races,' explains Balash. 'At the upper levels on the American side, before they went to the new [Next Gen] car, anybody could go to Mooresville and buy every part to build a car. But if you wanted to win races, you had to *build* every part. That makes a considerable difference to budget.

'Our philosophy is to maintain control of the teams and let teams have equal purchasing power of those parts. They don't have to pay for extra manpower, software or simulators to compete at a higher level in this championship.'

Walking the paddock at Brands Hatch, some teams clearly have bigger budgets than others. Some are running multiple cars, and the largest trailers are up there with the leading outfits in any other continental race series. But there are also smaller operations with fewer resources, so it's important for the organisers to keep a close eye on things to ensure healthy competition and strong grids.

'Teams will always find ways to spend budget, but we try to control the things that affect performance,' says Balash. 'We're running a sealed engine, so teams aren't allowed to go in and tinker with the engine internals to gain performance advantages. We seal the carburettor, ignition system and shock absorbers for the same reason. We also run spec gear sets in the transmission.'

Engineering gains

Despite the large number of spec components, there are some opportunities to make gains through clever set-up. Several aspects of the rear are fixed; the spoiler angle is determined by the series at 70 degrees + / – two percent, while the camber and toe are also set in stone. The Watt's linkage on the rear axle, however, is adjustable, as well as the trailing and upper links.

'We control the angle on the back of the car, and the nose height,' continues Balash. 'We also control the frame heights. If we didn't do that, the team would have the cars slammed on the ground to lower the centre of gravity. We control the basics.'

There is greater tolerance on tweaks to the front end, which can be used to refine the car's handling characteristics. Teams may alter the stiffness of springs and dampers, or adjust suspension settings such as camber, toe and caster on the front.

'Obviously, if you compare the adjustment with a single-seater Formula 3, or something like that, you don't have so many parameters to work from,' says Carmelo Scoglio, engineer for CAAL Racing, an Italian team that is one of the most experienced in the paddock. 'But, in this case, the parameters in which you can work are enough to modify the car's behaviour completely from one track to another.'

Nina Weinbrenner

Limited downforce, no traction control and rowdy V8 power make the Euro Series car entertaining to watch and tricky to drive

The level of adjustability increased even further in 2024, with the introduction of the 'Evo' upgrade kit. It consists of a new spring package and mandatory front spindles (stub axles) to make the car more agile in corners, and to give teams some more tuning options. Gradually, the organisers have eked out more ways in which the teams can play with the handling, without letting them run wild.

Evo upgrades

'Some years ago, we had dampers with only two parameters of movement – bump and rebound,' recalls Scoglio. 'Now, for about three years, we have bump in high and low frequency, and the same for rebound. In previous years, we had less parameters on which we could work.'

To this Balash adds, 'We have a fairly decent array of spring range for the car. We opened it up more this year, so they can choose different spring rates in the front and rear. Years ago, when the series first started, you had a single set of front springs and back springs. Now, you have choice.

'We also have a tender on the top that changes the combination, so there are a lot more adjustments [available] now.

'The shock package evolved over time, too. We now have adjustable shocks on the car [and] compression rebound adjustment so they can be tuned to a driver's liking, or needs.'

All this adds to the Euro Series' exciting on-track spectacle of drivers taking different lines through the same corner.

'The line you run, the angle you're going to take in that corner, how deep you're going to drive it or how soon you're going to let off, is all going to make the suspension work differently,' notes Balash. 'This is where the driver and the engineer really have to communicate on how to set the car up.'

Driver comfort

The Evo kit also includes a speed limiter for pit lane driving and Full Course Yellow periods. Additionally, driver comfort has been taken into consideration with a additional features.

'We added an air vent in the top of the roof to help the drivers,' says Balash. 'We were seeing some heat transfer from the headers into the chassis, which makes the interior of the car a little warmer, so we added the vent to improve airflow inside the car.

'When we configure the louvre supply, that will vent heat from under the car early, rather than radiating it back underneath.

'Because we have rules on noise levels at the tracks we run at, we have to use mufflers and that generates a little extra heat that transfers into the chassis. Moving that air gives the driver a fresher feel.'

This year, the Euro Series visited the road courses at Valencia, Vallelunga, Brands Hatch Indy, Most, Oschersleben and Zolder.

Stephane Azemard

The only American-style oval track on the calendar is Venray, where teams face a unique set-up challenge for the 25-degree banking

Japo Santos

Ride height is adjustable at the front, but must be in accordance with parameters provided by the series

However, the jewel in the crown was Venray, the only oval circuit on the calendar. The 0.88km Dutch track hosted the series from 2015-'17, and again in 2019, but dropped away during the Covid pandemic before making a welcome return in '24.

Previously, the Euro Series held an oval race at Tours in France. More accurately, it raced in the car park of an exhibition centre in Tours, with banked turns at each end, creating one of the most unique racetracks in Europe.

Tours last held a Euro Series round in 2018, so Venray is now carrying the torch for 'proper' NASCAR racing on this side of the Atlantic.

> "Years ago, when the series first started, you had a single set of front springs and back springs. Now you have choice"
>
> *Joe Balash*

Car set-up for the 100-lap race (or 70 laps for the second-tier Euro 2 series) at Venray is, naturally, very different to the other tracks, which played into the hands of the teams and drivers that had raced there before. There is no special car package deployed for this track; the Euro Series vehicle must be able to cope with the oval as well as the road courses.

'Normally, you have more or less the same ride height per axle,' says Scoglio. 'On the front and the rear, it's the same right and left. In the case [of Venray], you have different values on the front and rear, right and left. On the external wheel, you have a negative camber, but a positive one on the internal wheel because the car is on the bank. The external one needs a little bit more camber to have a complete tyre on the ground. On the other side, you have to think in the opposite way.'

Scoglio suggests a baseline front camber angle for Venray is around eight degrees. The wheels are still noticeably cambered for road courses, set at around five or six degrees, depending on how exactly the individual team wants to set their car up.

Japo Santos

Team FJ in France assembles the chassis, which is homologated as EuroNASCAR-RC01 and has been in use since 2009

Racing on an oval, albeit a small one, brings differences to the racing, too. Road courses tend to invite drivers into single file after a handful of corners, whereas at Venray they might be running for several laps adjacent to a competitor. Having that variety is part of the allure of a series where the technical regulations are tight.

American connection

Being part of the NASCAR structure means the Euro Series is an ambassador for this style of racing 'across the pond'. This year, it adopted NASCAR's updated branding, further strengthening the affiliation.

'There is a tremendous level of support and conversation between our business in Europe and the NASCAR management on the other side,' says Balash. 'They are super supportive of everything that's going on in the Euro Series. We all want to promote that brand of NASCAR racing as it's what makes us different. We don't want to just offer the same style of racing you get in the US. It is valuable having that ability to share things, to grow the sport both ways.'

The Euro Series has succeeded in being an established, healthy competition on its own turf, but it has found the aim of being a pathway to the US rather challenging. The 2021 European champion, Loris Hezemans, made five Cup Series starts the following year, but failed to make a lasting impression. Alon Day, the most successful driver in Euro Series history with four titles to his name, has also made infrequent Stateside appearances.

While there hasn't been as much east-west movement as the Euro Series might perhaps like, it is not backing down. This year, it launched a new programme aimed at training up drivers with a Europe-based NASCAR test team, potentially using an imported Xfinity car. Tests will also be held for young guns from other disciplines, such as karting and esports, to generate grassroots participation.

The Euro Series also wants more US drivers to come over and learn some road course tricks they can take home. This year, 24-year-old Californian, Ryan Vargas, raced in the Euro Series' top Pro division, alongside occasional outings in the NASCAR Xfinity Series.

'We would also like to be a development series for young drivers in the US who need training in road racing,' confirms Balash. 'There is a lot [of American road racing] but we offer the chance to learn it at a very high level.'

Sequential shift

The Euro Series car concept has, for 15 years, reliably provided cost-effective racing and a decent approximation of the sights and sounds you would expect from a NASCAR event. But the organisers also have eyes on the future, and are working on a 'Gen 3' update, the first stage of which – a five-speed, manual sequential gearbox from Lithuanian manufacturer, Samsonas – is coming in 2025. The previous Gen 2 update came in 2016, and included new dampers, brakes and an aero package, including an eight-inch spoiler, but the Gen 3 changes will be more significant.

The RS90 is a multi-purpose sequential transmission popular in drifting. At 42kg, it weighs around 7kg more than the manual it replaces. Samsonas has adapted it with a plate for attachment to the Euro Series car's bellhousing and a clutch shaft to mount the shifter directly to the 'box.

> “We would also like to be a development series for young drivers in the US who need training in road racing”
>
> *Joe Balash*

Cars run on a set of 330 / 700 R15 slick tyres from Hoosier, which replaced General Tire as the NASCAR Euro Series supplier in 2021

Japo Santos

For 2025, the Euro Series will drop its traditional four-speed, H-pattern, manual 'box, replacing it with a five-speed sequential transmission, marking the first stage in its plans to update the car

Balash hopes the extra gear will give drivers more options through the corners, rather than detracting from the challenge of a manual, and reduce running costs by eliminating ruinous missed shifts. The move aligns the Euro Series with the US Cup Series, which introduced a five-speed manual sequential transaxle for Next Gen in 2022.

The Euro Series tested the new gearbox at the 2024 season finale, using the opportunity to set the final, fixed gear ratios. It also trialled some other potential Gen 3 parts, including a rear-facing camera. Next is to explore a switch from carburettors to fuel injection, in line with the planned adoption of renewable fuel as part of a new partnership with European Energy. That will help define whether the series sticks with its 5.7-litre V8.

While the organisers have their fingers on the pulse, they are sensitive to making drastic changes too quickly, seeking to keep the format affordable and straightforward, and the car count high. The Gen 3 package will therefore be rolled out in stages.

Pushrod special

The Garage 56 entry at the Le Mans centenary race in 2023 was a highly-developed version of NASCAR's Next Gen Cup car. Racecar *pops its hood*

By Lawrence Butcher

The centenary of the 24 Hours of Le Mans in 2023 had more than just an anniversary to celebrate. For the first time in 50 years, NASCAR sent one of its cars to compete in the great race.

It was no standard car, though. Weight had been taken out of it, with considerable support from chassis design partner, Dallara. The brakes were improved, tyre development was undertaken at an incredible rate and the aerodynamics were totally different. In fact, the only two parts of the car that remained in Cup Series spec were the rear spoiler and the driver-side window, which featured standard NASCAR-grade safety netting.

Under the skin of the Chevrolet Camaro ZL1, the engine, suspension and gearbox were all upgraded to meet the demands of the endurance race, while other incidentals such as lights and a windscreen wiper were also fitted to the car for the first time.

The vehicle was prepared by a team led by Hendrick Motorsports, under the direction of decorated crew chief, Chad Knaus, with input from General Motors. The engine powering the beast was developed by ECR Engines, a spin-off of Richard Childress Racing, which runs Chevrolets in the Cup Series.

Endangered species

NASCAR's Next Gen car uses a 358ci (5.9-litre) pushrod V8, with cast iron blocks and aluminium cylinder heads. Since 2012, these have been equipped with a fuel injection system managed by a spec ECU developed by McLaren Applied. Though theoretically representing 'road car' engines, the power units are anything but, with Ford, GM and Toyota all using bespoke blocks developed purely for racing.

In the case of Chevy, its Cup engine (as well as Xfinity and Truck motors) is based on the R07 architecture, introduced in 2007 as a replacement for the SB2 (Small Block 2).

Since then, the engine has undergone multiple iterations, and is now technically an R07.3, though as Scott Meesters, director of special projects at ECR who was responsible for the Garage 56 build, notes, 'the .3 only denotes the block version. The heads are actually .11 heads. The block has had some serious work done to it as far as light weighting, changing some of the sealing surfaces and making it a little more user friendly in some areas. That work has been done almost 100 per cent by General Motors.

'That, combined with the cylinder head development, has shaved some decent weight. It's a nice little package for a cast iron block.'

Robust unit

The 90-degree V8 is already a robust unit, though performance in Cup guise is severely constrained by NASCAR's insistence on the use of a tapered spacer in the inlet at all tracks,

Unrestricted by the NASCAR-mandated tapered spacer, the engine in the Le Mans Garage 56 entry was capable of making around 900bhp, but that was dialled back in the interest of trying to finish the race

The drivers - Jenson Button, Jimmie Johnson and Mike Rockenfeller - climbed in through the window, despite the aero disadvantage

> "The idea with Garage 56 was to put on a good show, finish the race and make our partners look great. With that in mind, we looked at what power we actually needed and designed a camshaft around that"
>
> *Scott Meesters, director of special projects at ECR Engines*

The car that raced at Le Mans in 2023 was very close to standard Cup spec, but with some additional aids to help it cope with the unusual (for a NASCAR) combination of tight corners and long, very high-speed straights

pruning power to a maximum of 670bhp (on short ovals). In their heyday, before the introduction of rpm limits and tapered spacers, Cup Series motors were running in the region of 900bhp at non-restrictor plate (the predecessor to the spacer) tracks.

Meesters explains that, solid as the base engine is, and despite the increase in road courses on the Cup calendar, 'it is mainly designed for turning left, for use on oval tracks. So the one thing that was at the top of our minds was tailoring the engine to just do road courses.'

It is not possible to have road course and oval-specific engines in Cup, as the power units are sealed and must complete a set number of races each, regardless of track type. A current Cup motor will run for around 1500 miles before it is rebuilt, but for Le Mans this mileage needed to be more than doubled to around 3500 miles.

Naturally, some of the first modifications centred around the lubrication system. This saw refinement of the flow rate through the oil galleries in the block, as well as a different specification of oil pump.

'The oil volume is smaller than we use in NASCAR, more comparable to what we see in our sportscar engines,' notes Meesters.

'There weren't any huge architecture changes. We didn't change the oil pan, there was a small change to the oil pump in how the pressure stage works but even that is something we've done in the past.

'The way we get the oil out of the top of the engine is a little bit different than what we currently do in Cup, but it's not unlike what we have done in the past.'

Reciprocating parts

Likewise, the stock Cup crank, bearings and connecting rods were retained in the engine, Meesters saying that the only change was the use of tighter tolerances on the bearings.

'From our sportscar side, dealing with aluminium blocks, we always pre-heated the engine. That's not normally done [in NASCAR], even though we would love it to be.'

Pre-heating allows for tighter clearances to be run without fear of binding any bearings when the engine is cold. 'We were operating well within those clearances,' confirms Meesters, 'and we could get rid of some oil flow. And any time you tighten up clearances, the parts work better.'

The pistons, however, were another matter entirely, bespoke to the Garage 56 car.

'It was a blend of our Cup technology and some of our previous sportscar technology,' outlines Meesters. The ultimate performance of the piston is not as high as the Cup part, but was sufficient for this application.

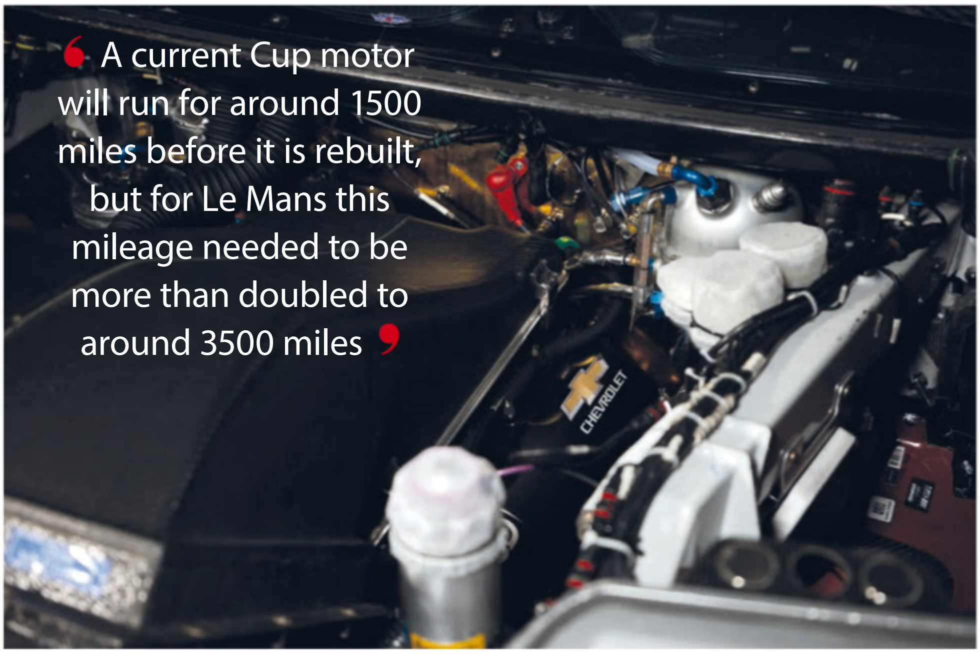
'The engine obviously had to go through the demands of a 24-hour race, so we erred on the side of safety vs using our Cup piston.'

Remarkably little was changed from Cup spec, just a tweak of the oiling system, a different cam and a new set of pistons and rings

The team didn't run into any problems with the Cup version, but felt that even though failure was unlikely, some issues with cracking were possible around the pin boss. So, for the Garage 56 pistons, this area was beefed up and the material grade subtly altered, though Meesters says the overall mass is very close to the regulation-defined 400g of a Cup piston. The ring pack is also more conservative.

'I opted to ditch the Cup ring pack and go back to our old DPi ring pack, which is .7, .8 [compression rings] and 3mm [oil control ring]. It's tried and true and runs a long time.'

With the duty cycle of an engine running at Le Mans a combination of what would be seen on NASCAR road course *and* ovals – extended periods at wide open throttle but also tight, low-speed corners – it was felt a custom cam profile was required.



A curve ball was the mandated 100 per cent sustainable fuel, which caused an unexpected issue at the pushrod / rocker interface

Initially, though, the team tested one of its existing grinds, from a higher output restricted Cup engine.

'It made great power,' remarks Meesters, 'but the idea with Garage 56 was to put on a good show, finish the race and make our partners look great. With that in mind, we looked at what power we actually needed and designed a camshaft around that.'

The result is a lobe shape modified from a design formerly used in DPi, which was in turn a development of an older Xfinity profile. The cam drives the rockers via conventional pushrods, with the former being high-ratio, steel productions.

'We wanted to use the rocker that we use in Cup. We have put a lot of design work into them and are proud of it, so wanted to carry that over. What we then did was reverse engineer the camshaft for that rocker ratio, which is vastly larger than what we used to run in our sportscar engines.'

The whole package was optimised with extensive running on ECR's Spintron (a machine able to spin the engine at high speed to assess valvetrain operation) using various tools such as laser valve tracing to ensure there were no unforeseen issues.

In the name of thoroughness, the team also tested several other lobe profiles, just to be sure they weren't missing a trick.

'What we came up with on paper [at the start] turned out to be the one we went with,' confirms Meesters.

> “The engine electronics architecture on the Garage 56 car was very close to what is in the Corvette C8.R. So, we took a lot of those learnings and transferred them over”
>
> *Peter Serran, GM Global Propulsion team lead at Corvette Racing*

Fuel for thought

One area that did cause some concern was the pushrods, components NASCAR engine developers are uniquely well informed about. Over the years, the team at ECR has conducted numerous optimisation studies into pushrod dynamics but, for the Garage 56 car, there was an unaccounted-for factor.

'Honestly, I had underestimated that interface [between the rod and rocker]. The previous sportscar engine was pushrod based and we rarely had any issue with that interface, so we didn't expect there to be any issue going forward with this project. But something got thrown at us and it had more effect than we thought. That was the fuel.'

The fuel in this case being the Total Energies-produced '100 per cent' sustainable product made from agricultural waste that is used across the Le Mans field. Compared to the fuel run in the Cup Series, Meesters says the team found the Le Mans-spec product led to far greater levels of fuel dilution in the oil. Fortunately, the only place this manifested itself as a component level problem was at the pushrod / rocker interface, but that still presented an unforseen issue that then had to be solved.

One solution would have been to simply change the oil more often. However, this was not an approach Meesters and his team wanted to take, instead deciding to get to the root cause of the issue.

With no mandate for using the Cup-spec, McLaren Applied ECU, the team chose a Bosch MS 7.4 unit, as used on GM's Corvette GTE car

'We asked what better parts do we already have sitting on the shelf can we use for this? We had different pushrod geometries that were more robust than what we started with, so fell back on those.'

These revisions, coupled with several other changes, seemed to do the trick.

'We wrapped our heads around it and decided, okay, there's multiple things going on here. Let's attack every one of them. We did that and haven't seen an issue since.'

Risk management

The cylinder heads ECR uses in its Cup motors are capable of supporting more than the power required at Le Mans, says Meesters. 'Because it doesn't have the tapered spacer, if we unleashed the engine and let it run at its maximum potential, the engine would make near 900bhp.' However, at this output it would be unlikely to finish a 24-hour race.

Instead, the team opted to minimise any risks and dialled back the performance of the heads, specifically the inlet valve.

'In NASCAR, we run a very large diameter inlet valve, with a very small stem. I just told the guys I didn't want to run the big intake valve, I wanted to make it more like what we used to use in sportscars as I knew we were going to be fine on power. That let us achieve the power target we were looking for really easily, and gave us a more robust part.'

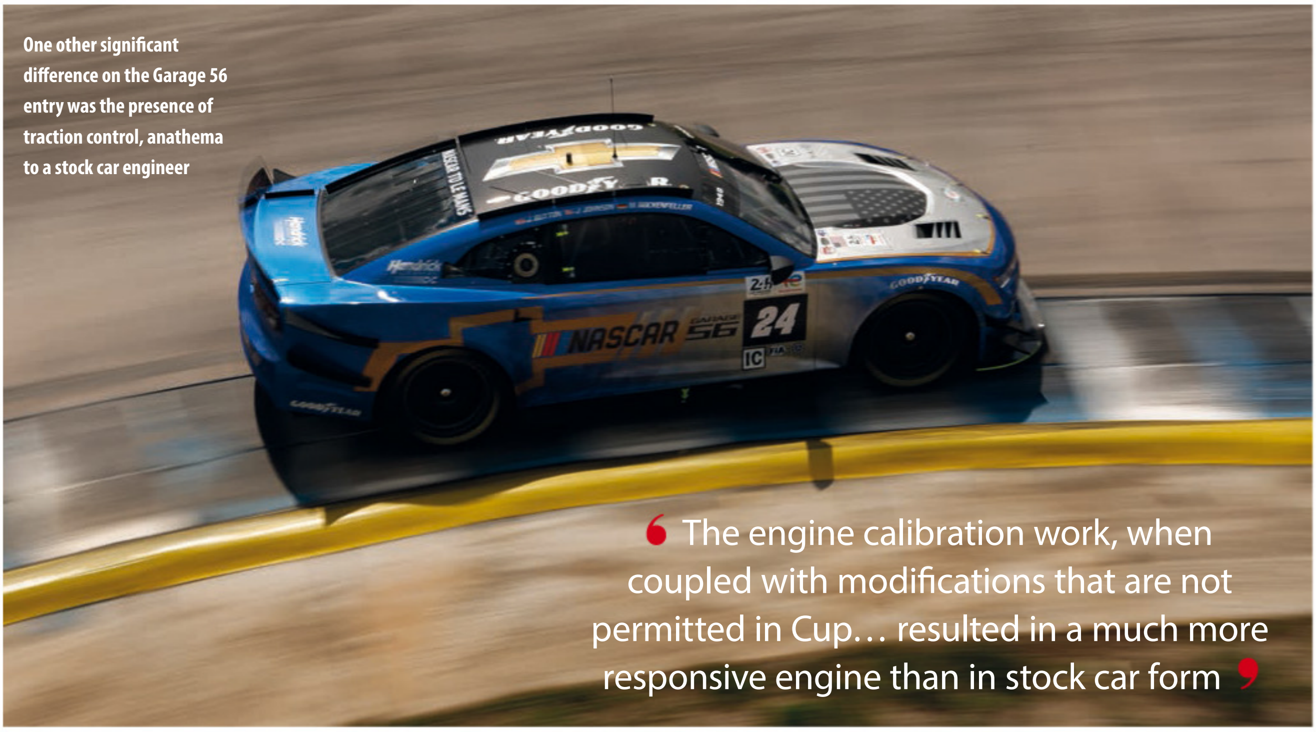
Reducing the valve size obviously influences the inlet port, leading ECR to look at its extensive back catalogue of designs, ending up with a port profile originally formulated for use when restrictor plates were still in Cup.

On the exhaust side, the standard valve was retained as these are much smaller than the inlets anyway, so durability wasn't a concern there. Though it was not specifically investigated, Meesters says the smaller valve and port likely increased port flow velocity and turbulence within the inlet charge. This, he muses, may have helped with another issue the team experienced with the spec fuel, wha greater propensity to knock.

The solution to this was a reduction in compression ratio. Potentially, suggests Meesters, if the larger inlet valve had been retained, knock could have become a more significant problem.

Control strategy

In Cup, all teams must use the same ECU supplied by McLaren Applied, but at Le Mans there is no such restriction. Common to GM's other sportscar programmes, ECR opted to run a Bosch MS 7.4 ECU, which was also used on the Corvette C8.R that won the GTE-Am class. ECR had experience running Bosch controls on its old IMSA DPi cars, but that was the older MS 5.0 unit, which is no longer supported by the company. Despite this, the



One other significant difference on the Garage 56 entry was the presence of traction control, anathema to a stock car engineer

> The engine calibration work, when coupled with modifications that are not permitted in Cup… resulted in a much more responsive engine than in stock car form

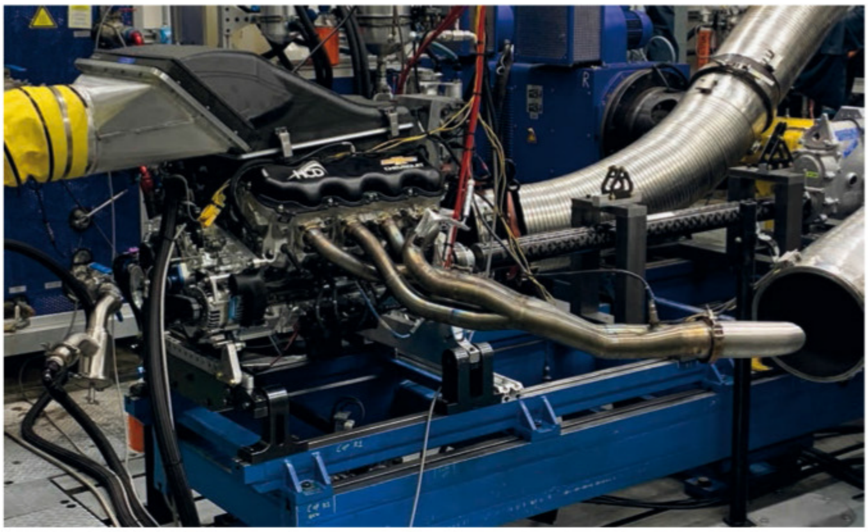
base code from that program was able to form the underpinnings of the new system.

'The engine electronics architecture on the Garage 56 car was very close to what is in the Corvette C8.R. So, we took a lot of those learnings and transferred them over, which let us hit the ground running,' states Peter Serran, who led the GM Global Propulsion team at Corvette Racing.

'Together with Pete and with Bosch, we executed writing custom code for this project,' adds Meesters. 'There were some things we needed, just for this application and going to Le Mans, which meant it was simpler to do that to get going. It wasn't a Bosch-based code, but a modification of that.'

The Bosch ECU also takes care of traction control, something stock cars certainly don't feature. The traction control program was based on ideas ECR had developed during its sportscar days but re-worked to operate with the latest hardware.

As with the engine calibration, it was not simply a case of plugging old into new and fresh code had to be written. Given the time constraints of the project, Meesters explains: 'We looked at the base code traction control and made some modifications to get where we wanted to go. It wasn't a mirror image of what we had before, it was something a little bit like it, not as thorough, and it did what we needed it to do.'



The modified camshaft and valvetrain package was thoroughly tested and optimised on the Spintron machine at ECR

'Box of tricks

On the same theme, transmission control is also handled by the ECU. The car ran a NASCAR-spec Xtrac 1334 transmission retro-fitted with an electronically-actuated paddle shift system (a capability the 'box already has) rather than manual sequential shift.

The ratios inside the 'box were similar to those used in Cup (where various gear set combinations are available to suit different tracks) but mixed and matched to suit the very different demands of Le Mans.

'The [gears] were not the full Cup set, but they fit in there. We did some driving-in-the-loop simulations with that, and some good old math to come up with the ratios we chose,' says Serran.

The engine calibration work, when coupled with modifications that are not permitted in Cup, such as individual inlet runners combined with two throttle bodies, resulted in a much more responsive engine than in stock car form. The drivers noticed this useful improvement, and it seems they're not the only ones.

'When the engines came out of ECR, and were transported down to Hendrick to go in the car, a lot of people working there next to their engine shop came out and commented that, audibly, they can hear a difference in response,' recalls Meesters.

Out of the shadows

There was certainly never a doubt as to where the car was on track in the race. The unmistakable sound of the pushrod V8, with short exhaust, identified the car when it was running… and when it was not. On Sunday morning, the project ground to a halt in the pit, the gearbox the unexpected culprit. The unit was changed (as the car ran outside of the regulation) and the car finished the race.

Today, the car travels the world on exhibition, but is often found in NASCAR's R&D facility in North Carolina. There, the team can pore over one of the most extraordinary projects to have been seen at Le Mans in recent years. The centenary race was the perfect place and occasion to run it. ●

Meeting, and setting, the standards

A typical NASCAR weighs in at nearly 1600kg, so the first job was to put the car on a diet. Working with Hendrick Motorsports and Dallara, the FIA took its base regulations for GT3 as a starting point for the car development, including setting a weight target.

'To reduce the weight for safety concern was important, but also for performance,' says Xavier Mestelan-Pinon, chief technical and safety officer at the FIA. 'It was crucial, and at the end the minimum weight we achieved was 1340kg, so more or less 70kg more than a GTE.'

Modifications to the rollcage and the brakes, which were switched to carbon, helped to achieve the goal.

Hendrick Motorsports elected to run a high-downforce package in the race, which gave a good time through the winding Porsche Curves, but the final race results show the Camaro had an average over its five quickest speeds through the traps of 312km/h, around 6km/h faster than the quickest GTE car's fastest five speeds.

Tyre development by Goodyear saw tyres able to double or triple stint, as well as manage the loads caused by the higher weight.

'We knew the car would be a rocket in a straight line, but there were more questions about the car in the corners. In the end, it was 0.5s faster than a GTE if you take the 20 per cent best lap time,' says Mastelan-Pinon.

The next issue that had to be looked at was a potential impact with the barrier. Here, the simulation work specified by the FIA was critical as the organisation did not crash test the car before the competition. Instead, it was up to the team to provide the computer simulation that confirmed the car would meet the FIA's standards.

By the FIA's own criteria, a car with 150kg extra mass over the homologated minimum (75kg for the driver, 75kg for fuel) must be subjected to an impact against a solid, vertical barrier placed at right angles to the longitudinal axis of the car at a minimum speed of 14m/s. For the rear impact structure, it is subjected to 11m/s impact speed.

At these speeds, the FIA's criteria for safety against the barrier is that the model must not exceed an average deceleration of 25*g*, and must absorb the impact throughout the structure of the car. To achieve that, the team needed to develop the front and rear crash zones.

To start with, the fuel tank was moved from behind the rear axle to a more central location, ahead of the rear axle. The steering column was another area of concern. Although the NASCAR regulations stipulate the steering column must collapse in an impact, the way in which it deforms is different to that specified by the FIA.

The NASCAR's polycarbonate windscreen was allowed to stay, but the fact the car didn't have any doors raised some eyebrows initially. This time it was NASCAR's turn to stand firm, wanting to retain some of its heritage. That included using trolley jacks in the pits.

The FIA agreed, and the car raced without side windows. A happy by-product of this decision was that with only netting covering the side window apertures, drag was increased, slowing the car in a straight line.

While Le Mans is an FIA-homologated race, and the car had to meet certain FIA standards, there were two areas in particular where the European organisation could learn from its American counterparts. The first is access to the driver through the roof hatch. The European standard is that the marshals must be able to reach a driver's head, in order to be able to remove a helmet before the driver is extracted from the car. NASCAR's hatch is far bigger, allowing marshals greater access to a driver in the event of a crash.

The second area was the way the seat is located within the car. NASCAR's solution is to create a monocoque within the car's safety cell, and mount the driver seat and belts to that, more akin to the FIA's criteria for a single-seater. However, this way of mounting the seat is more expensive and may never achieve a price point that will work for customer racing, or even factory-operated GT cars.

While the Garage 56 entry was not crash tested prior to the Le Mans race, modifying it to meet the necessary safety standards provided an interesting case study for both the FIA and NASCAR

Electric avenue

NASCAR is expanding its horizons with a sustainability programme headlined by this EV demonstrator car

By Eric Jacuzzi, Brandon Thomas, Charles Tobin

The internal combustion engine is an integral part of NASCAR's fabric and that is set to continue in the coming years. But, like other sanctioning bodies, NASCAR is also aware of the need to operate more sustainably. It has committed to reducing its carbon footprint to zero by 2035 and is using technology as a way of demonstrating how it can achieve that.

The advent of the in-house Next Gen car presented an opportunity to initiate special projects, including one showcasing a greener mobility option. While most of Next Gen's first season was dedicated to addressing normal teething issues, a number of fringe operations were simultaneously under way using the Next Gen architecture at NASCAR's R&D Center in Concord, North Carolina.

One was the Garage 56 effort in partnership with the Hendrick Motorsports team that famously returned NASCAR to the 24 Hours of Le Mans in 2023. Almost in parallel, beginning in the summer of 2022, NASCAR and its OEM partners also agreed it was time to take a step into the battery electric vehicle (EV) arena. NASCAR's design and aerodynamics groups worked alongside each other to develop not only a novel powertrain, but also a new body style to go with it.

Design challenges

The two major system design considerations for the prototype NASCAR EV were electric powertrain selection, and how to package it in the Next Gen platform. With performance and reliability uppermost in mind, NASCAR began the search for an experienced group in the electric vehicle space to partner with.

This venture did not last long before it was decided that STARD would be the supplier of the powertrain for the vehicle. The Austria-based company's track record for providing cutting-edge electric powertrain technology spoke for itself: for the past two years, it has partnered with Ford Performance on its SuperVan 4.2 and SuperTruck that competed at the Pikes Peak International Hill Climb.

With the powertrain partner secured, the design of the vehicle itself could begin. One of NASCAR's key partners in developing the Next Gen platform, Dallara, began the initial work of packaging the powertrain into the base car design. The first substantial obstacle the group encountered was the lack of space available for the rechargeable energy storage system (RESS).

Rather than undertake a complete chassis re-design to a skateboard configuration, as would be optimal, it was decided to continue with the existing platform to reduce costs to all partners. The logical choice was to put the 1300lb (590kg), 78kWh RESS on the right side of the car, where it would occupy a large portion of the available space. Due to the existing design, it would also need to be installed from underneath the vehicle.

This being the first electric stock car, and knowing all too well the style of racing it would be subjected to, the RESS casing needed to be robust enough to withstand high-speed contact with a wall, and other cars. Consequently, the RESS sits at approximately elbow height to the driver, in a carbon casing that can withstand a 40*g* hit without penetration to the RESS pack cells.

To the casual spectator, opening the front or rear of this prototype would raise a few questions. Primarily, they would ask where the traditional, OEM-specific, pushrod V8 went, and what happened to the Xtrac sequential gearbox they're used to hearing run through its gears at races every Sunday.

> Rather than undertake a complete chassis re-design… it was decided to continue with the existing [Next Gen] platform to reduce costs to all partners

NASCAR wants to showcase its sustainability efforts and building an EV prototype is one way of doing that. Discussions about the project between NASCAR and its OEM partners started mid-2022

> With the re-design of a few components on the chassis… the prototype EV weighs around 4000lb (1814kg), or approximately 600lb (272kg) more than a race-spec Next Gen

NASCAR vice president of design, Brandon Thomas, displaying the EV prototype during its Chicago debut in July 2024

In the front of the car is a single STARD six-phase UHP motor and accompanying single-speed gearbox, nestled in a modular front clip in the familiar Next Gen chassis.

To accommodate the new front driveshafts of what is now an all-wheel-drive racecar, the lower shaft end of the stock, Next Gen Öhlins damper features a 'fork' design. The next change a spectator will notice is that the steel firewall has been replaced with a carbon version that supports the inverter for the front motor and the DC-DC converter.

Look in the rear of the NASCAR EV and you'll see another carbon firewall, this time supporting two inverters for two further STARD six-phase UHP motors. Unlike the front, though, here an integrated rear clip supports the motors and gearbox. This rear clip is similar to that used in the Garage 56 project. Without the need for a fuel cell, though, the clip could be shortened to help with weight reduction and bumper structure packaging.

BComp's flax fibre bodywork was tested, possibly for future application

With the re-design of a few components on the chassis and accompanying systems, the EV prototype weighs in at around 4000lb (1814kg), or approximately 600lb (272kg) more than a race-spec Next Gen.

To help slow down the additional weight, the Next Gen-spec Heavy Duty (HD) brake package from AP Racing was selected, while NASCAR's rubber supplier, Goodyear, was tasked with developing an EV-specific tyre. The company worked for nearly a year on the project, coming up with a tyre capable of withstanding the unique demands placed on it by the prototype car.

Some of the challenges Goodyear faced included designing a tyre that experiences greater loads, higher torque and, in particular, the all-wheel drive arrangement, which adds drive torque at higher slip angles on the front tyres compared to what the rears are used to.

Goodyear drew upon lessons learned from its road car division in designing for the unique characteristics of the electric NASCAR. For example, on the materials side, sustainable materials from its roadgoing tyres were incorporated into the race rubber, which was based on the 70 per cent sustainable material tyre from Goodyear's EcoReady line of passenger car tyres. Goodyear integrated the next generation of its SightLine TPMS system, which made its debut as part of the Garage 56 programme at Le Mans.

The design team says it reflected on current automotive purchasing trends in the US so, while the EV uses the Next Gen chassis, the body design is based on a generic Crossover Utility Vehicle (CUV)

With the CUV-style body shape, aerodynamic performance was a concern, so the prototype was investigated at Windshear in North Carolina and at Stellantis' wind tunnel for its yaw angle capability

In this application, however, system weight was reduced by over half, while it also achieved the same level of reliability.

One of the most striking features of the NASCAR EV prototype is the body style, designed to mimic a Crossover Utility Vehicle, or CUV. Over the past few years, CUVs have come to represent a substantial portion of the North American vehicle market, and this trend looks set to continue with the introduction of new models from OEMs.

Raising the roof

To obtain the CUV shape, the roofline is a compromise between Chevrolet's Blazer EV, Ford's Mustang Mach-E and the Toyota bZ4X. NASCAR and its OEM partners defined the important areas to ensure there was enough design freedom in the body to adequately capture the differences in each of the three manufacturers' designs.

NASCAR worked with Craig Kember and John Dixon, two freelance automotive designers, to create the so-called generic body for the EV prototype, running through upwards of 10 iterations that blended the styling of all three vehicles, while also meeting the proposed rule set.

Once all parties were satisfied with the general proportions and areas of design freedom, NASCAR set to work on the aerodynamics of the vehicle.

One of the big mysteries to NASCAR's aero group was how this body shape would behave at the speeds of almost 300km/h that current stock cars are capable of. Like in the Next Gen project, parallel investigations into performance of the aero package, and the lift-off safety performance, were undertaken.

On the performance side, higher minimum ride heights were selected to keep the CUV appearance intact when racing. This reduced the effectiveness of some of the underbody aerodynamic devices, but the deficit was mostly felt at the rear of the car. The very high lift generated by the tall greenhouse and rear section produced a big challenge for the aerodynamicists, who

A rear wing was considered more effective than a traditional NASCAR spoiler, a major departure for the sport's aerodynamic concept

> One of the most striking features of the NASCAR EV prototype is the body style, designed to mimic a Crossover Utility Vehicle… to represent a substantial portion of the North American vehicle market

were tasked with offsetting that lift without drastically changing the body shape, or adding massive spoilers.

It was determined that a rear wing would offer several advantages over a conventional NASCAR spoiler. These include higher lift coefficients, a common solution for all three of the OEM body styles, and a tunable element to balance performance if needed.

Wing placement was such that it could accommodate varying roofline lengths, which was permissible in the design guidance developed between the OEMs and NASCAR.

Erratic behaviour

In addition to higher than expected lift, the body style also has some peculiarities at the rear. It was found early on that the rounded edges at the rear of the vehicle were particularly sensitive. They not only reduced lift and increased drag, but also made for some erratic behaviour in CFD.

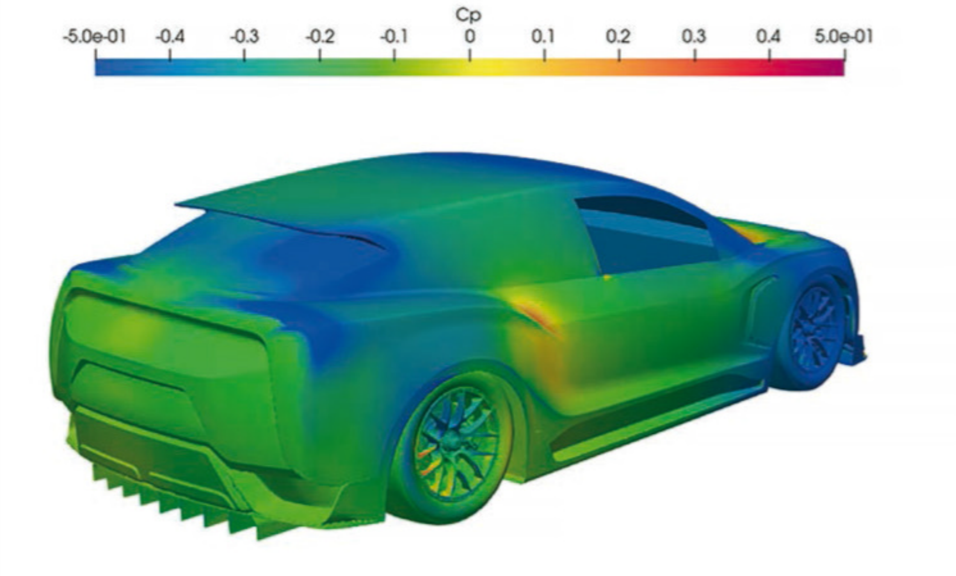
As is typical for NASCAR, body appearance is very important for maintaining fidelity to the production cars, so aggressive vents and performance shapes were largely avoided, unless they were subtle in nature.

On the lift-off safety side, the prototype EV performed very well from the beginning, even prior to adding the usual components of hood flaps, roof flaps and roof rails.

Initial CFD modelling predicted the concept would have the highest lift-off speed of any NASCAR vehicle, and the team was pleasantly surprised when this was backed up during a visit to the Stellantis aero acoustic wind tunnel at Chrysler's headquarters in Auburn Hills, Michigan.

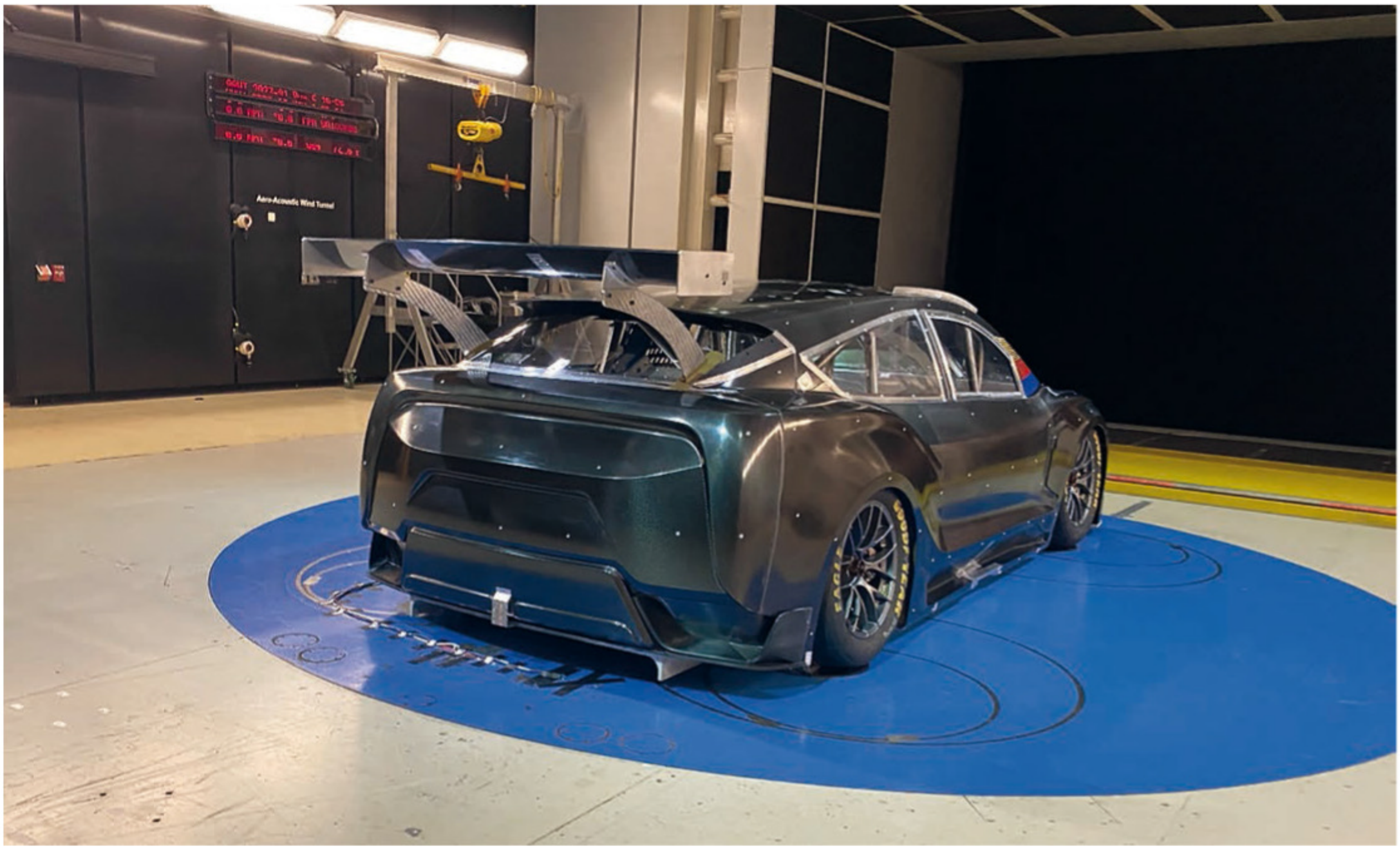
NASCAR studies lift-off by measuring the lift on either the side or rear of the vehicle and then calculating at what speed that lift will equal the weight of the vehicle, hence lift-off being reported in miles per hour.

The Stellantis wind tunnel can yaw from zero to 180 degrees in either direction, a unique feat for a full-scale wind tunnel, and a great advantage for a project such as this.



Initial CFD with no body treatments showed some concerning behaviour around the rear quarters and greenhouse

> "Initial CFD modelling predicted the new prototype would have the highest lift-off speed of any NASCAR vehicle"



The aero test mule undergoing investigations at Chrysler headquarters in Michigan. Engineers were surprised to find the vehicle shape performed better than expected in the lift-off safety tests

Rain delayed the official launch of the prototype from February to July this year, when a crowd-pleasing burnout was performed ahead of the Chicago Street Race after months of testing

> The first step in the testing process was selecting the correct Rechargeable Energy Storage System capacity for the defined performance targets of the car

With lift-off testing checked off, aero development concluded and work began on constructing the running vehicle prototype.

The final point of interest for the body is the material used in its construction. NASCAR spotted an opportunity to incorporate more environmentally friendly materials, as well as evaluate them for use in regular NASCAR racing, and so worked with Swiss company, Bcomp, to use its flax-based composite pre-preg and PowerRib stiffeners on the production vehicle (the aerodynamic test car used regular carbon fibre).

NASCAR anticipates that more sustainable fibres will be incorporated into production stock cars in the future, while it will also continue the carbon fibre recycling programme it has established with the cooperation of existing NASCAR teams.

Validation testing

Testing and simulation for the EV began almost a year prior to the first chassis being built. The first step in the process was selecting the correct RESS capacity for the defined performance targets of the car.

With Martinsville Speedway used as the benchmark track for simulation, it was only right track testing should take place there, too

Together, STARD and NASCAR ran numerous simulations on different RESS capacities to compare how they would perform on some of the defined benchmark tracks the NASCAR Cup Series races on, given an array of power levels and regeneration strategies.

Along with the simulations, NASCAR leaned on its OEM partners to help execute driver-in-the-loop (DiL) test sessions to fine tune powertrain and vehicle specifications.

After months of extensive simulation runs, a specific RESS was chosen, based on its power density, energy content and the trade-off of RESS weight.

Using Martinsville as the benchmark track for the simulation work, it was predicted that the chosen RESS at full race power would be able to manage more than 55 laps at, or around, the same lap times as the current Next Gen cars are capable of.

Table 1: Performance specifications

Peak power	1000kW
Race power	600kW
Energy content	78kWh
DC voltage level	756V DC max

Real life testing began at the drag strip beside Charlotte Motor Speedway in October 2023 for systems checks and low-speed running. With the shakedown complete, focus shifted to running the car in anger. November 14, 2023 marked the first time the EV ran

fast laps at any NASCAR track. The three-day test aimed to gather and verify data on RESS, systems and tyre performance.

Day one of the test focused on RESS and regen' management and performance of the vehicle system. In total, the car ran over 100 laps with nine different power and regen' settings. These laps were not only imperative in understanding the powertrain and chassis set-up on the engineering side, but also for driver acclimatisation to the vehicle.

NASCAR veteran and Ford test driver, David Ragan, had carried a heavy load in the earlier DiL work, so he was deemed the perfect fit when the EV took to the track.

In stockcar racing, the most heightened sense for fans attending has always been the sound of a pushrod V8 holding over 8000rpm. It is distinct and unlike any other race series. This also holds true for the drivers' audible experience inside the cockpit.

With the EV prototype, this experience is flipped on its head. As Ragan learned in the early laps of testing, he could now not only feel how the car was performing, but could also hear what he was feeling.

By all accounts, the chatter of the tyres as he rolled the corners and the squeal of the brakes on entry took some getting used to.

At the same time, he was also learning to understand what regen' did for his braking performance, and how the all-wheel drive system helped compensate for the heavier car on corner exit.

> ‘By the end of the test, the prototype NASCAR BEV had completed over 300 laps, and ran within a few tenths of a Next Gen car qualifying time at the same track’

Day one of testing was a huge learning experience for the entire group on the facets that make an all-electric vehicle different.

Day two of testing was primarily focused on tyre development. Goodyear performed an outstanding job, bringing several different stagger and compound options to test. The car ran over 130 laps around Martinsville on day two, finalising the tyre specification.

In addition to this, the laps also verified the simulation work done in the months prior.

The longest continual run of the day was 65 laps. Having achieved most of the targets for the day, this allowed the team to go into day three with the ability to throw a few more development options into the mix.

The first run of the final day was again used to verify RESS management, and to afford the driver more seat time. The 57-lap session went as expected, and was a further great learning experience for all involved. The car exceeded expectations and the team moved on to stretching the prototype's legs.

One of the perks of an electric vehicle is the fact that the powertrain is tunable with nothing more than strokes of a keyboard. Dialling up the power for Ragan, a few qualifying runs were conducted at close to the full 1000kW. Again, all went to plan.

By the end of the test, the prototype had completed over 300 laps (338km) and ran within a few tenths of a Next Gen car qualifying time at the same track. The public debut was planned for The Clash at the Los Angeles Memorial Coliseum in February, but rain forced the event to be run a day early. The EV was instead revealed in Chicago on July 6, followed by a showcase of its capabilities, including performing a huge, crowd-pleasing burnout and demonstrating the speed and acceleration of the electric powertrain.

Future plans

While the ICE has a long road ahead of it in NASCAR, the sport is committed to exploring future powertrain options to remain relevant with the automotive industry. There are no competition plans for the EV, but NASCAR and its partners will use the project to educate fans about the potential of electric vehicles. Whether the future of stockcars includes electric technology, hydrogen combustion or sustainable fuels, NASCAR plans to be ready for all possibilities. ●

Despite successful test sessions, NASCAR's EV will not be used in competition but will instead be put into service to educate the sport's considerable audience on the potential of such technology

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